

3.E.2 Maple Trees – Maple Syrup

Designing a receptacle for the collection of maple sap

Grade Level	3
Sessions	(1): 1 at 50 minutes
Seasonality	N/A
Instructional Mode(s)	Whole Class, Small Groups or Individual
Team Size	N/A
WPS Benchmarks	03.SC.TE.03, 03.SC.LS.06
MA Frameworks	3-5.TE.2.1, 3-5.LS.0.2
Key Words	Container, Design, Engineering Design Process, Maple Sap

Summary

Students will use their knowledge of the maple sugaring process to design a container for maple sap collection. The Engineering Design Process (EDP) will provide students with a framework for designing the container.

Learning Objectives

2002 Worcester Public Schools (WPS) Benchmarks for Grade 3

1. 03.SC.TE.03 Identify a problem that reflects the need for shelter, storage, or convenience.
2. 03.SC.LS.06 Study maple trees and go maple sugaring. Identify the structures in the maple tree and their functions.

2001 Massachusetts Frameworks for Grade 3

1. 3-5.TE.21 Identify a problem that reflects the need for shelter, storage, or convenience.
2. 3-5.LS.02 Study maple trees and go maple sugaring. Identify the structures in the maple tree and their functions.

Additional Learning Objectives

1. Students will apply their knowledge of maple sugaring, specifically sap collection and syrup production.

Required Background Knowledge

1. Students should have a solid understanding of:
 - a. Maple tree structures and their functions (see lesson 3.E.1 Maple Trees – Structure)
 - b. The maple sugaring process, including how/when to tap, how/when to collect sap (see Additional Resources and Appendix A: Teacher’s Notes)

Essential Questions

1. What are some methods used to collect sap from a maple tree?
2. What is the EDP?
3. How can the EDP help engineers invent new technologies?
4. How can the need to collect and store sap from maple trees be defined as a “storage problem”, in the engineering sense?
5. How does one design a container for the collection of maple sap?

Introduction / Motivation

The instructor may wish to refresh the important facts about maple sugaring by reading to students, “How Maple Syrup is Made” (see Appendix A: Instructor’s Notes – Maple Sugaring). If students are already familiar with the sugaring process, consider asking students to recall some of the methods used to collect sap from maple trees. These may include buckets or tube systems.

Procedure

The instructor will:

1. Ask students to recall the EDP and how the process was used in the past (see Appendix B: Instructor’s Notes – The Engineering Design Process).
2. Lead students through the attached worksheet (see Designing a Container to Collect Maple Syrup).

Materials List

Materials per student	Amount	Location
<u>Designing a Container to</u> <u>Collect Maple Syrup</u> Worksheet	One	End of lesson plan – print or photocopy

Vocabulary with Definitions

1. *Bucket* – the device used to collect flowing sap from a tapped maple tree.
2. *Container* – an object that can be used to hold or carry other objects, such as maple sap.
3. *Design* – to use pictures to plan a new product or idea.
4. *Maple sap* – a watery fluid that circulates within a maple tree, bringing nutrients to various tree structures; sap is boiled to make maple syrup.
5. *Spout* – a hollow plastic, metal or wood piece that fits into a hole drilled into a maple tree; allows sap to flow out of the tree into a collection receptacle.



<http://countryjoe.bizland.com/Xmapletap.jpg> (accessed 5 January 2006)

6. *Tubing* – a system of flexible, hollow hoses that are strung among a series of maple trees to collect flowing maple sap.

Assessment / Evaluation of Students

The instructor may assess the students in any/all of the following manners:

1. Collect student worksheets to determine whether students understand the EDP.
2. Collect student worksheets to determine the extent to which students can use engineering to solve a problem relating to storage.
3. Observe class discussions to determine whether students understand (a) that maple trees make sap, not syrup and (b) that sap must be collected in containers and boiled before it becomes syrup.

Lesson Extensions

1. Allow students to build prototypes of the containers they have designed. Allow students to test these prototypes with water (instead of sap).
2. Tap a local maple tree and use a covered bucket or adapted milk jug to collect flowing sap in February/March.
3. Use a maple recipe to create a maple treat that can be shared by students (see <http://www.massmaple.org> for recipe ideas).

