Changing Perspectives
Teacher's Guide for
Theme 4: European Sailing Technology
Video "How did Captain Vancouver navigate the oceans?"

Overview:

Students will learn more about the scientific elements of Captain Vancouver's voyage along the Pacific Northwest coastline. This lesson introduces students to the navigation concepts of longitude and latitude, and how sailors plot a course and create maps.

This lesson plan and activity are suitable for Grades 4-12 Social Studies (see the BC Curriculum Connections Chart for further details) and Grades 4-6 Math. Teachers are invited to review and customize the suggested lesson plan based on curriculum, grade and student needs.

Resources:

- Video "How did Captain Vancouver navigate the oceans?"
  - 0:15-0:35 What is latitude?
  - 0:35-0:55 How to use the North Star to calculate latitude?
  - 0:55-1:15 How to use a sextant to calculate latitude?
  - 1:15-2:30 How to calculate longitude?
  - 2:28-3:00 How to use a sextant to calculate longitude?
  - 3:00-3:40 What was the purpose of the marine chronometer?
  - 3:40-4:22 How did these technologies and knowledge contribute to mapmaking?
- Review questions worksheet for students
- Chart the Coast Math Activity for practicing longitude and latitude calculations

Thematic Questions:

- How did Captain George Vancouver and his crew navigate the oceans?
- What role did maritime technology play in late 1700s European overseas voyages?

Learning Objectives:

- Describe the technology that Captain Vancouver and his crew used to navigate and chart the Pacific Northwest Coast.
- Apply mathematical concepts and equations required to calculate longitude and latitude in the context of early Pacific Northwest exploration.

Key terms:

- **Cartography:** the practice of drawing maps.
- **Latitude**: the distance north or south of the Equator measured in degrees. Represented by horizontal, parallel lines on a map.
- **Longitude:** the distance east or west of the Prime Meridian (0 degrees). Vertical lines that meet each other in the North and South Poles.
- **Marine chronometer:** very accurate clock used to keep time at sea to calculate longitude. The first successful chronometer, called the H4, was introduced in 1759 by John Harrison, an English carpenter. The marine chronometer increased the safety and accuracy of long-distance sea travel.
- **Navigation:** the science of locating a ship's position and following a route. Involves determining one's position in the world, distance travelled, and course.
- **Sextant**: An instrument that measures the angular distance between two objects, typically a celestial object (such as the North Star) and the horizon. This measurement, known as the object's altitude, can be used to calculate latitude. The sextant is based on earlier instruments, such as the astrolabe. The knowledge required to use this instrument can be traced back thousands of years to the Chinese, Egyptians, Babylonians, Greeks and Arabs.

Sample Lesson Plan

Part 1: Activate Prior Knowledge
Intended audience: Grades 5-12
Use any of the following questions for group discussion or as think-pair-share. Students could draw a mind map to keep track of words and ideas that jump out at them.

- ➢ Imagine you found yourself on a small raft in the middle of the ocean with no phone or GPS. How do you know where you are? What kind of clues might you have?
    - Can you see anything to help you determine where you are? (for e.g. the horizon, stars, sun, ocean, clouds)
    - Throughout history, many peoples used stars to navigate. What might be some challenges of using the stars? (if it's cloudy; they move throughout the night; require a lot of knowledge
- ➢ Captain Vancouver's crew would have set out across the ocean with no Google Maps or GPS to guide them. They sailed on the ocean for weeks on end not knowing when they would next see land. What technology and knowledge do you think they had to help guide their ships?

Part 2: Watch *Changing Perspectives* Video
Intended audience: Grades 5-12
Watch the video "How did Captain Vancouver navigate the oceans?" as a class:
https://changing-perspectives.grmdgs.com/en/technologies/

Part 3: Review Questions
Intended audience: Grades 5-12
Resource: accompanying review questions worksheet
Ask students to answer the following questions, as written answers using the worksheet or as think-pair-share. These questions build from direct recall to active critical thinking.

Imagine you're a crew member of Captain Vancouver's 1791-1795 expedition, tasked with navigating the ship's route for the *HMS Discovery*:
Possible answers in red.

1. The distance you are north or south of the Equator is called: latitude
2. The distance you are east or west of the Prime Meridian is called: longitude
3. When sailing in the open ocean to North America, why is it difficult to know where you are? Can't see land or landmarks.

4. What could happen if you didn't know your location at sea?
    - Get lost, could sail into dangerous waters, get attacked by pirates or a navy, could sink if hit shallow water or rocks, crew could get mad and mutiny.
5. What could cause your ship to sail in the wrong direction?
    - Wind and currents can steer a ship off course. If the navigator is not keeping track of the effects of the wind and current, the ship could get lost. Having inaccurate maps, instruments, or measurements could take the ship off course. Cloudy days that don't allow for sextant measurements.
6. What technology and knowledge do you need to calculate your ship's latitude and longitude? Fill in the chart below.

