



QUESTIONING STRATEGIES

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The fundamental goal of national and state standards in mathematics has shifted from learning rules and procedures to understanding, communication, and problem solving. Our new mathematics assessments reflect that.

The previous articles in this series about including problem solving, reading and writing in your lessons may be easier to implement than creating an environment for student discourse. When the classroom is opened up for discussion of students' strategies and reasoning, the teacher cannot always anticipate what ideas will be generated or firmly set the direction of the discussion in advance. Even though there are some aspects that can be planned in advance, which will be mentioned in this article, there is a need for teachers to "think on their feet" as they respond to students. Teachers become facilitators rather than knowledge sources. They model important mathematical actions, coach student thinking, pose mathematical questions, select appropriate problems, and stimulate and moderate classroom discourse. Some of the things teachers can do to help achieve this are-

- Use small groups as part of the structure of the classroom.
- Accept alternative strategies and algorithms and demonstrate how to check their accuracy.
- Use questioning techniques that motivate student analysis, requiring them to substantiate their answers.
- Portray mathematics as a dynamic body of knowledge continually enriched by conjecture, investigation, analysis, and/or proof/justification.

All these activities will get students talking. The focus of this article is on questioning techniques that will get students involved.

National Council of Teachers of Mathematics' Position

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (2000) lists communication as one of the ten standards that cuts across grade levels. They state that all instructional programs should enable students to-

- Organize and consolidate their mathematical thinking through communication.
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- Analyze and evaluate the mathematical thinking and strategies of others.

- Use the language of mathematics to express mathematical ideas precisely.

NCTM's *Professional Standards for Teaching Mathematics* (1991) defines the teacher's role in discourse as-

- Posing questions and tasks that elicit, engage, and challenge each student's thinking.
 - Listening carefully to students' ideas.
 - Asking questions to clarify and justify their ideas orally and in writing.
 - Deciding what to pursue in depth from among the ideas that students bring up during a discussion.
 - Deciding when and how to attach mathematical notation and language to students' ideas.
 - Deciding when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with a difficulty.
 - Monitoring students' participation in discussions and deciding when and how to encourage each student to participate.
- They continue by defining the student's role. Students should have opportunities to-
- Listen to, respond to, and question the teacher and one another.
 - Use a variety of tools to reason, make conjectures, solve problems, and communicate.
 - Initiate problems and questions.
 - Make conjectures and present solutions.
 - Explore examples and counterexamples to investigate a conjecture.
 - Try to convince themselves and one another of the validity of particular representations, solutions, conjectures, and answers.
 - Rely on mathematical evidence and argument to determine validity.

To make this easier to understand the 1991 NCTM publication includes examples of classroom episodes that portray these different roles.

Strategies

There are some differences in questioning strategies when orchestrating discussion in the whole class, a small group or individual settings. Some strategies, however, are basic regardless of situation. First we list the stages of discourse and then give some general advice for eliciting desirable responses from students in the various settings.

Stages of Discourse (4-step QUILT model)

Stage 1: Prepare the Questions. Do this before the class session. You won't have time during it. In this stage you should identify the instructional purpose, determine the content focus, select the cognitive level and syntax.

Stage 2: Present the Question. Think about this ahead of time too. When you present the question indicate the format in which you want the answer, ask the question, and then three to five seconds later, select a stu-

dent to respond.

Stage 3: Prompt Student Responses. Don't neglect the pauses, they can lead to general discussion and questions from students. Pause another three to five seconds after the student responds. Assist a non-respondent with prompts or select another student. Teachers should not answer their questions themselves.

Stage 4: Process Students' Responses. Provide appropriate feedback. Expand and use correct responses. Elicit reactions and additional questions from other students.

Basic Strategies

1. Avoid yes/ no questions or questions with single word answers. They reveal little about understanding and are often answered with guesses.
2. Concentrate on questions that require students to describe their thinking.
3. Avoid rhetorical questions.
4. Look for opportunities that invite students to formulate hypotheses, write directions, make generalizations, etc.
5. Make "why" your most prominent question. It pushes students to explain their thinking.
6. Ask students to give reasons for correct answers as well as incorrect answers. Students often get correct answers by using invalid reasoning.
7. Provide time for a student to think before moving on to the next student or question.
8. Emphasize that choices between ideas must be justified on mathematical grounds. This teaches students about the nature of mathematics.
9. Become tuned into students' problem solving processes to be able to correct their errors and answer their questions immediately (e.g. proceed through their version of the solution before trying to explain it).
10. Translate unusual or unfamiliar mathematics vocabulary into language that students can understand when it is first presented, but then continue to use the proper mathematics language on a regular basis.
11. Respond to all indications of misunderstanding or incomplete understanding by asking students to elaborate.
12. Encourage students to freely admit their lack of understanding and freely disagree with others.

Whole Class Discussions

Some additional techniques lend themselves to whole class discussions.

1. Prepare a list of possible questions ahead of time, but be flexible.
2. Encourage students to listen to your question so that they can guide their thinking.
3. When answering a student's questions, guard against a conversation between just you and that student. Involve others; ask the class to respond as well.
4. Make sure you are not unconsciously directing the more "difficult" question to certain students, i.e. student with the highest grades or boys, etc.

