Great Lakes Geology and the Necessity of Locks

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Target: Grades 9-12 Earth Science and Technology

Lesson Overview

These lesson plans are intended to integrate an understanding of the geologic processes that resulted in the formation of the Great Lakes with lock technology that was developed to optimize the Great Lakes as a transportation waterway. The primary focus of the unit is to address technology as defined by the DOE as, " The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants."
http://www.doe.mass.edu/frameworks/scitech/2001/resources/glossary.html

While the frameworks listed are for high school, the lessons are readily adapted to meet many Massachusetts Curriculum Frameworks in Social Studies and Science for grade 4 see http://www.doe.mass.edu/frameworks/hss/final.doc and http://www.doe.mass.edu/frameworks/scitech/2001/0501.pdf

Room Arrangements and Safety Considerations:

The geology unit involves replicating a moving glacier. The glacier will melt leaving water, rocks and mud.

This is an ambitious project. The materials make it classroom worthy. The original model was constructed using wood and plexiglass by a freshman engineering class at UMASS/Lowell. Since the schematics of their project were lost. I built a replica out of Foamular and provided the measurements. The finished lock model is about four feet long. Students should either work at tables or push several desks together. Students will be working with Foamular insulation as the primary material in building the locks. It can be effectively cut with a sharp steak knife. A box cutter can be used, however, the steak knife works better and it provides more control. Students will also use Silicone II caulking. The odor is unpleasant, and if available the activity should be done outside. The number of student groups will determine the amount of ventilation required. The caulking gun is pretty straightforward but may cause blisters to very delicate hands. After laying down a bead, gloves should be worn to spread the silicone very smoothly. Peeling off any dried caulking will probably break the seal. The pieces will not fit together evenly if the silicone is left in chunks. Fasteners in the form of wooden skewers are used. These are sharp and require some strength to push in. Gardening gloves or a rolled up cloth may be helpful in pushing the skewers into the Foamular. The finished product needs about 10 gallons of water. Watertightness is best assessed outside or the model could be placed inside a water-table or kiddie swimming pool. Even if the students unit leaks at the base, sides and ends, a garden hose at the reservoir will provide enough water for the unit to function. The students can then write up their redesign to address the issues.

Massachusetts Curriculum High School Frameworks

1. Engineering Design Process
Broad Concept: Engineering design involves practical problem solving, research, development, and invention/innovation and requires designing, drawing, building, testing, and redesigning. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge.

1.1 Identify and explain the steps of the engineering design process. The design process steps are identify the problem; research the problem; develop possible solutions; select the best possible solution(s); construct prototypes and/or models; test and evaluate; communicate the solutions; and redesign.
1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify and explain examples of technologies, objects, and processes that have been modified to advance society.
1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial (isometric, oblique, perspective) drawings using various techniques.
1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings, such as, ¼" = 1'0", 1 cm = 1 m.
Interpret plans, diagrams, and working drawings in the construction of prototypes or models.

2.5 Construction Technologies
Identify and demonstrate the safe and proper use of common hand tools and/or power tools and measurement devices used in construction

3. Earth Processes and Cycles
Broad Concepts: Earth is a dynamic interconnected system. The evolution of Earth has been driven by interactions between the lithosphere, hydrosphere, atmosphere, and biosphere. Over geologic time the internal motions of Earth have continuously altered the topography and geography of the continents and ocean basins by both constructive and destructive processes.

3.1 Explain how physical and chemical weathering leads to erosion and the formation of soils and sediments, and creates the various types of landscapes. Give examples that show the effects of physical and chemical weathering on the environment

3.8 Trace the development of a lithospheric plate from its growth at a divergent boundary (mid-ocean ridge) to its destruction at a convergent boundary (subduction zone). Recognize that alternating magnetic polarity is recorded in rock at mid-ocean ridges.

