Activity 4: What Scientists Do

Overview

Throughout the *Oobleck* unit your students have been acting as scientists. In this session, they become much more aware of this, and get a chance to think about what science is all about and what scientists actually do. In this activity, the class brainstorms the many ways they have acted as scientists during each of the activities of the unit, becoming aware of how many scientific skills they have been engaging in and are able to list.

Students compare their efforts in investigating Oobleck, debating results and designing a space ship to the work of scientists who plan and implement actual missions to Mars. Through an overhead transparency presentation, students see how Mars scientists designed a real spacecraft with clever devices to land on and explore Mars. They also are shown an example of how scientists encountered an intriguing phenomenon on Mars, came up with different explanations for it, performed further tests, and then reached agreement. Students are encouraged to keep thinking like scientists!

One of the most important ideas in current science education research is that students need to develop both science-related abilities *and* a conscious understanding of the nature of science and the ideas behind scientific inquiry. They need to be able to do science and to reflect on science as a discipline. It's also beneficial for students to reflect on *how* they've learned something, which helps them to be able to apply the process to new learning situations. The Oobleck experience is made to order for deepening of both abilities and understandings.

Learning Objectives for Activity 4

- Deepen student understanding of and insight into the nature of science and the work of scientists.
- Develop student ability to reflect on and generalize about science from their firsthand experiences and from learning about the work of other scientists (secondhand experiences).
- Provide students with information about NASA Mars missions, particularly the Mars Rover missions.

If you've presented the "Microscope Eyes" optional activity prior to Activity 4, then students will also have that experience of making models and envisioning the microstructure of Oobleck to take into account during the brainstorm.

There are many excellent NASA-related websites that can provide you and your students with great images and information about past and current Mars missions, other missions, space science in general, as well as profiles of scientists from many backgrounds. A small sampling of these is provided in the Resources section.

This activity is a practical example of the recommendation in the National Science Education Standards that students should acquire both "abilities necessary to do science inquiry" and "understandings about science inquiry." It also exemplifies what education researchers and learning specialists call "metacognition." In its simplest sense, metacognition means "thinking about thinking." It's the awareness individuals have of their own thinking and learning processes and strategies. That awareness helps them monitor, regulate, and direct these processes and strategies toward new learning. In this case, your students are consciously reflecting on the things they did within the context of scientific inquiry (what scientists think and do). In doing so, they are more likely to recognize (and make use of) scientific modes and methods of doing and thinking the next times they encounter them. The real-world connection to the work of NASA scientists further strengthens their metacognitive understanding.

What You Need

- ❑ overhead transparencies of the Mars mission (pages 40–44)
- ❑ overhead projector
- ❑ *(optional)* LCD projector to project the transparency images directly from the Internet
- ❑ *(optional)* additional Mars images downloaded from the Internet

If you have done the Microscope Eyes activity, write it as a heading as well.

Getting Ready

1. At the top of the chalkboard write three headings: LABORATORY, CONVENTION, and SPACECRAFT DESIGN.

2. Nature of Science Quotation. Make an overhead of the Einstein quotation at the end of this session. You could also add other quotes on the subject, some of which appear throughout this guide.

If students are not familiar with what engineers do and/or to make sure all students understand the term, you may want to briefly explain what an engineer does. You could say that an engineer is a person who uses science and math knowledge to solve practical, technical problems for society. Engineers design, build, and/or operate equipment, structures, and systems. There are many different kinds of engineers, including electrical, mechanical, industrial, mining, chemical, environmental, biochemical, and aeronautical engineers.

Setting the Scene

1. **At this point you can announce that the research team of chemists you mentioned at the start of the first Oobleck investigation has just reported its findings on the exact composition of Oobleck.** They have revealed that Oobleck is made of cornstarch, water, and green food coloring.

2. **Remind your students that there were several parts to the Oobleck activity: a laboratory session, the scientific convention, and the spacecraft design challenge (also "microscope eyes," if you did it).** Explain to your students that during all of these activities they did many things that scientists and engineers do.

