TEAM-Math and AMSTI Professional Mathematics Learning Communities
Effective Questioning -- Discourse

Title of Activity/Lesson	Effective Questioning – Discourse
Time Allotment	60 minutes
Audience	All grade levels, with customized examples.
Content Objectives	Varies by gradeband
Pedagogical Objectives	Building discourse using effective questioning
Overview of Big Ideas	"Mathematical discourse includes the purposeful exchange of ideas through classroom discussion, as well as through other forms of verbal, visual, and written communication." The discourse in the mathematics classroom gives students opportunities to build their mathematical thinking. Questioning that "funnels" student thinking to predetermined responses is less effective in promoting effective discourse than questioning that "focuses" on facilitating student thinking.
Materials	Principles to Actions excerpt (see attached) PowerPoint for session Gradeband-specific vignette (see attached for K-2, 6-8, and 9-12)

Outline/Plans	What Might Happen/Dialogue
<u>Facilitate Meaningful Discourse</u>	
Have participants read pp. 29-31 from the Principles to Actions (PtA) handout.	"What is discourse"? "Why is it important? "What practices support effective discourse?" ("Have you seen these before?" These are the 5 Practices from Smith & Stein!)
Have participants look at the chart on p. 32 in PtA	"What do the components of classroom discourse?" "What do you notice as the level of discourse increases?" "Where does your classroom discourse typically fall in this chart?"
Discuss "Teacher and Student Actions" chart on p. 35 of PtA.	"How are the teacher and student actions connected?" "Which of these do you see on a consistent basis?" "Which of these are more challenging to do?"
Tie back to previous ideas.	"What connections to the Standards for Mathematical Practice do the Student Actions suggest?"
<u>Pose Purposeful Questions</u>	
First Approach Give participants a sample vignette that models "funneling" questioning.	"How well do you think this teacher is doing?" "How much thinking are the students doing? Are they really engaged in the mathematical practices?" "What is going wrong? What is derailing effective discourse from happening?"
Have participants read the Discussion on pp. 36-37 and use that to re-analyze the vignette	"What types of questioning did she ask in the vignette?" (refer to the chart) "Was she primarily focusing or funneling?"
Continue discussion of focusing and funneling.	"How are funneling and focusing the same or different?" "What are the consequences of these two patterns for student learning?" "What pattern do you think is most prevalent in classrooms?"
Alternate Approach Have participants read the Discussion on pp. 36-37	"How are funneling and focusing the same or different?" "What are the consequences of these two patterns for student learning?" "What pattern do you think is most prevalent in classrooms?"

Give participants a task and ask them to work in groups to write a focusing line of questioning and a funneling line of questioning	What makes this more focusing? What makes this more funneling?
Have them share back their examples to the group without saying which type it is.	Which type of questioning do you think this is? Why? To the authors – Is that what you intended?
Discuss “Teacher and Student Actions” chart on p. 41.	“How are the teacher and student actions connected?” “Which of these do you see on a consistent basis?” “Which of these are more challenging to do?”
Tie back to previous ideas.	“How does questioning tie to building classroom discourse?” “What connections to the Standards for Mathematical Practice do the Student Actions suggest?”

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<u>Vignette for K-2</u>

T: Everyone, let's solve this problem together:

> A gorilla at the zoo eats 5 bananas. He has 2 bananas left. How many bananas did he have to start with?

T: OK, what should we do first? How many bananas did he eat?

S: 5.

T: So how many counters should we put on the table to show that?

S: 5.

T: Great. Now how many bananas did he have left?

S: 2.

T: So how many counters should we put on the table to show that?

S: 2.

T: Now what are we trying to find?

S: How many he had to start with.

T: Great. So what should we do now?

S: Add

S: Subtract.

T: Should it be add or subtract? Will the answer be bigger or smaller?

S: Bigger, because that's before he ate some.

T: Great. So push your counters together and count the total. How many did he have?

S: 7.

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Vignette for 6-8

Ratios, Proportions, and Proportional Reasoning

It is often tempting to provide too much help when students struggle with ratio and proportion problems, thus removing their opportunities for genuine engagement with the mathematics. For example, consider the following problem:

Heart A beats 15 times in 8 seconds, and heart B beats 38 times in 20 seconds. Which heart is beating faster, A or B, or do they both beat at the same pace?

The discussion that follows presents two different dialogues between a teacher and a student working on the problem. The dialogues are based on an unpublished, small-scale study and reflect the general tone and substance of the interactions, although they are not direct transcripts.

Student: I don't know how to solve this problem. I'm stuck.

Teacher: How can you compare two heart rates?

Student: I don't know.

Teacher: Think of other rates you've heard of before. What are some rates you know of?

