Thinking about Inquiry: The Mystery Cube and Biological Box

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References:
This lesson was put together by the National Institutes of Health.
http://science.education.nih.gov/Supplements/NIH6/inquiry/guide/guide_lessons_toc.htm
Lesson 1 Inquiring Minds
It is part of a learning module on scientific inquiry. Italicized parts of this lesson plan were taken from http://science.education.nih.gov/Supplements/NIH6/inquiry/guide/lesson1.htm

Course Name:
8th Grade Science

Core Curriculum Standard Fulfilled:
Standard II: Students will understand that energy from sunlight is changed to chemical energy in plants, transfers between living organisms, and that changing the environment may alter the amount of energy provided to living organisms.

Core Curriculum Objective Fulfilled:
Objective 2: Generalize the dependent relationships between organisms.
a. Categorize the relationships between organisms (i.e., producer/consumer/decomposer, predator/prey, mutualism/parasitism) and provide examples of each.
b. Use models to trace the flow of energy in food chains and food webs.

Intended Learning Outcomes (ILO's) Fulfilled:
1. Use Science Process and Thinking Skills
   a. Observe objects and events for patterns and record both qualitative and quantitative information.
   b. Sort and sequence data according to a given criterion.
   c. Develop and use categories to classify subjects studied.
   e. When given a problem, plan and conduct experiments in which they:
      - Form research questions.
      - Discuss possible outcomes of investigations.
      - Analyze data and construct reasonable conclusions.
      - Prepare written and oral reports of their investigation.
   f. Distinguish between factual statements and inferences.

Time Needed To Complete Inquiry: One class period

Inquiry:

The investigation will be hands-on structured inquiry.

Prior Knowledge Needed: None

Introduction:

1. *Before students take their seats, arrange the desks or chairs such that each team of students will be able to view their Mystery Cube, which you have placed in a central location. During the activity, students in each team should sit on different sides of the table so that each student sees a different side of the cube. Place the cube for each team on a desk or table so that the side displaying the number 2 is on the bottom. As students take their seats, instruct them not to touch the cubes.*

   If your are concerned that some students may look at the bottom of their cube despite your instruction, consider gluing the cubes to a piece fo cardboard so that the bottoms are not visible.

2. *Divide the class into teams of four. Begin by asking the class, "What is science?"*

   Quickly generate a list of student responses. Write their responses on the board or on an overhead transparency. If possible, try to relate the students' responses to the idea that science is one way in which we learn about the natural world.

   Asking this question requires students to call on their prior knowledge and to engage their thinking. At this point, do not critique student responses. Appropriate comments are short and positive, such as, "Good," and "What else?" Other appropriate responses include, "Why do you believe that?" and "How do you know that?" Such questions allow you to assess students' current knowledge about the topic and help you adjust the lesson accordingly. They also provide a springboard to "Let's find out" or "Let's investigate." In general, it is time to move forward when you see the thinking has been engaged.

3. *Ask the class, "How do scientists go about their work? How do they investigate things?"*

   As before, quickly generate a list of student responses. Write their responses on the board or an overhead transparency. Students may respond that scientists make observations and perform experiments. Students may define a scientific investigation as a process that follows the scientific method or that involves collecting and analyzing information.

Materials/Resources Needed for the Investigation:

Each group will need one of following:

- Mystery Cube (already folded and taped) found at NIH website- Master 1.1
- Biological box (already folded and taped) found at NIH website- Master 1.2
- Each student will need a "Thinking about Inquiry" handout found at NIH website- Master 1.3

Procedures of the Investigation for Part 1 Mystery Cube:

1. *Announce that the students will perform an investigation of their own. Designate one student for each team to write down the team's questions, observations, and conclusions.*

   Instruct the students not to touch the cube or move from their seats while examining it. It is critical that students make observations about only what they can see of the cube. Because students cannot move around the cube, each must communicate his or her observations with the other team members to learn more about the cube.