5. Avoid repeating a student's question for the rest of the class yourself; have the student repeat it, or have another class member repeat the question.
6. Promote students asking questions of other students.
7. Add the statement "Explain how you arrived at your answer."
8. Pose questions to all students. You might want to start with "I would like each of you to think about...."
9. Give think time. The process a student goes through in answering a question includes listening to the question, understanding the question and relating it to the appropriate content knowledge, formulating an answer and answering aloud. This takes time. Most teachers only give about one second for a student to do all this.
10. Avoid targeting a student with a question. Call on the student after the question so every one has time to think.
11. Follow responses with student summaries. When a student gives a response have another student summarize or explain how they understand what the first student said.

Small Group Discussions

The benefits of small group work are the availability of immediate student to student feedback and explanations, use of language that fellow students can understand and a shared understanding of the difficulties that fellow students are having with mathematical problems, making this setting a potentially effective one for mathematics learning. (Webb, 1991) The way you formulate questions when dealing with small groups should differ from the way you formulate questions for the whole class. The teacher is trying to facilitate student thinking, help the group to keep moving forward when they encounter difficulty, and negotiate group processing. Some general guidelines for this role include-

1. When asked a question by an individual in a group, always check to see if the entire group is ready to have the question addressed at that time.
2. Make sure that the students in the group examine the thinking process, not just the step-by-step procedure necessary to get the answer.
3. Try not to provide any answer directly, but ask a question that will direct the group to the correct way of thinking.
4. Ask probing questions of groups to be sure they understand.
5. Be sure all group responses do not come from the same person.

Specific questions for specific purposes

The Linked Learning in Mathematics Project (LLMP) has found that teachers ask certain questions for certain purposes and have been able to classify them into types. These seem quite useful for group work.

Question Type	Sample Questions
Managing Intended to help set students on task, get their work organized, etc.	<ul style="list-style-type: none"> • Who's in charge of writing it down? • Are you guys working? • What are you doing now?
Clarifying Intended to request information from the student when the teacher isn't clear about what the student meant or intended; also, when the teacher is trying to help the student clarify the questions.	<ul style="list-style-type: none"> • Do you know what perimeter is? • How did you get 2?
Orienting Intended to get students started, or to keep them thinking about the particular problems they are solving; may suggest ways to focus on the problem; also, orient and/or motivate the student toward the correct answer or away from the incorrect answer.	<ul style="list-style-type: none"> • What's the problem asking you to find? • Have you thought about trying a table? • If you have that number and it increases by 3, what do you get? (trying to get student to see an error). • How can you check your answer? (has wrong answer)
Prompting Mathematical Reflection Intended to prompt mathematical thinking that the student (not the teacher or text) owns. Questions may ask students to reflect on and explain their thinking; have them extend their thinking about the mathematics in the problem.	<ul style="list-style-type: none"> • How do you explain that? • Explain how you got the values in the table. • Why did the two of you reach different conclusions? • Anyone have a different way? • What do you estimate the answer is?
Eliciting Algebraic Thinking Intended to prompt a particular kind of mathematical thinking: to ask the students to undo, to build rules for describing functional relationships, to abstract from computations they have made; ask about the meaning of the work they're doing; ask about what statements are "always" true, about n-th terms, about finding patterns and looking for what changes; working forwards and backwards, etc.; ask students to justify generalizations.	<ul style="list-style-type: none"> • What process reverses the one you are using? • How does the rule work? • How are things changing? • Can you find a more helpful way to write the rule? • Is there information here that lets you predict what's going to happen? • How can you predict what's going to happen without doing all the calculation? • What are your operation shortcut options for getting from here to there? • When you do the same thing with different numbers, what still holds true? What changes?

Individual Interviews

The main reason teachers conduct individual student interviews is because they need more information concerning how the particular child is thinking or how well he/she understands.

Some general guidelines for effective interviews from John Van De Walle (1990) are-

1. Be accepting and neutral as you listen to the student. Develop neutral responses such as, "I see" or even a silent nod of the head.
2. Avoid cueing or leading the child. Questions like "Are you sure about that?" often cue the student that they have made a mistake and they will change their response. A similar form of leading is to ask a series of easily answered questions that direct the student to a correct response. Neither tells you what the student is thinking.
3. Do wait silently. This is the same wait time advice given previously.
4. Do not interrupt. Let the child's thoughts flow freely. Encourage the student to use his/her own words.
5. Phrase questions in a directive manner to prevent avoidance. Use phrases like "Show me...", "Do...", or "Try..." rather than "Can you...?" or "Will you...?"
6. Avoid confirming a request for validation. When a student asks "Is that right?", probe for the student's reasoning by asking, "Why do you think it is correct?" or "Why do you think it might not be correct?"

Individual student intervention in problem solving can be facilitated using the Newman Five Point Error Analysis. Follow the steps below to the point at which you can identify the problem.

Step	Question	Purpose
1	Read me the problem, please.	Identifies reading errors.
2	What is the question asking you to do?	Identifies errors in comprehension
3	How are you going to find the answer?	Identifies transformation errors.
4	Do the work to get the answer and tell me about you're thinking as you work.	Identifies process skill errors
5	Write down the answer to the question.	Identifies encoding errors

We hope this series of articles on questioning strategies, reading, writing, problem solving and assessments have proved helpful. We know we only scratched the surface and that most of you reading this journal have probably incorporated many of the ideas into your instruction and assessments years ago. But if you found one suggestion helpful, we feel that we have accomplished our objective.

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¹ This is the sixth and final article in a series of articles by Lynn and Carolyn Richbart formerly of the New York State Education Department on "Achieving the Standards." They have shared ideas on what teachers can do in their classrooms to support their students in achieving the New York State Learning Standards in Mathematics. The concluding article discusses questioning techniques.