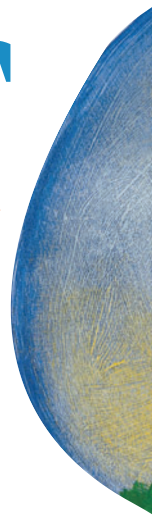
Questioning Our *Patterns* of Questioning



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TEACHERS POSE A VARIETY OF QUESTIONS to their students every day. As teachers, we recognize that some questions promote deeper mathematical thinking than others (for more information about levels of questions, see Martens 1999, Rowan and Robles 1998, and Vacc 1993). For example, when asking, "Is there another way to represent or explain what you are saying?" students are given the chance to justify their thinking in multiple ways. The question "What did you do next?" focuses only on the procedures that students followed to obtain an answer. Thinking about the questions we ask is important, but equally important is thinking about the *patterns of questions* that are asked.

Although *Principles and Standards for School Mathematics* (NCTM 2000) highlights the importance of asking questions that challenge students, we conjecture that focusing only on the questions asked is not going far enough to help students to clarify and develop their mathematical thinking. When engaging students in discussion, consider what happens in the exchanges *after* an initial question is posed; in other words, examine the *interaction patterns* that occur. In some situations, the pattern of interaction encourages students to participate, shows that students' thinking is valued, and helps them clarify their thinking. In other situations, the interaction may hinder students from describing what they think. Early research on classroom interactions documented the Initiation-Response-Feedback (IRF) pattern (Mehan 1979) as the most prominent form of interaction that occurs between the teacher and learners. With this pattern, the teacher asks a question, a student provides a response, and the teacher offers evaluative feedback. This IRF pattern can be seen in the following example from an eighth-grade mathematics classroom.

Example 1

Teacher [Initiation]: What kind of mathematical relationship does this equation [$y = 2x + 5$] show?

Student [Response]: A linear relationship.

Teacher [Feedback]: Okay. It's a linear relationship [Herbel-Eisenmann 2000].

Although this form of interaction was identified and described over twenty-five years ago, it is still prevalent in classrooms today (Stigler and Hiebert 1999). Since this type of interaction has been shown to lead students through a predetermined set of information and does little to encourage students to express their thinking (Cazden 1988; Nystrand 1997), we offer alternative ways to broaden the interactions that occur.

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We begin with another common form of interaction called "funneling" (Wood 1998), which limits the students' responses but not as much as the IRF described above. Next, we illustrate the open-ended "focusing" (Wood 1998) interaction, which draws on students' thinking, and then suggest ways to turn funneling into focusing interactions. The examples that we use come from two nontracked eighth-grade classrooms that are using curriculum materials from the Connected Mathematics Project (Lappan, Fey, Fitzgerald, Friel, and Phillips 1998a). After illustrating these two forms of interaction, we conclude by suggesting a plan for using these ideas to examine one's own classroom interactions by further encouraging students to share their thinking.

Funneling

Funneling occurs when the teacher asks a series of questions that guide the students through a procedure or to a desired end. In this situation, the teacher is engaged in cognitive activity and the student is merely answering the questions to arrive at an answer, often without seeing the connection among the questions. This pattern can be seen in example 2 below when the teacher directs students to find the equation for graph B in **figure 1** (Lappan, Fey, Fitzgerald, Friel, and Phillips 1998b, p. 63).

Example 2

Teacher: (0, 0) and (4, 1) [are two points on the line in graph B]. Great. What's the slope?

[Long pause—no response from students.]

Teacher: What's the rise? You're going from 0 on the *y* [axis] up to 1? What's the rise?

Students: 1.

Teacher: 1. What's the run? You're going from 0 to 4 on the *x* [axis]?

Students: 4.

Teacher: So the slope is ______?

Students: 0.25 [in unison with the teacher].

Teacher: And the *y*-intercept is?

Students: 0.

Teacher: So, $y = 1/4x$? Or $y = 0.25x$ would be your equation [Herbel-Eisenmann 2000].

1. Circle the name of the graph or graphs that show a linear relationship, and write their equations.
2. Explain how you can recognize a linear relationship from a graph.

