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Anne Tweed

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Mathematical and Scientific Discourse in the Classroom

Session 2

ANNE TWEED

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Supporting Mathematics Thinking Through High-Quality Discourse in the Classroom

Conversation is the natural way we humans think together.
- Margaret Wheatley

Encouraging Math Talk[1]

One important way to make students' thinking visible is through math talk — talking about mathematical thinking. This technique may appear obvious, but it is quite different from simply giving lectures or assigning textbook readings and then having students work in isolation on problem sets or homework problems. Instead, students and teachers actively discuss how they approached various problems and why. Such communication about mathematical thinking can help everyone in the classroom understand a given concept or method because it elucidates contrasting approaches, some of which are wrong — but often for interesting reasons. Furthermore, communicating about one's thinking is an important goal in itself that also facilitates other sorts of learning. In the lower grades, for example, such math talk can provide initial experiences with mathematical justification that culminate in later grades with more formal kinds of mathematical proof.

An emphasis on math talk is also important for helping teachers become more learner focused and make stronger connections with each of their students. When teachers adopt the role of learners who try to understand their students' methods (rather than just marking the students' procedures and answers as correct or incorrect), they frequently discover thinking that can provide a springboard for further instruction, enabling them to extend thinking more deeply or understand and correct errors. Note that, when beginning to make student thinking visible, teachers must focus on the community-centered aspects of their instruction. Students need to feel comfortable expressing their ideas and revising their thinking when feedback suggests the need to do so.

Math talk allows teachers to draw out and work with the preconceptions students bring with them to the classroom and then helps students learn how to do this sort of work for themselves and for others. We have found that it is also helpful for students to make math drawings of their thinking to help themselves in problem solving and to make their thinking more visible (see Figure 5-1). Such drawings also support the classroom math talk because they are a common visual reference for all participants. Students need an effective bridge between their developing understandings and formal mathematics. Teachers need to use carefully designed visual, linguistic, and situational conceptual supports to help students connect their experiences to formal mathematical words, notations, and methods.

[1] From: National Research Council. (2005). *How students learn: History, mathematics, and science in the classroom*. Committee on How People Learn, A Targeted Report for Teachers, M. S. Donovan and J. D. Bransford, (Eds.). Division of Behavioral and Social Sciences and Education. Washington, D.C: The National Academies Press. p. 238. Used with permission.

The Components of High-Quality Mathematical Discourse

There are four components of high-quality mathematical discourse: questioning, facilitation of conversation, appreciation for accuracy/reliance on reasoning and proof, and collaborative exchange of ideas.

- Questioning

- Facilitation of Conversation

- Appreciation for Accuracy/Reliance on Reasoning and Proof

- Collaborative Exchange of Ideas

Supporting High-Quality Mathematical Discourse

High-quality mathematical discourse doesn't just happen. Teachers must take specific steps to ensure that all students participate in and benefit from the exchange of ideas in the mathematics classroom. High-quality mathematics discourse is supported by: establishing a psychologically safe environment, scaffolding students' experiences with mathematical discourse, encouraging students to take an active role in talking about mathematics, and incorporating rich mathematical tasks with higher-levels of cognitive demand.

- Establishing a psychologically safe environment

- Scaffolding students' experiences with mathematical discourse

- Encouraging students to take an active role in talking about mathematics

- Incorporating rich tasks that incorporate a variety of formats

Exhibit 1: Strategies for Promoting High-Quality Mathematical Discourse

Strategy	Explanation
Help students recall prior knowledge	Remind the student of what they already know about the topic and ask probing questions to help them recall more details.
Restate student responses	Restating the student's words allows the student to confirm that the teacher understands the student's thinking.
Allow students to direct the conversation	Let students do the talking while you listen.
Model active listening	Students learn how to listen to one another when they see the teacher listening carefully to them.
Attend to mathematical content	Listen for understanding of the concept first and how the understanding was articulated second.
Stay present/act spontaneously	Stay vigilant about unexpected student comments. These provide teachable moments that support the topic at hand.
Move conversation from small group to large group and back again	Prior to asking students to share comments with the whole group, provide time for them to work in small groups. Questions raised in the large group can be referred back to the small group to encourage engagement of all learners.
Offer student questions to the class to address	When a student asks a question, let students discuss it before reacting to the students' idea as the teacher.
Provide wait time	Provide time for students to think before accepting answers. This encourages students to think more deeply about the question.
Do the mathematics yourself	Solving the problem ahead of time allows you to anticipate student responses, questions, and errors.

