Learning through Effective Questioning

Effective questioning is a researched-effective approach to mathematics teaching that directly impacts student interest and willingness to pursue tasks. In this study, we found that examining, planning and executing effective questions has immediate impact on the level of student engagement and achievement. Teacher participants were the creators of the questions they used, rather than using externally-created questions; the strategies became their own and were integrated into regular and on-going teaching.

Through the Ministry of Education Math GAINS initiative, the Halton District School Board had the opportunity to guide a critical mass of teachers of mathematics through job-embedded professional learning experiences that shifted their questioning behaviours in ways that quickly led to improved student achievement and closed gaps.

This Digital research paper reports on a conceptual model for effective questioning in the mathematics classroom that was tested for effectiveness.

The research question asked in this work was:

Does the approach to questioning used by teachers in the classroom promote student understanding of mathematics - resulting in increased student achievement?

The learning was embedded in the classroom and the professional work of the teachers deepened their content knowledge and expertise as they learned to use more precise, personalized, and powerful questions to:

- focus on important mathematics
- provide access to learning for students across a broad range of readiness levels, and
- maintain a high cognitive level for all students, mathematically strong or struggling.

Through collaborative work including co-planning, co-teaching and debriefing , teachers developed their own emerging knowledge of questioning, enhancing their questioning practice.

The research results clearly showed that students of teachers who were involved in improving their use of questioning in the topics algebra or number sense made significant gains from the pre to the post assessment – a finding that was not observed in the comparison group. It is also interesting to note that students of the questioning teachers showed significant improvements in both strands although only focused on one strand during the questioning intervention. The increases in student achievement demonstrated the ease of transferability of teacher practice to other areas of the mathematics curriculum.

Teachers in the project used questions both to describe or set tasks as well as to scaffold and consolidate the learning. A single open question or a pair of parallel questions were often used to define the major task for students to pursue. But questions were also used to foster student discussion of their thinking on the questions and to determine to what extend and in what way the big ideas that led the teacher to set the task were understood by the students.

Outside the Classroom

Consider the Math

Curriculum coherence requires a focus on interconnections, or big ideas. Big ideas represent fundamental principles; they are the ideas that link the specifics.

Big ideas form the framework for the learning of the important mathematics and they span across many grade levels. Differentiated instruction and the asking of good questions which meet the needs of a wide range of students in the classroom started with this approach to teaching through the big ideas.

Outside the classroom, we were focusing on deconstructing the expectations, figuring out what is important to each by 'filtering through big ideas' and planning lessons. Teachers looked at a curriculum expectation in light of the big ideas for the strand and focus in on appropriate lesson goals and consolidating questions.

In this video clip, teachers are co-planning their lessons and deciding on math lesson goals. They were thinking about what they wanted the students to learn in the lesson – is the goal about isolating a variable, or solving equations? Once teachers decided on what the goal was, they designed tasks and planned questions that brought the big ideas to the surface. The big idea for this lesson was that algebraic reasoning is a way to describe and work with mathematical relationships that apply to a large number of situations; and variables, or letters, are often used to efficiently describe these relationships.

Outside the Classroom

Plan Powerful Questions

Outside the classroom, we thought about how our students differed - whether it was developmental readiness or how structured they liked their math to be. We prepared open and parallel questions by running through in our minds how those students might respond. In that way we verified whether our open or parallel questions make sense but you also anticipated some problems students might have so that we were prepared to scaffold. A scaffold is a temporary framework that is put up for support and access to meaning and taken away as needed when the child secures control of success with a task. The scaffolds provided by the teacher do not change the nature or difficulty level of the task; instead, the scaffolds - in the form of key questions - allowed the student to successfully complete the task. Scaffolding questions were not used as much to break questions up into bits for students, but to prompt their thinking in a relevant direction when they appeared stuck. We also thought hard about the math when creating the common questions to make sure they worked for the specific tasks provided.

Open Questions:
An open question is a single question that can be used so that all of the learners in the classroom can participate and engage in meaningful mathematics.
For example, consider this question: An expression has a value of 12 when the variable ♥ in the expression is equal to 6. What could the expression be?
This open question allows for many different responses, ranging from a very simple answer to a much more complicated one.
Eg. ♥ + 6 2 × ♥ 18 - ♥ 72 ÷ ♥ ♥2 + 2♥

Because we were asking students to come up with an expression for given input/output combination, it was much easier to differentiate the instruction. Students were usually asked to evaluate an expression for a given value of the variable. Sometimes the expression was difficult for a child or the calculation with a particular number might be difficult; in this situation students can control that sort of difficulty and more likely meet success.

For example, in relation to the open question above, the following scaffolding questions could be asked:
How do you know that the expression has a heart in it?
Could the expression have an addition sign?
Could the expression have a subtraction sign?
Could there be more than one heart in the expression? How many could there be?
Could the expression involve more than one operation?
Why is the heart the variable in the expression?

Parallel Tasks:
Open questions not only allow for a range of difficulties in the solutions, but also can reinforce a wide range of mathematical concepts and skills. Open questions also provide choice, which is implicit in differentiating instruction. Students will answer the question in a way that is suitable for their cognitive level.

Parallel tasks are questions that focus on the same big ideas but have different levels of difficulty, taking into consideration the student readiness.

Consider the following question and choices:
Write each the phrase as an algebraic equation:
Option 1: Triple a number
Option 2: Add 1 to a number then double it

Both questions are asking students to work on the relationship between verbal expressions and algebraic ones. The first option had the student work with a phrase where only one operation is used. The second option had the student working with phrases that involve more than one operation. The big idea that is addressed in both options is that algebraic reasoning is a process of describing and analyzing generalized mathematical relationships and change using words and symbols.

