A Rising People: Benjamin Franklin and the Americans

Teacher’s Workshop Lesson Plans

Innovation and Invention

Introduction

Benjamin Franklin lived during the eighteenth century that was known as the Age of Enlightenment. This was a time when philosophers and scientists placed importance on observations and experience to understand the laws that governed the physical universe and the natural world. As Professor Gerhard Grempel of Western New England College notes:

Their new ideal of knowledge was simply a further development of 17th century logic and science. But there was a new emphasis on 1) the particular rather than the general, 2) observable facts rather than principles, and 3) experience rather than rational speculation. 1

As Franklin addressed serious issues of the time, he was ingenious for combining technical invention, clever experiments, and practical efficiency. He was not only an inventor creating new products, but an innovator making improvements to products, processes, and people's lives.

Guiding Questions:

How did Franklin use this new scientific process of observation and experience to help people improve their lives? How is this done today?

Learning Objectives

After completing these activities, students will be able to
- identify the difference between an inventor and an innovator

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- understand that through observation and experience, Franklin was able to help people improve their lives with his innovations.

- become observers and begin to understand how to observe the patterns of human nature
- learn to use the scientific method by asking a questions about something observed; do some research about the topic; construct a hypothesis; test the hypothesis by doing an experiment; analyze the data and draw a conclusion; show results.

- design a sample of paper currency with a botanical design.
- design an underwater obstruction.
- perform experiments on surface tension and the affect of oil on water.
- understand the importance of scientific research in today's society.

Prepare to teach the lesson
- First read or discuss the "Forward" in order to introduce student to Ben Franklin's role in France, the rumors revolving around his scientific advancements, as well as his inventions and innovations.
- Gather materials for researching plant varieties in your state or region.
- Gather materials for surface tension experiments and "throbbing oil" experiment.

Activities
1. Noll's "Black Magic" activity to encourage observation of patterns in human behavior.²
2. Noll's "Innovation and Invention" activity to encourage brainstorming which allows innovators to take something that already exists and thinks of a new or better way to use it.³
3. Student research on common plants and design paper currency with botanical design.
4. Brainstorm and design an underwater obstruction.
5. "Surface Tension: An Attractive Force" experiment to understand the principals behind surface tension.⁴

"Floating Paperclip and Other Surface Tension Experiments" to understand the affect of oil on surface tension.5

6. "Throbbing Oil Experiment" to help understand the importance of observation and science research in today's society. 6

**Foreword**

In the winter of 1776, Benjamin Franklin had been chosen in secrecy by the congressional committee to be a diplomat in Paris to persuade France to give aid and alliance to America. He thought he would take a low profile, "thinking it prudent first to know whether the court is ready and willing to receive ministers publicly from the Congress." 7 Instead Franklin, who was known throughout France as a celebrity philosopher, statesman, and scientist, was greeted by people lining the streets and was the distinguished guest at a grand ball.

That December, Franklin met France's foreign minister, the Comte de Vergennes, to push for a French alliance. In a memo Franklin wrote to Vergennes, he noted that if France and her ally Spain joined the American's side, Britain might not only lose her colonies, but also her West Indian assets and ports. Franklin recommended that France and Spain could keep the West Indies islands that the British lost. On the contrary, he also stated that if France refused or delayed their decision, there might be consequences to their land holding if America sided with Britain.

As Isaacson notes in *Benjamin Franklin: An American Life*, "wild rumors began to circulate about Franklin's various strategies and schemes." 8 A report from a British spy in France included Franklin's plan to create "a great number of reflecting mirrors" that would be placed on France's coast at the town of Calais that overlooks the narrowest point in the English Channel, only 21 miles from England. These reflecting mirrors would focus heat from the sun on the British navy, and destroy it. There was also a rumor that there would be an electric

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5 Exploratorium Teacher Institute, "Floating Paperclip and other Surface Tension Experiments, "http://www.exo.net/~jillj/activities/surfacetension.pdf


8 Walter Isaacson, p. 340.
shock sent across the English Channel on a cross-channel chain that would disrupt the entire British island.

Did the British people really believe these rumors? How did they think Franklin could accomplish these feats?

If we were to look at Franklin's myriad of accomplishments it would be easier to understand how some British may have thought the reflecting mirrors and electric chain could be possible threats. A prominent scientist in the 1800s, Franklin invented many products including the lightning rod, bifocal glasses, odometer, and armonica. Franklin was also an innovator. He tried to understand the laws that governed the natural world and use that knowledge to help people improve their lives and improve transportation. For example, through observation and experiments he learned that:

- some people who worked with hot lead, and those who drank rum from stills that used metal coils, suffered from stiffness, paralysis, and "dry belly ache" were suffering from lead poisoning. "He suggested, among other things, coils of stills be made of pure tin, instead of pewter that included lead."  

