Teacher's Guide

Lesson 1—Engage/Explore
Inquiring Minds

At a Glance

Overview

Lesson 1 introduces students to basic aspects of scientific inquiry and the nature of science. In this lesson, students begin developing their own understanding of the process of scientific inquiry. Although students model the process of *scientific inquiry*, they are not introduced to the term scientific inquiry until the next lesson. Explicit connections to scientific inquiry are made in Lessons 2 and 3.

In the first activity, students are presented with a numbered paper cube and guided to ask, What is on the bottom of the cube? After making observations and sharing information, students propose explanations and defend their reasoning. In the second activity, students are presented with another paper cube that displays information of biological interest. As before, they are asked to propose an explanation for what is on the bottom of the cube. This activity helps students relate the more abstract concepts presented in the first activity to a biological context. The final activity allows students to reflect on the process they used in their investigations of the cubes.

Major Concepts

The process that scientists use to learn about the natural world is characterized by

- asking questions that can be answered through investigations,
- designing and carrying out scientific investigations,
- thinking logically to make relationships between evidence and explanations, and
- communicating procedures and explanations.

Objectives

After completing this lesson, students will be able to

- show their current understanding of the process of scientific inquiry,
- recognize that science uses a process as a means of learning about the natural world,
- identify the major components of the process by which scientists learn about the world, and
- appreciate that experiments help scientists test predictions.

Teacher Background

Consult the following sections in Information about the Process of Scientific Inquiry:

3 Inquiry and Educational Research (info_process-a.htm#research)
4 Inquiry in the National Science Education Standards (info_process-b.htm#nses)
5 Misconceptions about Inquiry-Based Instruction (info_process-b.htm#misconceptions)
6.1 The Nature of Scientific Inquiry: Science as a Way of Knowing (info_process-c.htm#knowing)
6.2 Scientifically Testable Questions (info_process-c.htm#testable)
7 Teaching Scientific Inquiry (info_process-c.htm#teaching)

In Advance

Web-Based Activities

Activity	Web Component?	Photocopies	Materials
1	No	Master 1.1, *The Mystery Cube Template* (Make 1 copy per team of 4.)	1 Mystery Cube per student team 1 pair of scissors 1 roll of transparent tape
2	No	Master 1.2, *The Biological Box Template* (Make 1 copy per team of 4.)	1 Biological Box per student team 1 pair of scissors 1 roll of transparent tape 1 metric ruler per student team
3	No	Master 1.3, *Thinking about Inquiry* (Make 1 copy per student.)	No materials except photocopies

Preparation

Use scissors to cut out the cube templates from the copies of Masters 1.1 and 1.2. Assemble each template into a cube and use transparent tape to secure. Tabs are provided on the templates to make this easier. Constructing the cubes out of regular copy paper can be difficult. If possible, use a thicker (card) stock. To prevent students from looking at the bottom of the cube, you can glue the cube to a piece of cardboard. Organize the class into teams of four for Activities 1 and 2.

You can use a single, large cube for this activity instead of several smaller cubes. To construct a large cube, multiply the dimensions of the cube template on Master 1.1 by a factor of 3 or 4 and trace it on a large piece of poster board. Draw numbers on the template and add shading, as depicted on Master 1.1. Use a razor knife to score the lines on the poster board that will be folded. Fold the poster board into a cube and fasten with tape. Place the large cube on a table at the center of the room in full view of the class.

Procedure

Activity 1: *Mystery Cube*

Note to teachers: This activity is designed to give students a brief introduction to the major aspects of scientific inquiry. Proceed through the activity at a steady pace. Do not allow students to spend too much time on any particular aspect of the model.

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.

1. **As students take their seats, instruct them not to touch the cubes.**

   If you are concerned that some students may look at the bottom of their cube despite of your instruction, consider gluing the cubes to a piece of 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.

Note to teachers: 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 that thinking has been engaged.

