Bulding a Permanent Human Presence in Space

Grades K-4

Lesson 2: Exploration Yesterday and Today

The United States and its partners around the world are building the International Space Station (ISS), arguably the most sophisticated engineering project ever undertaken. The ISS is an orbiting laboratory where astronauts conduct research in a variety of disciplines including materials science, physiology in microgravity environments, and Earth remote sensing. The ISS provides a permanent human presence in low Earth orbit.

This lesson is one of many grade K-12 lessons developed by Challenger Center to bring the ISS experience to classrooms across the nation. It is part of Building a Permanent Human Presence in Space, one of several Education Modules developed for Challenger Center's *Journey through the Universe* program. This Education Module addresses the essential question "How can we build a permanent human presence in space?" Start the *Journey* at www.challenger.org/journey.

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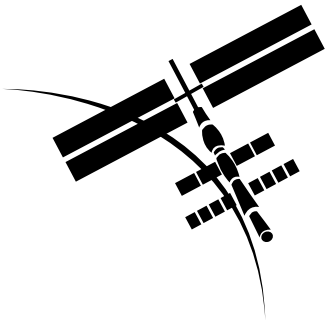


Lesson 2:
Exploration Yesterday and Today

Lesson at a Glance

Lesson Overview

Throughout human history, people have demonstrated a desire to explore. From Ferdinand Magellan through Lewis and Clark to modern-day explorers such as Robert Ballard (who discovered the remains of the Titanic), people are continually pushing the boundaries of their knowledge and abilities. In this lesson, students will investigate the nature of explorations, past and present, and identify traits of two very different explorations.

Lesson Duration

One 45-minute class period

Core Education Standards

National Science Education Standards

Standard E2: Understandings about science and technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work.
- Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

Essential Question

- How do explorations of the past compare to modern-day explorations?

Concepts

Students will learn the following concepts:

- At the heart of every exploration are curiosity and the quest for knowledge.

Objectives

Students will be able to do the following:

- Compare and contrast elements of historic and modern-day explorations.

Science Overview

To explore is to step into the unknown. However, it could be dangerous, or at least unsuccessful, if an explorer really, truly knew nothing about the terrain ahead. How can an explorer know how much food to pack, what weapons to bring, what clothes will be necessary, and what kind of instrumentation will be needed? In reality, successful explorers rarely are unprepared. In a real exploration, the explorer has a good idea of where the trip will go, how long it will take, what to do there, what to expect to find, and what tools will be needed to deal with whatever is found. The purpose of an exploration is to find out the details that could not be predicted, to find out the ways that the explorer's predictions are wrong. If the world were always exactly as predicted, people would never learn anything new. It is only when expectations turn out to be wrong that the world shows explorers something genuinely new. A successful explorer, one who comes home alive and with new knowledge, prepares for the expected while knowing the expectations could be wrong in important ways—but is prepared for that, too.

Exploring the Oceans

Up through the nineteenth century, the world's oceans were explored with sailing ships. The results of these journeys included maps of the shoreline of islands and continents. The earliest of these explorers did not know much about where they were going, but they knew a little. They knew that between them and what they aimed for lay an expanse of sea so broad that they must plan for many weeks, or even months, of open-water travel before they might sight any land. They knew that the world really is (very close to) a sphere, so they could sail west and expect eventually to encounter lands that they knew about to the East—contrary to modern popular opinion, it had been known in educated circles in Europe for a thousand years or more that the world is not flat. Explorers suspected that they might find climate similar to the known parts of Europe and Asia in any new lands they might encounter, with plants and animals similar to those they were accustomed to. All these things factored into the choice of ships, the number of crewmen, how much food to pack, whether to plan on hunting and fishing to replenish supplies, and whether to plan on cutting trees in far-away lands to repair damaged vessels. As prepared as possible, early explorers like Erickson, Columbus, Magellan, and Drake set out to discover new lands and to report their location, their width, their breadth, and their properties to the countries that sent them.