2. *Ask, "What questions do you have about the cube?"*

   Each team should develop one or two questions. Students' questions may include the following:
   - *What is on the bottom of the cube?*
   - *What is inside the cube?*

3. *Guide the discussion to focus on the question, "What is on the bottom of the cube?" Explain to students that they will develop an explanation of what is on the bottom of the cube and that their explanation must be based on evidence.*

4. *Ask the teams, "What do we mean by evidence?"*

   Students often think that evidence is information acquired through personal experience or from people they know. Clarify for students that evidence refers to observations or the results of experiments.

5. *Ask the teams, "How do you think an explanation based on evidence is different from other explanations?"*

   Students may respond that an evidence-based explanation also supplies a reason for the explanation. Guide the discussion to bring out the idea that such a reason (evidence) is objective and does not merely reflect a personal preference. Another important point is that evidence provided by one source can be verified by another source. Since this will probably not be obvious to students at this time, consider making this point again during Step 10.

Data Collection:
Instruct the teams to make and share observations about the cube and develop an answer to the question, "What is on the bottom of the cube?"

Student observations likely will include the following:

The cube has six sides.
The cube has five exposed sides.
The exposed sides have numbers 1, 3, 4, 5, and 6.
The numbers on opposite sides add up to 7.
The even-numbered sides are shaded.
The odd-numbered sides are not shaded.
The numbers are black.

Data Analysis:

1. *Ask several student teams to share their answers to the question and to explain their reasoning.*

   Use this discussion as an opportunity to make the point that an explanation is strengthened by being supported by more than one type of observation or line of reasoning. For example, students may reason that the number 2 is on the bottom of the cube because that number is missing from the sequence 1, _, 3, 4, 5, 6. The observation that the numbers on opposite sides of the cube add up to seven (1 + 6, 3 + 4, and _ + 5 = 7) also supports the explanation that 2 is on the bottom of the cube. Additionally, students may suggest that the bottom of the cube is shaded, since 2 is an even number and the other even numbers, 4 and 6, are on shaded faces.

2. *Ask students whether they are convinced that their answer is correct and to explain why or why not.*

   Emphasize that their answer should be consistent with all the evidence. You could also extend the discussion by asking whether they can think of any evidence that would contradict their answer.

3. *Ask the teams how their investigation of the cube is similar to a scientific investigation.*

   Student answers will vary. Some may suggest that their investigation was scientific because it involved making observations and reaching explanations based on evidence. Others may point out that their investigation was not scientific because they were not able to conduct an experiment to see what was on the bottom of the cube.

4. *Explain that different scientific investigations may require different approaches. Some use laboratory experimentation, while others do not.*

   In some investigations, performing experiments may not be an option because it is not possible to manipulate the phenomenon being studied. In such cases, investigators may proceed by making observations and measurements that can address the question. Examples of such studies are found in behavioral sciences, where, for instance, investigators may study the influence of various factors on behavioral choices, such as nutrition and physical activity. Other examples are found in ecological and population studies, or in the study of disease patterns.

5. *Conclude the activity by picking up the cubes without letting the students see the bottom face.*

   If students complain that they want to see the bottom of the cube, explain that the process of scientific inquiry often fails to provide a definite answer to a question. The results of the investigation provide a possible explanation that is consistent with the available evidence. The investigation may suggest additional questions that, when answered, may lead to a better explanation. You may also consider allowing the students to see the bottom of the Mystery Cube but not the bottom of the Biological Box used in the next activity.

Procedures of the Investigation for Part 2 Biological Box:

1. *Keep the class formed into the same teams as in the previous activity. Place a Biological Box in front of each team. The side displaying the grass, question mark, and lion should be on the bottom. Do not glue or tape down the cubes.*

   The orientation of the Biological Box was chosen so that students would be able to see two environments that are easy to identify (arctic and forest) and organisms that represent a food chain within each environment (fish, seal, and polar bear; acorn, squirrel, and hawk). The third environment, the savanna, is also visible, but it may be harder for students to identify. If necessary, you can identify it for the students as an African savanna.

