"Take (Careful) Observations of Latitude and Longitude"
(Thomas Jefferson to Captain Lewis prior to expedition)

Objectives. After completing this lesson, students will be able to

- explain how latitude and longitude can be used to locate places.
- describe some of the tools used by Lewis and Clark and determine latitude using those tools.
- analyze the limitations of the tools and techniques of Lewis and Clark.

Lesson Overview.
In this online simulation, students will explore the concepts of latitude and longitude, examine the mathematical instruments used by Lewis and Clark for navigation, and try to determine their latitude position using those instruments. Students will compare notations of latitude made by the explorers with actual latitudes known today and analyze differences.

Preliminary Activities (Optional)	Introduction (10 minutes)	Web Activity (30 minutes)	Assessment (10 minutes)	Extensions (Optional)
Learn about the object of the Lewis and Clark mission; explore latitude and longitude.	Connect to previous knowledge; review purpose of expedition, latitude, longitude.	Simulate the use of navigational tools of Lewis and Clark; evaluate accuracy.	Questions for class discussion or written assessment.	Topics and resources for additional research; longitude calculations.

Background for the Teacher.
The main goals of the Lewis and Clark expedition included scientific discovery, economics, and politics. In his directions to Meriwether Lewis, President Thomas Jefferson wrote,

> "Beginning at the mouth of the Missouri, you will take careful observations of latitude and longitude, at all remarkable points on the river... Your observations are to be taken with great pains and accuracy, to be entered distinctly and intelligibly for others as well as yourself..."

Among the most important aspects of scientific discovery were the identification of plants and animals of each region, descriptions of the soil, landforms, and climate, and the mapping, complete with latitude and longitude. Meriwether Lewis had little prior experience with survey and navigation equipment, so, prior to the expedition, Jefferson sent him to be trained by respected mathematician Robert Patterson, as well as Major Andrew Ellicott, a leading surveyor of that time. William Clark, on the other hand, had considerable experience as a wilderness surveyor, and some experts have suggested that his expedition data were more accurate than that of Lewis.

Today, surveyors rely on sophisticated tools such as global positioning systems. Two hundred years ago, Lewis and Clark relied on the best technology available to them. If cost can be used as a measure of importance to the expedition, then the mathematical instruments they carried with them were among the most important items in their cargo. These instruments included a sextant, an octant, an artificial horizon, a surveying compass, and a chronometer, and reference books. Here's how they were used.

1. At noon, Lewis and Clark lined up the horizon in the telescope of their sextant, moving the index mirror on top until they could see the sun superimposed on the horizon.
2. They read the angle of the sun from the scale on the sextant, then looked up the current date in the Nautical Almanac of 1765 to find the degrees of latitude.
3. The octant was very similar to the sextant, but it had a larger scale, so it was during the summer months when the sun was higher in the sky.
4. When the true horizon was obscured (as it often was) by mountains, trees or fog, Lewis and Clark used an artificial horizon, a simple tool containing a pool of water or liquid mercury covered by a sheet of glass. The artificial horizon could be held in front of the sextant to reflect the image of the sun into the instruments mirrors, resulting in an angle reading exactly twice the altitude of the sun. Dividing by two would give them the angle to look up the latitude in their Nautical Almanac.

Figuring longitude, however, was a different ball game. Lewis and Clark used various methods, but invariably, their measurements were quite inaccurate. This problem was not unique to Lewis and Clark, however, but was largely the fault of the unreliable portable chronometers of the day. One method required finding exact local time using the sextant and comparing it with Greenwich Mean Time. Another method involved measuring angles between the moon and certain stars, then using extensive navigational charts to determine longitude based on those relative positions at specific times on specific dates. Though they faithfully attempted to determine longitude throughout their journey, modern analysis shows that even all their practice did not improve their results.

Classroom Management Tips.

