Lesson 11.1 "Water Power"

Unit 11: Big Factories and New Industries

Lesson Objectives

- Students will evaluate the process of the production of goods using only human power.
- Students will identify and explain how the water wheel transforms one kind of energy into power for tasks in a textile mill.
- Students will analyze the advantages and disadvantages of hydropower and steam power in mills and reflect on why new technologies are adopted.

Lesson Competencies

- I can interpret and use information delivered orally or visually and respond by asking relevant questions, summarizing key points, or elaborating on ideas. (ELA 7)
- I can analyze primary and secondary sources and draw appropriate conclusions. (Moose SS)
- I can use observational data to predict or draw conclusions about cause and effect relationships (e.g., forces and interactions, properties of matter, energy, interdependent relationships in ecosystems). (SCI 3)

Essential Questions

How has New Hampshire come to be the way it is?

Focus Questions

How did industrialization change the way people worked in New Hampshire?
How did New Hampshire modernize because of the Industrial Revolution?

Estimated Time

Two 40-minute class sessions

Materials & Equipment

"George Washington's Vest" images for printing or projection
"Communities in New Hampshire with More Than 10,000 Residents 1920" map for printing or projection
"Water Power" infographic
Materials for making water wheels
Class set of "Water Power in Action" handout
"Steam Power" infographic
Group sets of "Steam Power Steps," pre-cut and shuffled
"Water Power vs. Steam Power" Venn diagram for printing or projection
Class set of "Water Power Reflection" worksheet

Educator Introduction & Rationale

New Hampshire's industrial era in the 19th and early 20th centuries transformed the state from a collection of quiet, rural, agricultural communities to an economic powerhouse on the world stage. The state's many rivers, most of which had waterfalls, powered the machines that would fuel the Industrial Revolution. Although water power initially ran the factories, it was replaced by the 1860s with steam power, which could be maintained more consistently and was less subject to environmental conditions such as rainfall and snow melt. Steam power was in turn replaced by oil and then electricity by the early 20th century. Reference the Educator Overview for more information.

This is the first lesson in Unit 11: Big Factories and New Industries. This lesson introduces students to two major innovations that shaped New Hampshire's environment and economy during the Industrial Revolution: hydropower and steam power. This lesson can stand alone from the unit. Please note, lesson vocabulary and definitions are at the end of the document. You may wish to preview these with your students.

The learning activity begins by activating students' background knowledge about the production of goods before industrialization. After using maps, infographics, and historic photographs to investigate how the power of New Hampshire's rivers changed the process of production, students conduct a hands-on experiment to build their own waterwheel. Students will reflect on the advantages and disadvantages of hydropower for growing businesses and then investigate an infographic to learn about the technology of steam power, which ultimately replaced hydropower in New Hampshire's mills. Students complete a cause-and-effect sort to reinforce their understanding of the scientific principles behind steam power. The lesson closes with a reflection about why we adopt new technology. Please note that the "Water Power" and "Steam Power" infographics used in the lesson in black and white are available on the "Moose on the Loose" website in color with additional reflection questions.

Two reinforcement activities are suggested for students who will benefit from more time with the main concepts of the lesson. Two extension activities are suggested for students who are ready to apply their understanding in new ways. Please adapt all the material in this lesson, as necessary, to meet the needs of the students in your classroom.

Learning Activity

Activation

George Washington's vest. Project the images of "George Washington's Vest." Explain to students that this item of clothing was something commonly worn by men 250 years ago. It would have been worn over a shirt and under a suit coat. You can share that it's said that this particular vest was worn by George Washington.

This vest is made of red wool, with a lining of cotton and linen, and has brass buttons. Ask students to think about how that vest came to be in George Washington's closet. Remind students that around the time Washington would have worn this, there were no factories and no electricity; he would not have been able to go into a store and just pick it off the rack. As a whole group, make a list of steps from raw material to finished vest.

Possible outcomes:

- Raw material collected: wool sheared from sheep, cotton picked by hand
- Raw material prepared: wool and cotton cleaned and carded
- Raw material turned into thread: fibers twisted using a spinning wheel
- Thread dyed to color of choice
- Thread woven into cloth
- Cloth measured and cut into pieces
- Pieces sewn together by hand

Direct Instruction

Water power and mills. Students will likely have observed that a great deal of time and human energy went into making a single vest in the 18th and early 19th centuries. Remind them that, because of this, clothing was expensive. Most people, unless they were very wealthy, did not have many articles of clothing. In fact, most people living in the United States during that time had to grow or make everything they needed at home.