Criteria for Worthwhile Tasks

Worthwhile tasks meet the following criteria[2]:

1. Come from the students' environment, that is, students can relate to the problem
2. Are challenging yet within the reach of students
3. Pique students' curiosity
4. Encourage students to make sense of mathematical ideas
5. Encourage multiple perspectives and interrelated mathematical ideas
6. Nest skill development in the context of problem solving
7. Promote communication about mathematics
8. Represent mathematics as an ongoing human activity
9. Promote the development of all students' disposition to do mathematics[3]

In comparison to other tasks, worthwhile tasks demand higher levels of thinking. Exhibit 2 provides other details about how worthwhile tasks are different from other tasks.

Exhibit 2: Comparing Worthwhile Tasks and Other Tasks

Worthwhile Tasks	Other Tasks
• Demand higher levels of thinking • Support learning of concepts as well as procedures • Engage students' creative faculties in the effort to solve mathematics problems	• Only demand memorization of procedures • Mostly support memorization of basic procedures and facts • Have surface level features that "steer" students to a specific procedure

Cognitive Demand

Several of the criteria for worthwhile tasks are related to cognitive demand. Cognitive demand refers to the level of thinking that is required to complete a task. Although complexity of a problem or the number of steps involved in solving the problem are related to cognitive demand, the distinction between low-cognitive demand and high-cognitive demand is the required level of thinking.

Lower-level Demands	Higher-level Demands
• Memorization • Procedures without connections	• "Doing" mathematics • Procedures with connections

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[2] Criteria 1-7 are from Reys, B. & Long, V. (January, 1995). Teacher as architect of mathematical tasks. *Teaching Children Mathematics*, *1*(5), 296-299.

[3] Criteria 8 and 9 are from National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Lower-level tasks are characterized by the following:

- There is little ambiguity about what needs to be done to solve the problem and how to do it.
- The focus is on producing correct answers rather than on developing understanding.
- Explanations of the solution focus on describing the procedure that was used.

Tasks with higher-level demands are characterized by the following:

- Although general procedures may be followed, they cannot be followed mindlessly.
- Students may feel some level of anxiety because the path to a solution isn't immediately obvious.
- There are multiple approaches to solving the problem, but there isn't much in the problem to suggest one approach over another.
- The student must draw on his or her knowledge of different strategies, and use that knowledge in creative ways, to solve the problem because a well-rehearsed approach might help only to a certain extent.

Memorization:

Procedures without Connections:

Procedures with Connections:

Doing Mathematics:

To determine if a task has <u>low-level cognitive demand</u>, ask yourself these questions:

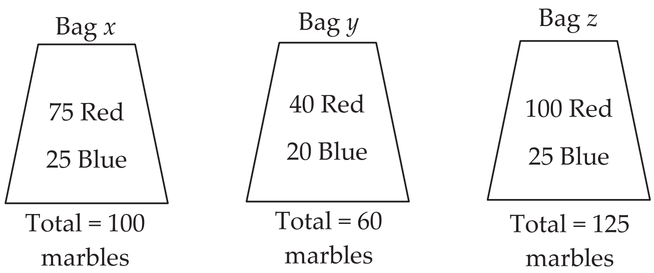
- What is the rule or procedure that would be used to solve the task?
- What has been memorized that needs to be recalled to solve the task?
- Does the task require deep thinking and mathematical communication or simply one or more procedures?

To determine if a task has <u>high-level cognitive demand</u>, ask yourself these questions:

- What has to be considered in order to solve the task?
- What decisions or judgments have to be made?
- Would this task represent a "problem" (as opposed to an "exercise") for the student?

Managing Problem Solving and Mathematical Discourse

Ms. Mason's math class was studying statistics. She brought in three bags containing red and blue marbles. The three bags were labeled as shown below.



Ms. Mason shook each bag. She asked the class, "If you close your eyes, reach into a bag, and remove 1 marble, which bag would give you the best chance of picking a blue marble?"

Which bag would you choose?

Explain why this bag gives you the best chance of picking a blue marble. You may include a diagram if needed in your explanation.

Show your work below.

Smith, M., Hughes, E., Engle, R., & Stein, M. Orchestrating Discourse, *Mathematics Teaching in the Middle School,* Vol. 14, No. 9, May 2009, pp. 549-555. Used with permission.

Strategy Used	Who and What (Student and Note on Work)	Order for Presenting

Smith, M., Hughes, E., Engle, R., & Stein, M. Orchestrating Discourse, *Mathematics Teaching in the Middle School*, Vol. 14, No. 9, May 2009, pp. 549-555. Used with permission.