1. Complete any desired preliminary activities (below) prior to beginning this activity.

2. Prior to activity, reserve computer lab as necessary.

3. Decide ahead of time how you will organize your class for the online activities. If you have enough computers, you may wish to have students work alone at a computer. Two students per computer may stimulate additional discussion and interaction. Three or more students to a computer can result in some students being left out of the activity unless you use certain strategies such as assigning each group member a task. If a projector and interactive whiteboard are available, you may wish to do this as a whole class activity, allowing students to take turns manipulating the activities with a mouse or on the whiteboard.

Preliminary Activity Ideas.

Before beginning this lesson with your students, you may wish to do one or more of the following activities.

1. "Using Latitude and Longitude to Map the Lewis and Clark Trail" In this activity, students will practice using latitude and longitude to plot coordinates recorded by Lewis and Clark on a map. Using those coordinates, students will trace the course of the Lewis and Clark expedition. Student Activity Guide and Teaching Tips are available at the end of this Lesson Plan.

2. Show your class segments of the Lewis and Clark Rediscovery Interactive CD using a computer projector. (Note: The CD will need to be installed on the computer prior to use and inserted during use.) From the Main Menu, select North America 1803 for a brief slide show (5 minutes) about the events leading up to the expedition. For a brief slide show about the challenges of river travel, select Expedition from the Main Menu, then The Known from the territory choices. Click on the Expedition Case, then Technology/Daily Life to see a number of Peace Medal icons. Clicking on the second Peace Medal, upriver from St. Louis, will launch "Latitude and Longitude." Explore other segments and show those that you find appropriate, or allow your students to explore on their own. A limited number of these CDs are available from the Columbia Gorge Discovery Center at no charge. Contact Education Director, Steve Thompson, for information. steve@gorgediscovery.org or (541) 296-8600

3. "Lewis and Clark: The Object of the Mission" (1 hour). National Geographic / Marco Polo Xpeditions online lesson plan http://www.nationalgeographic.com/xpeditions/lessons/13/g68/object.html Students explore the mission of the Lewis and Clark Expedition and why the expedition was so important to Thomas Jefferson.

Suggested Procedure.

1. Activate students' prior knowledge with the following questions for discussion. (5 minutes)
   - What do you think were the most important tasks or missions of the Lewis and Clark expedition? *Answers should include: to map the area, to find the most direct route to the Pacific Ocean, to open the area up for later trade and expansion, to find out about the native people of the area.*
   - How long did it take them to get to the Pacific Ocean and back? What were some reasons it took so long? *Answers should include: their methods of travel were very primitive by today's standards, they had no maps.*
2. Divide students into small groups and have them make a list of things they would want to take if they were going on a long backpacking trip (or cross-country bike trip or car trip) perhaps in a foreign country, to help them navigate. Share ideas with the class after five minutes. Ask the class which of those things they think Lewis and Clark had available to them. (5 minutes)

3. Have students do the online activity. (30 minutes) Go to our Distance Education site at http://www.gorgediscovery.org/distanceEducation.aspx and click on the link for the interactive activity link portion of "Take Careful Observations."

4. Follow-up discussion questions. (10 minutes)
   - Name and describe the navigational tools Lewis and Clark used on their journey. *Answers should include a sextant, compass, artificial horizon, and a nautical almanac.*
   - How were these tools used to determine latitude? *Students may describe viewing the sun through the eyepiece until it is superimposed on the horizon, reading the angle from the index arm, then looking up the angle (and other factors) in the nautical almanac to determine the corrected latitude.*
   - How accurate were Lewis and Clark in their measurements of latitude? *Answers should recognize that Lewis and Clark were within the accepted standard of error for their time – 35 minutes. But this error meant that their coordinates of latitude and longitude could be off by several miles.*
   - Describe some of the limitations of the tools and their methods. *Even the most experienced navigators of the day experienced, a significant error by today's standards. There was error in the instruments themselves and error in the techniques. In addition, these techniques were time-consuming and required certain specific conditions in order to be possible in the first place. Today, once a GPS unit is calibrated, it can be used to pinpoint latitude and longitude most anywhere on Earth, whether it's daytime or night, cloudy or clear, hilly or flat.*

Extensions.