The important thing is not to stop questioning. Curiosity has its own reason for existing… I am neither especially clever nor especially gifted. I am only very, very curious.
*— **Albert Einstein***

Students as Scientists

1. **Ask your students to describe some of the ways they behaved like scientists during the laboratory session.** List their ideas on the chalkboard under the "LABORATORY" heading. Following is a typical list: looked, touched, smelled, wrote ideas, experimented, tested ideas, talked, used instruments (plastic spoons, etc.), compared Oobleck with things we know about.

2. **Ask the students to list the ways they acted like scientists during the scientific convention.** List their ideas under the "CONVENTION" heading. Here is what one class listed: talked, disagreed, argued, explained our experiments, changed words, defined words, criticized, did more experiments, voted, decided if we thought something was true.

Note: If you did the Microscope Eyes activity with your students, ask how they acted like scientists during that activity as well. They might come up with a list like this: created explanations, designed models, illustrated ideas, shared models with each other, evaluated models, critiqued each others explanations, changed ideas, thought about properties of Oobleck.

The purpose of this part of the activity is to draw a parallel between what scientists and engineers do and what your students have done in investigating Oobleck, conducting a scientific convention, and designing spacecraft. Sometimes groups have a hard time generating lists of ways they acted like scientists or engineers. In these situations, rather than trying to pull these responses out of them, go ahead and list how you noticed them acting as scientists and engineers.

3. **Ask students to list the ways they acted like engineers when they designed spacecraft to land on an ocean of Oobleck.** List their ideas under the "SPACECRAFT DESIGN" heading. They might come up with a list like this: defined a problem, came up with solutions to the problem, discussed and evaluated ideas, illustrated ideas, thought about properties of Oobleck and about how other materials behave in Oobleck, considered constraints, invented machines, changed ideas.

The scientist merely explores that which exists, while the engineer creates what has never existed before.
— Theodore Von Kármán

4. **Point out that many of the ways they acted like scientists and engineers directly reflect what professional scientists and engineers think about and do.** Tell students that, as an example of this, you are going to show them a series of overhead transparencies of the Mars Rover missions of 2004.

5. **But first, say that are going to propose a quick challenge to your students.** Say, "You designed spacecraft to land on Oobleck, taking into consideration what you knew about the fictitious moon and its surface. Mars is an actual planet, and we know many things about it, such as: it's a rocky planet, like Earth is; its atmosphere is 1% as thick as Earth's; and its gravitational pull is 38% of Earth's.

6. **Ask students—"If you were scientists designing a spacecraft to land on and explore Mars you would need to take these factors, or constraints, into consideration.** If you were to design a spacecraft that could safely land on Mars, what kinds of devices do you think might be needed?" Hold a brief discussion. [Answers will vary]

7. **Use the following notes and the overhead transparencies you prepared to present a glimpse of how scientists have addressed the challenges of real world Mars exploration.**

Almost all of these images can be found at: http://marsrovers.jpl.nasa.gov/mission/tl_entry1.html in case you would prefer to project them from a computer rather than an overhead projector. The "blueberries" picture (#14) can be found on several sites, including: http://marsrovers.nasa.gov/gallery/press/opportunity/20040312a/xpe_blueberry_b-B047R1_br.jpg

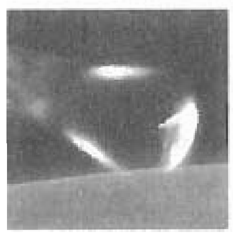
Mars Exploration

1. In 2004, two vehicles without people on them, called "rovers," and named Spirit and Opportunity, landed on Mars to explore and look for evidence that there once was liquid water on Mars. Scientists and engineers built a clever series of devices to land the Rovers safely on this rocky planet with an atmosphere 1% as thick as Earth's and with 38% of the gravitational pull as Earth's. As the two landers approached Mars, they were traveling at about 12,000 miles per hour. They were controlled by NASA scientists on Earth.

2. In what the NASA scientists called "six minutes of terror," because they were worried that something would go wrong, the spacecraft had to be slowed down from 12,000 miles per hour to 0 in just six minutes.