No explorer could visit every place along every shore. No explorer could claim to have discovered everything out there that was there to be discovered. An explorer could say only what had been seen, and what had not. Later explorers could use that information to plan new explorations, building on the first ones. If one explorer discovered a landmass, a later explorer could use the reported climate, distance, position, and so forth, to plan an expedition to explore that land. If a well-documented cruise across the ocean showed no islands, subsequent explorers could take it as proven that islands were not along that course. Islands might be found, however, on another course, out of sight of earlier explorers. Explorers seeking unknown regions that had been only skirted before studied maps made in earlier journeys. By such methods, explorers could estimate the risks, the costs, and the possible benefits of sailing into an unknown region of the map. In the end, the shores of the world's continents were mapped, showing what places could be reached only by ship, and what places could be reached by ship or by land travel. What remained was to discover what lay within the lands that sailors had only explored at the edge.

Exploring the Continents

By the late eighteenth century, the outline of most of the world's land was already known, although there was enough left still to keep sailors busy searching for northern routes around the continents, mapping the coast of Antarctica, searching for tropical islands, and so forth. With the borders mostly known, what remained was the process of filling in the details, like coloring the pictures in a coloring book.

In the United States in 1803, President Thomas Jefferson chartered the Corps of Discovery to explore the vast new Louisiana territory that the United States had acquired from France. The Corps was led by Army Captains Meriwether Lewis and William Clark. The Corps was to identify the natural resources of the new Territory; to map its features; to trace rivers that might be used to transport settlers and goods; and to discover anything new and unexpected. The core mission of the Corps was to search for a water route to the Pacific Ocean—the mythical Northwest Passage. At the time, the only way to reach the Western shore of North America was to travel by ship around South America or by land through the Spanish territories of Mexico and Texas into California. The possibility of a shorter route by water, making it possible to travel quickly by boat, was enough to justify the mission.

Meriwether Lewis was hand-picked by Jefferson to lead the Corps. Lewis insisted that William Clark be the co-leader, as a man with great practical experience. They prepared for the mission as carefully as possible. Lewis already was an educated man. He obtained further technical training in preparation for the journey in order to be able to recognize the significance of plants and animals that the Corps should find, to record accurate and useful maps of the route, and to prepare specimens for return. The Corps was supplied with equipment and provisions to travel by river at least part of the way and to prepare for long overland travel. To save weight, they planned to live off the land as much as possible, hunting for food. Gunpowder for the rifles was packed in lead boxes. Despite the weight of the containers, it meant that emptied containers could be melted down to make bullets, so that spare ammunition did not need to be packed. Among the most important possessions were materials to pack the plant and animal specimens, paper to keep journals, and oilskin in which to wrap them for protection from the weather. An expedition without a record would have been of no value as an exploration. The expedition was as prepared as possible for cold weather, hot weather, and rain; to identify discoveries and to record them; to live off the land; and to use rivers for transport. The Corps carried goods to trade with native peoples who occupied the continental interior and who already knew the land perfectly well.

In the end, there was no Northwest Passage that could be used for shipping. Many of the fantastic predictions for the journey were incorrect—there were no mammoths or llamas in the American West. Proving that the predictions were false, the Corps learned a multitude of truths. The Corps was well prepared both for the expected hardships and for those that could not have been expected such as the vast expanse of the Great Plains and the formidable Rocky Mountains. They were well-prepared to see what they could not have predicted and to record it for the benefit of others. In place of the magical wonders that had been anticipated, the Corps of Discovery brought back to the Atlantic Coast some inkling of the true grandeur and extraordinary resources—the real wonders—that lay to the west.

Exploring the Unknown

The approach that scientists take to plan a scientific exploration is much like earlier explorers who risked life and limb to explore the world, although laboratory investigations usually are less risky. Scientists have limited resources of time and money. They have to choose carefully how to explore the unknown, using what already is known to decide which experiments have the greatest opportunity to show errors in current understanding—either the experiment is relatively easy to do, or there is so little current understanding that any

exploration will be productive. There is not much point in using limited resources to discover something that already is known, so a scientist spends time beforehand to ensure that the planned experiment will explore something new.

Modern scientific research usually is not so personally dangerous as in the old days of exploration. Nevertheless, scientific expeditions to the bottom of the sea, to Antarctica, to space, or to any number of other remote locations certainly carry a significant personal hazard. Some investigations can be carried out only in regions that have not been altered too much by human influence. That tends to mean no access to hospitals, little availability of goods and services, and bad roads or other difficulties in transportation. An expedition of this sort needs to be prepared as well as any expedition of the past, taking food, medicines, communications equipment, and the scientific instruments that make the trip worthwhile. The majority of scientific investigations, of course, are carried out in laboratories or observatories that are not so difficult to reach.