- stoves in Europe reheated stale air, keeping houses warm, but very stuffy. By using information about air expansion and contraction, he redesigned the stove so it burned less fuel, created more warmth, without making the house stuffy.  

- ships passing through shallow canals went more slowly than larger ships because of displaced water creating water pressure as it rushed by the sides of the ship, thus slowing it down. He recommended deeper canals for more efficient transportation.  

- mail sent by ships went faster to England than coming from England because of the flow of currents. Franklin encouraged captains to avoid what he called the "Gulf Stream" current when returning to America, thus avoiding long delays.

Activities

Cheryl Kirk Noll, author of *The Ben Franklin Book of Easy & Incredible Experiments* recommends having students become observers. Not only do they need to use their senses,

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9 Isaacson, p. 325, Ben Franklin letter to Anna Shipley, Aug. 13, 1771.
10 Noll, p. 13.
11 Isaacson, p. 265.
12 Noll, p.16.
but observe patterns in nature and patterns in human behavior in order to give them extra insight. An intriguing game to play is Noll's "Black Magic."

Activity 1: "Black Magic"
- Tell the class you are going to play "Black Magic."
- Select a student to send out of the room and explain one object will be chosen in the room. Tell the student when he/she returns, that you will touch a series of objects and ask if it is the one the group chose. Tell the student the right object will be the first object after you touch something black.
- Play the game a number of times and see if the class sees the pattern of the game. (You can remind them they are playing "Black Magic.")

Just like Benjamin Franklin, other inventors and innovators discover problems or needs through observations. To encourage students to follow suit have them do Noll's "Innovation and Invention"

Activity 2: "Innovation and Invention"
- Take your students outside and, in pairs, observe all they can about an object or an area that includes a group of objects for five minutes.
- Each student makes a list of everything he/she observed and then share the findings with their partners.
- Students place a checkmark next to something that may have raised a question in their mind. (For example, why is part of a rosebush drooping or why is only certain playground equipment being used?) Noll reminds students, when Franklin learned mail arrived from England late he didn't just shrug his shoulders, he looked for an answer. "He had some ideas, but he did not assume his ideas were correct-he worked to uncover the possibilities."13
- Students repeat the observation, note-taking, and writing of questions at home that evening.
- Students pick a question from either the school day observations or the home observations. Then have them write all the possible answers they can imagine.

13 Noll. p. 16
- Students pick one possible answer. This is a hypothesis. (For example, "If the rose bush gets too much sun, then it will dry out.") The hypothesis should be created in a way to help answer the original question.
- Students test the hypothesis by doing an experiment to find out if the hypothesis is true or false. Remind them to test only one factor to make it a fair test, so they can determine which answer is correct.
- Students analyze the data and draw a conclusion. If their hypothesis wasn't the answer to the question, have them try another one.
- Students share their results with the class.

An extension would be to have students take action on their findings. For example, if the drooping rose bush is getting too much sun, they could make an arbor. If the swings aren't being used because they are too high, work with the administration or maintenance person to get them lowered.

Noll reminds students not be discouraged if the first attempt is not successful. Ben Franklin and others had to try many solutions before they succeeded in solving a problem. Troubleshooting and trying again is part of innovating or inventing.

**Extensions of Franklin's Innovations**

**Activity 3: Design Paper Currency**

As America's new postmaster general, Franklin was in charge of replacing the British run postal system and establishing a system of paper currency. In order to make the paper currency more difficult to counterfeit, he used his botanical knowledge of the vein structure of different leaves and personally drew the leaf designs on the various notes.14

- Have students study common plants in their state or region and then have them design a paper bill (currency) that contains a botanical design of a particular state plant.

**Activity 4: Design Underwater Obstruction**

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14 Isaacson, p. 302.
Franklin was also made president of the Pennsylvania defense committee. He oversaw the construction of a secret system of underwater obstructions to prevent enemy warships from navigating up the Delaware River.

- Have students brainstorm what type of underwater obstruction they would build to prevent British ships from coming up the Delaware River. Have them take in consideration the materials available in the 1700s. Have students draw their designs and share with the class.

