NASA's Deep Impact Mission: Decision Making

Capture the Issue

TEACHER GUIDE

BACKGROUND INFORMATION

In this activity, students are introduced to the problem that mission planners dealt with during the planning phase of the Deep Impact Mission. The activity starts by having the students read the Deep Impact fact sheet. This is analogous to looking at the end of a good novel before one reads it. The next step is to look at the decision-making process, where students think about how they have made decisions in the past. "The Camera Controversy" then allows students a similar experience in making a decision about a controversial real-life problem. Students then hear a summary of an interview from the Principal Investigator, Dr. Michael A'Hearn. Dr. A'Hearn explains the problem, "How do we optimize our data collection?" This introduction not only provides the "hook" for student interest, but serves as a focus for the entire module.

Dr. Michael F. A'Hearn

Photograph of comet Hale-Bopp taken by Principal Investigator Michael A'Hearn

The National Science Education Standards call for teachers of science to develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing so, teachers should display and demand respect for the diverse ideas, skills, and experiences of all students. This respect for diverse ideas is modeled in this opening activity in which students are exposed to different perspectives and then to an informal discussion based on a shared understanding of rules of scientific discourse.

The standards also call for teachers to engage in ongoing assessment of their teaching and of student learning in order to guide teaching. This activity begins with a short scenario that requires students to make a decision. Teachers can use this as a tool to see how students have made difficult decisions in the past.

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5-8

Science As Inquiry

Abilities necessary to do scientific inquiry.

Identify questions that can be answered through scientific investigations.

Recognize and analyze alternative explanations and predictions.

Science and Technology

Understandings about science and technology.

Science in Personal and Social Perspectives

Science and technology in society.

History and Nature of Science

Science as a human endeavor.
Nature of science.

Grades 9-12

Science As Inquiry

Abilities necessary to do scientific inquiry.
Identify questions and concepts that guide scientific investigations.
Recognize and analyze alternative explanations and predictions.

Science and Technology

Understandings about science and technology.

Science in Personal and Social Perspectives

Environmental Quality.
Science and Technology in local, national, and global challenges.

History and Nature of Science

Science as a human endeavor.
Nature of scientific knowledge.

(View a full text of the National Science Education Standards.)

LANGUAGE ARTS STANDARDS

Listening and Speaking

Uses listening and speaking strategies for different purposes

Uses strategies to enhance listening comprehension.
Listens in order to understand topic, purpose, and perspective in spoken texts.

LIFE SKILLS STANDARDS

Thinking and Reasoning

Effectively uses mental processes that are based on identifying similarities and differences

Compares different sources of information for the same topic in terms of basic similarities and differences.

Applies decision-making techniques

Identifies situations in the community and in one's personal life in which a decision is required.
Secures factual information needed to evaluate alternatives.

(View a full text of the McREL Compendium of Standards and Benchmarks for K-12 Education.)

MATERIALS

For the teacher:

- Listening Notes Example transparency

For each student:

- Deep Impact Mission fact sheet
- Deep Impact interview sheet:
  Dr. Michael F. A'Hearn
- Listening Notes sheet

- Highlighters (optional)
- Appendix G: Rule-Based Strategy (optional)

PROCEDURE

Begin this activity by asking students to read the Deep Impact fact sheet. This two-page document details the context for this entire mission.

1. The following is a procedure for using an inferential strategy with your students for reading the Deep Impact mission fact sheet.
   a. The teacher should analyze the content of the fact sheet for important ideas.
   b. Select three or four ideas that are important and might be difficult to understand. (For this fact sheet one idea might be what comets are and what they are made of.)
   c. Develop two questions for each idea identified in (b). The first should be about the background knowledge and the second should be a prediction question. (For this fact sheet and idea, a background question might be, "What do you know about comets?" or "Describe a time when you saw a comet in the nighttime sky." A prediction question might be, "If you could send a spacecraft to visit a comet, what would you want to know?"
   d. Discuss the responses to both the background and prediction questions **before** the students read the fact sheet.
   e. After the discussion, assign the fact sheet to be read.
   f. After reading, relate the prediction questions to what actually is being planned for the Deep Impact mission. Evaluate the ideas that motivated the background and prediction questions

2. Ask students to think about a time when they had to make a difficult decision. Ask them to relate the process they used to make that decision. Hold a class discussion about decision making. Ask students questions similar to the following:
   - Why are some decisions easier to make than others?
   - What is it that makes a decision difficult?
   - In a difficult decision that you made in the past, what helped you to arrive at your conclusion?
   - What are some things that you believe are critical in order to make an informed decision?
   - After you make a difficult decision, what would you do if you needed to change your decision?

3. Explain to students that you are going to read an example of a controversy. As they listen to the story, ask them to think about both sides of the story, and whether additional information might be needed to make a decision. Read "The Camera Controversy" (located on the next page) aloud.

Alternate Strategy Tip
Use the "Rule-Based Strategy" in Appendix G to help students summarize this passage.

4. Ask students to list the process of how they would make this decision on a sheet of paper, and to add additional pieces of information that they would need to have before they could make this very difficult decision. Collect these sheets and read over the process and the types of information that the students would need to make this decision. You can use the student responses to provide a snapshot of how the students in your class make decisions. Explain to students that the module that they are about to begin is one about decision making based on a NASA mission called Deep Impact.

