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Classroom Assessment in Middle Grades and High School

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The "bottom line" for mathematics instruction is to help students learn more. Professional development that helps teachers understand both mathematics and students' thinking more deeply is one strategy for ultimately improving students' learning. This is supported by a clear argument that is consistent with arguments made about professional development at the elementary level (Carpenter, & Fennema, 1999; Carpenter, Franke, & Levi, 2003; Fosnot & Dolk, 2001a, 2001b, 2002, Ma, 1999; Schifter, Bastable, & Russell, 1999; Seago, Mumme, & Branca, 2004).

- First, more learning is associated with better instruction.
- Second, better instruction happens when teachers align instruction with the needs of students.
- Third, aligning instruction is more likely to happen when teachers have clear understanding of what students know and can do.
- Fourth, clear understanding of students' thinking requires having accurate information about students' thinking and interpreting that information within frameworks of mathematics and student development.

The starting point, then, is gathering accurate information about students' thinking. In order for this information to be useful, however, it must be interpreted and those interpretations should be used to influence instructional decisions. We label this process as classroom assessment; that is, classroom assessment is the process of gathering information about students' mathematical thinking, making inferences from that evidence about what students know and can do, and designing instruction to account for the inferred levels of students' understanding. While there are many purposes for assessment, in general, the purpose of classroom assessment is to make better instructional decisions so that students learn more. Professional development on classroom assessment can provide teachers with the tools that they need to implement this process for the ultimate benefit of students.

There is considerable evidence that effective implementation of classroom assessment leads to greater student learning.

> Black and Wiliam (1998) conclude from an examination of 250 research studies on classroom assessment that "formative assessment does improve learning' — and that the achievement gains are "among the largest ever reported for educational interventions." The effect size of 0.7, on average, illustrates just how large these gains are…. In other words, if mathematics teachers were to focus their efforts on classroom assessment that is primarily formative in nature, students' learning gains would be impressive. These efforts would include gathering data through classroom questioning and discourse, using a variety of assessment tasks, and attending primarily to what students know and understand. (Wilson & Kenney, 2003, p. 55)

> Classroom-based formative assessment, when appropriately used, can positively affect learning. According to the results of this review, students learn more when they receive feedback about particular qualities of their work, along with advice on what they can do to improve. They also benefit from training in self-assessment, which helps them understand the main goals of the instruction and determine what they need to do to achieve. But these practices are rare, and classroom assessment is often weak. The development of good classroom assessments places significant demands on the teacher. Teachers must have tools and other supports if they are

> to implement high-quality assessments efficiently and use the resulting information effectively. (Pellegrino, Chudowsky, & Glaser, 2001, p. 38)

Classroom assessment does not always receive high priority, in spite of the research that supports its efficacy.

> U.S. society generally places greater value on large-scale than on classroom assessment… National standards in science and mathematics recognize this type of assessment [classroom assessment] as a fundamental part of teaching and learning… To guide instruction and monitor its effects, teachers need information intimately connected to what their students are studying, and they interpret this evidence in light of everything else they know about their students and their instruction. The power of classroom assessment resides in these connections. (Pellegrino, Chudowsky, & Glaser, 2001, p. 41)

Classroom assessment is likely to have its greatest impact directly on the learning that occurs in individual classrooms; this learning can in turn affect results of large-scale testing. However, teachers will not be able to use classroom assessment effectively unless they understand how to incorporate it into their everyday work. Professional development can help teachers learn to do this.

One side benefit of implementation of classroom assessment seems to be that teachers often develop a greater sense of satisfaction about their teaching. This seems to be because they are able to identify what students know, and they can better interpret the progress that students are making. Teachers can point to specific student responses and behaviors that document learning.

Key Elements of Professional Development on Classroom Assessment

There are several elements that professional development on classroom assessment needs to address. These are outlined below, with examples taken from *Dynamic Classroom Assessment (DCA)*, a program created with support from a National Science Foundation grant (#9819914). *DCA* helps middle grades and high school mathematics teachers learn to incorporate classroom assessment into their regular instructional planning. *DCA* consists of a core module (ten 3-hour sessions) and three extension modules (10 hours each), totally 60 hours of professional development.

