Assessment and Accountability: Strategies for Inquiry-Style Discussions

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Teachers' actions are what encourage students to think, question, solve problems, and discuss their ideas, strategies, and solutions. The teacher is responsible for creating an intellectual environment where serious mathematical thinking is the norm.

—Principles and Standards for School Mathematics (NCTM 2000, p. 18)

Teachers at my school recently watched a video of a model inquiry lesson, in which the instructor gathered her fifteen students on a rug to discuss fractions and share drawings and ideas. My neighbor whispered, “Sure, it’s easy when you have just fifteen kids. Forget it! I’ve got thirty!” How does a teacher with a large class facilitate a mathematical discussion that produces important ideas, engages all students, and includes assessment? It may sound impossible, but many strategies can make inquiry-style discussions accessible to all teachers.

As mathematics instruction shifts from direct instruction in which students memorize algorithms to inquiry-style instruction in which students discover properties of numbers, teachers must modify the classroom environment and assessments. Susan Jo Russell defines computational fluency as “efficiency, accuracy, and flexibility” (p. 154). A strong understanding of the base-ten number system helps children choose strategies that demonstrate computational fluency, which requires both basic skills (to assist problem solving) and conceptual awareness (to justify answers). When students work on problems alone, share strategies, then practice the new strategies, they build flexibility from seeing one problem solved in multiple ways; accuracy arises from using these strategies to verify answers and justify solutions. In order to create efficiency and flexibility, I alternate mathematical discussions with practice using a variety of problems and hands-on investigations.

One way to create rich discussions, both in small and large groups, is to post a problem on large paper and gather the students in front of the problem with papers, pencils, and something to write on. Without teaching an algorithm, the teacher asks students to solve the problem using their own strategies and prior knowledge. Then students share their work and confirm or debate one another’s reasoning. The emphasis is on how each student arrived at the answer. The teacher’s main question and comment are the following:

1. How do you know?
2. Please label your pictures with numbers.

Asking this question when students are correct as well as incorrect is important because mistakes are an integral aspect of inquiry-based discussions. Students gain number sense when they make, discover, and analyze mistakes. Figures 1 and 2 illustrate how a student’s mistake can initiate discussion.
To make these mathematics discussions powerful opportunities for all students, teachers must foster a student-centered environment, make students accountable for participating, and take notes about student understanding. This article describes specific strategies that teachers can implement to create powerful participation and discusses how to assess students during mathematical discourse.

**Setting the Scene**

In inquiry-based instruction, students play the lead role while the teacher makes sure that students are listening to one another and building meaning from one another’s work. Creating the discussion-centered classroom begins on the first day of school. Students must learn to pay attention to one another and be accountable for what others share with the class in all subjects.

The following three discussion “rules” provide a good base for the strategies discussed in this section:

1. Keep your eyes on the speaker.
2. Think about what others say.
3. Always be ready to explain another’s ideas and/or offer your own.

Teachers should establish clear expectations that all students are aware of what has just been spoken and that students will ask questions when they do not hear or understand the speaker. One of the biggest mistakes that some teachers make is always repeating students’ answers. This not only detracts from the authenticity of the students’ answers but also places the teacher at center stage. Keeping a note card box that contains every student’s name on three different note cards is one strategy that supports students’ awareness of one another. At any point during the day, the teacher can randomly pull out a name and that student must either rephrase what another student has just said or ask a thoughtful question of the student. At the beginning of the year, this strategy is used heavily until the students begin to listen to one another naturally.

When students with quiet voices share ideas, the teacher can ask all students who heard that student’s idea to raise their hands, then choose one student to repeat or rephrase the idea. The teacher asks again who knows the student’s idea and chooses a new hand. Two to three rounds of this are usually necessary before the entire class understands the student’s ideas. By that point, some students have heard the idea three times.