	Latitude	**Longitude**
Technology	Sextant	Chronometer
Knowledge	Which star is the North Star, trigonometry, how to use a sextant	Time in England, time where you are, Earth moves 15° in one hour, Earth rotates around the sun every day

7. Which do you think is more important: the technology, or the knowledge of how to use it? Or do you think both are equally important? Explain your thinking.
    - Responses vary. The emphasis is on forming and communicating their opinion.

Part 4: Chart the Coast Math Activity
Intended audience: Grades 5-6
Student Resources: Activity Worksheet
Teacher Resources: Activity Background Sheet (below) and Activity Answer Key (below)

Before beginning the *Navigation Learning Activity*, you may want to review the key concepts of longitude and latitude, preferably using a globe to demonstrate. If the students are already familiar with these concepts, you can jump right into the activity.

4A. Activity Background

If a navigator knew both their latitude and longitude, they could figure out where their ship was in the world.

<u>Latitude</u>
Latitude measures the distance north or south of the Equator, from 0° to 90°. In Captain Vancouver's time, they used a sextant to determine their latitude by measuring the angle of a star to the horizon. The North Star, part of the Little Dipper, can be seen year-round in the Northern Hemisphere* and sits almost directly above the North Pole. Demonstrate using a globe and figurine that if you're standing on the North Pole (90°), the North Star appears directly above you (aka 90 degrees from the horizon). If you're standing on the Equator (0°), the North Star appears to be on the horizon (aka 0 degrees from the horizon).

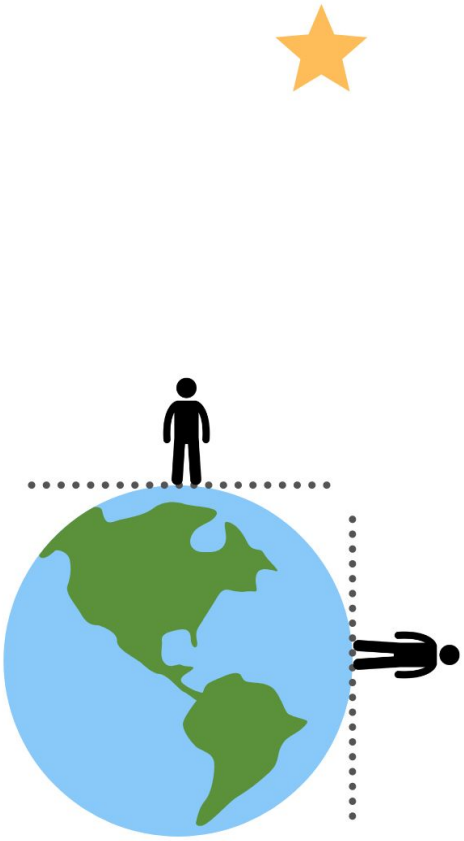


Figure A. Where the North Star is compared to our horizon.

What do you notice about the degree of latitude and the angle between the horizon and North Star? They are the same degree. (Example: The Equator is 0° latitude, and the horizon at the Equator has an angle of 0° to the North Star). This is how using a sextant could let sailors know how far North or South they were.
*In the Southern Hemisphere they used the Crux, a constellation of stars.

Note: Although the North Star in Figure A doesn't look like it's directly above the North Pole, in reality, the North Star is so, so far away from Earth that it *appears* to be right

above. You can demonstrate this by moving your North Star farther away from the globe and using a protector to see how this distance changes the angle of the horizon to your North Star.

Longitude

Longitude measures your location east or west from the Prime Meridian. Locate the Prime Meridian, this is 0° longitude. The British often set their chronometers to Greenwich time, a place near London that the Prime Meridian passes through. Halfway around the world is the antimeridian passing through the Pacific Ocean. Like all other spheres, the world can be divided into 360 degrees.

Time is the key to calculating longitude. The Earth fully rotates once a day (every 24 hours), meaning it rotates 360° each day. If the world rotates 360° every 24 hours, how many degrees does it rotate every hour? (360/24 = 15° every hour).

Chronometers are clocks that could accurately keep time at sea. Before starting the voyage, the ship's chronometer would be set to the time at the Prime Meridian. To calculate your longitude, you also needed to know what time it was where you were. If you're in the middle of the ocean, how could you know when it's noon? When the sun is at the highest point in the sky, you know it's noon. At noon, read the time on the chronometer. Calculate the difference between these two times. Multiply this number by 15 degrees. This will give you your longitude.