First, classroom assessment involves setting clear learning targets and exploring how different assessment methods can be aligned with those learning targets. Learning targets — sometimes called learning goals or learning objectives — are specifications of what students are intended to learn. Teachers should also think about what kinds of evidence would be acceptable as indication of attainment of those targets; that is, what behavior or response or verbalization is acceptable as a clear indicator that the desired learning actually occurred. Different assessment methods — for example, multiple choice item, open-ended problem — have the potential to reveal different information about students' thinking, just as different approaches to solving mathematics problems may indicate different levels of sophistication of mathematical thinking. Thinking about the evidence that is related to a learning target can help teachers choose an assessment method that might reveal that kind of evidence.

In the last decade or so, there has been a lot of attention in professional development on "alternative assessments," so many teachers can identify different assessment methods and understand some of the advantages and disadvantages of each. In *DCA*, therefore, we point out that many of the incorrect answers that students give result from the application of a particular "logic;" incorrect answers are seldom completely random, though of course there is the possibility that they result from carelessness. One of the problems we discuss is a division problem:

What is 6 ÷ 2/3?

A. 9 B. 4 C. 1 D. 1/9

We challenge teachers to identify thinking that might generate each of these options. Choice A is the correct answer, and choice B could indicate multiplication of 6 and 2/3. Choice C is more of a challenge for many teachers to "see;" if students interpret the fraction bar as a division sign and apply order of operations, they would execute the two "divisions" from left to right, first computing 6 ÷ 2 (with 3 as the answer) and then computing 3 ÷ 3 (with 1 as the answer). Choice D would be generated if students "inverted" the wrong factor; that is, computing 1/6 x 2/3. Recognizing the need to look for the logic behind students' incorrect answers is an important first step for many teachers in being able to understand students' thinking.

Second, feedback to students will be more effective when teachers distinguish between errors in what students know and errors in the way that students show what they know. That is, errors that students make may be fairly accurate communication of a significant misunderstanding of mathematics (e.g., an error of substance) or miscommunication of what turns out to be fairly accurate understanding of mathematics (e.g., an error of presentation). For example, *DCA* provides two student responses to this problem: ***What is 2 more than 3 times 4*?** Two of the responses are given below:

Student A: (3 + 2) x 4 = 20
Student B: 3 x 4 = 12 + 2 = 14

Many teachers initially classify both response as "incorrect," though for different reasons. Often they say that "Student A does not understand order of operations;" that is, there is an error of substance, while "Student B has written a number sentence that makes no sense;" that is, there is an error of presentation. Debriefing of these initial thoughts often leads teachers to the view that Student A might have read the question with a pause after "3": What is 2 more than 3 (pause) times 4. If so, this students' answer is reasonable, even though it is not what most teachers desire. Most teachers agree that Student B probably has a correct understanding of the problem but has presented that thinking in a way that leads to incorrect symbolism. One teacher used the phrase "run-on equation" to describe Student B's response.

The terminology that we use to describe these underlying issues is "substance of an idea," which is the meaning that students have internalized, and "presentation of an idea," which is the way that this meaning is communicated. This terminology evolved from the work of Pimm (1987, 1995). Students' errors can typically be categorized as errors of substance or errors of presentation. Feedback to students will be more effective when teachers distinguish between these two kinds of errors and tailor their feedback accordingly. That is, when teachers can identify the nature of a student's error, they can provide feedback that helps that student understand whether the error reflects deep misunderstanding or mistakes in communicating understanding. "Teachers should give specific feedback on errors and strategies, with suggestions on how to improve, but should keep the focus on deep understanding rather than on superficial learning of procedures" (Wilson & Kenney, 2003, 59). The net result is improved learning for students and better self-monitoring of learning by students.

Third, skillful questioning is an important part of the way that teachers can gather information about students' thinking. There are several kinds of questions that teachers might ask, but the most important ones for revealing students' thinking are clarifying and probing questions. These questions help students clarify their own thinking and clarify that thinking for the teacher and other students. The main focus of clarifying and probing questions is to reveal more of the information that is inside students' heads, not to put more information into students' heads as a means of "fixing" perceived errors. Developing skill at creating specific questions takes practice and reflection.

Weiss and her colleagues, in a national study of mathematics and science instruction, found that the most common form of questioning in instruction is "low-level 'fill-in-the-blank' questions, asked in rapid-fire, staccato fashion, with an emphasis on getting the right answer and moving on, rather than helping the students make sense of the mathematics/science concepts" (Weiss, Pasley, Smith, Banilower, & Heck, 2003, p. 67). Overall, "questioning is among the weakest elements of mathematics and science instruction, with only 16 percent of lessons nationally incorporating questioning that is likely to move student understanding forward" (Weiss, et al., p. 65). Instruction seems to be oriented much more toward covering the curriculum and getting students to say the right things rather than helping students make sense of the underlying mathematical ideas.