5. Explain to students that the rest of this module deals with the decision making process that the science team and mission planners used in **deciding on the best time to impact Comet 9P/Tempel1** in order to get the best combination of data sources. Emphasize to students that they will be using information from interviews, data sheets, and the Internet to go through the same process as the mission planners. Also mention that although the mission planners have made a baseline decision, this decision could change prior to launch of the spacecraft.

The Camera Controversy

Mariner 2 was the first space probe to visit a planet other than Earth. It was launched on August 27, 1962 in order to fly to Venus. The now famous astronomer Carl Sagan was immersed in a controversy about whether Mariner 2 should carry a camera. He and some of his colleagues argued for placing a camera onboard.

During the 1960's images from telescopes were hazy and not useful for scientists. Opponents to having a camera onboard maintained that a camera would only take up already-limited space and power resources on the space probe. Scientists who were opposed to the camera thought the space on board the probe would be better suited for "real" science instruments like the microwave radiometer, infrared radiometer, flux-gate magnetometer, ion chamber and Geiger-Mueller counters, cosmic dust detector, solar plasma detector—all of which were scheduled to fly on Mariner 2. These scientists preferred to make predictions about what would be found near a planet and then send specific instruments to test these predictions.

Sagan, on the other hand, expected to use cameras to "discover the unexpected." Sagan felt that cameras were important "precisely because they could answer questions we were too stupid to ask." Sagan thought these pictures would be valuable in their own right stating that they would help people to see Venus as more than the bright morning star, rather it being a complete world. In hindsight, images from other space probes have let the science community see a solar system that is much more complex than was thought previously.

Opponents countered with the fact that thick clouds on Venus would make it very difficult to see the "unexpected." Besides, are pictures real data? Many scientists preferred quantitative data that could be analyzed with their new computers.

Still, Sagan thought that if there was a break in the clouds, the camera could see evidence of possible life forms found in the cooler mountainous regions he thought were just below the clouds. These mountains, he thought might be cool enough to support life.

If you were on the panel at the Jet Propulsion Laboratory, what would you decide? Should a camera be flown on Mariner 2? What additional information about the benefits of the camera would you need to know before making the decision? What more should you know about the issues raised by the opponents?

6. Tell students that they are going to listen to an interview with the Principal Investigator Michael A'Hearn. Have one volunteer come forward to read the interview sheet. Give the volunteer the sheet and instruct him or her to read it silently. Tell the volunteer that they are going to read the sheet dramatically to the class.

Alternate Strategy Tip
Consider recording the oral readings from the student volunteers of the interviews. Students with learning disabilities could then listen to these tapes several times to meet individual needs.

7. While the volunteer is silently reading the interview sheet, distribute one Listening Notes sheet to the rest of the class. If they have never used listening notes before, give them the following instructions:
   a. Use the right side of the table for taking notes on what is said.
   b. Encourage students to use an indent or numbering system to categorize new ideas as they listen.
   c. Have the students put labels in the left-hand column and give them the chance to fill in gaps in the notes. This labeling should be done as soon as possible following the

Alternate Strategy Tip
Review the Deep Impact fact sheet a second time. This time, model the process for taking listening notes.

note taking.

d. The main ideas and notes can then be used by the students to compare the interview and find areas that are similar and areas that are different.

8. Display the Listening Notes Example transparency to show students what their completed notes might look like. Once everyone is ready to start, ask the student volunteer to dramatically read the interview sheet to the class. You may want to have the volunteer read the interview twice; this will allow students to take more complete notes on the interview. Students who are taking notes should listen for information concerning the problem of determining the best time for impact of Comet 9P/Tempel 1. There are many variables that should inform this decision.

Teaching Tip
Provide key terms from the glossary to students before the presentation so they can listen for the main ideas.

9. Once the interview has been read, distribute the interview summary sheet to the class and instruct the class to label the main ideas of their notes in the left-hand column.

10. Divide the class into groups of three. This is now their home group and will be used during the research phase of the module in the next activity. Instruct the students to compare notes in this small home group for each person. You may want to pass out highlighters for students to color code commonalties and differences in the opinions of the mission planners. A venn diagram is a useful tool for making comparisons and contrasts.

11. End this session by asking the student questions similar to the following:
    - Based on what you have heard so far, what questions do you now have?
    - What do you think would be appropriate next steps to answer these questions?

TEACHER RESOURCES

Publications

Davidson, Keay. (1999). *Carl Sagan: A Life.* John Wiley & Sons, Inc. New York, NY. Pp. 116-117.

Vacca and Vacca. (1993). *Content Area Reading.* Harper Collins College Publishers. New York, NY.

Web sites

http://fuse.pha.jhu.edu/overview/mission_ov.html
FUSE overview page

http://sci.esa.int/rosetta
ESA's Rosetta mission homepage

http://www.ball.com/aerospace/deepimpact.html
Ball Aerospace Deep Impact page

http://www.graphic.org/venbas.html
Venn Diagram information

http://www.jpl.nasa.gov/missions/past/mariner1-2.html
Information on Mariner 1 & 2 missions

http://www.psrd.hawaii.edu/Feb97/Hale-Bopp.html
Information about comets