8. Reading and Literature Strand:
• 8.34 Analyze and evaluate the logic and use of evidence in an author's argument.
19. Composition Strand:
• 19.30 Write coherent compositions with a clear focus, objective presentation of alternate views, rich detail, well-developed paragraphs, and logical argumentation.
• 20.5 Use different levels of formality, style, and tone when composing for different audiences.
• 22.10 Use all conventions of standard English when writing and editing

Objectives:

Students will be able to:

1. Write a news report on the Laurentide Ice Sheet: what it was, where it was located, when it moved, how often it moved, and why it is important for US commerce.
2. Create a timeline for glacial movement during the Wisconsin Ice Age.
3. Describe the effects the glacier movement and mass has on the landscape.
4. Explain why the Great Lakes' basin is still rebounding---seeking isostatis.
5. Trace commercial waterways from the Great Lakes to the Atlantic Ocean.
6. Describe why locks are needed to travel the Great Lakes.
7. Build a working model of a lock system.

8. Using data, write an opinion article on the usefulness of spending tax dollars to build or improve a lock.

Lesson1
Time Needed: 3 class periods

Materials needed:

- United States Map
- Geologic Time Chart
- 4 foot piece of Foamular (rigid insulation product available at Home Depot/Lowes) placed on a slight angle using books
- Sand, Rocks,
- (2) 2 liter soda bottle cut in half filled with water, sand and gravel. This should be frozen in advance.
- Two foot wide bucket that can hold 4 liters of water.
- One pound flour
- 5 pieces of overhead projector transparencies for each group of students.
- Markers
- Brass

Invitation to Learn/Pre-Assessment:
Compile on the board a list of what students know about the Great Lakes. Correct any misconceptions. Discuss glacier movement. Point to Lake Erie on the US map. Tell the students it was the first Great Lake to form. Have students speculate at to why. Tell the students that over the course of the next week we will be discussing how the glacier changed the landscape and created the Great Lakes and how civilization has used, adapted and modified this natural environment to conduct commerce.

Activity set-up:
Set up the glacier movement table. Put the Foamular in an undisturbed area of the class room. The bottom should drain into a bucket. The top should be angled atop 14 inches of books. The bucket should be on 4 inches of books. Cover the Foamular with flour. This represents the land. Take the glaciers out of the soda bottles and place at the top of the land. Let melt.

Procedure

Part I
Have students access the following flash movie.
How the Great Lakes were Formed. (2006, May 25). Retrieved August 23, 2006, from Environment Canada Web site: http://www.on.ec.gc.ca/greatlakeskids/greatlakesmovie5.html

Part 2
Review homework. Ask name of ice sheet. Discuss the Wisconsin Glaciation as the last part of the Pleistocene Ice Age.

Discuss what happened to the glacier set up the following day. Lay the Foamular flat. Discuss what happened to the land. In our model what does the bucket represent? In this model how could the water in the bucket at up in the ocean? Lead to rivers and waterfalls. How would the rivers develop?

Enlarge the five maps from:

Damery, D. (2004, December 1). *Formation of the Great Lakes*. Retrieved August 27, 2006, from Emporia State University Web site: http://www.emporia.edu/earthsci/student/damery1/gl_form.html

Tell students that they will be making a flip chart. The chart shows the regression of the Laurentide Ice Sheet during the end of the Wisconsin Glaciation and the creation of the Great Lakes. Depending on time the students can do individually or in groups.
Discuss how the transparencies should be marked so that the water is in the right place and the regressions line up. Punch holes 11/2 inch from the top. At the end of the activity the 5 sheets will be attached with brass fasteners. This will also help with the orientation of the maps.

Students are to trace the modern map of the Great Lakes on a transparency. Students should all the lakes and the rivers and make an outline of the surrounding land. Each additional transparency: 14000, 9000, 7000 and 4000 years ago should delineate the ice and amount of water. Suggest that water from each year be colored slightly different. Put the maps in order and fasten together. Flip through to see the progression.

Assignment: Write a news report on the regression of the Laurentide Ice Sheet in their journal.

Part 3
Read some of the journals. Highlight any that speak about the weight of the ice. Discuss rebound/isostatic rebound. Review again the Foamular land model. Remind that the bucket represented a lake and that this lake was higher than the river level. If a boat wanted to go from the lake to the river to the ocean what would happen. It is helpful to put the lake on some books and cut a strip of paper to represent river.

If necessary finish flip charts. Other students can brainstorm ideas of how to get the boat from the lake to the river without it tipping. Write on the board the *design process* of how students attempted to come up with an idea.