Attachments

1. [Appendix A: Instructor's Notes – Maple Sugaring](#)
2. [Appendix B: Instructor's Notes – The Engineering Design Process](#)
3. [Designing a Container to Collect Maple Sap](#)

Troubleshooting Tips

1. The picture below is an example of a clean milk jug being used as a container to collect maple syrup.



http://www.massmaple.org/jug_bucket.jpg (accessed 5 January 2006)

2. If students have difficulty selecting materials to use for their container, or trouble visualizing how the materials might be put together, consider prompting them by asking leading questions such as:
 - What types of materials hold liquids?
 - How much liquid would you like to collect?
 - How will your container attach to a maple tree?

Safety Issues

None

Additional Resources

1. Mass Maple Association: Watson-Spruce Corner Road, Ashfield MA 01330. Online at <http://www.massmaple.org>. Via email at info@massmaple.org.
2. Mass Maple Association Video: "A Sweet tradition-The Love and Labor of Maple"
3. University of Maine Bulletin #7036: "How to Tap Maple Trees and Make Maple Syrup". Accessed 5 January 2006 from <http://www.umext.maine.edu/onlinepubs/PDFpubs/7036.pdf>.
4. Yankee Grocery "Sleepy Mountain Maple Syrup – Maple Sugaring Glossary". Accessed 5 January 2006 from http://www.yankeegrocery.com/maple_glossary.html.

Appendix A: Instructor's Notes – Maple Sugaring

The following information about maple sugaring was taken verbatim from <http://www.massmaple.org> (accessed 4 January 2005).

How Maple Syrup is Made

“Pure maple syrup is made by concentrating the slightly sweet sap of the sugar maple tree. The basics needed for making maple syrup therefore are some sugar maple trees and a method of concentrating the sap into syrup. As winter comes to an end, usually in late February or early March, sugarmakers prepare for their annual harvest of the maple trees. The group of maple trees that is used is called sugarbush, or maple orchard. The sugarmaker prepares his sugarbush by clearing access roads in the snow, removing fallen branches, and setting up his buckets or sap tubing systems. Whether they use tubing or buckets, sugarmakers must be sure that all their sap gathering, collecting, evaporating and bottling equipment is absolutely clean and in good condition before the beginning of the season.

“There is no set time when a sugarmaker must tap his trees. He must be aware of the clues of nature to tell him when the time is right. The temperatures are not as extreme as earlier in the winter, the streams run with melting snow, icicles drip faster, the crows can be heard announcing the not-too-distant arrival of spring. Mostly what the sugarmaker is waiting for is the arrival of the time of year known as “sugar weather,” when the nights are below freezing and the days are mild. This is the type of weather that makes the sap flow.

“When the sugar farmer feels the time is “right” he will start to tap his trees. Tapping involves going from tree to tree in the sugarbush, drilling holes 7/16 of an inch in diameter, about 3 inches deep, into the wood which carries the sap. If buckets are used to collect the sap, a metal spout or “spile” is tapped snugly into the hole, and a bucket is hung from a hook on the spout. A cover is put on the bucket to keep out rain, snow, and debris. If a plastic tubing system is used to collect the sap, a plastic spout, which is connected to the pipeline system, is tapped into the hole in the tree.

“The maple tree must be a least 10 inches in diameter and in good health before it can be tapped. It usually takes about forty years before a tree will reach tappable size. The hole is usually placed about waist high on the tree, and not near previous tapholes. Larger trees may take as many as three or four taps, but only if they are healthy. The sugarmaker has a feeling of respect for his trees and he knows he must take care of this tree which provides for him. Trees that are in poor health or have been defoliated by insects are often tapped less, or not tapped at all. If proper taping procedures are followed, tapping will not endanger the health and vitality of the tree. A healthy sugar maple can provide sap every year for a hundred years or more.

“Throughout the 4-6 week sugar season, each tap hole will yield approximately ten gallons of sap. This is only a small portion of the tree's total sap production and will not hurt the tree. The average amount of syrup that can be made from this ten gallons of sap is about one quart. These amounts vary greatly from year to year, and depend upon the length of the season, the sweetness of the sap, and many complex conditions of nature, such as weather conditions, soil, tree genetics, and tree health.