Student: Well ... there's miles per hour.

Teacher: Good. What makes that a rate?

Student: Because it has a *per*.

Teacher: Another way of saying that is because it's "per one." How many miles you travel in one hour. So how can you turn this into a rate?

Student: Find a "per one"?

Teacher: Good. So do you think it should be beats per minute or minutes per beat?

Student: Beats per minute.

Teacher: Okay, so divide to see how many beats per minute each heart will give you.

Reflect 3.2 asks you to evaluate the teacher's handling of the various "teachable moments" in this scenario.

lect 3.2

sider the dialogue above in which the student struggles to determine which t is beating faster.

o you think the teacher provides the student with sufficiently rich problem-lving opportunities?

what ways might you intervene differently with your own students?

Do you think the teacher helps the student too much? Are you nevertheless unsure about how you could manage the dialogue differently? Consider the following alternative scenario, in which the teacher scaffolds the student's thinking but deliberately avoids solving the problem for her:

Student: I don't know how to solve this problem. I'm stuck.

Teacher: What's the problem asking you to do?

Student: Figure out which heart is faster.

Teacher: Okay, so what does "faster" mean to you?

Student: Whichever heart beats quicker ... has more beats.

Teacher: Okay, ... so does that help you answer the question?

Student: Well, B gives 38 beats, but it takes more time—20 seconds instead of 8.

Teacher: Why does that matter?

Student: How many seconds it takes matters too. That's why I'm stuck.

Teacher: Ah, okay. So beats *and* seconds matter?

Student: Yeah.

Teacher: So you have A that gives 15 beats in 8 seconds, and B that gives 38 beats in 20 seconds. Can you figure out a way to compare those two?

Student: I can't really do it, because even though 38 is more than 15, 20 is also more than 8.

Teacher: Let me give you a different problem. Say that A gives 15 beats in 8 seconds, but B gives 20 beats in 16 seconds. Which heart beats faster?

Student: Hmmm... [*Starts to write*].

Teacher: I'll leave you to work on this for a while.

...

Teacher: So what did you figure out?

Student: Well, this one was pretty easy because if A beats 15 in 8 seconds, you can just multiply that by 2 and get 30 beats in 16 seconds. That's more than 20 beats in 16 seconds, so A has to be faster.

Teacher: Okay, so it looks like you multiplied A by 2. Why did you do that?

Student: Because then I have the same number of seconds.

Teacher: Why is that important?

Student: Because if the time is the same, then I can just see which heart had more beats in the same amount of time.

Teacher: So is there a way you could do that to solve the original problem?

Student: Make the time the same? I don't know, because the numbers don't work out very well.

Teacher: Why don't you try it out—see what you can come up with. I'll come back in a little while to see how you're doing.

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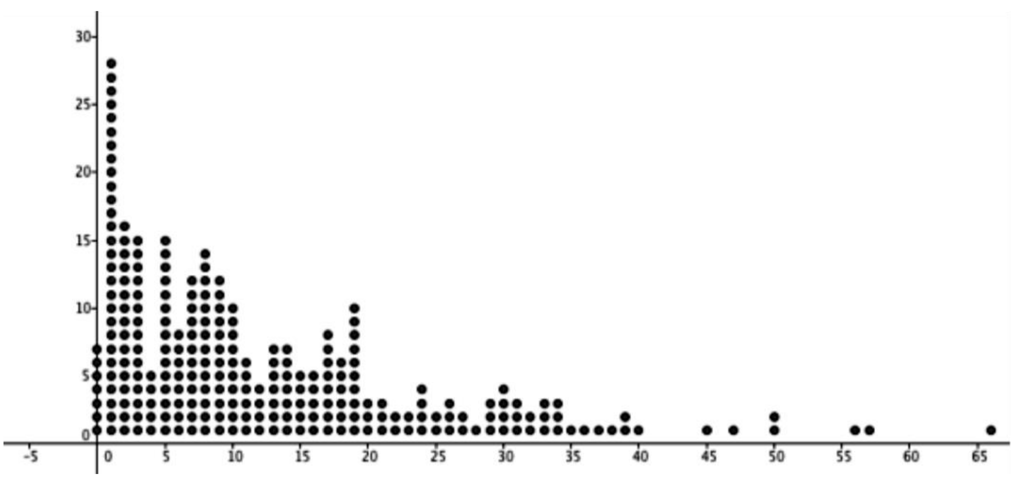
<u>Vignette for 9-12</u> (NCTM, 2014)