Lesson 2
3 class periods if material pre-cut
5 class periods if diagram is to be read and materials cut by students

Invitation to learn: Discuss manual locks. Put pictures of 19C (attached) locks on overhead.

Materials Needed per lock system:

- one piece one inch 2x8 Foamular
- 1/3 piece two inch 2x8Foamular
- 1 caulking gun
- Square
- Ruler
- tubes Silicone II caulking
- Piece of plastic wrap to cover the caulk opening when not in use.
- steak knives
- 15 long wooden skewers
- Many short wooden skewers or cocktail toothpicks with fringe removed
- Kitchen Scissors or pliers
- 2 tape measures
- 2 clamps
- Pencils
- 1 inch PVC pipe cut into 10 inch lengths.
- 3 cd cover tops
- Tin Foil
- putty
- Small fish tank pump with 48 inches of tubing

Attached to the lesson plan is the diagram of the lock model and a photograph of the individual pieces. Ideally the students should build the model from the attached diagram. In the alternative or for the initial implementation of the lesson the teacher can cut out the necessary pieces and have the students read the diagram and put the model together. Written directions are attached so that the teacher can guide the students when/if that becomes necessary. To avoid confusion, students should be encouraged to label the pieces as they go along. Students must have an understanding of how locks work before this can be started. In the animations as well as the pictures point out to the students the different levels and where the water is going when it flows from one section of the lock to the next.

The model has several parts: base, sides, ends, sub-floors top rails, bottom rails, sluice dams, sluice gates, gate frames, gates, drainage floors.   The model is held together with wooden skewers and is made watertight with silicone II caulking. All measurements should be made strong, so that students may trim individual pieces allowing the pieces to fit tightly together. Pieces should not be too tight as to cause buckling.
Length width height

Measurements in inches		Material:	Quanity
Base	48.5 x 8.5	2” Foamular	1
Sides	48x8	1” Foamular	2
Ends	6.5X8	2”Foamular	2
Sub-Floor	24 x 6.5	2” Foamular	1

Sub-Floor Rails	24 x 1.5	1" Foamular	2
Sub Floor Rail	5 x 1.5	1" Foamular	1
Top Sluice Dams	2.25 x 4 7/8	1" Foamular	2
Top Drainage Floor	24x6.25	1" Foamular	1
Bottom Rails	23.5 x 1.5	1" Foamular	2
Bottom Drain Floor	21 7/8 x 6 3/8	1" Foamular	1
Bottom Sluice Dam	2.25 x 4 7/8	1" Foamular	1
Base Gate Frames	6.25 x 1.5	1" Foamular	3
Top Sides Gate Frames	1.5 x3 3/4	1" Foamular	4
Bottom Side Gate Frames	1.5 x 5 ¾	1"Foamular	2

Instructions:

1. Attach the base to one end by inserting large skewers through the base into the end. Cut off any exposed skewer. Put a dab of caulk at the insertion point.
2. Attach the sides to the base by inserting large skewers into the corners at 45 degree angles. Trim any exposed skewers. Put dab of caulk at insertion point.
3. With the base side up, insert numerous small wooden skewers through the base and into the sides and end. Trim exposed skewers and dab with caulk.Reinsert any skewers that are exposed inside the lock.
4. Turn the lock right-side up. Line with tin foil to cover seams.

Reminder about caulking: students should wear gloves. After laying down a bead, the students should use a gloved finger and evenly spread the caulk. It may be helpful to practice on scrap pieces of Foamular.

