New Jersey School of Conservation
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Metalsmithing

In this session, students are introduced to the history and process of metalsmithing, with a focus on the Colonial Era. Each student will use metalsmithing techniques to make an iron plant hook and a decorative tin (aluminum) plaque. Coal is discussed as an important non- renewable resource, whose use has severe environmental effects.

OBJECTIVES:

1. Students will simulate the role of *apprentice* and *striker* for a Colonial blacksmith.
2. Students will demonstrate the whitesmith technique of punching.
3. Students will identify several items a Colonial blacksmith might have made.
4. Students will identify the tools of a blacksmith and describe their uses, including but not limited to: hammer, anvil, tongs, and forge.
5. Students will relate the demise of blacksmithing to the advent of the foundry industry.
6. Students will recognize that coal is a nonrenewable resource; explain the environmental effects of its use as a fuel source for electricity; and generate a list of ways in which electricity can be conserved.

MATERIALS:

blacksmithing – kindling, matches, iron strips, hammer, tongs, anvil, blacksmithing tools, 2 aprons, 2 pairs of goggles, 2 pairs of gloves, iron ore, sample iron products, laminated info pictures, samples of: coal/ coke/ clinker

whitesmithing – paper, tape, pencils, nails, patterns, mallet, snips, rubber hammer, wood blocks

PROCEDURE:

1. Arrive at the Pavilion about 15 minutes before your class is to begin, in order to have enough time to build a small, but strong fire in the forge. While you are oxygenating the fire with the crank bellows, lay out the teaching tools you will be using during your class, e.g. laminated cards; iron ore sample; the iron tools needed for the class (and some sample tools that you will show); and several items made by a blacksmith.

2. Begin the class by asking students to define metalsmithing – *art of hammering metal into any desired shape or form*. We do not know when or where metalsmithing first occurred, because evidence of it is found in many different cultures all over the world, including Africa, Arabia, China, Japan, and India.

3. *Show students the two types of metal they will be using in your class: iron and aluminum. Where did these two resources come from? Aluminum is the third most plentiful element in the earth's crust, next to oxygen and silicon. It is known as bauxite before it is mined and smelted. Mining areas* include: Africa, Brazil, Jamaica, Guyana, and Australia. Aluminum in this form was first made in 1829, but was not commercially produced until 1886. *Iron is the fourth most plentiful element in the earth's crust.* Iron is also not usually found in its pure form, but as an ore which must be smelted, to have the iron extracted from it. During smelting, charcoal is used as a reducing agent, causing the iron particles in the ore to be attracted to one another and isolating the impurities. *Show students the iron ore.* When Colonists first arrived in this country, the blacksmiths were forced to use imported iron, which was very expensive. Gradually, deposits of iron ore were located in the new world. e.g. Pine Barrens of New Jersey, where a bog-iron industry quickly sprouted when iron ore was found in its marshy lowlands.

4. Ask students what humans might have made when they first began metalsmithing. (weapons, tools) What might a Colonial blacksmith have made? Show students several actual objects, such as the the horseshoe, the wagon wheel rim, hinge and the square nail.

5. Ask students it they have ever visited a blacksmith to buy something. *Why aren't there many blacksmiths left today?* In the early 1900s, with the invention of foundries and the first car, the blacksmith's business declined. People began using cars for transportation, and their parts and the tools used to fix them, were made by assembly lines, which were fast and cheap. The only blacksmiths still in business today are called *farriers* and they specialize in horseshoes. Farriers were also the first veterinarians. Others practice blacksmithing as an art.

6. What are the tools of the blacksmith? Introduce students to the *forge*. Most forges were about five feet wide and eight feet long. They consisted of a stone foundation with a brick box on top and a chimney at the back. The bottom of the hearth was a stone slab with a round hole at the center, where the *tuyere* ('tweer') connects. The tuyere was an iron rod running to the outside of the forge where the blacksmith could rotate the bulb and adjust the direction of the airflow under the fire. Show the *bellows*, *crank bellows*, and laminated picture of the blacksmith shop. Beyond the hearth, the brickwork of the forge formed a flat table where the blacksmith could lay objects to cool. Nearby was a *quenching bucket*, or slack tub, for cooling the iron.

7. *The placement of the anvil was very specific. It was normally placed a quarter-turn from the forge with the horn of the anvil to the blacksmith's left, if he was right-handed. Its height was adjusted to be at the bottom of the blacksmith's hammer stoke, so that the hammer would strike the anvil squarely and not tire out the blacksmith. The anvil normally sat on a wooden post buried four or five feet deep in the ground. Most anvils were about five inches wide, and twenty inches long, with a 16 inch horn curving up from one end. The 250 lb. anvil consisted of a slab of tool steel welded to the wrought iron base. Use the laminated guide sheet to describe the parts of the anvil and their uses.*

8. Introduce students to the *tongs* and *hammer*, the blacksmith's two main tools. Show them a few different types of hammers and tongs, and use the laminated guide sheet to help describe their uses.