1. "A Little Latitude in those Latitudes (and Longitudes)." Downloadable from activity website and included at the end of this Lesson Plan. In this activity, students will use Mapquest to compare the latitude and longitude taken by Lewis and Clark with today's known latitude and longitude, analyze sources and impact of error.

2. "The Long and Short of Longitude." Downloadable from activity website and included at the end of this Lesson Plan. Lewis and Clark were within the accepted standard of error of their time with their latitude readings. However, many of their longitude readings contained significant errors. In this web-quest activity, students will learn how Lewis and Clark tried to determine longitude and why they were so far off in many instances.

3. Borrow our Classroom Navigation Kit, which includes a working sextant, an artificial horizon, a nautical almanac and directions. Contact Education Director, Steve Thompson, for information. steve@gorgediscovery.org or (541) 296-8600

4. Learn how to use a handheld GPS unit or have a car dealer bring a new car with a GPS unit installed and show class how it works.

Additional Resources.

Websites

Explanations of the use of the mathematical instruments by Lewis and Clark; includes links to media of an octant and sextant and a sidebar comparing GPS to Lewis and Clarks' techniques.
http://www.lewis-clark.org/MAPTERRINCOG/nav_mti4.htm

An interesting discussion of sources of error in Lewis' calculations.
http://www.irbs.com/lists/navigation/0306/0030.html

Discussion of the inaccuracies in measurements by Lewis and Clark.
http://www.l3-lewisandclark.com/ShowOneObject.asp?SiteID=79&ObjectID=872

Charts made by L&C to record navigational data.
http://www.edgate.com/lewisandclark/mapping_on_trail.html

The companion website with classroom lessons for the PBS Ken Burns Lewis and Clark documentary series.
http://www.pbs.org/lewisandclark/class/idx_les.html

The Journals of Lewis and Clark Online. http://libtextcenter.unl.edu/lewisandclark/index.html

"Latitude, Longitude, and Mapmaking" National Geographic / Marco Polo Xpeditions online lesson plan http://www.nationalgeographic.com/xpeditions/lessons/01/g68/mapmaking.html

Books

Sobel, Dava, and J.H. William Andrewes. The Illustrated Longitude. London: Fourth Estate Limited, 1998.

Articles

Large, Arlen J. "How Far West Am I? The Almanac as an Explorer's Yardstick." Great Plains Quarterly. Spring 1993, 13:117-131.

Starr, Eileen. "Celestial Navigation Basics: How the Captains Found Latitude and (Sometimes) Longitude." We Proceeded On. November 2001, 27(4): 12-18.

Bergantino, Robert N. "Revisiting Fort Mandan's Longitude: Lewis Doubted his Data, but the Fault was in his Calculations." We Proceeded On. November 2001, 27(4): 19-26.

Rudner, Lawrence A. and Hans A. Heynau. "Revisiting Fort Mandan's Latitude: Lewis Got it Almost Right." We Proceeded On. November 2001, 27(4): 27-18.

Oregon Benchmarks.

Math Grade 8

- Collect and display data as lists, tables, and plots using appropriate technology (collect and display data)
- Determine actual distances from scale drawings, blueprints, and maps and solve problems involving scale factors (direct and indirect measurement)

Math Grade 10

- Determine the precision of a given measuring tool (units and tools)
- Develop and understand, and use the formula for determining arc length (direct and indirect measurement)
- Make and use scale drawings and models to solve problems (direct and indirect measurement)

Science Grade 8

- Summarize and analyze data including possible sources of error. Explain results and offer reasonable and accurate interpretations and implications. (scientific inquiry)

Science Grade 10

- Summarize and analyze data, evaluating sources of error or bias. Propose explanations that are supported by data and knowledge of scientific terminology. (scientific inquiry)

Social Science Grade 8

- Understand fundamental geography vocabulary such as concepts of distance, latitude, longitude, interdependence, accessibility, and connections.
- Read, interpret, and understand how to construct geographic representations to analyze information, understand spatial relationships, and compare places.
- Evaluate data within the context it was created, testing its reliability, credibility, and bias.
- Understand how individuals, issues, and events changed or significantly influenced the course of U.S. history post American Revolution through 1900.