Explain that new technologies changed this. In England and Scotland, during the mid-1700s, people discovered they could use the power of a natural resource to run machines that could do all the work of making and weaving cloth. People from those countries brought those ideas to New England, where it just so happened that New Hampshire had an abundance of that natural resource.

Project the map "Communities in New Hampshire with More Than 10,000 Residents 1920" and give students time to look at it. Then ask them if they can use the information from the map to figure out which natural resource was the source of power for this new technology.

Possible outcome: Students should observe that the map shows the many rivers that crisscross New Hampshire as well as the largest towns in New Hampshire in 1920. All the towns are on rivers so rivers are the source of water power.

Project "Water Power" infographic to explain how the waterwheel harnessed the power of the river to make machines inside a mill work.

Guided Practice

Making a water wheel. Explain to students that they will experiment with some materials to build their own model of a water wheel. Project and review the instructions on the "Water Power in Action" worksheet as a whole group. Divide students into small groups and provide each group with:

- copies of "Water Power in Action" worksheet
- an aluminum pie plate
- scissors
- a pencil or wooden dowel
- a small basin or dish tub
- a pitcher or large bottle of water
- a permanent marker
- a piece of masking tape

Give students time to construct their water wheels and complete the tasks on the worksheet. If time allows, review their responses to the tasks as a whole group.

Teaching tip: This is a good place to pause if you are dividing the lesson into two sessions.

Direct Instruction

The innovation of steam power. Remind students about some of their main observations about the water wheel and how it operated. Then present this scenario:

> A family started a textile mill on a small river in New Hampshire. For many years theirs was the only mill in the area, and they produced enough cloth to have a successful business. Eventually, their success drew the attention of some other companies which set up mills further downstream on the same river. What would happen if many mills, on the same river, built dams in order to channel the river's power to their own water wheels?

Possible outcome: Students should determine that the flow of water would slow significantly and that would impact how much work the mill machines could do, especially for the mills upstream.

Explain that people realized that, between the competition for water power among mills and the seasonal unpredictability of water levels due to snow, rain, and drought, they needed a new way to power mills. Water would still be part of the equation, but this new technology no longer required the running force of a river.

Project or print out the "Steam Power" infographic and review as a class. How do the infographics demonstrate the differences between the water wheel and steam power?

Guided Practice

Sort the steam power steps. Divide students into the same groups they used for the water wheel experiment. Provide each group with a set of "Steam Power Steps." Challenge the groups to put the steps in order and then find one thing that water power and steam power have in common and one thing that makes them different from one another. Review the order of the steps as a whole group, project the Venn diagram, and collect group responses on the "Water Power vs. Steam Power" Venn diagram.

Reflection

Adopting new technology. Distribute the "New Technology" worksheet. Ask students to complete the questions and tasks on the sheet. Students should use the writing process that is most familiar to them to complete the paragraph response.

Reinforcement

1. **Label a diagram.** Provide students with the diagram of the Stevens Mill in North Andover, Massachusetts. Work together to identify where the main wheel is located. Provide students with highlighters to trace the system of pulleys and gears that move the energy from the main wheel to the machines on different floors of the mill.

2. **Simplify the steps.** Ask students to think of a task they do every day (e.g., brushing teeth, washing dishes, or getting dressed) and make a list of all the steps they take to complete that task. Can they think of a way to eliminate a step or combine steps? What will they need to do to shorten the process? What tools or resources can they use to simplify the process or make it go faster?

3. **Comparing water power.** Provide students with access to the "Moose on the Loose" website and the color "Water Power" and "Steam Power" infographics. Process the reflection questions from each infographic.

Extension

1. **Build a power train.** A power train is the system of gears, pulleys, and belts that connects the main shaft of a water wheel to other machines. It's a "train" of simple machines that transfers the water wheel's power of rotation to make more complex machines work. Challenge students to expand their water wheels by using simple materials to add the function of a power train. Provide students with corks, empty spools, and rubber bands. They should use the materials to connect their water wheel to another machine. They may determine that they need other materials to make the system work. What will their power train operate?