Example:

Noon local time	12:00 PM	
Prime Meridian time	07:00 AM	
Difference	**05:00 hours**	5 hours x 15° = **75° west of the Prime Meridian**

When writing longitudes, a common practice is to write if the location is east or west of the Prime Meridian up to 180° (ex. Singapore 103° E; New York City 104°W).

4B. Navigate the Coast Math Activity Answers

Can you chart the *HMS Discovery* and *HMS Chatham*'s route along the Pacific Northwest Coast during the summer of 1794? The coordinates are approximates based on maps and journal entries from this voyage.

Latitude

1) Calculate how many degrees of latitude the ship is north of the Equator. The following sextant measurements show the angle of the North Star relative to the horizon on each day.

   (Remember, the North Star is at 90 degrees to the horizon in the North Pole. At the Equator, the North Star is 0 degrees to the horizon).

Day	Sextant measurement	Latitude
July 30, 1794	56.5 degrees	56.5°
August 24, 1794	55.5 degrees	55.5°
September 1, 1794	50.75 degrees	50.75°
September 2, 1794	49.5 degrees	49.5°

2) Is the ship travelling north or south? South

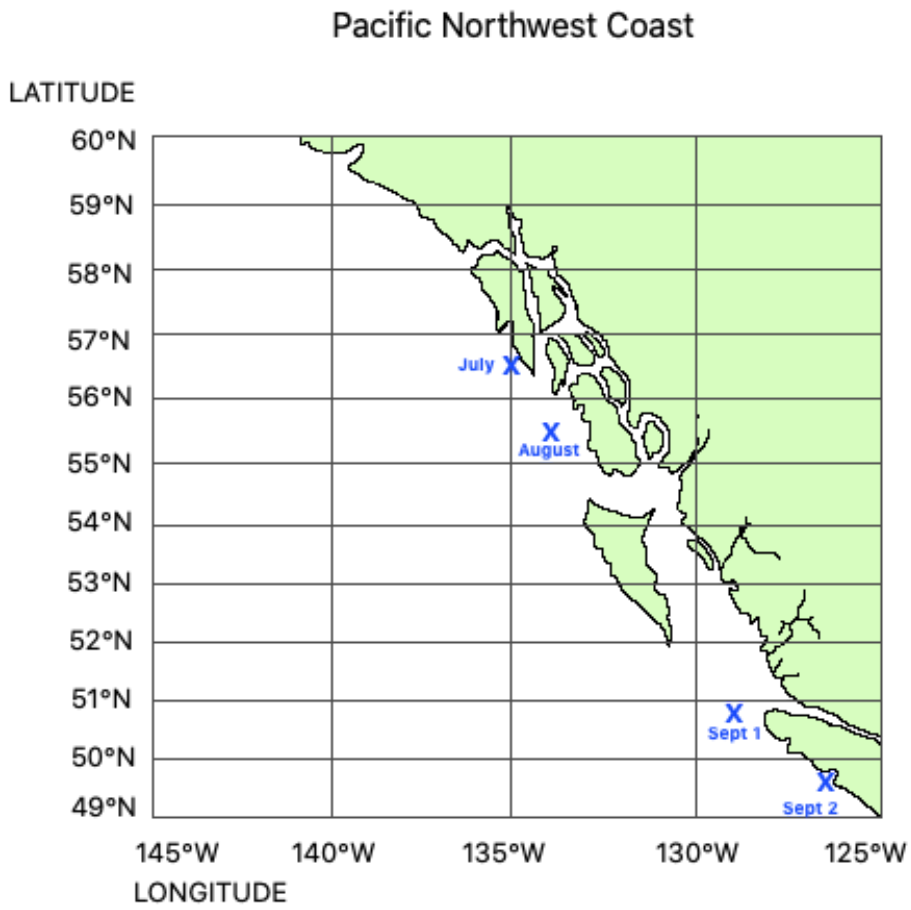
Longitude

1) How many degrees does the Earth rotate every hour?
   360° ÷ 24 hours = 15° every hour
2) How many degrees does the Earth rotate every minute?
   15° ÷ 60 minutes = 0.25°
3) How long does it take for the Earth to rotate 1°?
   60 minutes ÷ 15° = 4 minutes
4) A chronometer aboard the *HMS Discovery* and *HMS Chatham* kept track of the time back in Greenwich, England at 0 degrees longitude. Using the chronometer, calculate the ship's position for the following readings:

Day	When it is 12:00pm where the ship is, the chronometer reads the time in Greenwich is:	Longitude
July 30, 1794	9:00 PM	(9hr x 15°)=135°
August 24, 1794	8:56 PM	(8hr x 15°)+(56m/4°)=134°
September 1, 1794	8:36 PM	(8hr x 15°)+(36m/4°)=129°
September 2, 1794	8:24 PM	(8hr x 15°)+(24m/4°)=126°

Chart the Coordinates

Using the longitude and latitude coordinates you have calculated, plot the ship's location for each of the four days.