Inquiry (Problem-based) Learning Process—Maths Sample Lesson

One type of inquiry is an inquiry investigation. This can be based on a real-life issue or on problems or worthwhile tasks that can be investigated using a problem-based learning approach. Look at the inquiry (problem-based) learning process provided and relate the process to what we know about the features of inquiry.

This is a process to help students describe the procedure they will use to engage in the problem-based learning process before actually gathering data and evidence to use with their explanations.

Problem-based (Inquiry) Learning Process
1. What information do you know already from the problem or scenario
1. What information don't you know from problem or scenario
2. What are some possible hypotheses for how to solve the problem or issue described in the scenario (Learner engages in a mathematically oriented question)?
3. What strategies to you plan to use to check your hypotheses?
4. What were your priority hunches (predictions based on data) and why?
5. Describe the research or problem solving procedure you would follow (the steps of your inquiry process).
6. Create a visual diagram (like a concept map) that illustrates the thinking pathways that are possible to find out the answer to the problem
7. Conduct your research and gather evidence that either supports or refutes your prediction (Learner gives priority to evidence)
8. Using your evidence, develop explanations related to your question or the problem or task
9. Communicate and justify your explanation through discussions with others in the classroom
10. Based on the classroom discussion and teacher facilitated interpretations describe your new evidence based understanding of the problem or task

Practice Task—Designing a Theater for Galileo

You and your architectural engineering team are competing for the contract to design a new circular theater with a revolving center stage. The theater is to be built beneath the great dome R-3 at the lunar space port Galileo. The Arts Director of Galileo has asked each potential engineering team to submit its design and its calculations for the new theater. Although overall design is important, the job will go to the team that produces the design with the greatest seating capacity. The director has given you the following restrictions and guidelines.

1. The theater must contain only one level and seat at least 1000 people.
2. The stage should be at least 10 meters in diameter.
3. The outer diameter of the theater interior should be at most 42 meters

4. The seating should be divided into sections by equally spaced aisles radiating from center stage. There should be no fewer than four radial aisles and no more than eight radial aisles. Each radial aisle should be at least 1 meter in width.
5. There should be two concentric aisles. The innermost concentric aisle around the stage should be a least 1 meter wide and at most 2 meters wide. The outer concentric aisle should be at least 2 meters wide and at most 4 meters wide and should ring the perimeter of the theater.
6. Safety codes at the lunar colony require that each seat be at least 60 centimeters wide and that each seating position be at least 90 centimeters in depth.
7. Safety codes require that there be no more than 30 seats in a row.

Your job is to draw a scaled plan of the theater, including seating, aisles, and the stage. Your plan should maximize seating capacity. You should be able to support your design with calculations that verify your seating capacity. You will need to calculate the following:

- The number of rows and the number of seats in each row
- The width at the stage end of each radial aisle and the width at the back end of each radial aisle; the width of the concentric aisles
- Total seating capacity

Adapted from *Discovering Geometry* from Key Curriculum Press, Berkley, California.

If you have questions or need help, feel free to contact me. Anne Tweed, atweed@mcrel.org

Developing Mathematical Thinking with Effective Questions

To help students build confidence and rely on their own understanding, ask…

- Why is that true?
- How did you reach that conclusion?
- Does that make sense?
- Can you make a model to show that?

To help students learn to reason mathematically, ask…

- Is that true for all cases? Explain.
- Can you think of a counterexample?
- How would you prove that?
- What assumptions are you making?

To check student progress, ask…

- Can you explain what you have done so far? What else is there to do?
- Why did you decide to use this method?
- Can you think of another method that might have worked?
- Is there a more efficient strategy?
- What do you notice when…?
- Why did you decide to organize your results like that?
- Do you think this would work with other numbers?
- Have you thought of all the possibilities? How can you be sure?

To help students collectively make sense of mathematics, ask…

- What do you think about what _____ said?
- Do you agree? Why or why not?
- Does anyone have the same answer but a different way to explain it?
- Do you understand what _____ is saying?
- Can you convince the rest of us that your answer makes sense?

To encourage conjecturing, ask…

- What would happen if…? What if not?
- Do you see a pattern? Can you explain the pattern?
- What are some possibilities here?
- Can you predict the next one? What about the last one?
- What decision do you think he/she should make?

What other questions would you add to this list?