Students also must participate in discussions through attentive body language. When a student shares an answer, I announce, “Everyone put their eyes on [student’s name], your new teacher.” The class waits until all the students are looking at the speaker, while I stand behind or to the side of the class. Another attending strategy is to have students call on one another to share answers. Each year I choose a small (and soft) object, such as a stuffed animal or Koosh Ball, and students toss it to one another during mathematics discussions. Students are eager to receive the object and share an idea. Although I use this strategy often, I sometimes select students myself to make sure that a variety of ideas are shared by a diverse mix of students.
I wrote the problem in figure 1 on a large piece of paper and told my fifth and sixth graders that we needed three batches of brownies and one of the ingredients is \( \frac{1}{4} \) cup of chocolate chips. The students had not yet learned how to multiply fractions. After working alone for three minutes, this is part of the discussion that followed.

**Kendra.** First I drew the \( \frac{1}{4} \). [She draws a circle, divides it into four pieces, and colors it in.] This is the \( \frac{1}{4} \). [She draws a circle beside it, divides it into four pieces, and colors one section in.] This is the \( \frac{1}{4} \). Since I was multiplying it by \( 3 \), I knew I needed to draw this two more times. [She draws two more identical pictures below the original.] So I knew I had three wholes [pointing to the three wholes] and I saw that I had \( \frac{3}{4} \). [She finishes by writing the numbers.]

Mark raised his hand to share next. I knew that his comments would be interesting because I had seen that he had the wrong answer.

**Mark.** I solved it the regular way. First I multiplied \( 3 \times 4 \) and \( 3 \times 1 \). Then I multiplied \( 3 \) times \( 1 \) again and I got \( \frac{3}{3} \).\( /4 \).

**Teacher.** Mark, I'm confused. Why did you multiply \( 3 \times 4 \) and \( 3 \times 1 \)? [I saw that he had actually multiplied \( 3/3 \times 1/4 \) instead of \( 3/1 \times 1/4 \), but I wanted the students to come to this realization on their own.]

**Mark.** Well, the \( 3 \) is the whole number, and I got the \( 4 \) and \( 1 \) from the fraction [pointing to the denominator and numerator]. [Several hands fly up.]

**Teacher.** Angel?

**Angel.** I did it the regular way, too, but Mark made a mistake. I got a different answer.

**Teacher.** Can you explain or show it? [Angel comes to the paper and writes “\( 3 \times 1 = 3 \)”] Where did you get the \( 3 \) and \( 1 \) from?

**Angel.** They are the whole numbers [pointing]. Then I multiplied \( \frac{3}{1} \times \frac{1}{4} \) and I got \( \frac{3}{4} \). I added this to the \( 3 \) and got \( 3 \times \frac{3}{4} \). [Hands are up in the air again; students want to share and clarify.]

**Teacher.** Simon?

**Simon.** I know that Mark's answer doesn't make sense. \( \frac{3}{12} \) can be simplified to \( \frac{1}{4} \). I know the answer can't be \( \frac{1}{4} \) because if you multiply \( 3 \times \frac{1}{4} \), you'll get more than \( \frac{1}{4} \). [Nods from classmates, including Mark.]

The discussion continued, with Simon changing the fractions into decimals and another student reiterating this, using the analogy of money.

**Fig. 2. Sample dialogue**

**Keeping the Discussion Going**

When a lull occurs in the discourse, teachers can help students generate ideas by posing a question and having students pair-share ideas. Using the name box to call on someone afterward ensures that all students are accountable for at least sharing what they discussed in pairs. The pair-share is also a good assessment of the students’ knowledge: If most pairs do not have much to share, they do not have enough background knowledge to solve the problem. In this case, the teacher must either stop the lesson and revisit it after providing more experiences or directly teach a concept and revisit the challenge afterward.

Attaching meaning to the problem is another way to generate ideas during discussions. Sometimes I intentionally write numbers without context for the students to work with, because this can prompt a greater diversity of ideas. With more difficult concepts, such as multiplying a fraction by a whole number, I find that story problems work best. Having students write the problems brings their personal interests and experiences to the lesson, creating ownership. If the teacher decides to have students write scenarios for the mathematics problem, he or she can choose two or three scenarios that require different kinds of pictures in their solutions. In figure 3, students wrote story problems for \( \frac{3}{4} \times 4 \). The first problem warrants drawing either round or rectangular cakes, then grouping them into one big whole. The candy-bar problem encourages students to draw individual bars, then find the total. For the third problem, students drew glasses and imagined them being filled with liquid. Although the answer to every problem is 15 units, the different situations encourage flexible thinking.
Making mathematics tools available is one more suggestion to generate discussion ideas. I have found this strategy most effective when students work in small groups before coming to the whole-class discussion. Instead of choosing manipulatives for the students, teachers should let them choose their own. This creates a wide range of solutions and piques the interest of students who like to experiment with different tools.