The typical questioning strategies used by teachers can have the effect of limiting the amount of engagement of students with key mathematics ideas. The questions can also limit the amount of information that a teacher can get about how students are thinking about mathematics.

> If the teacher limits questions to a narrow band of procedural questions, the answers given may not be sufficient for the teacher to make informed inferences about the breadth or depth of students' understanding. That is, the teacher may take a series of correct answers by a student as evidence of understanding, when in fact it is very limited evidence merely of the student's ability to give the correct answers. (Wilson & Kenney, 2003, 56)

Rapid-fire, low-level questioning is not likely to reveal much about students' thinking, so in order for classroom assessment to be implemented effectively, teachers need to consider carefully the kinds of questions they ask and the purposes for those questions.

In *DCA* we propose a categorization of questions based on a teacher's purposes. There are three purposes:

a. ***Engaging questions:*** invite students into a discussion, keep them engaged in conversation, invite them to share their work, or get answers "on the table"

b. ***Refocusing questions:*** help students get back on track or move away from a dead-end strategy

c. ***Clarifying questions:*** help students explain their thinking or help the teacher understand their thinking

DCA offers teachers opportunities to think about questioning through reviewing (a) a transcript of a conversation between a teacher and students, (b) curriculum materials, and (c) a classroom vignette on videotape.

Fourth, information about students' thinking and inferences about what students understand are not useful unless they can inform instructional decision-making. It is through better instruction that students will learn more. Improving instructional planning happens when there are opportunities for a teacher to reflect, discuss options with colleagues, explore different instructional strategies, and consider possible ramifications on students' learning of use of these strategies.

Because classroom assessment helps teachers make instructional decisions that are better aligned with the needs of students, teachers who use classroom assessment effectively can be expected to deliver "stronger instruction" in the sense that students will more likely be engaged in significant learning. In a phrase, these classes can be described as having greater intellectual rigor. "Fewer than 1 in 5 mathematics and science lessons are strong in intellectual rigor; include teacher questioning that is likely to enhance student conceptual understanding; and provide sense-making appropriate for the needs of the students and the purposes of the lesson" (Weiss, Pasley, Smith, Banilower, & Heck, 2003, p. 103). Making sense of students' thinking is a key to effective implementation of classroom assessment.

The *DCA* materials offer opportunities for teachers to reflect on and improve their instructional decision-making. This process begins in the first session, but the emphasis on this important issue increases across the remainder of the program.

Shauna, a high school geometry teacher

DCA materials were field-tested in several different settings in North Carolina, South Carolina, and Virginia. A sample of teachers were interviewed and their instruction was observed multiple times during the delivery of the professional development. Here is a brief description of what happened to one teacher. (The quotes set off below are taken from the interviews.)

At the start of the professional development program, Shauna taught geometry in a block schedule; each class was 90 minutes long. She planned lessons carefully and followed through on those plans, but with little deviation from her plans. She was attentive to her students' understanding through observation of students' work; her questioning focused mainly on leading students through the material to get them to the answer. She explicitly encouraged students to talk about their mathematical ideas, but she attended mainly to the most vocal students. This seemed to "leave out" some students from engagement with mathematical ideas. Some students' inattention resulted in off-task behavior.

The structure of the initially observed lesson was a variation on a traditional high school lesson. It began with two "brain teasers" on content unrelated to the lesson. Then there was an introductory activity in which students computed the measure of angles formed by parallel lines cut by a transversal. Next, Shauna reviewed the homework. Then she asked students to study a textbook page and complete a worksheet; answers were shared informally among groups of students. Finally, students worked independently on new homework. The worksheet asked students to analyze work from four unnamed "students;" the work of three of these hypothetical students was incorrect. Shauna had participated in a similar activity in the professional development program.

> *"I had four different students' answers to the first question. I had my students critique each one of those. If they did it correctly, then they explained how they went about doing that. If the student didn't do it correctly, I wanted my students to tell me why. What was it that the student didn't do correctly? What was their mistake? Did they set it up wrong? Did they work out the problem wrong?"*

> *"That was one of the assessment methods [in the professional development sessions]. It's almost the approach that*

a teacher has to use. When we get their papers, we have to actually figure out did the students work the problem correctly. If not, what was incorrect. I had never had a lesson like that before with this class. I was really impressed with their discussions, because they are my lower class. It really was beautiful."