The teacher planned common questions that focus on using the expression to represent the words.
Common questions:
What operation sign(s) appear in our expression? Why those?
Are there other ways to write your expression algebraically?
Did it matter which letter or symbol you used for your variable? Why or why not?
Could the words be slightly different but your expression the same? Explain.

In this video, the vice-principal is discussing the work of her teachers with Marian Small. Open questions and parallel tasks are the focus of the lessons and tasking questions that are inclusive. Open questions are ones that leave room for students to come at a broad idea in a manner of and often to an extent of their choosing. It is the student who, in essence, decides on the level of differentiation. With parallel tasks, the teacher anticipated how to change a problem or task to make it more accessible to a different group of students and so it was the teacher who controls the level of differentiation. In both cases, however, there was an underlying big idea which became the focus of discussion for all students.

Outside the Classroom

Consider Student Engagement

Outside the classroom, prior knowledge of students was used to simply predict what their readiness might be and what sorts of contexts or styles would attract engagement.

Teachers tend to want to see their students produce the correct answers. However, when asking questions with one correct answer, only the one answering the question is engaged. Once the question is answered, there's no more need for other students to be engaged. Crafting engagement-focused questions with multiple “right” answers that relate to students’ experiences, can solicit many more responses.

Teachers are often worried about the time it takes to “cover” the material. If students engage in a quick “minds on” activity – the teacher can pool what they already know about a topic. Teachers are concerned about the time this might take, or students will be led down the wrong path. Teachers in this study found that surprisingly – their students’ collective knowledge can be extensive and after hearing their discussions could decide more on what they needed to focus their questions on or what difficulties they may be experiencing. Teachers worked on questions to evoke and expose thinking.

In the first part of this video clip, teachers are considering their struggling learners in the class and how they could ensure that these students are engaged with the task of the “minds on” question. The second part of the video clip shows an excerpt of a debriefing session with Marian Small and the math teacher. They are discussing the benefits of giving choice to the students and how empowering it can be to provide choices in their tasks. It also was important for the teacher to provide clear explanations as to how the choices were different. This helps ensure that the student selects the appropriate task without the teacher telling which task a student should complete.

Inside the Classroom

Consider the Math

In the classroom, teachers have to take what students say (which will rarely be the nice succinct goal that was planned), and connect what they do say to that goal. Remember that students say a lot of things; some are germane to where we want the lesson to go and some are not. The teacher has to pick up on the germane parts. Sometimes a student will respond to a question and may not be right on point toward the lesson goal, but the teacher can probe in a way to help the student shape his/her response to get closer to the goal.

Follow up discussions play a significant role in cementing learning and building confidence in students. Responses of students will vary and the teacher must convey the message that all responses are valued. Open questions will solicit many answers that can be shared with the rest of the class.

In this video clip, the teacher responds to the student's suggestion that instead of drawing a picture of ticket 5 times, you could draw one ticket and multiply by that ticket by 5, leading to the algebraic equation of 5xT + 15 = 145.

The goal of this lesson

5 tickets + 15 = 45
1 ticket x 5
5t +15 = 45

The teacher uses the response from the student to get at the essence of how we write things simply with variables.

Inside the Classroom

Pose Power Powerful Questions

Inside the classroom, if students don't respond the way you expected, then we will need to change the way we ask the question. Teachers may have planned an open question or parallel task that they thought would work, but several things can happen:

- maybe the question is not clear enough to the students and the teacher has to adapt or adjust it.

- maybe a student says something that could actually improve the intended question or task

- maybe the specific actions students take mean scaffolding questions are needed which were not planned or some of the questions that were planned are not needed. Occasionally, students can be encouraged to make different and more appropriate choices. Teachers should also make sure that they don't "close down" the question by giving away too much or make it seem like one parallel task is more desirable than another. It is also important to adapt follow-up questions based on what kids actually say.

In the first part of the video clip, the teacher is presenting a "Minds On" open question to the class. In the follow-up to the task, she is focusing on how numbers are used for the shapes can change.

In the second part of the video clip, a parallel task is being introduced with two choices for the students. The differences between the two questions are clarified for students. An example of common questions is shown, which are asked of everybody no matter which question they chose.

Inside the Classroom

Respond to Students

Inside the classroom, a teacher may alter some things based on what students say, but engagement can be kept up by interacting directly and specifically to students. That includes, in large part responding to specific issues that students raise and providing descriptive and personal feedback. Responses need to show that the students were really “heard”.

In our study, student engagement was measured by counting the number of questions that students asked during the math class. Prior to the planning and use of questions to evoke and expose thinking – there were measurements taken in Grade 7, 8 and 9 classrooms over 60 minutes. The average number of questions asked by students was 30. The average number of questions asked by students after teachers attended to their questioning in the classroom – the number increased to 96 by students. This is a significant increase in questioning by students and an indication that students were more engaged in their classroom activities.

When students offer something or when teachers overhear some students talk, it is important that feedback be specific to what the student says. In fact, some of the student’s own words can be used in the response or feedback.

Sometimes the response is a scaffold for a student struggling with the task and other times it’s encouragement to move the student even further forward.

In this video clip, we see the teacher persisting with Emily to help her understand why she is setting up the equation as she is. The teacher is encouraging her to keep going and to ask her more questions – still focusing on the big idea. The teacher also listen to other responses, in this case an alternate solution to the same problem.