Strategy 1

Brainstorming and Discussion

WHAT: DEFINING THE STRATEGY

Which substance has the highest pH value?

Why do finer steel wools burn much longer than thicker ones?

Why will a paper clip float on water?

How do lasers work?

Of all the content areas, science is probably the one that most naturally lends itself to finding answers to relevant questions. When a science teacher arouses the natural curiosity of students' brains through meaningful questioning, discussing the answers to those questions and brainstorming ideas become natural parts of any lesson.

Try the following activity as one that will cause students to think outside the box, much like a scientist. Ask the following question and have students work in cooperative groups to brainstorm as many creative answers as possible: *What is ½ of 8?* The standard answer of the nonscientific mind would be 4. However, consider these responses: Three (3) is the right half of the number (8). The letters *ei* and half of the letter *g* are the left half of the word *eight.* The other half of the letter *g* and the letters *ht* are the right half of the word *eight.* This type of outside-the-box thinking should be encouraged in any classroom but particularly a science one. However, for students to feel comfortable during the process, a variety of ideas should be encouraged and criticism strongly discouraged. After all, the person in the classroom who is doing the most talking about the content is actually growing the most dendrites, or brain cells. Students have got to be let into the conversation.

WHY: THEORETICAL FRAMEWORK

Well-used questioning is a superb way to help students observe and come to understand the ideas and skills that they are learning, while simultaneously absorbing and retaining a great deal of information. (Caine, Caine, McClintic, & Klimek, 2009, p. 209)

The quality and quantity of the questions that real-life scientists ask determines the progress of science in the real world. (Berman, 2008)

During discussion, people can offer data; give their knowledge, ideas, information, and rationales on their positions; and attempt to convince others to see their side. (Costa, 2008)

Questions can be used to promote and show evidence of student thought and play a crucial role in all of the following five phases of instruction: engage, explore, explain, elaborate, and evaluate. (Hammerman, 2009)

When graphic organizers are used in cooperation with group discussion or brainstorming activities, all students are encouraged to contribute. (Jensen, E., 2004)

With appropriate questioning strategies, students can have their minds engaged and transformed. Learners are presented with problems and questions where the answers are not necessarily apparent. (Costa, 2008)

In effective classrooms, the teacher's questioning and guidance encourages students to do most of the talking and doing. (Breaux & Whitaker, 2006)

Having students stop for constructive discussion breaks, even as short as 30 seconds, is not a waste of time but makes class time more productive. (Jensen, R., 2008)

Asking students to discuss with one another any questions about what the teacher has just explained, forces them to verbalize what has been covered and what is not clear. When actual questions come up, they are more concise and articulate. (Jensen, R., 2008)

When students develop their own questions that go beyond the recall level, they must practice metacognition and recognize the level or understanding needed to both ask and answer the question. (Keeley, 2008)

HOW: INSTRUCTIONAL ACTIVITIES

WHEN: Before a lesson

CONTENT STANDARD(S): Systems, order, and organization (K–12); Structure and function in living systems (5–8)

- To prepare students for the concept of classification, ask them to place one shoe in one corner of the room and the other shoe in another corner. Put students in two groups. Have each group brainstorm as many ways to classify the shoes in one pile as they can think of in 20 minutes. Determine which group comes up with the larger number of different classifications.

WHEN: Before or after a lesson

CONTENT STANDARD(S): Characteristics of organisms (K–4); Systems, order, and organization (K–12)

- Put two pieces of chart paper on the wall. Prior to the study of classification, have students brainstorm which animals are vertebrates and invertebrates. Then place five pieces of chart paper on the wall and ask students to name animals that are birds, amphibians, reptiles, mammals, or fish. For younger students, write the lists for them as they name the animals. Then following the study, have them make the lists again and compare the two.