5. Caulk along the entire inside seams of the lock.
6. Using the caulking adhere the subfloor to the base so that the sub-floor butts against the end and side walls.
7. Adhere the two bottom rails to the sides where they meet the base.
8. Caulk along the top of the rail, so that water cannot seep between rail and sides.
9. Adhere the three pieces of the sub-floor rails along the end and side edges of the subfloor.
10. Caulk around the top of the rail, so that water cannot seep between the rails and the sides and the end.
11. Place a scrap piece of Foamular along each side and clamp close to the end and close to the end of the sub-floor.
12. Let Dry.
13. Prepare Drainage Floors.
14. Decide the best fit for the top drainage floor. Then from the edge closest to the end measure 9 inches.
15. Use the pvc pipe as a "cookie cutter" to make a the first drainage hole. The diameter of the hole should run through the middle of the 9 inch mark.
16. Make the second hole is a sluice drain and is be measured from the end to 11 inch mark.
17. The third drainage hole is located 15 inches from the end.
18. The fourth hole is for another sluice and is located 17 inches from the end.
19. There are three holes on the bottom drainage floor. They are located at 4, 7.5 and 11.5 inches from the end of the bottom drainage floor.
20. Prepare the sluice dams. Use the pvc pipe as a "cookie cutter" again and put a hole through the middle of each sluice dam.
21. These holes are to stop the water from flowing. The pvc pipe is used as the sluice gate.
22. The next holes run horizontally through the sluice dam.

23. Hold the sluice dam so the long side is facing you. Insert a pencil through the middle of the long side, so that it passes through the diameter of the hole made with the pvc pipe and continues through the other side.
24. Water will flow through this sluice. It is only stopped when the gate, pvc pipe blocks the sluice.
25. Position the top sluice dams on the sub-floor. Put the drainage floor on top of the sluice dams. The sluice dam holes should be directly under the 11 inch and 17 inch sluice holes.
26. Insert two pvc pipes to make sure the holes are lined up. The pvc pipe should go through the drainage floor and the sluice dam and rest on the sub-floor.
27. Remove pipes and gently lift drainage floor without moving sluice dams. Mark the location of the sluice dams. Put the floor on again to make sure measurements are correct.
28. Once a correct measurement has been ascertained, adhere the sluice dam to the sub-floor and caulk around the edges. Do not get any caulk inside the sluice hole.
29. Repeat with the bottom drainage hole by putting the sluice dam under the 7.5 inch hole.
30. Let dry
31. Adhere the top drainage floors to rails and sluice dam.
32. Connect the three pieces using small skewers. Cut a groove on the three sides to receive the cd case. The fit should be very tight. When the gates are open then the boat can pass through the next section of lock. When the gate is closed it should hold back almost all of the water. If the frames don't fit snuggly to the sides, then fold pieces of tin foil to fill in any spaces.
33. After the groove has been cut, use the silicone to adhere the pieces. Don't get the silicone in the grooves.
34. Line the grooves with putty. Place the gate frames in between the drainage holes and the sluice gate.
35. Skewer to keep tight.
36. Caulk along the inside of the top drainage floor to prevent water seepage and around the gate frames.
37. Use scrap pieces of Foamular and clamp the sides to the top drainage floor.
38. Let dry.
39. Repeat items 31-37 for the bottom drainage floor.
40. Attach the end piece with skewers. Angle 4 large skewers at 45 degrees. Place several skewers straight in. Caulk from the inside to make water tight.
41. Let dry.
42. Cut any exposed skewers. Those below the waterline should be dabbed with caulking.

Using the Lock system.

Hose from the fish tank pump should be located in both the top and bottom sections. A the pump is used because this lock is not in the middle of a river and therefore doesn't have an available stream of water. Make sure students understand that in a lock system water is not pumped. The system uses waters' own desire to seek its own level.

Make sure the cd gates are down, and sluice gates are up.

Fill the lock with water so the floors are filled to the drainage hole.

Put down the sluice gates.

Continue to fill first lock chamber.

Use a scrap piece of Foamular as a boat insert a penny in the top to help stabilize the boat.

Place boat in first lock chamber.

Move the boat through the lock system using sluice gates and gates.

Lesson 3: Great Lakes Transportation

Time Needed: 2 class periods

Invitation to learn:
Provide students with map that shows the area from Wisconsin to the Altantic Ocean and from Iowa to Quebec. Have students trace waterways to lead from west to the Atlantic Ocean. Label cities that could be used as ports. Put up the filled in map showing routes and cities. Discuss the idea of a fourth coast.

Activity:
Give the students the two graphic pages
http://graphics.jsonline.com/graphics/news/img/oct05/corridor2G102905.pdf

http://graphics.jsonline.com/graphics/news/img/nov05/water30.pdf

http://www.greatlakes-seaway.com/en/pdf/welland.pdf#search=%22sea%20lock%20improvement%20st.%20lawrence%22

Use this information to discuss global shipping from the Great Lakes Region.