9. Most blacksmiths had one or two apprentices. These apprentices pumped the bellows, turned the grindstone (for sharpening tools), swept and cleaned, and ran errands. When they gained enough experience, they became *strikers*. The striker stood opposite the blacksmith on the other side of the anvil holding a heavy sledgehammer. The blacksmith

would tap a spot on the hot metal with his smaller hammer, and the striker's job was to hit the exact same spot with the same force and at the same angle as the blacksmith. When the blacksmith wanted the striker to stop, he would lightly tap the anvil to one side of the work. Back and forth the tapping went until the iron was shaped. Often, the striker was not hitting the hot iron itself, but the head of a tool the blacksmith held over the iron, such as a *top swage* or a *top fuller*.

10. Choose one student to be the *striker* and one to be the *apprentice* (or *bellows-boy*). Show the students a straight piece of iron and a finished plant-hook. Have the striker put on the apron, safety goggles, and gloves. Tell the bellows boy to stop cranking the bellows when you move near the fire, and to continue, when you move away. Make certain the students can see the striker at work but are not in danger of having flying metal or sparks hit them. Hand the hammer to the striker and show him/her exactly where s/he will be hitting the iron. Place the iron in the fire, step away, and have the apprentice crank the bellows.

11. Check the color of the iron. First it will turn red, then yellow. The forging color is a bright lemon yellow. Beyond that, the iron is too hot; it turns white and small pieces of iron explode and are consumed as they fall back into the fire. Forging consists of 8 separate operations. (Most tasks required 3 or 4.) The 8 operations include: a. *cutting:* very small iron was cut cold with a chainsaw, the rest was heated and cut with a variety of hardies; b. *fullering*: extra hammering before shaping, which compacted and strengthened iron; c. *upsetting*: used to thicken or bulge iron; d. *bending*: iron must be bent when hot, otherwise it would lose strength; e. *welding*: joining 2 or more pieces of iron; f. *punching*: making holes in iron; g. *riveting*: used to join 2 pieces of iron, not as strong as welding, but faster; h. *tempering*: reducing the hardness of a finished tool to a fixed point by rapid heating and cooling.

12. The operation from the preceding list that students will be using when they make their plant hooks is labeled: d. *bending*. Ask students to count off, starting with #1, and tell them you will keep their hooks in chronological order on the edge of the water bucket. Give a demo to the class, and work with the students who will be making hooks # 1 and 2. The student who is making hook #1 will work as the striker, and student who will make the second hook works as the apprentice.

13. While other students are waiting for their turn, they can work on a whitesmithing project in the other side of the Carriage House. Show students the laminated picture of the tinsmith's shop. *Why do they think a tinsmith was called a whitesmith?* The metal that the tinsmith worked with was very malleable and did not have to be heated. Therefore, the tinsmith did not get black from coal, as the blacksmith did. *What kinds of colonial products might have been made out of tin?* Show the laminated card of tin products.

14. Carefully explain how the students will be making their decorative plaques. Make sure the students and teachers know from the start that each child gets only one piece of pre-cut metal. Follow the laminated guidelines to explain the process. Provide a bucket for students to put metal scraps in, if they choose to round the corners of their piece of tin. All students should file the corners of their tin to reduce the sharpness. Put a teacher or parent in charge of handing out and collecting materials, while you complete the blacksmithing portion of the session.

15. Encourage students to work carefully and slowly on their tinsmithing projects.

16. When students have completed their projects, gather them together to discuss the blacksmith's main resource: charcoal. The students will most likely think that it is

charcoal that you have used to fuel your fire, and since this was what blacksmiths used until the late 1800s, it is important to discuss it. Show the laminated picture of the charcoal burner. Charcoal was made by stacking pieces of wood around a pole in a clearing to make a mound about the size of a large beaver house. The whole mound was covered with sod, dirt, damp earth, or wet green hay. The center stake was then removed to leave a shaft where hot charcoal was placed to start the fire. The wood was not allowed to burn, only to smolder for one or two weeks (depending on the size of the pile and the type of *wood) where it was transformed by carbonization into a clean-burning fuel. Much of the land in eastern areas of the United States was cleared to create charcoal for iron furnaces.*