WHEN: During a lesson

CONTENT STANDARD(S): All (5–12)

- Teach students to know the difference between *minnow* or *skinny* questions and *whale* or *fat* questions. Skinny questions ask for quick recall of facts while whale questions call for students to analyze or explain facts or to predict based on previous knowledge. Have students use Bloom's Taxonomy Revised: Key Words, Model Questions, and Instruction Strategies (which appears at the end of this chapter) to formulate minnow and whale questions regarding a science topic for discussion. (Berman, 2008, pg. 10)

WHEN: During a lesson

CONTENT STANDARD(S): All (5–12)

- Give students a science question to which there is more than one appropriate answer. Form cooperative groups of four to six students and brainstorm as many ideas as possible in a designated time period while complying with the following DOVE guidelines:
  - **D**efer judgment: Students should not comment positively or negatively on any of the brainstormed ideas. The goal is to get as many ideas as possible written down.
  - **O**ne idea at a time: Only one idea at a time is written down since students will be giving their full attention to the originator of each idea.
  - **V**ariety of ideas: Students should be encouraged to *think outside the box* and share original ideas.
  - **E**nergy on task: All students in each cooperative group should give their undivided attention to the task of brainstorming ideas and not to anything else at the time.

WHEN: During a lesson

CONTENT STANDARD(S): Science as a human endeavor (5–12)

- Review the progress of inventions over the past 20 years. Put students in cooperative groups and have them discuss inventions that they are excited about. Have them brainstorm future inventions based on current technology and the benefits and consequences of each.

WHEN: During a lesson

CONTENT STANDARD(S): All (K–12)

- Use the think, pair, share technique with students. Pose a question or discussion topic to the class. Have them *think* of an individual answer. Then have them *pair* with a peer and *share* their answer. Then call on both volunteers and nonvolunteers to respond to the entire class.

WHEN: During a lesson

CONTENT STANDARD(S): Abilities necessary to do scientific inquiry (5–12); Evidence, models, and explanation (5–12)

- Before conducting an experiment in class, have students discuss the reasons for having a control group and an experimental group. Have them identify the variables and discuss which variable is being tested.

WHEN: During a lesson

CONTENT STANDARD(S): Abilities of technological design (5–8); Systems, order, and organization (K–12)

- Bring in a variety of unique or antique kitchen gadgets. Put them in equal piles around the room. Have students form groups and rotate to visit each pile. Have them brainstorm and guess the function of each of the gadgets. Then, reveal the function for which the gadget was intended.

WHEN: During or after a lesson

CONTENT STANDARD(S): All (K–12)

- When asking questions in class or creating teacher-made tests, provide opportunities for all students to be successful by asking both knowledge or short-answer questions and those that enable students to use their reasoning and critical- and creative-thinking skills. Refer to Bloom's Taxonomy Revised: Key Words, Model Questions, and Instruction Strategies (which appears at the end of this chapter) to ensure that students have opportunities to answer questions at all levels of the revised taxonomy, particularly those above the *knowledge* level.

WHEN: During or after a lesson

CONTENT STANDARD(S): All (5–12)

- When reviewing for a test, have students brainstorm expected test questions. Then, have them review Bloom's Taxonomy Revised: Key Words, Model Questions, and Instruction Strategies (which appears at the end of this chapter) and categorize each question based on the appropriate level of questioning.

Bloom's Taxonomy Revised

Key Words, Model Questions, and Instructional Strategies

Bloom's Taxonomy (1956) has stood the test of time. Recently, Anderson and Krathwohl (2001) have proposed some minor changes to include the renaming and reordering of the taxonomy. This reference reflects those recommended changes.

I. REMEMBER (KNOWLEDGE)
(shallow processing: drawing out factual answers, testing recall, and recognition)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Choose	Who?	Highlighting
Describe	Where?	Rehearsal
Define	Which one?	Memorizing
Identify	What?	Mnemonics
Label	How?	
List	What is the best one?	
Locate	Why?	
Match	How much?	
Memorize	When?	
Name	What does it mean?	
Omit		
Recite		
Recognize		
Select		
State		

(Continued)

Figure 1.1 (Continued)