Social Science Grade 10

- Understand and use geographic information using a variety of scales, patterns of distribution, and arrangement.
- Interpret and evaluate information using complex geographic representations.
- Understand how contemporary perspectives affect historical interpretation.

Appendices. Student Activity Guides and Teaching Tips are provided on the following pages for the following activities described in this Teacher Lesson Plan. The two extension activities are also available at the end of the interactive activity.

Preliminary Activity 1
Using Latitude and Longitude to Map the Lewis and Clark Trail

Extension 1
A Little Latitude in Those Latitudes (and Longitudes)

Extension 2
The Long and Short of Longitude

Name_____ **Take Careful Observations**
Preliminary Activity 1

Using Latitude and Longitude to Map the Lewis and Clark Trail
Student Activity Guide

Introduction
How do we know where Meriwether Lewis, William Clark, and the Corps of Discovery traveled on their famous expedition? Fortunately for us, the captains and several members of the crew kept journals with detailed descriptions of their travels, including their latitude and longitude positions. The tools they had available to them for determining latitude and longitude were primitive by today's standards, but experts generally agree that Lewis and Clark did a pretty good job under the circumstances. In this activity, you will use latitude and longitude coordinates to map the course of the Lewis and Clark Expedition from St. Louis, Missouri to the Pacific Ocean.

Objectives
After completing this activity, you will be able to
- Plot latitude and longitude coordinates on a map
- Describe the course of the Lewis and Clark expedition

Materials
- Map of the United States with latitude and longitude lines
- Colored pencils

Directions
1. Use the table on the next page to look up coordinates of latitude and longitude recorded by Lewis and Clark.
2. Plot each point on the map provided by your teacher. You can round off to the nearest degree of latitude or longitude as your map will not be detailed enough to represent minutes. (Each *degree* of latitude or longitude is sub-divided into 60 units called *minutes*, and each minute is sub-divided into 60 units called *seconds*.)
3. As you plot each coordinate, fill in the column of the table describing the present-day *location* of that coordinate as accurately as you can (the first one is done for you as an example).
4. When you have plotted all the coordinates, connect your points with a line which will roughly show the course of the Lewis and Clark Expedition.
5. Answer the questions on the next page.

Table - Lewis and Clark's Latitude and Longitude Coordinates

Latitude	Longitude	Location
38° 31' N	91° 47' W	Near the city of St. Louis, Missouri
39° 05' N	94° 08' W	
40° 27' N	93° 11' W	
41° 06' N	96° 24' W	
42° 51' N	97° 28' W	
47° 21' N	100° 37' W	
48° 06' N	103° 39' W	
47° 29' N	108° 31'W	
47° 27' N	111° 18' W	
45° 24' N	111° 19' W	
44° 40' N	112° 56' W	
46° 30' N	116° 15' W	
45° 0' N	121° 0' W	
46° 19' N	124° 4' W	

Questions for Practice and Analysis

1. Using your map scale, estimate how far Lewis and Clark traveled on their entire journey. (Hint: Don't forget that they had to go back to St. Louis once they got to the Pacific Ocean.)

2. How is the map that you used for this activity probably different than the map that Lewis and Clark had as they traveled through this territory?