Extra Problem Solving Question:

Captain Vancouver's expedition sailed far north in the spring and summer of 1794 to chart the Pacific Northwest Coast. According to their expedition maps, on June 29 1794, the ship's coordinates were 59.75°N latitude and 142°W longitude. When it was noon local time on the ship, what time was it in Greenwich?

There are many ways to get to the answer 9:28 PM

It takes one hour for the Earth to rotate 15°. 15° fits into 142° nine times. Therefore it is at least 9 PM. But, there are 7 degrees remaining.

It takes 4 minutes for the Earth to rotate 1°. 7° x 4 minutes = 28 minutes

Part 5: Analysis Prompts

Intended audience: Grades 8-12

These additional prompts expand on the review questions above, and ask students to further analyze what they've learned from the video, either as written responses or discussion. These questions ask students to reflect on the practice of history and incorporate evidence to justify their claims. In some cases, students may benefit from further resources to explore these questions. Expansion ideas might include asking students to debate opposing views, think/pair/share, or write in-depth essays.

1. What can artifacts from Captain Vancouver's expedition contribute to our understanding of navigation? Follow the "Artifacts of Exploration" Teacher's Guide to try a close looking activity.
2. Compare the two maps in the video at timestamp 4:08. The map on the right was created by Captain Vancouver in the late 1700s, and the map on the left is a Russian map created in the mid-1700s showing a similar area.
    a. What are the similarities and differences between the two maps?
    b. Why are there differences between the maps?
    c. Can you find the regions represented by the maps on Google Maps or Google Earth? What makes it easy or difficult to locate the region?
        i. Google Maps coordinates
        (Note: Google Maps does not show lines of longitude or latitude, but can show a location's coordinates)
        ii. Google Earth coordinates
        (Note: Google Earth can show lines of longitude and latitude. Go to Menu → Map Style → Turn on Gridlines)
3. Challenge students to identify some late 1700s navigation techniques that are still in use today and some which are not. Why are some no longer used?

Example: Like the chronometer, GPS systems today rely on extremely accurate timekeeping to triangulate our position.

4. What do you think was the role of navigation technology and knowledge in globalization? Consider how navigation technology and knowledge interact with social, economic and cultural forces.
5. Do you think mapmaking is an art or a science, or a combination of the two? Argue for your opinion.
6. What tools do you use when you are travelling today? Does access to directions and modes of modern transportation influence your willingness to travel? How is your travel experience different from a member of Captain Vancouver's crew?
7. Before 1884, there were multiple different locations identified as 0 degrees longitude (ex. Beijing; Paris) depending on the cartographer's nationality. It's an imaginary line that could be located anywhere. At the International Meridian Conference of 1884, twenty-five countries agreed that the meridian passing through Greenwich, England would be the defined Prime Meridian (0°). Why do you think this Prime Meridian was chosen as the standard 0° longitude?

Part 6: Wrap Up Discussion

Intended audience: Grades 5-12

Wrap up your lesson with a reflective discussion. Ask students to give answers to the following questions, either as a class, in small groups, or as an independent writing exercise.

- ➢ What did you learn that surprised you?
- ➢ What did we learn that made you see the world differently?
- ➢ What questions do you still have?
- ➢ Are these technologies, skills, and knowledge in this lesson relevant today?

Further Learning Activities (Beyond the Video)

Creative Activities

Explore the following creative activities with your students, either as written answers, group discussion, or projects:

- ➢ Build a sextant using materials found around the classroom, such as protractors. There are multiple tutorials online on how to build a sextant, or challenge students to make one without instructions. The finished sextant can be used to locate your latitude using the North Star or pick an object on the ceiling to demonstrate.
- ➢ The search for a way to measure longitude was a problem that perplexed sailors and inventors for centuries. Identify a challenge we face today. Do you think a single piece of technology could solve this problem? Why or why not?

Inquiry Projects

Expand on learning with an inquiry-based project, such as:

- ➢ There are many ways people can locate where they are. Reflecting on your own experiences and different cultural practices, list some ways you can locate where you are. Research navigation or mapmaking technology/knowledge from another culture or time period.
- ➢ This video shows the challenge of determining longitude at sea, and how the invention of the chronometer helped solve this problem. Research another technology that changed the course of history.
    - What technologies and knowledge informed the invention of your chosen technology?
    - What historical events were enabled by this technology?
    - Who did this technology impact?