   As before, instruct the students not to touch the cube or move from their seats while examining it. This second cube provides an opportunity for students to reinforce their skills of making observations, sharing information, and proposing explanations in a biological context.

Data Collection:

As in Activity 1, instruct teams to make and share observations about the box and develop an answer to the question, "What is on the bottom of the box?" Encourage students to record their observations and the evidence that supports their answers.

Give the teams a few minutes to complete their tasks. Student observations will likely include the following:

- *The box has six sides.*
- *The box has five exposed sides.*
- *Three exposed sides depict an environment (arctic, savanna, and forest).*
- *Two exposed sides display three images (acorn, squirrel, and hawk; fish, seal, and polar bear).*
- *Environments and the organisms that live in them are found on opposite sides.*
- *The exposed faces with three images on them represent food chains.*

Data Analysis:

1. *Ask a member of each team to share the team's answer to the question and to explain its reasoning.*

   The patterns on the exposed box faces should allow students to propose that the bottom face shows three images that together depict a food chain found in a savanna.

2. *Ask the teams, "What experiment could you perform to determine what is on the bottom of the cube?"*

   Students may suggest simply picking up the cube and looking at the bottom.

3. *Explain that each team will be able to perform one "experiment" to learn more about what is on the bottom of the cube:*

   - *Give each team a metric ruler.*
   - *Ask teams to select one corner of the bottom face they would like to see.*
   - *Designate one student from each team to slide the cube toward the edge of the table until the corner they selected extends no more than 2 centimeters off the edge of the table.*
   - *Instruct another student to glance up at the exposed corner and share his or her observation with teammates.*
     Students should be able to explain why they chose the corner that they did. Explain that sliding the cube along the table represents an experiment being performed that produces evidence needed to help them answer the question, What is on the bottom of the cube?

4. *After teams have performed their experiment, ask them to share the evidence they collected with the rest of the class. Can they now conclude what is on the bottom of the cube?*

   Depending on which corner of the cube they exposed, students will report that they see nothing, a clump of grass, or a lion. The image at the center of the bottom face should not be visible. Students should conclude that the bottom face contains three images that depict a food chain found on the savanna. The first organism of the food chain is grass, and the third organism is a lion. Students can only guess at the identity of the middle member of the food chain. Animals eaten by lions include zebras, wildebeests, impalas, gazelles, antelopes, and warthogs. They should reason that it must be an animal that eats grass and is itself eaten by lions. Students may suggest animals such as zebras or antelopes. The cube actually displays a question mark. This, too, relates to the nature of science, where an investigation may point to more than one equally correct, evidence-based answer.

5. *Conclude the activity by asking the teams to consider how their experience with the cubes is similar to the process that scientists use to learn about the natural world. Guide the discussion to make connections between the cube activities and the following abilities and*

understandings about scientific inquiry from the National Science Education Standards:

- *Ability: Identify questions that can be answered through scientific investigations.*
  Students asked testable questions about the cube, such as, What is on the bottom of the cube?

- *Ability: Use appropriate tools and techniques to gather, analyze, and interpret data.*
  Students performed an experiment to obtain information that either supported or refuted their proposed explanation.

- *Ability: Develop descriptions, explanations, predictions, and models using evidence.*
  Students used their observations about the cube to recognize patterns and propose an explanation for what is on the bottom of the cube.

- *Ability: Communicate scientific procedures and explanations.*
  Students communicated their results by speaking to the class.

- *Understanding: Different kinds of questions suggest different kinds of scientific investigations.*
  The cube investigation relied on students' making observations and recognizing patterns. Other types of investigations rely on collecting specimens, performing experiments, making models, and seeking more information.

- *Understanding: Scientific explanations emphasize evidence; have logically consistent arguments; and use scientific principles, models, and theories.*
  The more students made observations that supported their proposed explanation, the stronger their explanation—even though they could not confirm the answer by examining the bottom of the cube.

Assessment:

To wrap up the lesson, give the class a brief homework assignment. Give each student a copy of Thinking about Inquiry. Ask students to list the specific characteristics of the Biological Box activity that model the process scientists use to learn about the natural world.