3. Do you think the line you drew represents the exact route that Lewis and Clark traveled? Why or why not?

Using Latitude and Longitude to Map the Lewis and Clark Trail
Teaching Tips

Suggestions

- Make copies of the Student Activity Guide for your class.
- If you have a good map of the United States that shows latitude and longitude lines, make copies ahead of time for your students. If not, try these online sources for making and printing such a map.
  http://www.nationalgeographic.com/xpeditions/atlas/index.html
  http://www.nationalatlas.gov/
- If your map has state boundaries, remind students that the state boundaries didn't exist at the time of the Lewis and Clark Expedition, but for this activity, they will help students visualize the route of the Expedition.
- Remind students that each ***degree*** of latitude or longitude is sub-divided into 60 ***minutes*** and each minute is sub-divided into 60 ***seconds***, emphasizing that these are not units of time, but rather units of distance to help locate places on Earth. In this activity, students can simply "round off" to the nearest degree since the map will not be detailed enough to plot minutes or seconds.
- If your students haven't had much experience plotting latitude and longitude positions, make a transparency of your map and plot the first couple of coordinates together with the class, demonstrating for them how to estimate approximately where the coordinates would be.

For Fun

Your kinesthetic learners will enjoy learning about significant lines of latitude this way. Begin by explaining what significant lines of latitude are – the North and South Poles, the Arctic and Antarctic Circles, the Equator, and the Tropics of Cancer and Capricorn. Have your students draw a circle to represent the earth and label these lines of latitude on their "planet." Model it for them on the board or an overhead projector.

Next, have the students "be the earth." Identify each significant line of latitude with a part of the body as follows:

- North Pole = top of head
- Arctic Circle = ears
- Tropic of Cancer = shoulders
- Equator = waist
- Tropic of Capricorn = knees
- Antarctic Circle = shins
- South Pole = toes

After students have these locations figured out, the class begins "globe aerobics" aka Simon Says! (Source: http://geography.about.com/od/teachgeography/a/classlatitude.htm)

Suggested Answers to Questions for Practice and Analysis

1. Using your map scale, estimate how far Lewis and Clark traveled on their entire journey. (Hint: Don't forget that they had to go back to St. Louis once they got to the Pacific Ocean.) *Answers may vary but should be somewhere around 8,000 miles.*

2. How is the map that you used for this activity probably different than the map that Lewis and Clark had as they traveled through this territory? *Answers may include that the map students are using shows state boundaries and at the time of Lewis and Clark, there were no states west of Ohio, Kentucky, Tennessee, and Georgia. The map students are using may show cities, and at the time, there were no cities established west of St. Louis.*

3. Do you think the line you drew represents the exact route that Lewis and Clark traveled? Why or why not? *These are the coordinates established by Lewis and Clark. Their measurements and calculations were not exact. Students my note that they cannot plot the coordinates very accurately because of the map scale.*

Name_____ **Take Careful Observations**
Extension 1

A Little Latitude in Those Latitudes (and Longitudes)
Student Activity Guide

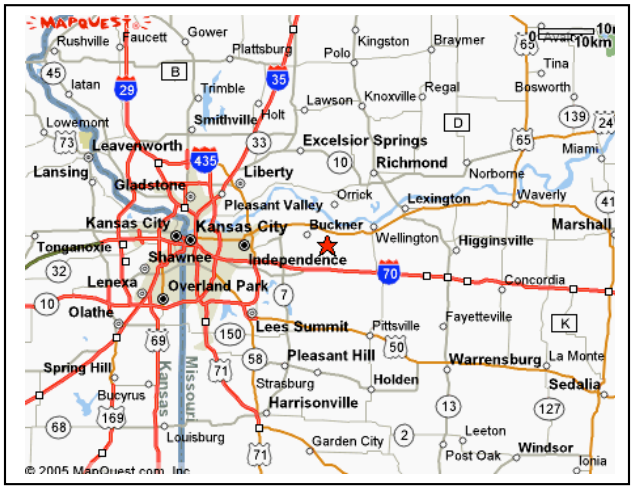
Introduction
Compared to modern global positioning technology, the tools Lewis and Clark had available to them to determine latitude and longitude were quite primitive. Today, using a hand-held GPS unit, you can pinpoint your location to within a couple of inches. How do the latitude and longitude positions recorded by Lewis and Clark during their expedition compare to the coordinates we know for these same locations today? In this activity, your task is to find out just how far off Lewis and Clark were.