Other information: The friction also heated up the outside surface of the heat shield to as hot as the surface of the Sun (1,447 degrees Celsius, or 2,637 degrees Fahrenheit). Protected inside, the rover stayed at about room temperature.

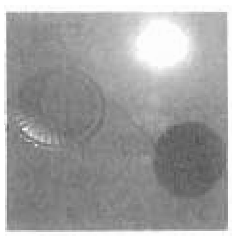
Image #1 – Heat Shield



- The friction of the heat shield in the Martian atmosphere slowed the lander down by thousands of miles per hour.

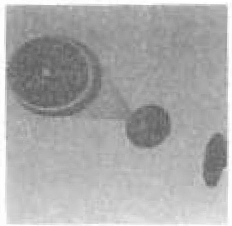
Other information: The parachute was deployed after about four minutes and at about 30,000 feet above the surface when the spacecraft was traveling at about 1,000 miles per hour.

Image #2 – Parachute



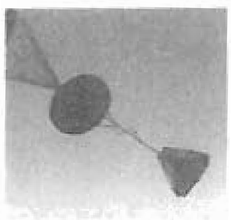
- The "supersonic parachute" was deployed. Because the Martian atmosphere is only 1% as thick as Earth's, a parachute alone could not slow it down enough.

Image #3 – Heat Shield Separating



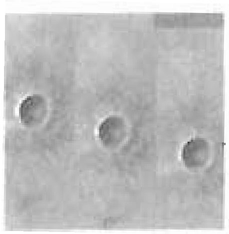
• After 20 seconds the heat shield separated and fell off.

Image #4 – Lander on Tether



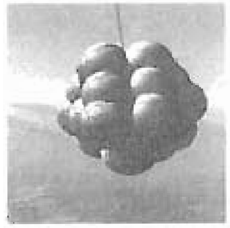
• 10 seconds later, at 20,000 feet, the lander separated from the back shell and slid down a long tether. At the end of the tether it was far enough away from the rockets and had space to inflate its airbags.

Image #5 – Three Photos of Surface



• At about 8,000 feet above the surface of Mars, with only about one minute till landing, the Rover took three photos of the surface and used its radar to figure out how high it was and how fast it was falling. It used this information to guide how it fired its rockets to slow itself down.

Image #6 – Airbags

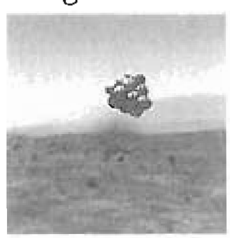


- Airbags surrounding the lander inflated. The airbags had to be strong enough to protect the aircraft as it was landing on hard rocks.

Image #7 – Retro Rockets Fire

- At only one football field length above the ground, the retro rockets fired. They slowed the lander to a complete stop at about 40 feet above the ground.

Image #8 – Freefall

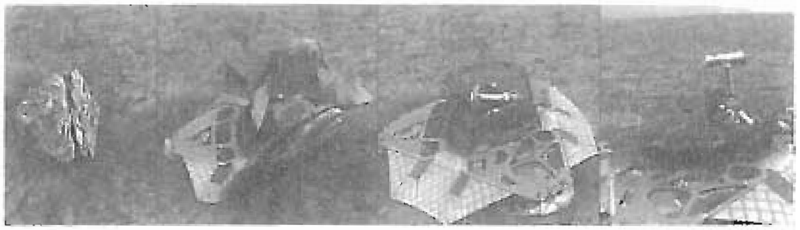


- 3 seconds before landing, the tether was cut and the 1,200-pound lander went into a freefall.

Image #9 – Landing

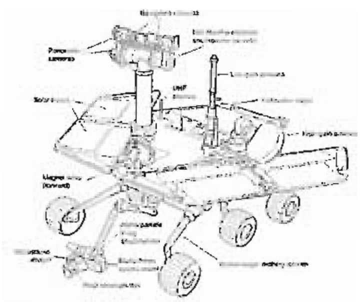
- The spacecraft bounced about 32 times up to four or five stories high! It bounced and rolled at freeway speeds for about 10 minutes then came to a complete stop.