A scientist preparing an exploration needs to be prepared for a variety of outcomes. Hardly ever is a scientific investigation performed truly blindly, but there always is the potential—actually, the hope—that something unexpected will appear and the scientist needs to be able to recognize both the expected outcome and the unexpected outcome. If an experiment is set up to signal the experimenter only when a certain condition is true, then it may miss those important cases in which it is false. The scientist needs to be prepared to recognize either situation.

Even when the scientist has literally no idea what the outcome will be, there is some level of preparation at least in terms of predicting what kind of instrument will be needed to discover something interesting. For example, the first infrared satellite observatory, IRAS, was put in space with only a rough idea of what it would find, knowing only that warm things emit infrared light and that the Earth's atmosphere makes it difficult (not impossible) to detect infrared light because the air absorbs at least some of it. The satellite was equipped, however, to detect infrared radiation from objects over a wide range of temperature, thus detecting both cool interstellar dust and hot supergiant stars. Astronomers still mine the IRAS data archives for guidance about interesting places to look with modern equipment of vastly greater capability because IRAS mapped the whole sky. IRAS performed the role of the first great global explorations. The follow-up expeditions are under way, exploring the interior of the regions whose borders were mapped out by IRAS.

Exploration Yesterday and Today
Lesson at a Glance
Science Overview
Conducting the Lesson
Resources

Conducting the Lesson

Warm-Up & Pre-Assessment

Preparation & Procedures

1. As a class, ask students to plan a trip to a new place. Where would they go? Why? What would they try to learn about the place before they went? What would they bring to this place?

2. After students have planned a trip, ask them what we call people that go to new places or discover something new. (*Desired answer: explorers*)

NOTES:

Activity: Comparing Explorers

In this activity, students will investigate the nature of explorations past and present, and identify traits of two very different explorations.

Teacher Materials

- Blackboard or whiteboard

Student Materials (per student)

- Benjamin Banneker biography
- Timothy Livengood biography
- Student Worksheet

Preparation & Procedures

1. Ask students to brainstorm a list of some famous explorers. (*Desired answer: Columbus, Magellan, Lewis & Clark, etc.*) Ask students what areas these people explored. Ask students if there are explorers today. Accept all answers. Ask students if they know any modern-day explorers or if they know places they might explore. Accept all answers.

2. Ask students if they think people explore the same way they did in the past. Accept all answers and then tell students that they will be reading two articles about exploration, one past and one modern-day exploration, in order to determine if exploration has changed over time.

3. Have the students read the two articles, or you can read them aloud to the students, and then have them create a Venn diagram in the Student Worksheet, comparing and contrasting the explorations.

Reflection & Discussion

When all students have completed the Student Worksheet, discuss the similarities and the differences between the two explorations as a class. Ask students whether they feel these explorations are more similar to each other than they are different. Ask students to provide facts or conclusions from their Venn diagrams to support their opinions.

Transfer of Knowledge

Have students write a report about a new place they recently visited (vacation, a new house, a new playground, a new doctor's office, etc.) Why did they go? How did they prepare for the visit? What did they learn there? How did they discover these things?

Ask students to look at the similarities between the two explorations, past and present. Now ask them to look at the report of the exploration that they conducted; does it share the same characteristics? Ask students whether they think that they also are explorers.

Extensions

- Research other explorers and their explorations. How do their explorations compare to Benjamin Banneker's surveying expedition or the modern-day explorer Timothy Livengood?

Placing the Activity Within the Lesson

As tools and technology develop, so do the types of explorations we conduct. However, at the heart of every exploration are curiosity and the quest for knowledge. Discuss with students how these characteristics unify all forms of exploration, from the grand study of the Universe to the smaller-scale survey of a new playground.

Assessment Criteria for Activity

4 Points

- Venn diagram is well organized so that a reader can understand it.
- Student demonstrates solid understanding of the similarities and differences between past and present explorations.
- Venn diagram is complete.
- Student conducted his/her own investigation and clearly documented the exploration.