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Developing Mathematical Thinking with Effective Questions

To promote problem solving, ask…

- What do you need to find out?
- What information do you have?
- What strategies are you going to use?
- Will you do it mentally? With pencil and paper? Using a number line?
- Will a calculator help?
- What tools will you need?
- What do you think the answer or result will be?

To help when students get stuck, ask…

- How would you describe the problem in your own words?
- What do you know that is not stated in the problem?
- What facts do you have?
- How did you tackle similar problems?
- Could you try it with simpler numbers? Fewer numbers? Using a number line?
- What about putting things in order?
- Would it help to create a diagram? Make a table? Draw a picture?
- Can you guess and check?
- Have you compared your work with anyone else? What did other members of your group try?

To make connections among ideas and applications, ask…

- How does this relate to…?
- What ideas that we have learned before were useful in solving this problem?
- What uses of mathematics did you find in the newspaper last night?
- Can you give me an example of…?

To encourage reflection, ask…

- How did you get your answer?
- Does your answer seem reasonable? Why or why not?
- Can you describe your method to us all? Can you explain why it works?
- What if you had started with… rather than…?
- What if you could only use…?
- What have you learned or found out today?
- Did you use or learn any new words today? What do they mean? How do you spell them?
- What are the key points or big ideas in this lesson?

What other questions would you add to this list?

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Developing Scientific Thinking with Effective Questions

To help students build confidence and rely on their own understanding ask...

- Why is that true?
- How did you reach that conclusion?
- Does that make sense?
- Can you draw a model to show that?

To help students learn to reason scientifically, ask...

- Is that true for all cases? Explain.
- Can you think of a counterexample?
- How you would prove that?
- What assumptions are you making?

To check student progress, ask...

- Can you explain what you have done so far?
- Why did you decide to use this procedure?
- Can you think of another procedure that might have worked?
- Is there a more efficient strategy?
- What do you notice when...?
- Why did you decide to organize your results like that?
- How do you think this would work if you changed the variable being tested?
- Have you thought of all the possibilities? How can you be sure?

To help students collectively make sense of science, ask...

- What do you think about what _____ said?
- Do the rest of you agree? Why or why not?
- Does anyone have the same answer but a different way to explain it?
- Do you understand what ____ is saying?
- Can you explain why your answer makes sense?

To encourage hypothesizing, ask...

- What would happen if...? What if not?
- What are some other possibilities?
- Can you predict what happens if you change the variable?
- What decisions should be made to answer the question?

What other questions would you add to this list?

Adapted from the PBS Teacherline document, Developing Mathematical Thinking with Effective Questions, 2004

Developing Scientific Thinking with Effective Questions

To promote problem solving, ask...

- What do you need to find out?
- What do you already know?
- What information do you have and what information do you need?
- What strategies are you going to use?
- How will you solve the problem?
- What tools or equipment will you need?
- What do you think the answer or result will be?

To help when students get stuck, ask...

- How would you describe the problem in your own words?
- What data do you have?
- Would it help to create a diagram? Make a data table?
- Have you compared your work with anyone else?
- What have you tried? What did other members of your group try?
- What background information do you know that might help you?
- What about putting things in order?
- Could you try your experiment again?

To make connections among ideas and applications, ask...

- How does this relate to...?
- What previous concept understanding connects to this question?
- What science issues did you find in the paper last night?
- Can you give me an example of...?

To encourage reflection, ask...

- How did you get your answer?
- How does you work demonstrate conceptual understanding?
- Does your data seem reasonable? Why or why not?
- Can you describe your procedure to the rest of the class? Can you explain why you got the results that you observed?
- What if you had started with...rather than...?
- What if you could only make observations of...?
- What have you learned or discovered today?
- What are the key concepts or big ideas in this lesson?
- Can you summarize what you learned today?
- Can you create a diagram to show the relationship of the concepts?

What other questions would you add to this list?

Adapted from the PBS Teacherline document, Developing Mathematical Thinking with Effective Questions, 2004

Anne Tweed, ©McREL 2005

Inquiry Questioning

One questioning strategy that is very effective at determining student understanding is inquiry questioning. In this activity, you will practice with a partner, by asking open-ended inquiry questions to find out what the "student" – your partner for this activity – understands about a science concept (see below).

1. Before beginning, review the document entitled *Developing Scientific Thinking with Effective Questions*.
2. Use its first three sets of questions and any others that make sense for your discussion in trying to find out what your partner understands. Be sure they pick a question that they're most familiar with and can answer. You have five minutes to question them. Ask probing questions from the list to find out more about their ideas.
3. After you are finished with the first round of inquiry questioning, change places and try another example.
4. Discuss with each other how it felt to be the questioner and the responder in terms of discovering what the other person understood about the concept.