After discussion, students are to write an editorial for or against a "proposed" public works project to improve one of the Welland Locks in Canada at a cost of "1 billion dollars".

Vocabulary:
Isostatic Rebound
Ice Age
Wisconsin Glaciation
Laurentide Ice Sheet
Sluice
Wicket
Lock
Lock chamber

The following citations provide sufficient information to complete the lessons. They are in order of usefulness:

Geology:
This power point information provides a great outline.
***How the Great Lakes were Formed*. (2006, May 25). Retrieved August 23, 2006, from Environment Canada Web site: http://www.on.ec.gc.ca/greatlakeskids/greatlakesmovie5.html**
This site provides all the background needed to understand the St. Mary's River. Best if you are doing just the Soo Locks, Lake Huron, Lake Superior and Lake Michigan.

St. Marys River. (n.d.). Retrieved August 23, 2006, from The Canadian Heritage River System Web site: http://www.chrs.ca/Rivers/StMarys/StMarys-F_e.htm

Short and to the point this site provides sufficient information on the geology of Lake Erie.
Geology of the Lake and Islands. (n.d.). Retrieved August 23, 2006, from National Park Service Web site: http://www.nps.gov/archive/pevi/HTML/geology.html

This is the entire EPA Great Lake resource site. It covers everything from the geologic time line to the direction the Great Lake communities will take in the future. If these lessons are incidental to a large unit on the Great Lakes this is the site to go to.
Great Lakes an Environmental Atlas and Resource Book. (n.d.). Retrieved August 23, 2006, from U.S. Environmental Protection Agency Web site: http://www.epa.gov/glnpo/atlas/index.html

This site has useful print pictures of ice sheet movement.
Damery, D. (2004, December 1). _Formation of the Great Lakes_. Retrieved August 27, 2006, from Emporia State University Web site: http://www.emporia.edu/earthsci/student/damery1/gl_form.html

Locks:
This British site provides historical and technical aspects of different types of locks. This is a good lock background site. For physics teachers it also does a good job of explaining why locks waste work energy.
Bromley, N. (2005, February 16). _Canal Locks_. Retrieved August 23, 2006, from http://dspace.dial.pipex.com/nib/locks.htm

This short British animation shows how a lock works. Their associated web site “Up the Cut” also provides background information.
How Locks Work. (2003). Retrieved August 23, 2006, from Up the Cut Web site: http://www.starling101.btinternet.co.uk/canals/lckworks.htm

This short animation is interactive assessment. Here students choose which gates to open.
TerraX.org. (2002). Retrieved August 23, 2006, from TerraX.org Web site: http://terrax.org/sailing/locks/locksjs.aspx

This is an elementary student resource book and describes how to make a paper model of locks.
Oxlade, C. (Ed.). (1994). _Canals and Waterways_. New York: Franklin Watts.

Commerce:
This was part of a series of newspaper articles on the St. Lawrence Seaway. It is also the location of the graphics used in Lesson 3.

Egan, D. (2005, October 29). Sinking Treasure. In *JS online*. Retrieved August 23, 2006, from JS Online database: http://www.greatlakes-seaway.com/en/pdf/welland.pdf#search=%22sea%20lock%20improvement%20st.%20lawrence%22

This site provides a historical prospective of the Welland Lock in Canada. It is the lock used in the fictional public works project in Lesson 3.

***Welland Canal Section*. (2003, March). Retrieved August 23, 2006, from The St. Lawrence Seaway Management Corporation Web site: http://www.greatlakes-seaway.com/en/pdf/welland.pdf#search=%22sea%20lock%20improvement%20st.%20lawrence%22**

Assessment:

Assessments for the lessons are embedded. Students will submit a news report on the creation of the Great Lakes. They will articulate how locks work by building and demonstrating their models. They will complete the interactive animation at: **http://terrax.org/sailing/locks/locksjs.aspx.** They will write a proposal for a redesign for the lock model and articulate a position on whether or not more money should go into lock systems.