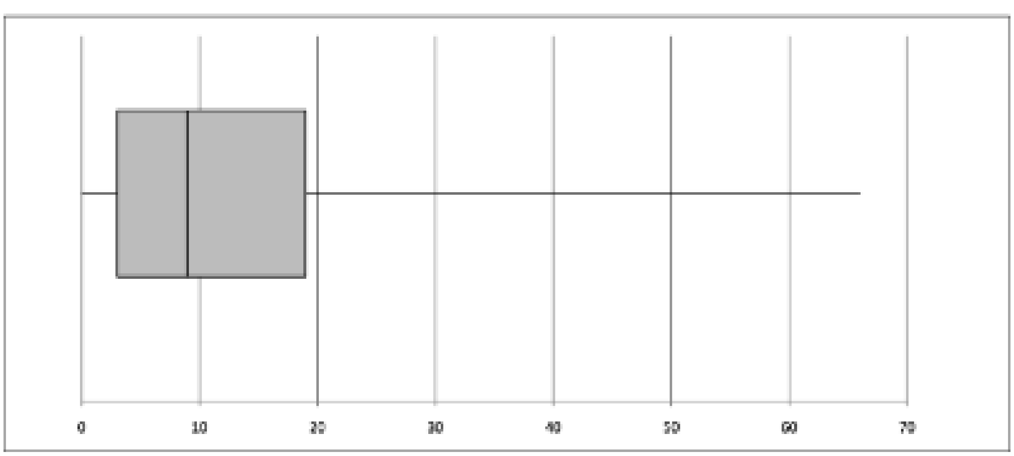
Students in two high school classrooms are investigating how much money it costs to mint coins. As part of the investigation, the students decide that it would be helpful to determine the approximate number of years that a coin stays in circulation. Rather than studying all different types of coins, the students choose to collect data about the ages of pennies. This sets the stage for the students to investigate the question, "How many years does a penny stay in circulation?"

The teachers' mathematics learning goals for the task are for students to collect data, analyze the data, and reach a conclusion, as well as to identify the limitations of this investigation with respect to its sampling method. Specifically, the teachers want the students to recognize that the results do not generalize to a larger population.

Both teachers ask all the students to bring in pennies. The goal for each class is to bring in the equivalent of about one roll for every two or three students. Small groups sort their pennies by the year of minting and determine the age of each coin. The data from the entire class is recorded in a table on the board. The small groups then create dot plots and box plots similar to those shown below, based on the age of the coins.



Age (years)



Coin age (years)

Fig. 15.

The teacher subsequently leads a class discussion of their findings:

T: What do you notice about the graph? [*waits briefly*] Do you see a pattern in the data? [*waits briefly again*] What are the measures of center for the pennies?

S1: The mean is about 12.9 years, and the median is about 9 years.

T: What does the box plot tell us about the variability of the data?

S2: It has a long tail on one side.

T: That may be true, but what about the interquartile range—the IQR? What does it tell us?

S3: Where most of the pennies occur.

T: Is that really what the IQR tells us? What does each part of the box plot stand for?

S4: Each part is 25 percent.

T: Yes, so what else?

S5: The middle is 50 percent of the pennies and is from 3 to 19 years old.

T: Good. What can we say about pennies on the basis of this information?

S6: That most of them are about 10 years old.

T: But since these are pennies, what does that tell us about all coins?

S7: That coins will be about 10 years old.

T: Well, 10 years is for pennies, but this wouldn't necessarily be the same for, say, quarters. Why not?

Here is an alternative approach the teacher might take:

T: What things do you notice or wonder about the age of pennies?

S1: It doesn't seem like many of them are very old.

T: What about the graph makes you say that?

S1: There's a big mound for newer pennies.

T: Is there anything else that you notice?

S2: I found the interquartile range and saw that most pennies are from 3 to 19 years old.

T: Explain to us what the interquartile range tells us.

S2: It is where most of the pennies occur.

T: What do you mean by "most of the pennies"?

S2: Well, I mean the middle 50 percent. I thought the graph made it hard to tell where things really were. It doesn't look normal, so I couldn't use the middle 68 percent thing we talked about.

T: I'm not sure I understand. Can someone else comment on what she's saying?

S3: She means that since there's a tail, the graph isn't like the normal curves we studied. If it were, we could approximate where the most likely ages are—like 68 percent of the data would be within one standard deviation of the mean.

[*More discussion follows, and the students determine that 75 percent of the pennies are not more than 19 years old.*]

T: Would I be correct if I said that a fifty-cent piece would probably be no more than 19 years old?

S4: Yes, because these coins were a random sample, and that means we can generalize.

S5: But we looked at pennies, so we can't generalize to quarters. People use pennies more.

T: What do you mean by that?

S5: Pennies may wear out. We don't know about other coins from our sample, because quarters would be a different population.