Image #10 – Lander Unfolds



- The lander deflated and pulled in the balloons, then slowly it unfolded to reveal the Rover.

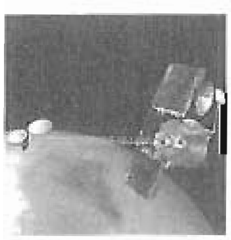
Image #11 – Mars Rover



- The Rover explored the Martian surface with sensory tools to learn about its properties, much like you explored Oobleck's properties with your own senses. On its robot "arm" it had:
    - a close-up magnifier to see the texture of the rock.
    - a device that can tell what chemicals are in the rock.
    - a tool that breaks open rocks to see what they look like inside.

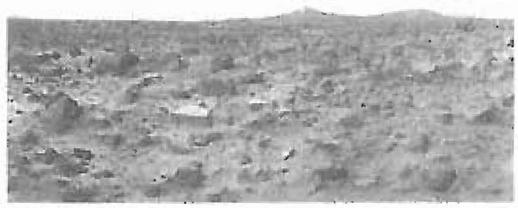
  It also had a panoramic camera on its "mast," and was able to travel around the Martian surface on wheels.

Image #12 – Orbiting Spacecraft



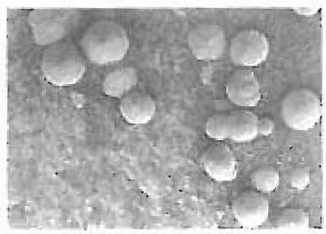
- The Rover sent information to another spaceship orbiting Mars, which then sent it back to Earth.

Image #13 – Martian Surface Photo



- This is a photo of the Martian surface that the Rover sent back to Earth.

Image #14 – "Blueberries"



- The next example of what the scientists did is similar to the testing and exchange of ideas you did with Oobleck. The Rovers discovered interesting round mineral formations about the size of BBs that they called "blueberries." There was disagreement and debate about what they were.

3. **Ask students about these formations.** Ask, "How do you think these mineral formations might have formed? [answers will vary]

4. **Tell the class that some scientists thought they might have been formed by volcanic lava flying through the air.** Others thought they might have been formed in water—which would fit with other evidence they'd collected for the presence in the past of liquid water on Mars. Others said that the triplet formation (three balls connected in a row) shown in the photo is unlikely to have been formed by lava.

5. **Explain that Mission scientists evaluated all these ideas and decided to perform a chemical test on the "blueberries" to learn more.** The test showed that the "blueberries" matched a type of mineral (hematite) that forms in water on Earth. They decided that these minerals were probably more evidence that liquid water once existed on Mars.

Image #15 — "Spirit Celebration"

- This photograph shows NASA scientists and engineers celebrating the successful landing of Spirit, one of the Mars rovers.

Summing Up

1. **Explain that there have been many other missions aimed at finding out more about Mars, but never a mission where people traveled there.** Who knows, the first person to ever travel to Mars might be sitting in the classroom!

2. **Explain that science attempts to explain the physical world based on evidence and logic.** Even if most scientists agree on the correctness of an idea, they remain open to a new experiment or argument that might change their opinions. One of the greatest strengths of science is that it welcomes critique and testing of old ideas as well as the proposing of innovative new ideas, when they are supported by all available evidence, or when new evidence is gathered.

Many students are surprised that humans have never traveled to Mars!

3. **Say that because many ideas in science are based on observations and experiments over many years, they are likely not to change.** They are supported by a lot of evidence. Nevertheless, all scientific ideas are open to change and improvement based on evidence—science is an ever-changing body of knowledge. Science is a constant questioning process. Over the course of the history of science, sometimes even the most widely accepted ideas and theories have been overturned.

4. **You may want to end with one or more of the quotes on the nature of science included in this guide or a favorite of your own.** If you don't think most of these would be appropriate for your students, we at least recommend this one by Albert Einstein:

"The important thing is not to stop questioning. Curiosity has its own reosan for existing… I am neither especially clever nor especially gifted. I am only very, very curious."

— Albert Einstein