Shauna acknowledged that the sessions helped her recognize that students work problems in different ways, and in ways that are different from her strategies. However, her favorable reaction to the sessions appears to be due to the fact that she got new activities to use with students; she was not yet distinguishing much between classroom assessment and assessment in general.

"We need to continually vary our assessments. We need to continually vary our activities, especially with block scheduling. I tend to get in a rut. Let's check our homework, let's take notes, here's a few problems — the same old same old. It [the professional development] challenges me to continually think of different ways and more effective ways to assess and to teach. There's definitely more than one way to learn, and I have to keep my eyes open to that."

By the end of the professional development program, Shauna asked more clarifying questions. After she questioned a student, she encouraged other students to expand on the response. When a student's response seemed incomplete, she posed questions that focused clearly on what she thought was the point of confusion. Her students were engaged in the content, almost to the point of exuberance, so Shauna had to refocus students' attention repeatedly on the mathematics of the lesson. Shauna clearly used assessment strategies to try to understand her students' thinking.

The final observed lesson began with review problems that were worked individually and then debriefed with the class as a whole. Then students worked as teams to play a game (a variation of Wheel of Fortune) that lasted the rest of the period. In each round of the game, teams had to reach consensus on an answer. Shauna chose one student to give the answer for each group, and she asked clarifying questions as necessary to be sure the answer was understood both by the team and by the rest of the class.

Shauna's beliefs about the role of questioning in instruction seemed to have changed dramatically. She used more — and better — clarifying questions during instruction, and she thought about questions as she planned instruction. She realized that having students share thinking was helpful to them. It was less clear how she used information about students' thinking in adapting lessons, since she never commented on how it affected her planning.

"I got the idea [having students reach consensus in their teams] from a graduate course I took 4 or 5 years ago. But the workshop [the classroom assessment sessions] really made me concentrate on how I question my kids. I have changed a lot of my questioning techniques, but I'm not really good with words. I'm not very good at asking questions on the fly, but when you actually get in to a lesson, you need to ask probing questions. So questioning is part of your planning."

"Just giving the right answer is not enough. You get them to explain how they got it and demonstrate different ways of doing problems. Just because a child gets the right answer that does not mean that they understand. And just because a child gets an answer wrong, that does not mean that they do not understand parts of the techniques. You really probe them. Why did you do it this way? Why does this work?"

"I'm the one that got hung up on get the right answer, not really explain it, just it's right or wrong. I was hung up in that kind of a rut, and this [the sessions] kind of got me out of that rut. I make my kids write more and I make them talk more in class. I make them explain what they did. I'll continue to give them problems where they have to really dig and make sure that they are looking for detail. They learn from each other. They learn from each other's mistakes."

Other Comments from Teachers

Other teachers in the field test responded positively to their interactions with the *DCA* materials.

I have told several people that this professional development program is the only "staff development" class I have actually put into action CONTINUOUSLY.

Effective mathematics instruction is more holistic than I previously thought. Processes and procedures and understanding of concepts aren't always equally developed in students.

> *I have found myself spending more time "assessing" my students' work. I evaluate more about their answers and give more feedback about what they are thinking.*
>
> *I am listening to see if they understand the process or concept — not just whether they have the correct answer.*
>
> *I think more about how students can grasp a concept rather than just pumping them with more information.*

It is important to note that effects on teachers happened over time. No single activity produced dramatic effect. Rather, effects accumulated as teachers learned more, implemented ideas in their teaching, and reflected on changes in students' behavior and learning. This result speaks to the importance of treating the materials as a coherent entity. Extracting components of the program and using them in isolation should not be expected to have the desired effects.

In Closing

Any effective professional development program on classroom assessment needs to be long-term and classroom-focused, so that teachers can apply what they are learning fairly quickly. Participants need time to internalize the information they are learning and to become comfortable using that information in their own teaching. Any program will be deemed a success if teachers use classroom assessment to help students learn more. Teachers who understand what students know and can do are able to plan instruction so that it is better aligned with the needs of students.

One of the most important pieces of advice about implementation of classroom assessment strategies is that teachers should *talk less and listen more*. It is only by listening to the ways that students reason that we can expect to adapt instruction to fit students' needs. If we want students to learn more, we have to meet them on their ground and talk with them using language that will make sense to them. In a real sense, students are the clients of our instruction, and instruction must satisfy the needs of those clients.

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