Science Concepts

- Explain what happens when an ice cube falls on the floor and melts.
- Explain how a light bulb lights when you turn the wall switch on.
- Explain where clouds come from and why some produce rain or snow.
- Explain why an apple that falls on the ground eventually rots and disappears.

Argumentation

Engaging in argument from evidence in Years 9–12 builds on Years K–8 experiences and progresses to using appropriate and sufficient evidence and mathematical or scientific reasoning to defend and critique claims and explanations about the mathematical problem or the natural and designed world(s). Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

- ✓ Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- ✓ Respectfully provide and/or receive critiques on mathematical or scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
- ✓ Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
- ✓ Make and defend a claim based on evidence about the mathematical problem, the natural world or the effectiveness of a design solution that reflects mathematical or scientific knowledge and student-generated evidence.

Engaging in argument from evidence in Years 6–8 builds on Years K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims or explanations.

- ✓ Compare and critique two arguments on the same topic or problem and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
- ✓ Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- ✓ Construct, use, and/or present an oral and written argument supported by empirical evidence and reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- ✓ Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.

INFORMAL COOPERATIVE LEARNING

1. NUMBERED HEADS TOGETHER (Kagan)**:**

The teacher asks a question, students (each with a different number) in a group consult to make sure everyone knows the answer. Then one student's number is called on to answer.

STEPS

1. Number off the students in each group, up to four. If one group is smaller than the others have no. 3 answer for no. 4 as well. The teacher can give numbers or students can give numbers themselves.

2. Teacher asks the students a question or sets a problem to solve. It must be stressed that everyone in the group must be able to participate and answer the question. Ensure enough wait time is given for the group to do the task.

3. Teacher calls out a number, or rolls a die and whatever number is determined is asked to share their answer from each table.

2. THREE STEP INTERVIEW (Kagan)**:**

Seat students in groups of 4. Students interview each other in pairs. Students each share with the group information they learned in the interview.

STEPS

1. Students interview their partner by asking clarifying questions (What, How, When, Where, Why) about their understanding of a topic, skill or process.
2. During the second step partners reverse the roles.
3. Students share their partner's response with team.

This process activates prior knowledge and encourages peer tutoring. It can also be used to review and reinforce previously learned material.

3. THINK-PAIR-SHARE

Involves a three step cooperative structure.

STEPS

1. Teacher poses a problem or asks an open-ended question to which there may be a variety of answers.
2. Teacher gives the students ‘think time’ and directs them to think about the question.
3. Following the ‘think time’ students turn to face their learning partner and work together, sharing ideas, discussing, clarifying and challenging.
4. The pair then shares their ideas with another pair, or with the whole class. It is important that students need to be able to share their partner’s ideas as well as their own.

4. THREE-MINUTE REVIEW

Good to use for review during learning.

STEPS

1. Teacher stops any time during a lecture or discussion and give teams three minutes to review what has been said, ask clarifying questions or answer questions.

5. TEAM PAIR SOLO (Kagan)

Designed to motivate students to tackle and succeed at problems which may initially seem beyond their ability.

STEPS

1. Students do problems first as a team, then with a partner, and finally on their own.

When you allow students to work on problems they could not do alone, first as a team and then with a partner, they progress to a point they can do alone that which at first they could do only with help.

6. CIRCLE THE SAGE (Kagan)

Good way to address group questions.

1. Teacher asks class who has special knowledge to share; e.g., who was able to solve a difficult math homework question.
2. Those students become “the sages” and spread out in the room.
3. The rest of the class divide themselves equally around different sages.
4. Sage shares knowledge and students return to teams.

5. Students share what they learned with team (each team member has visited a different sage).

7. MIX-FREEZE-PAIR

STEPS

1. Teacher poses a question.
2. Teacher calls “mix” and students walk quietly around the room.
3. Teacher calls “freeze” and when all students are still
4. Teacher calls “pair” and students pair with closest student and they share answers to the question.

8. INSIDE-OUTSIDE CIRCLE (Kagan)

Students stand in pairs in two concentric circles. The inside circle faces out. The outside circle faces in. Students respond to teacher questions, rotating, after each one to the next partner.