3 Points

- Work is organized so that a reader can understand it.
- Concepts are in the appropriate categories.
- Student demonstrates understanding of the similarities and differences between past and present explorations.
- More items could be added to the Venn diagram.
- Student conducted his/her own investigation and documented the exploration.

2 Points

- Some attempt at organization, but work is incomplete.
- Student demonstrates some understanding of the similarities and differences between past and present explorations.
- Many items are missing from the Venn diagram.
- Student conducted his/her own investigation and documented some aspects of the exploration.

1 Point

- Work is incomplete or unreadable.
- Little or no understanding demonstrated for the similarities and differences between past and present explorations.
- Most items are missing from the Venn diagram.
- One or more sections of the Venn diagram are left blank.
- Student conducted his/her own investigation and documented little of the exploration.

0 Points

- No work turned in.
- Responses completely unrelated.

NOTES ON ACTIVITY:

Lesson Wrap-Up

Lesson Closure

After they have read the biographies of the past and present explorers and after conducting their own explorations, ask students whether they think that they too are explorers. Ask students to share their opinions, using information and conclusions from the articles and from their own exploration to support their opinion.

NOTES:

Resources

References for Benjamin Banneker Biography

Conley, Kevin. Benjamin Banneker, Scientist and Mathematician. Chelsea House Publishers: New York, 103 pg., 1989.

McGill, Alice, and Chris K. Soentpiet (ill.). Molly Bannaky. Houghton Mifflin Co., 32 pg., 1999.

Print Resources

Bedini, Silvio A. The Life of Benjamin Banneker: The First African-American Man of Science. 2nd ed. Maryland Historical Society, 428 pg., 1999.

Cerami, Charles A. Benjamin Banneker: Surveyor, Astronomer, Publisher, Patriot. John Wiley & Sons, 288 pg., 2002.

Pinkney, Andrea Davis and Brian Pinkney (ill.). Dear Benjamin Banneker. Voyager Books, 32 pg., 1998.

Internet Resources & References

Student-Friendly Web Sites:

Biographies of Explorers
http://www.mariner.org/educationalad/ageofex/biographies.php

Lunar Exploration
http://nssdc.gsfc.nasa.gov/planetary/lunar/

Zoom Explorers
http://www.enchantedlearning.com/explorers/

Teacher-Oriented Web Sites:

Age of Exploration Timeline
http://www.mariner.org/educationalad/ageofex/timeline.php

Challenger Center
www.challenger.org/journey

The Explorers Club
http://www.explorers.org/

Journey through the Universe
http://www.challenger.org/journey

Teacher Answer Key

1. Answers will vary but most students should say the two explorers are more similar than they are different. Both explorers used tools, explored where people had not explored before, and worked with others in order to conduct their exploration.

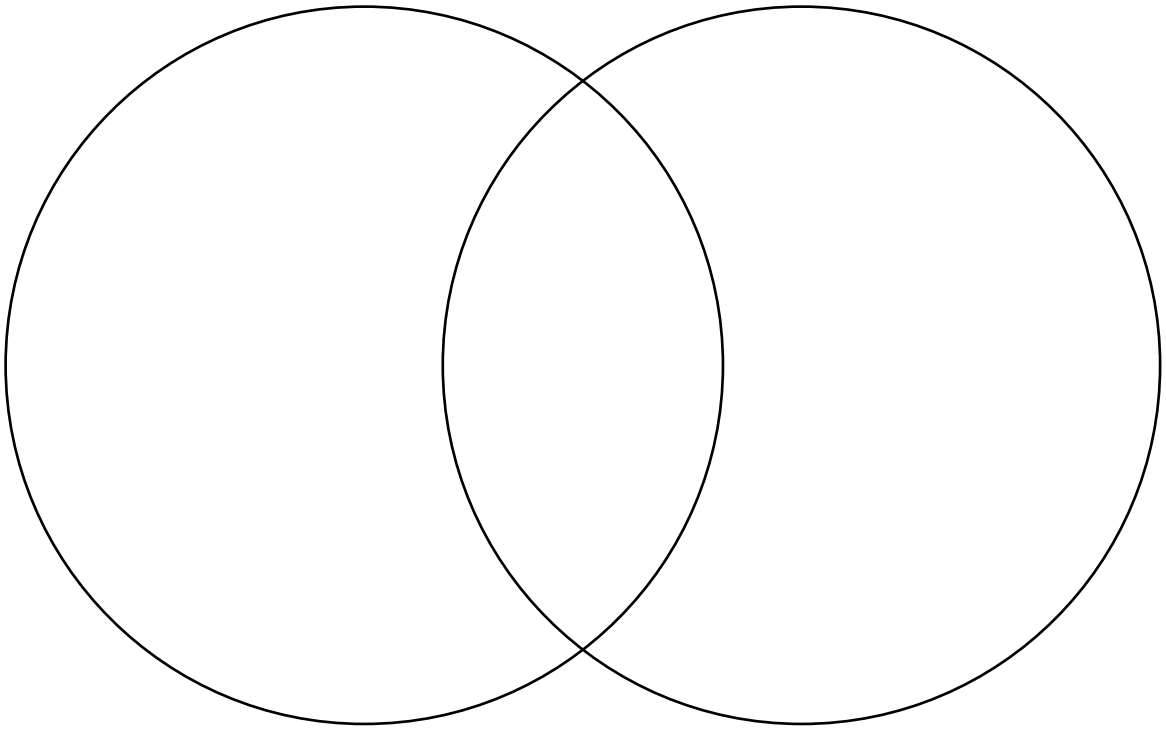
2. Both explorers shared a love for discovering something new, mathematics, and astronomy.