17. Ask the students if they know what resource we used for the fire in our forge, and where that resource comes from. *We used to use coal but we now use charcoal.* Coal was used because it burns hotter than charcoal, coal had replaced charcoal in the iron furnace by 1875. Unlike charcoal, which comes from trees, coal is a nonrenewable resource that is known as a fossil fuel. Coal formed around 300 million years ago, when the climate of earth was warmer and the surface was covered by numerous steamy swamps. When plants died, their remains decomposed at the bottoms of these swamps, forming peat. When sand, clay, and other minerals were deposited on top of the remains, the pressure and temperature transformed the peat into coal. Coal can be found in 4 forms: lignite, sub-bituminous, bituminous, and anthracite. The latter is the hardest coal with the highest carbon content which burns the cleanest. Unfortunately, this is the least plentiful type of coal in the world. Most of the anthracite coal in the United States can be found in Pennsylvania.

SUMMARY:

Although the trade of blacksmithing was lost to the foundry industry, we use even more coal today than was used in the colonial era. Ask students to share with you how they use coal. *According to the U.S. Department of Energy, most families use several tons of this nonrenewable resource per year. An electric stove uses about 1/2 ton per year, an electric water heater uses about 2 tons per year, and a refrigerator uses another 1/2 ton per year.* Show the laminated pie chart of energy production sources, as well as the laminated sheet showing the amount of coal required, to power certain appliances.

What are the environmental effects of using coal? First, coal must be mined from the earth. Strip mining occurs when the top layer of land, including the topsoil and all that is growing and living upon it, is destroyed to get at what lies beneath. Mining also has negative health effects on miners – the particulate matter stirred up in the mine during the mining process can cause respiratory diseases. This is why minors traditionally sent a canary down into the mine with them. When the canary died, it was time for the miners to leave the mine.

Secondly, most of the coal in the Eastern U.S. formed under seawater, which had a lot of sulfur in it. That sulfur is locked in the coal and is released when it burns, along with other elements such as nitrogen and carbon. The sulfur and nitrogen combine with water vapor to form acid rain. *Show laminated picture*. The carbon that is released combines with oxygen to form carbon dioxide, which retains the sun's heat and contributes to the greenhouse effect. Burning coal also contributes to particulate pollution, which can make the air difficult for people to breathe near power plants and cities. *Show the laminated picture of the factory*. Have the students contribute ideas for ways in which they can reduce their use of coal.

Conclude by having students interpret the meaning of the following blacksmithing metaphors, still in use today, such as: "Strike while the iron is hot." and "Don't put too many irons in the fires."

BIBLIOGRAPHY:

Bealer Alex. *The Art of Blacksmithing*. New York: Funk & Wagnalls, 1969.

Porter, Robert. *Office of Fossil Energy: How fossil Fuels Formed*, 2004. www.fe.doe.gov/education/energylessons/coal/coal_howformed.html.

Watson, Aldren. *The Village Blacksmith*. New York: Thomas Y. Crowell Company, 1968.

Lesson plan developed by Jill Quinn
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NJ Student Learning Standards

SOCIAL STUDIES

6.1.5.GeoPP.2:	Describe how landforms, climate and weather, and availability of resources have impacted where and how people live and work in different regions of New Jersey and the United States.
6.1.5.GeoGI.4:	Explain how cultural and environmental characteristics affect the Distribution and movement of people, goods, and ideas.
6.1.5.EconEM.2:	Identify examples of the variety of resources that are used to produce goods and services (i.e., human capital, physical capital, natural resources).
6.1.5.EconEM.4:	Compare different regions of New Jersey to determine the role that geography, natural resources, climate, transportation, technology, and/or the labor force play in economic opportunities.
6.1.5.EconNE.4:	Explain how creativity and innovation resulted in scientific achievement and inventions in many cultures during different historical periods.

COMPREHENSIVE HEALTH AND PHYSICAL EDUCATION

2.1.8.SSH.3: Demonstrate communication skills that will support healthy relationships

LIFE LITERACY AND KEY SKILLS

9.4.5.CT.1: Identify and gather relevant data that will aid in the problem-solving process

9.4.5.CT.4: Apply critical thinking and problem-solving strategies to different types of problems such as personal, academic, community and global

CLIMATE CHANGE

3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

6.1.5.GeoHE.2: Cite examples of how technological advances have changed the environment in New Jersey and the United States (e.g., energy, transportation, communications).

6.1.5.GeoHE.3: Analyze the effects of catastrophic environmental and technological events on human settlements and migration.

SOCIAL AND EMOTIONAL LEARNING

All of our field lessons integrate the concepts of self-awareness, self-management, social awareness, responsible decision-making, and relationship skills found in the New Jersey's Core Social and Emotional Learning (SEL) Competencies.