> During inside-outside circle, students either sit or stand facing each other in two concentric circles. Students respond to teacher questions or note-card prompted questions and then rotate to the next partner. In the end of this type of structure, students will have both been teachers and learners of new information. This structure also facilitates peer tutoring and checking for different levels of knowledge acquisition.

9. FOUR CORNERS (Kagan)

Give students a prompt that necessitates their forming an opinion about the prompt. Use Likert scale options such as Strongly Agree, Agree, Disagree, and Strongly Disagree. Ask students to determine their level of agreement with the prompt and do a Quick Write expressing their opinion including reasons why they choose this point of view. Post the response options in four corners of the room. Students walk to the area where their Likert scale choice is posted. In their groups, students discuss their reasons for choosing the option they did. Each group then reports out to the class. As a follow-up, you can ask students to go to another corner and argue the prompt from that point of view.

10. TEAM WORD-WEBBING

Students write simultaneously on a piece of chart paper, drawing main concepts, supporting elements, and bridges representing the relationship of ideas in a concept and talk about them.

Small groups of students write simultaneously on a piece of chart paper, drawing main concepts, supporting elements, and bridges representing the relation of ideas in a concept. This allows them an opportunity to develop the concept, analyze the concept into components, visualize the multiple relations among ideas, and practice the associated vocabulary.

11. ROUNDTABLE

Each student in turn writes one answer as a paper and a pen are passed around the group. In teams, students take turns recalling knowledge, generating written responses, solving problems, or making a contribution to the team project.

1. Students sit in teams of four.
2. Each student takes a turn drawing, pasting or writing one answer to a query, as a paper and pencil (or paste) are passed around the group. Each student is encouraged to contribute orally or written.

With Simultaneous Roundtable more than one pencil and paper are used at once.

12. JIGSAW

Each student in the group becomes an expert on one topic by working with members from other teams assigned the same expert topic. Upon returning to their groups, each one in turn teaches the group. All students are assessed on all aspects of the topic.

13. CO-OP

Students work in groups to produce a particular group product to share with the whole class. Each student makes a particular contribution to the group.

14. PARAPHRASE PASSPORT

Students engaging in group discussion paraphrase what others have said. Before a student can go on to offer an opinion, or input, the student must paraphrase what was last said.

The person whose statement was paraphrased indicates whether the speaker has correctly captured their meaning. Once the speaker is satisfied that she or he has been accurately paraphrased, the discussion continues with the next speaker's comments.

15. TALKING CHIPS

The strategy is called "Talking Chips." Each student gets 3-4 chips (poker chips work well). The students are then divided into groups of 4-5 people. The groups are given discussion points to talk about. Every time a student speaks, they must put a chip in the center of the group. When a student runs out of chips, they are no longer allowed to speak until all other group members have all of their chips in the middle. If there is more to discuss, they go in reverse...every time they speak, they take a chip out of the center until they have all 3-4 chips back.

16. TEAM STATEMENT

This is a multi-level strategy for synthesizing information by having students state an opinion, discuss it in pairs, then present a written statement (in turns) in their groups. Once individual written statements are all presented, students work in a whole group to write a group statement that incorporates all of the most important elements of individual statements.

17. QUICK WRITE

Provide specific open-ended prompts for students to write about or simply ask students to write about what they've learned. Give students a specific amount of time to do their quick-writes.

18. THREE 3'S IN A ROW

Choose nine concepts for students to review, and write these in the boxes of a 3 X 3 matrix. Ask student to find someone who can explain to them what is asked for in a box. (one person per box). Ask the student who helped them to explain the answer to only initial the box. The students should paraphrase and write their classmate's answer in the box. Conduct a whole class review to share out answers.

RELATED RESOURCES

Available from Hawker Brownlow Education

Qty	Code	Title	Price
	111001	Classroom Instruction That Works, 2nd Edition	$29.95
	NST0782	Designing Effective Science Instruction: What Works In Science Classrooms	$39.95
	NST0881	Hard-to-Teach Biology Concepts	$37.95
	GLA1321	Inside the Black Box: Maths	$10.95
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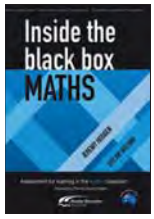

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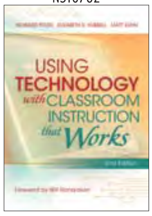

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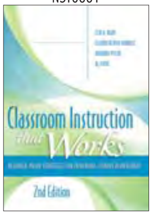

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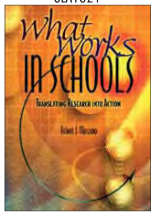

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