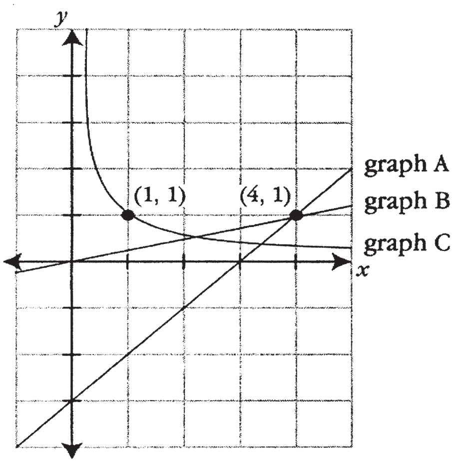

Fig. 1 Students find the equation for graph B.

When students do not respond to the teacher's initial question of "What's the slope?" the funneling pattern begins. The teacher walks through a series of steps with the students until they find the correct equation for the line. The students' attention is focused on subtracting the numbers that the teacher gives rather than on thinking about the relationship between points on a line and rise, run, and slope. With funneling, although the "teacher may intend that the child use strategies and learn about the relationships between numbers, the student needs to know only how to respond to the surface linguistic patterns to derive the correct answer" (Wood 1998, p. 172). The end result is that the teacher "funnels" the students' responses to include only the exact information that they were investigating. Only the teacher's thinking process is explicit; little is known about what the students were actually thinking.

Another interpretation of this example could be that the teacher is scaffolding the students' thinking by modeling the questions one would ask when finding a linear equation (given two points on a line). However, two important aspects need to occur in future interactions: (1) the teacher should discuss these particular questions and the purpose for attending to them, and (2) the questions need to be diminished and eventually removed. Students will not immediately understand the significance of this series of questions because they view asking questions as being characteristic of the teacher's role. To distinguish this set of questions as being *different* from other questions the teacher asks, it would be important to stop and discuss the purpose of these particular questions for finding a linear equation. Also, if the teacher continues to ask this same series over time, the questions are not serving a "scaffolding" purpose; the assistance would need to be gradually withdrawn until students had learned to ask themselves these questions independently (Cazden 1988).

Employing a funneling-interaction pattern limits what students are able to contribute because it directs their thinking in a predetermined path based only on how the teacher would have solved the problem. Students need more opportunities to articulate their thinking so that they can build on prior knowledge and make their ideas clear to the teacher and their classmates. An alternative interaction pattern that allows this situation to occur is called "focusing."

Focusing

As an alternative to funneling student responses, Wood (1998) suggests "focusing." A focusing-interaction pattern requires the teacher to listen to students' responses and guide them based on what the students are thinking rather than how the teacher would solve the problem. This pattern of interaction serves many purposes, such as allowing the teacher to see more clearly what the students were thinking or requiring the students to make their thinking clear and articulate so that others can understand what they are saying. This type of interaction values student thinking and encourages students to contribute in the classroom.

Example 3 below, from a different eighth-grade mathematics class, illustrates one way to focus the discussion. Students were given a point on a line (5, 9.5) and the slope for that line (1.5). They were asked to find the *y*-intercept so that they could write the linear equation. When one student, Becky, offered a novel way to use the graphing calculator to find the equation, the teacher asked questions or replied in ways that helped Becky articulate her thinking so that it would make sense to the teacher and the students in the class.

Example 3

Teacher: I don't know this [pointing to the *y*-intercept]. I've got to find it. How do I find it [the *y*-intercept] if this [the slope and one point on the line] is all I know?

Becky: You know what you can do? You can put an equation in the graph and just calculate it out.

Teacher: How?

Becky: If you put $y = 1.5x$ and then go to the table and find where 5 is.

Mark: Yeah, but then the starting point would be 0.

Becky: No, when 5 is *x*, you find whatever *y* is and then whatever the difference is between *y*, that *y* and your other *y*. . . .

Mark: 7.5 [is the *y*-value when *x* is 5].

Becky: . . . is the *y*-intercept.

Teacher: Help.

Sam: Come again?

Becky: You put in $y = 1.5x$ in the graphing calculator.

Teacher: Okay.

Becky: And you go to table [on the graphing calculator].

Teacher: Let's do that because she lost me after that. But if you're putting 1.5*x* into your calculator and you know it's crossing at 0, 0 . . . . So, you said put 1.5*x* in even though you know that's not the right equation?

Becky: Yeah.

Teacher: Okay, then you wanna do what?

Becky: Go to the table and look for where 5 is [the *x*-value]; it's 7.5, right?

Teacher: Yeah.

Becky: And then whatever the difference is between that one and 9.5 is your [inaudible] or your *y*-intercept.

Teacher: So, you're saying the *y*-intercept is 2?

Becky: Yep. And then you can [inaudible] $5x + 2$ and where *x* is 5.