Objectives
After completing this activity, you will be able to
- Compare latitude and longitude coordinates recorded by Lewis and Clark with the known coordinates of today
- Use a map scale to estimate the amount of error in the coordinates recorded by Lewis and Clark
- Analyze the impact of that error upon modern efforts to study the Lewis and Clark Expedition

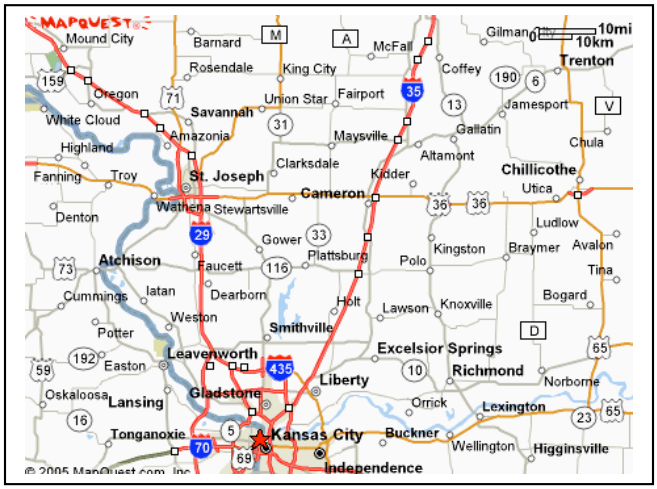
Materials
- Computer with internet access
- One index card
- Pencil

Directions
6. Use the table on the page 3 of this activity to look up coordinates of latitude and longitude recorded by Lewis and Clark and coordinates of known latitude and longitudes of those same places today.
7. Open two web browser windows and type the following URL in the address bar of both: **http://www.mapquest.com/maps/latlong.adp .** You will see a MapQuest website that provides maps based on latitude and longitude coordinates.
8. In one of the browser windows, enter the latitude and longitude coordinates Lewis and Clark recorded for June 29, 1804.
    a. An entry is required for every field. Since Lewis and Clark did not record seconds, enter "0" in the seconds field.
    b. MapQuest requires that distance north of the Equator and east of the Prime Meridian must be entered as positive numbers, and distance south of the Equator and west of the Prime Meridian must be entered as negative numbers. So, all the latitude coordinates for this activity, being north of the Equator, will be entered as positive numbers. But, all the longitude coordinates, being west of the Prime Meridian will be entered as negative numbers.

9. In the second browser window, enter the known latitude and longitude for the location Lewis and Clark visited on June 29, 1804. Follow the same directions as in number 3 above.
10. Resize both browser windows so that both maps can be seen on your monitor at the same time. Compare the location of the latitude and longitude coordinates recorded by Lewis and Clark with the known coordinates for those locations. You may need to zoom out once or twice using the zoom tool to the right of the map. Just be sure that if you zoom out the same amount on both maps. Your map scales should be the same on both maps.
11. Using the map scales provided, estimate how far off Lewis and Clark were. To do this, locate the red star marking the location on the map showing the known latitude and longitude coordinates (below, right). Next, locate that same site on the map showing the Lewis and Clark coordinates for June 11, 1804 (below left). Using the map scale, estimate how far off Lewis and Clark were. You may want to use an index card to mark the map scale along one edge, and use that to measure the approximate distance between the known location (in this case, Kansas City) and the coordinates recorded by Lewis and Clark (in this case, a little southeast of Buckner).