II. UNDERSTAND (COMPREHENSION)
(translating, interpreting, and extrapolating)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Classify	State in your own words.	Key examples
Defend	What does this mean?	Emphasize connections
Demonstrate	Give an example.	Elaborate concepts
Distinguish	Condense this paragraph.	Summarize
Explain	State in one word . . .	Paraphrase
Express	What part doesn't fit?	STUDENTS explain
Extend	What exceptions are there?	STUDENTS state the rule
Give Example	What are they saying?	"Why does this example . . . ?"
Illustrate	What seems to be . . . ?	Create visual representation (concept maps, outlines, flow charts organizers, analogies, pro/con grids) *PRO/CON*
Indicate	Which are facts?	
Interrelate	Is this the same as . . . ?	
Interpret	Read the graph (table).	Note: The faculty member can show them, but *they* have to do it.
Infer	Select the best definition.	Metaphors, rubrics, heuristics
Judge	What would happen if . . . ?	
Match	Explain what is happening.	
Paraphrase	Explain what is meant.	
Represent	What seems likely?	
Restate	This represents . . .	
Rewrite	Is it valid that . . . ?	
Select	Which statement supports . . . ?	
Show	What restrictions would you add?	
Summarize	Show in a graph, table.	
Tell		
Translate		

III. APPLY
(knowing when to apply; why to apply; and recognizing patterns of transfer to situations that are new, unfamiliar, or have a new slant for students)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Apply	Predict what would happen if . . .	Modeling
Choose	Choose the best statements that apply.	Cognitive apprenticeships
Dramatize	Judge the effects.	"Mindful" practice—NOT just a "routine" practice
Explain	What would result?	
Generalize	Tell what would happen.	Part and whole sequencing
Judge	Tell how, when, where, why.	Authentic situations
Organize	Tell how much change there would be.	"Coached" practice
Paint	Identify the results of . . .	Case studies
Prepare		Simulations
Produce		Algorithms
Select		
Show		
Sketch		
Solve		
Use		

IV. ANALYZE (breaking down into parts, forms)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Analyze	What is the function of . . . ?	Models of thinking
Categorize	What's fact? Opinion?	Challenging assumptions
Classify	What assumptions?	Retrospective analysis
Compare	What statement is relevant?	Reflection through journaling
Differentiate	What motive is there?	Debates
Distinguish	Related to, extraneous to, not applicable.	Discussions and other collaborating learning activities

(Continued)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Identify	What conclusions?	Decision-making situations
Infer	What does the author believe?	
Point Out	What does the author assume?	
Select	Make a distinction.	
Subdivide	State the point of view of . . .	
Survey	What is the premise?	
	What ideas apply?	
	What ideas justify the conclusion?	
	What's the relationship between?	
	The least essential statements are . . .	
	What's the main idea? Theme?	
	What inconsistencies, fallacies?	
	What literacy form is used?	
	What persuasive technique?	
	Implicit in the statement is . . .	

V. EVALUATE (according to some set of criteria, and state why)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Appraise	What fallacies, consistencies, inconsistencies appear?	Challenging assumptions
Judge	Which is more important, moral better, logical, valid, appropriate?	Journaling
Criticize		Debates
Defend	Find the errors.	Discussions and other collaborating learning activities
Compare		Decision-making situations

VI. CREATE (SYNTHESIS)
(combining elements into a pattern not clearly there before)

Verbs for Objectives	*Model Questions*	*Instructional Strategies*
Choose	How would you test . . . ?	Modeling
Combine	Propose an alternative.	Challenging assumptions
Compose	Solve the following.	Reflection through journaling

Verbs for *Objectives*	*Model Questions*	*Instructional Strategies*
Construct	How else would you . . . ?	Debates
Create	State a rule.	Discussions and other collaborating learning activities
Design		
Develop		Design
Do		Decision-making situations
Formulate		
Hypothesize		
Invent		
Make		
Make Up		
Originate		
Organize		
Plan		
Produce		
Role Play		
Tell		
Tell		

Figure 1.1 Key Words, Model Questions, and Instructional Strategies

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REFERENCES

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing*. New York: Addison Wesley Longman.

Bloom, B. S. (Ed.). (1956). *Taxonomy of educational objectives.* The classification of educational goals, by a committee of college and university examiners. New York: Longmans.

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REFLECTION AND APPLICATION

How will I incorporate *brainstorming* and *discussion* into instruction to engage students' brains?

Which brainstorming and discussion activities am I already incorporating into my science curriculum?

What additional brainstorming and discussion activities will I incorporate?