“When the trees have been tapped and all the equipment is ready, the sugarmaker is ready for the “first run,” that exciting time of the year when the sap first starts to flow, sap flow requires freezing nights and warm (but not hot) days. These must alternate and be in long enough series to allow the sap to move in the trees. For the first time each season the sap will drip into a bucket or slowly start to flow down the tubing system towards a collection tank. Prolonged periods of either below freezing temperatures or days without freezing nights will stop the sap flow. As a result, sugarhouses often start and stop boiling at different times due to local climatological factors. The gentle geographic progression is a reverse of the fall foliage season. That is the lower elevations and more southern regions of Massachusetts usually start their maple, seasons before the higher elevations and more northerly areas. Prolonged warm spells or cold snaps during the season may halt sap flow for several days, and it may start again when conditions are favorable. As a result, 24 hour work days are often interspersed with two, three or even more days of relative inactivity. This gives the

sugarmaker a chance to recover lost sleep, make repairs, clean equipment, and get ready for the next sap “run.”

“Maple sap, as it comes from the tree is a clear, slightly sweet liquid. The sugar content ranges from one to four percent. A device called a “hydrometer” can be floated in the sap to determine the exact sugar content. Sweeter sap is favored because less water will have to be evaporated to make maple syrup. The sap must be evaporated as soon as possible because the freshest sap makes the best quality syrup. Where the bucket collection method is used, a sap gathering tank is mounted on a sled, wagon, or truck, and is moved through the sugarbush as the sap is gathered. Tractors are most often used, but sometimes teams of horses or even oxen pull the sleds or wagons. The sap is collected from each tree by workers using large gathering pails. These pails are dumped into the gathering tank, which is then taken to a large sap storage tank at the sugarhouse, where it will soon be boiled down into pure maple syrup. If the tubing system is being used, the sap drips from the taphole, through the spout, and into a 5/16 inch diameter section of tubing. This tubing is joined to other trees, and eventually turns into a larger pipeline called a “mainline.” The mainline carries the sap downhill to a sap storage tank either at the sugarhouse, or at a low spot where it can be collected easily and transported to the sugarhouse.

“Maple syrup is traditionally made in a building called a “sugarhouse” - the name of the building comes from the time when most sap was actually turned into sugar. Sugarhouses vary in size and shape, each with its own character. Some may be rustic wood buildings out in the woods with poor access and no electricity, full of old tools and memories of grandfather's sugar seasons of the past. Still others might remind you of a modern food processing plant, brightly lit and streamlined. Each sugarhouse will have vent at the top, a cupola - which is opened to allow the steam of the boiling syrup to escape the building. All throughout the maple producing regions, steam rising from the cupola is a signal that maple syrup season is under way.

“Antique or modern, each sugarhouse will contain an evaporator used to boil down the sap into syrup. Evaporators are made up of one or more flat pans which sit on an “arch,”

a type of firebox. Wood or oil, and sometimes gas or coal is burned at the front end, and the flames are drawn along the underside of the pan, heating and boiling the sap as they travel towards the rear. It commonly takes about one cord of wood or sixty gallons of oil to boil down 800 gallons of sap into maple syrup. Depending on the size of the evaporator and the number of trees tapped, this may represent anywhere from two hours to two whole days of boiling. The basic design of maple syrup evaporators has changed little over the years, although sugarmakers are always tinkering with new designs to make the process faster or more fuel efficient. The size of the evaporator depends on the number of trees a producer has tapped. Most are from two feet wide and six feet long up to six feet wide by twenty feet long. Many backyard and hobby sugarmakers use smaller arrangements, or boil down their sap on the kitchen stove.

“An evaporator pan is divided into partitions, so that the sap is continuously flowing through the pan. Fresh sap enters at the back of the pan, where a float valve keeps the sap about an inch deep. As the water is boiled off, two things happen: First, the liquid becomes sweeter, and begins to move towards the front of the pan, traveling through the partitions. Secondly, more fresh sap is allowed into the rear of the pan. In this way the water is constantly being evaporated away, the liquid is becoming sweeter as it moves towards the front of the pan, and the float valve in the rear is always allowing more sap to be added to keep the level about an inch deep. It takes about forty gallons of this slightly sweet sap, boiled down, to make one gallon of pure maple syrup.