Lewis and Clark: 39º 5' N 94º8' W



Actual Coordinates: 39 7' 12"N 94 36' 0"W

12. Record your estimate in the table in the space provided.
13. Repeat the procedure for the other four sets of coordinates provided.
14. Find the average error in Lewis and Clark's latitude and longitude coordinates. Record the average error in the table in the space provided.
15. Complete the Questions for Practice and Analysis

Table - Lewis and Clark's Latitude and Longitude Coordinates Compared to Known Coordinates of Today

Date	L&C Latitude	L&C Longitude*	Known Latitude	Known Longitude*	Estimated Difference in miles
June 29 1804	39º 5' N	94º 8' W	39º 7' 12" N	94º 36' 0" W	
July 12 1804	39º 56' N	94º 51" W	40º 1' 48" N	95º 22' 48" W	
February 6 1805	47º 21' N	100º 37' W	47º 16' 54"N	101º 16'24"W	
June 9 1805	47º 29' N	110º 29' 4"W	47º 55' 45"N	110º 29' 4" W	
August 20 1805	44º 40' N	112º 56' W	44º 59' 25"N	112º 51' 52W	
Average					

*Remember to use a negative number when entering degrees west of the Prime Meridian in Mapquest field.

Questions for Practice and Analysis

1. Were Lewis and Clark more accurate on their measurements of latitude or of longitude? Why do you think that might be?

2. What was the average error? Is that good or bad, considering the equipment they had to use?

3. What problems might have resulted from inaccurate latitude and longitude data during the time of Lewis and Clark?

4. What problems might such error present for modern day historians and archaeologists who might be researching the Lewis and Clark Expedition?

A Little Latitude in Those Latitudes (and Longitudes)
Teaching Tips

Suggestions

- Reserve the computer lab ahead of time, if necessary.
- Make copies of the Student Activity Guide for your class.
- Provide index cards for measuring during the activity.
- Decide ahead of time how you will organize your class for the online activities. Depending upon the skill level of your students, you may wish to demonstrate the first problem to your class using a computer with a projector. Juggling and keeping track of the two browser windows at once can be challenging to students who have not used computers in this way before. For many of them, however, this sort of multi-tasking is second nature. An alternative would be to pair students who are more comfortable using computers with those who are not as comfortable.
- If computer access is limited, you can create a handout with maps for each of the sets of coordinates beside each other, and have students estimate error from that.
- Remind students to use a negative number when entering degrees west of the Prime Meridian to the Mapquest input field.

Suggested Answers to Questions for Practice and Analysis and Information for Class Discussion

1. Were Lewis and Clark more accurate on their measurements of latitude or of longitude? Why do you think that might be? *Students may answer that latitude may have been easier to figure out with their equipment.*

2.What was the average error? Is that good or bad, considering the equipment they had to use? *The average error in miles for these five sets of coordinates is about _____ miles. Lewis and Clark were off by as little as 2.5 miles and as much as 62 miles. It took more than reading a sextant to establish a global position during their time. The numbers from the instrument reading had to be plugged into a mathematical formula that required the translation of several charts, such as a nautical almanac. There were plenty of opportunities for error. Nevertheless, they were generally within the accepted standard of error for their time for latitude, about 35 minutes. Longitude was less accurate.*

3. What problems might have resulted from inaccurate latitude and longitude data during the time of Lewis and Clark? *People who came to the same area after them may not have been able to find the same places.*

4. What problems might such error present for modern day historians and archaeologists who might be researching the Lewis and Clark Expedition? *Lewis and Clark made over 600 campsites during their expedition. Only two of them have been located by archaeologists. Historians would like to go to the exact sites of some of these camps to look for evidence, and thus possibly more information about the expedition. Without precise latitude and longitude coordinates, the task is much more difficult.*