Assessment

Assessing students’ knowledge is one of the biggest challenges during inquiry-style discussions in a large group. Most of the learning occurs inside students’ heads as they make sense of one another’s strategies, and because teachers cannot see the processes, we must create situations to make them visible.

I have found two strategies most helpful. The first is for students to record others’ strategies and apply them to new mathematical problems. After the mathematics discussion, students choose four strategies that they are interested in trying on their own. They copy the work on a page I call “Multiple Strategies” (see figs. 4 and 5). Then I assign a new, yet similar, problem, and on the back of the page students apply three of the four strategies to the new problem. This homework assignment holds every child accountable for classroom discourse. When students know they need to use one another’s strategies, they listen better and ask more questions of their peers. They also engage in a complex skill by applying the strategies to new situations. They build flexibility with numbers, as well as methods to check the accuracy of their work. I grade the students’ work using a four-point scale:

- 4 = Exceeds standard
- 3 = At standard
- 2 = Approaching standard
- 1 = Not at standard

A second assessment strategy holds learners directly accountable for their participation during discourse. When facilitating a discussion, I carry a clipboard that includes all students’ names beside blank lines (see fig. 6). At the top of the page, I write the concept for that day’s lesson or the actual problem that we are discussing, then choose a colored pen and write the date in that color. I write all comments for that day in the same color, and beside my notes I assign points (four points are possible, using the same scoring system as above). As long as the lessons focus on that particular concept, I continue to record my observations on the same sheet, using different colors for subsequent days. This ensures that I reach all students by the end of the week. A benefit of using the clipboard is that students know I am recording notes on their understandings (as well as behavior), and they perk up when they see me with it.

Reflection

I have found great success using the strategies outlined in this article with my fifth- and sixth-grade classes, not only in mathematics but in all subjects. The name box makes students accountable for what is being said in class at any time; they learn to be ready to ask a question or make a comment, which keeps them engaged. When students practice attentive body language, the classroom develops a dynamic and caring atmosphere. Implementing “pair-sharing” ensures that all students participate in discussions, even though only a few students may stand in front of the class and explain a strategy.

Most important, when students call on one another instead of waiting for the teacher to call on them, they see themselves as the source of learning. This generates questions because students are not sure that information that comes from other students rather than from teachers is “correct.” Instead of passively learning and memorizing informa-
tion that a teacher feeds to them, students consider one another’s ideas and discover even more about the concept. When students look to one another for the answers, diversity fills the classroom and students take ownership for building their own understandings.

![Fig. 3. Students' story problems](image)

**Math problem:** $5 \frac{2}{3} + 3 \frac{1}{5} $

**Solving it my way:**

$\frac{5}{3} \times \frac{2}{3} = \frac{10}{9}$

$\frac{5}{3} \times \frac{1}{5} = \frac{5}{15}$

$\frac{5}{3} + \frac{1}{5} = \frac{32}{15}$

*Strategy #2*

$\frac{1}{5} = \frac{3}{15}$

$\frac{2}{3} = \frac{7}{15}$

$\frac{3}{5} = \frac{9}{15}$

$\frac{2}{3} + \frac{1}{5} = \frac{17}{15}$

$\frac{3}{5} + \frac{1}{5} = \frac{1}{5}$

$13 \frac{3}{5} + 3 = \frac{21}{15}$

$23 \frac{4}{5} + \frac{1}{15} = \frac{133}{15}$

$\frac{133}{15} = 8 \frac{1}{15}$

*Strategy #3*

$\frac{6}{1} = \frac{12}{2}$

$\frac{2}{2} = \frac{4}{1}$

$\frac{3}{5} = \frac{9}{15}$

$\frac{10}{5} = \frac{12}{15}$

$\frac{10}{15} = \frac{12}{15}$

*Fig. 5. Students' strategies*

**Fig. 6. Recording students' understanding**