Student Worksheet: Comparing Explorers

Name _____ Date _____

Read the biographies of the two explorers, Benjamin Banneker and Timothy Livengood. Compare the two explorers in the Venn diagrams below.

Benjamin Banneker **Timothy Livengood**



1. Do you think that the two explorers are more similar than they are different? Why?

2. What characteristics do both explorers share?

Modern-Day Explorer:
Dr. Timothy A. (Tim) Livengood (1962-?)

What I Explore:

I'm working on the planet Mars. Not really ON Mars, but Mars is what I'm exploring. I use telescopes here on Earth to learn more about Mars. This is a lot cheaper than going to Mars or sending a robot.

Why I Explore:

I've always been curious about the world we live in. I like trying to make sense of the world and why things are the way that they are. Right now, I'm trying to find out more about the air on Mars. Why is it made out of certain chemicals? Why is there so little air on Mars? Why is there any air on Mars? The answers can help to tell us why Mars and Earth ended up being very different worlds. I'm not able to answer these questions by myself. I am doing my part to find out basic facts about air on Mars. Other scientists and I will try to figure out explanations for Mars and its air that fit the facts. I don't know yet what the answers are to my questions about air on Mars. Nobody knows. That's part of why it's interesting to find out, because it's something nobody else has ever known before.

How I Explore:

I use instruments to determine what colors of light come from Mars. The colors give us clues about what chemicals are in the air and in the soil and what temperature they are. I work on a team. Each of us has different skills. I lead this project, but on other projects, I am a helper and someone else leads the project. Working together, we can learn more about the Universe than we can learn working alone.

What He Explored:

Benjamin Banneker helped to survey a wilderness area that is now the nation's capital city, Washington, D.C. The survey determined where to put the borders of the city and mapped hills, swamps, and rivers, to see where buildings could be built.

Why He Explored:

Benjamin Banneker was the son and grandson of freed slaves. He was a farmer for most of his life, but he loved mathematics and puzzles. At age 59, he taught himself astronomy in order to understand the sky. In the late 1700's, an act of Congress created the territory of Washington, D.C., as the place for the new nation's capital city. President George Washington hired Major Andrew Ellicot as the chief surveyor to map the territory. Surveyors used astronomy and mathematics to make accurate maps. Major Ellicot could not command the survey team during the day and also make astronomical measurements at night, so he hired Mr. Banneker for his astronomy and mathematics skills.

How He Explored:

The survey team began work in early February of 1791—it was late winter. The expedition camped in the wilderness. Mr. Banneker viewed the stars every night with a telescope and chronometer to measure the time that certain stars passed overhead. He used his observations to determine the telescope's exact location on Earth. Major Ellicot combined Mr. Banneker's measurements with measurements made by the survey team in order to map the territory. Thanks to Benjamin Banneker's work, the first cornerstones for the borders of Washington, D.C., were laid in 1791.