Keith: [Asks the teacher] can you say that in English so we can write that down?

Teacher: I'm not sure that I understand her. I'm going to ask if I'm correct. On her calculator—and you can look at it on yours—um, she said she put in [$y =$] 1.5*x*, even though she knew that wasn't right. That's assuming it crossed at (0, 0.) She went down to 5 and at that equation, it was at 7.5. So, then you took the difference between 9.5 and 7.5? And said the new *y*-intercept should be 2 [Herbel-Eisenmann 2000].

In this example, Becky is using the graphing calculator to figure out the equation of the line. The teacher recognizes that Becky's method is novel and has not appeared in the mathematical solutions in previous class sessions. Becky is asked to explain what she did to everyone in the class (including the teacher) when the teacher says, "Help." To assist Becky in articulating her strategy and to aid everyone else's sense-making, the teacher suggests that Becky go back through the process while everyone else follows along on their graphing calculators. At points when the teacher thinks Becky's strategy might be confusing, she asks questions (e.g., "So, you said put 1.5*x* in even though you know that's not the right equation?") and restates Becky's strategy, focusing student attention on what Becky did. This situation does not allow students' attention "to fade or change or be interrupted" (Wood 1998, p. 174). Rather than attempt to funnel Becky's strategy to the teacher or textbook's solution strategy, the teacher instead holds Becky responsible for articulating her thinking. The teacher "tries to anticipate what the other students might not understand and asks clarifying questions [and restates particular aspects of the solution] to keep attention focused on the discriminating aspects of the solution" (Wood 1998, p. 175). The classroom discussion then turned to figuring out why Becky's strategy worked and pursuing how changes in the slope and *y*-intercept in the equation effect the shifts in the line on the graph. Although funneling is a more common classroom interaction pattern, we maintain that the long-term benefits of focusing make it imperative that mathematics teachers "focus" more often.

When a strategy might be confusing, the teacher asks questions

Turning "Funneling" into "Focusing"

WE NOW RETURN TO EXAMPLE 2 AND DISCUSS how this classroom interaction *could* have "focused" students' ideas rather than "funneled" them. The first two italicized lines are the same as those in the original example 2; the remainder of the dialogue explores how a funneling pattern was changed to a focusing pattern. In this revised version, the teacher helps students make conceptual connections and draws out students' thinking.

Example 2 (Revised)

Teacher: (0, 0) and (4, 1) [are two points on the line in graph B]. Great. What's the slope?

[Long pause—no response from students.]

Teacher: What do you think of when I say slope?

Kara: The angle of the line.

Teacher: What do you mean by the angle of the line?

Kara: What angle it sits at compared to the *x*- and *y*-axis.

[Pause for students to consider.]

Teacher: What do you think Kara means?

Sam: I see what Kara's saying, sort of like when we measured the steps in the cafeteria and the steps that go up to the music room—each set of steps went up at a different angle.

Teacher: How did we know they went up at a different angle?

Sam: The music room steps were steeper than the cafeteria steps.

Teacher: How did we decide that the music room steps were steeper?

Lana: We measured how far up the step went and then we measured how far back the step went and then we divided the numbers.

Teacher: Lana, could you draw us an example of what you mean?

Lana: Hmm. Yea. [She draws stair steps on the board where the height is 12 inches and the depth is 12 inches.] So here the steepness is 1, because 12 ÷ 12 is 1.

Teacher: Okay. Let's say the height was 10 inches and the depth was 12 inches—which set of stairs is steeper? Jennifer?

Jennifer: I would say the first set, because you are going up as much as going forward, but in the second set you aren't going up as much as forward.

Teacher: Tom, do you agree?

Tom: Yes, because I think the steepness of the second is 10/12, which is not as big as 1.

Teacher: So, let's consider what Jennifer and Tom are saying. If I were to lean a board against the two sets of stairs, the 12 by 12 steps have a steepness, or slope, of 1 and are steeper than the second set of steps, which have a slope of 10/12. Is this right?

[Class nods and says "yes."]

Teacher: So, let's go back to our original problem and think through it again. This time I need to think about leaning a board against the points (0, 0) and (4, 1). How steep would it be—or what is its slope?

Is the interaction pattern allowing the discussion to achieve the goals of the lesson?

Jennifer: Well, we would go up 1 and over 4.

Teacher: Okay, so how could we determine the value of the slope?

Lana: We have to divide the numbers.

Teacher: How do we divide them?