2. **More steam power.** Students can further investigate the ways steam powered the Industrial Revolution. What other kinds of machines used steam? How did those machines improve or change the way people worked and lived?

3. **Local waterfalls.** Investigate a nearby waterfall or river with a mill pond. Is a business located nearby that uses hydropower? Were mills located near it in the past? Use resources from a local historical society or the New Hampshire Historical Society to learn more.

Supporting Materials

New Hampshire Historical Society Resources

1. George Washington's Vest, circa 1780–1800
2. Communities in New Hampshire with More Than 10,000 Residents 1920
3. "Water Power" and "Steam Power" infographics

Other Resources

- Stevens Mill, 1865; Courtesy of the Kheel Center, Cornell University
- Parts of this lesson have been adapted from "Mills: Machines of Industry," a lesson in *Rivers: Bringing New Hampshire to Life*, a natural science and history curriculum developed by the Children's Museum of New Hampshire. www.childrens-museum.org/media/uploads/RiversCurriculum.pdf
- D. Macaulay, *Mill* (Boston: Houghton Mifflin, 1983).
- PBS, "Mill Times," 2001.

Standards

"Moose on the Loose" Content:

- ✓ Students will understand that economic activities in New Hampshire were varied and have changed over time with improvements in transportation and technology. (3-5.T4.1)

"Moose on the Loose" Skills:

- ✓ Gathering, Interpreting, and Using Evidence (3-5.S1.1, 3-5.S1.2)
- ✓ Communicating and Critiquing Conclusions (3-5.S2.1)
- ✓ Effective Historical Thinking (3-5.S3.1)
- ✓ Comprehensive Geographic Reasoning (3-5.S4.2)
- ✓ Understanding Economics and Economic Systems (3-5.S5.1)

New Hampshire Social Studies Frameworks:

- ✓ Geography: The World in Spatial Terms (SS:GE:4:1.5)
- ✓ Geography: Places and Regions (SS:GE:4:2.2)
- ✓ Geography: Environment and Society (SS:GE:4:5.2, SS:GE:4:5.4)
- ✓ US / NH History: Economic Systems & Technology (SS:HI:4:4.1, SS:HI:4:4.2)

NCSS Themes:

- ✓ Theme 1: Culture
- ✓ Theme 3: People, Places, and Environments
- ✓ Theme 8: Science, Technology, and Society

C3 Frameworks:

- ✓ Exchange and Markets (D2.Eco.3.3-5)
- ✓ Geographic Representations: Spatial Views of the World (D2.Geo.3.3-5)
- ✓ Human Population: Spatial Patterns and Movements (D2.Geo.7.3-5)
- ✓ Change, Continuity, and Context (D2.His.2.3-5)

Common Core ELA:

- ✓ Text Types and Purposes in Writing (W.4.2)
- ✓ Range of Writing (W.4.10)
- ✓ Comprehension and Collaboration in Speaking and Listening (SL.4.1)
- ✓ Presentation of Knowledge and Ideas (SL.4.4)

Science NextGen:

- ✓ Influence of Engineering, Technology, and Science on Society and the Natural World (4-ESS3-1)
- ✓ Energy and Matter (4-PS3-4)

Lesson Vocabulary

cottage industry	(noun) Making products to sell when people work in their own homes and use their own equipment
efficiency	(noun) The ability to accomplish a job in a short period of time and with little effort
factory	(noun) A building designed to house machines and other technology
hydropower	(noun) Using water to power machines and other technology
Industrial Revolution	(noun) A period of major change in the economy focusing on the change from making things at home to making things in factories
industrialization	(noun) The shift to making many products on a large scale, using machinery and factories
industry	(noun) 1 Making products by using machinery and factories 2 A group of businesses that provide a particular product or service
product	(noun) An object made by labor, either by hand or by machine
raw material	(noun) Material that has not yet been processed or manufactured into a final form
steam power	(noun) The use of water vapor to power machines and other technology
strike	(noun) When a group of workers organize together and stop working in order to force their employer to agree to their demands, usually about higher pay, shorter hours or safer working conditions
textiles	(noun) Types of cloth or fabric
water power	(noun) Using moving water to power machines