Assessment:
Listening to student responses will help you assess their current understandings and misconceptions of inquiry.

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.

4. **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.**

   Note to teachers: 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.

5. **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?

Content Standard A:
Identify questions that can be answered through scientific investigations. Think logically and critically to make the relationships between evidence and explanations. Communicate scientific procedures and explanations. Different kinds of questions suggest different kinds of scientific investigations.

6. **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.**

7. **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.

8. **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.

9. **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.

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

Assessment:
This activity allows you to assess students' scientific reasoning skills.

   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.

   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.

11. **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.

12. **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.

13. **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.

Activity 2: ***The 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.

   Note to teachers: 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.

2. **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.

3. **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.

4. **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.

5. **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?

6. **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?**

Assessment: Listening to student responses will allow you to determine how well students are now able to reason scientifically.

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.

7. **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*:**

Content Standard A: Students develop abilities necessary to do scientific inquiry. Students develop understandings about scientific inquiry.

Content Standard C: Students develop an understanding of populations and ecosystems.

Content Standard G: Students develop an understanding of science as a human endeavor. Students develop an understanding of the nature of science.

- **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.

Activity 3: *Thinking about Inquiry*

1. **To wrap up the lesson, give the class a brief homework assignment. Give each student a copy of Master 1.3, *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.**

   As you progress through the rest of the module, relate aspects of the student activities to these elements of scientific inquiry. The abilities and understandings about scientific inquiry reappear throughout the module and provide a foundation for students to build on as they use inquiry during the rest of the school year and, indeed, during their continuing education. Remember that students do not need to recognize the term scientific inquiry in this lesson. Scientific inquiry is defined for students in the lessons that follow.

Assessment:
The homework will help you determine what students learned as well as whether misconceptions have been corrected.

Lesson 1 Organizer

Activity 1: *Mystery Cube*	
What the Teacher Does	**Procedure Reference**
Instruct students not to touch the cubes.	Step 1
Divide class into teams of four. Ask: • "What is science?" • "How do scientists go about their work?" • "How do they investigate things?"	Steps 2 and 3
Announce that teams will conduct their own investigation about the cube. Ask: • "What questions do you have about the cube?"	Steps 4 and 5
Explain to students that they will develop an evidence-based explanation of what is on the bottom of the cube.	Step 6

Ask the teams: • "What do we mean by evidence?" • "How do you think an evidence-based explanation is different from other explanations?"	Steps 7 and 8
Instruct teams to make and share observations about the cube.	Step 9
Have several teams share their answers with the class. Ask them to explain their reasoning.	Step 10
Compare the student investigations with scientific investigations. Explain that scientific investigations use different approaches.	Steps 11 and 12
Collect cubes without letting students see the bottom face.	Step 13

Activity 2: *The Biological Box*

What the Teacher Does	Procedure Reference
Place a Biological Box, in the proper orientation, in front of each team. Explain that they will develop an evidence-based explanation of what is on the bottom of the cube.	Step 1
Instruct teams to make and share observations about the cube.	Step 2
Have several teams share their answers with the class. Ask them to explain their reasoning.	Step 3
Ask the teams what experiment they could perform to determine what is on the bottom of the cube.	Step 4
Have teams perform an experiment: • They select one corner of the cube to observe. • They slide that corner of the cube off the edge of the table and observe what it reveals.	Step 5
Have several teams share their answers with the class. Ask them to provide their evidence and explain their reasoning.	Step 6
Ask students to compare their experience with the cubes with the process used by scientists. Make connections to abilities and understandings from the *National Science Education Standards*.	Step 7

Activity 3: *Thinking about Inquiry*

What the Teacher Does	Procedure Reference
Give each student a copy of Master 1.3, *Thinking about Inquiry*. As a homework assignment, instruct students to list characteristics of the Biological Box activity that model the process of scientific inquiry.	Step 1 

 = Involves copying a master.