Once students have shared their models of underwater obstructions, introduce students to Chevaux-de-Frises. These colonial underwater obstructions came in a variety of forms. One type were long log boxes with projecting, iron-tipped wooden spikes meant to pierce the underside of ships and sink them. Others were sunken crates of stone with heavy spears of timber pointed with iron to receive vessels.

Activity 5: "Surface Tension and "Floating Paperclip and Other Surface Tension Experiments"

Franklin was also fascinated by the affect of oil on water. While crossing the Atlantic in the summer of 1757, he noticed the wakes of the ships in the convoy were different. Most of the wakes were ruffled and large, while the wakes behind two of the ships was remarkably smooth. Always curious, he asked the captain and was told that smooth wake was caused by the grease the cooks had emptied behind the ships. "The Cooks, says he, have I suppose, been just

emptying their greasy Water thro' the Scuppers, which has greased the Sides of those Ships a little.  

Later while on another ship in 1762, Franklin spoke to an old sea captain that told him this phenomenon of oil stilling water was probably similar to the practice of Bermudan fishermen who put oil on water to smooth it so they could see the fish they were trying to catch.  

Other stories from travelers included how divers in the Mediterranean, who needed light from the surface, would let small quantities of oil from their mouths to smooth the water's surface. By getting rid of the waves, that caused refraction of the light and making it hard to see, the divers could then view their quarry.

There were also cases of fishermen who could see at a distance where shoals of herring were by the smoothness of the water. This reaction was thought to be caused by the oil from the fishes' bodies. Similarly a fisherman noted the Newport harbor was smooth whenever the whaling vessels were in port, probably caused from the blubber loose in the hold or leakage from barrels.

Franklin did numerous experiments with oil and water to help him understand the reaction between these substances in dishes of water, ponds, and bays sheltered from the sea.

Discuss the surface tension of water with your students and allow them to experiment with oil and water. For those that have not done experiments with surface tension I recommend the following sites:

- "Surface Tension: An Attractive Force"
- "Floating Paperclip and other Surface Tension Experiments"
  http://www.exo.net/~jillj/activities/surfacetension.pdf

**Activity 6: "Throbbing Oil Experiment"

Once students have a basic understanding of surface tension, have them try this "throbbing oil" experiment.

1. Pour clean water onto a small plate and wait for the ripples to stop.

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2. Then mix a small amount of mineral oil with a smaller amount of detergent. (Point out that detergents or surfactants are materials that reduce the surface tension of a liquid, allowing easier spreading.)

3. Place a drop of the mixture onto the water.

4. Have students explain what they see! (The oil appears to pump like a beating heart.)

5. Next have students place a clear/glass cover over the plate.

6. What happens? (It stops beating.)

Explain to students that this experiment has stumped scientists for years. However, this last summer at MIT an engineer, Roman Stocker, and a mathematician, John Bush, found what was causing the oil to pump like a beating heart and then stop when covered. It was changes in surface tension (or more precisely, evaporation-induced variations in surface tension. In "Gumshoes Solve 'Throbbing' Oil Mystery" at http://www.scienceblog.com/cms/gumshoes-solve-throbbing-oil-mystery-13725.html it is suggest that you think of the oil detergent drop as a small lens with a rounded bottom. The detergent in the drop moves to the bottom surface of the lens, where it interacts with the water to decrease the surface tension where oil meets water. As the detergent settles the oil and detergent near the outer edges of the drop begin to circulate which generates very tiny waves rolling outward toward the edge of the drop. When these waves reach the edge, they cause small droplets to erupt and escape onto the water surface outside the drop where some of the detergent evaporates. This affects the surface tension and causes the cyclical process to begin again. By putting the lid over the water's surface, the detergent can't evaporate, the oil drop remains stable, and the beating ceases instantly.

It took three years without funding, help from two undergraduate students, and a video camera attached to a microscope to finally solve the problem. It is thought that the results of this experiment could have application in environmental engineering and biology, but they don't know specifically. "One rationalizes the physical world by understanding the mechanisms," said Bush, explaining the importance of scientific research. "One can never predict which mechanisms will be important."

Just as Benjamin Franklin saw things and questioned them, scientists today are following suit. It is important for our students to observe, question, brainstorm, and know how to utilize the scientific method in order to help improve their future and that of their environment.
Bibliography


http://ericksonland.com/hosting.domaindirect.com/chevauxdefrisepage.htm, "Chevaux-de-Frise."


http://www.exo.net/~jillj/activities/surfacetension.pdf, "Floating Paperclip and other Surface Tension Experiments."