“The sugarmaker concentrates his attention to the front of the evaporator where the boiling sap is turning a golden color as it approaches being maple syrup. From time to time he will check the temperature of the boiling liquid. When it reaches seven and a half degrees above the boiling point of water, it has reached proper density and has become maple syrup. Another way of checking for the proper density or sugar content is to place a scoop into the boiling syrup. If the drops along the bottom edge of the scoop begin to hold together like a sheet or apron, then the sugarmaker knows the syrup is done. Coming from the tree, maple sap is approximately 98% water and 2% sugar. When the syrup is finished, it is only 33% water and 67% sugar.

“At this stage a valve on the front of the pan is opened and some of the finished boiling syrup is drawn off the pan and is filtered. After filtering, the syrup is bottled and is ready for sale or ready for a fresh pile of warm pancakes.

“The length of the sugaring season is totally dependent upon the weather. It may last only a few weeks, or as long as six or eight weeks. As the days become increasingly warmer, and the nights rarely get below freezing, the buds on the branches of the maple trees begin to swell, marking the end of the season. Chemical changes take place within the tree as baby leaves begin to form within the buds. At this time the sap is no longer suitable for boiling down into syrup. Sugarmakers know it is now time to clean up all the buckets, spouts, tanks, and miles of tubing with plenty of hot water so that the equipment can be put into storage and ready for the next winter.”

Appendix B: Instructor's Notes – The Engineering Design Process

“The Engineering Design Process for Children” and associated text comes directly from: <http://www.mos.org/doc/1559> (accessed 7 October 2005).

The Engineering Design Process



“The Engineering Design Process is a series of steps that engineers use to guide them as they solve problems. Many variations of the model exist. While having a guide is useful for novices who are learning about engineering, it is important to note that practicing engineers do not adhere to a rigid step-by-step interpretation of the process. Rather there are as many variations of the model as there are engineers. Because our curriculum project focuses on young children, we have created a simple process that depicts fewer steps than other renditions and that uses terminology that children can understand. The engineering design process is cyclical and can begin at any step. In real life, engineers often work on just one or two steps and then pass along their work to another team.”

“A few questions can guide students through each of the steps:

“ASK

- What do I want to do?
- What is the problem?

- What have others done?

“IMAGINE

- What could be some solutions?
- Brainstorm ideas.
- Pick one to start with that you think will work the best.

“PLAN

- Draw a diagram of your idea.
- Make lists of materials you will need to make it.
- Decide how it works. How will you test it?

“CREATE

- Build a prototype.
- Test it.
- Talk about what works, what doesn't, and what could work better.

“IMPROVE

- Talk about how you could improve your product.
- Draw new designs.
- Make your product the best it can be!”

Designing a Container to Collect Maple Sap

Name: _____

Date: _____

Engineers design tools and technologies that help people do work faster and better. You have learned about maple sugaring and you know that maple sap flows out of a maple tree by means of a spout. Pretend that you are an engineer who is designing a container to collect maple sap.

The Engineering Design Process



The Engineering Design Process for Children: <http://www.mos.org/doc/1559> (accessed 21 January 2006)

1. **Ask:** What will you design? _____
2. **Imagine:** Close your eyes. Visualize your design.
3. **Plan:** Place a check in the box beside the materials that you would like to use.

<input type="checkbox"/> Plastic pail	<input type="checkbox"/> Plastic milk jug, 1 gallon size
<input type="checkbox"/> Sponge	<input type="checkbox"/> Soft plastic tubing
<input type="checkbox"/> Metal pail	<input type="checkbox"/> Plastic milk jug, ½ gallon size
<input type="checkbox"/> Wooden pail	<input type="checkbox"/> Paper bag, large size
<input type="checkbox"/> Copper tubing	<input type="checkbox"/> Glass tubing

4. **Create:** In the space below, draw picture of your design. Label the materials that you would use to make each part.