[Students respond with both 1/4 and 4/1.]

Lana: I would say that it's 4, because you should do 4 divided by 1.

Jennifer: But 4 is bigger than 1/4 and 4 would be steeper than the 12 by 12 we looked at, so to me that would mean that we went up 4 and over 1, not up 1 and over 4.

Tom: Right, I say its 1/4.

Teacher: Tom, why do you say it is 1/4?

Tom: Because like we talked about with the music stairs, it's the amount we go up or down divided by the amount that we went over. It was 10/12, not 12/10.

Teacher: Lana, what do you think about what Tom and Jennifer are saying?

Lana: Yes, I agree, it makes sense what they said—steeper would mean up more than over. And, the slope of 4 would be much steeper than the slope of the 12 by 12, but this line is not as steep as that.

Teacher: Now, I would like you to consider the points (–1, 3) and (2, 5) and write down the value of the slope and what you thought about to arrive at your answer.

In this revised example, the teacher thinks that the pause indicates that students are not sure about what is being asked; they may not remember what the slope is or how to find it. Acting on this assumption, the teacher requires the students to articulate what the slope is and refer back to a previous problem they solved. Students are often asked what they mean and to decide if they agree or disagree with others' ideas. The teacher repeats important information and keeps students focused on the components of slope, not only valuing the language that students use ("steep") but also subtly offering the more mathematically appropriate language ("slope") (Herbel-Eisenmann 2002). In this revised example, the teacher does not do the thinking for the students. Instead, students are helped to make connections and articulate their thinking by using their contributions to probe further and by referring back to common activities that occurred in the classroom. Not only does this action value and draw out student thinking but it also supports two of the teacher's goals: (1) to help students make connections and (2) to encourage multiple representations (by capturing a visual image of the slope of a line and its relationship with two points on the line).

In sum, managing classroom interactions needs to include paying attention to how an initial question is followed up and how it relates to the goals of the lesson. After a question is asked, a teacher might only offer evaluative feedback, which does little to further the thinking about the mathematical content. Two classroom interactions are "funneling" and "focusing." When funneling, the student is still guided toward a predetermined solution strategy. The teacher takes over the thinking for the students, who may be paying more attention to language cues rather than the mathematical topics at hand. An alternative to consider following initial questions, and one that we suggest is applicable to most lessons, is to "focus" student solutions. In this situation, the teacher points out salient features of the students' solution strategies by asking them to explain what they mean, then restating what students have said. This interaction pattern helps students articulate their own thinking to one another and encourages students to make sense of one another's strategies and reasoning.

Examining Management Strategies

PRINCIPLES AND STANDARDS FOR SCHOOL MATHematics (NCTM 2000) challenges teachers to "encourage students to think, question, solve problems, and discuss their ideas, strategies, and solutions" (p. 18). Getting students to articulate their thinking is difficult and must include looking beyond the initial questions that are posed. To help with the transition to focusing more often, we have seen how important it is to get a broader view on one's own teaching by audio- or videotaping a classroom session (Breyfogle and Herbel-Eisenmann 2004). By watching segments of classroom discussions, it is easy to identify what kinds of interaction patterns are taking place.

An important question to consider when investigating one's own teaching practice is this: Is the interaction pattern allowing the discussion to achieve the goals of the lesson? It is then important to examine whether the pattern is helping students' articulate their thinking or is mainly providing feedback (as in the IRF) or funneling students to use only the strategy we want them to use. Once we identify our current interaction patterns, we can then try to modify them to focus student thinking more often so that students contribute more frequently and can see that we value their thinking. For a way to use these ideas to reflect on your own classroom interactions, we suggest the following reflective process:

- When students are prepared to discuss a "worthwhile mathematical task," use an audio- or videorecorder to capture the conversation that takes place.
- Listen to the interaction that took place and attend carefully to both the initial question that was asked and (more important) how that question was followed up. Write down the series of questions that were asked and try to identify when an IRF pattern was being used, when funneling was occurring, and when students' thinking was being focused. Then pinpoint instances when student's thinking could have been focused rather than using an IRF or a funneling pattern. Make a list of questions that could have helped in understanding or valuing the student's thinking in a "focusing" manner.
- Find another worthwhile mathematical task to use with students. When planning, try to anticipate multiple solution strategies that students might offer as well as areas that might be confusing for some students. Use that information to decide what kinds of questions to ask to focus student thinking.
- Audio- or videotape the implementation of this task. Repeat the reflection process to see if students' were helped to focus their thinking.

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