Name_____ **Take Careful Observations Extension 2**

The Long and Short of Longitude
Student Activity Guide

Introduction
As you learned in the activity, "Take Careful Observations," Lewis and Clark did a respectable job finding latitude during their expedition. Finding longitude, however, was a different story. In theory, finding longitude should have been relatively easy. In practice, though, it was quite difficult. In fact, Lewis and Clark completed just one computation of longitude, and that was completed very early on during the expedition. Instead, Lewis and Clark gathered the necessary data and recorded it faithfully in their journals, with the intent of bringing the data back for professional mathematicians to use in making longitude calculations after the expedition. In this activity, you will learn more about the challenge of determining longitude during the time of Lewis and Clark.

Objectives
After completing this activity, you will be able to
- Determine your longitude using the techniques available to Lewis and Clark.
- Explain limitations of those techniques.

Materials
- Computer with internet access
- Calculator

Directions
1. Go to the websites identified in each Question of this activity to read about a topic or practice a skill.
2. Complete the questions and problems as provided.

Questions for Practice and Analysis

1. In theory, calculating longitude was relatively simple. Go to these two web pages to read about the methods Lewis and Clark used to find longitude.

http://lewisandclarktrail.com/clarksmap.htm
http://www.esri.com/lewisandclark/locationthen.html

In the space below, describe the captains' methods for finding longitude.

2. Try it yourself! Go to this NOVA website and click on "Play Find Your Longitude."
http://www.pbs.org/wgbh/nova/longitude/find.html
Now, imagine that you are Captain Lewis. With your sextant, you determine the precise moment the sun reaches its *zenith*, its highest point in the sky. This is exactly noon, local time. Using your chronometer that is set to Greenwich, England time, the Prime Meridian, you can calculate your longitude. Try these problems on your own.

a. It's 12:00 pm (noon), local time. Your chronometer shows that it's 7:00 pm in Greenwich. What is your longitude?

b. It's 12:00 pm (noon), local time. Your chronometer show that it's 6:20 pm in Greenwich. What is your longitude?

c. It's 12:00 pm (noon), local time. Your chronometer show that it's 7:24 pm in Greenwich. What is your longitude?

d. Super Challenge! It's 12:00 pm (noon), local time. Your chronometer show that it's 6:49 pm in Greenwich. What is your longitude?

3. That wasn't so difficult. So…why did Lewis and Clark do so well with latitude and so poorly with longitude? Go to these web pages to find out.
http://www.lewis-clark.org/content/content-article.asp?ArticleID=1268
http://www.nps.gov/jeff/LewisClark2/TheJourney/Mapmaking.htm
In the space below, list as many reason as you can think of why Lewis and Clark's longitude calculations were often inaccurate.

The Long and Short of Longitude
Teaching Tips

Suggestions

- Reserve the computer lab ahead of time, if necessary.
- Make copies of the Student Activity Guide for your class.
- Decide ahead of time how you will organize your class for the online activities. This activity works well with two students working together at one computer. You may wish to pair students who are more comfortable using computers with those who are not as comfortable. Also, because there are some math skills involved, you may wish to group students more skilled in math with those less skilled.

Suggested Answers to Questions for Practice and Analysis and Information for Class Discussion

1. In theory, calculating longitude was relatively simple. Go to these two web pages to read about the methods Lewis and Clark used to find longitude.

http://lewisandclarktrail.com/clarksmap.htm
http://www.esri.com/lewisandclark/locationthen.html

In the space below, describe the captains' methods for finding longitude.

The primary method of determining longitude was to compare local time to the known time at the Prime Meridian in Greenwich, England. Knowing that the earth rotates around its axis one time, in other words 360 degrees, in 24 hours, we can calculate that any point on Earth travels 15 degrees in one hour (360/24).
Lewis and Clark used a sextant or octant to determine when the sun was at it's zenith, or highest point. This represented 12 pm or noon, local time. They calculated the difference between local time and Greenwich time, to which their chronometer was set. If the difference was 6 hours, they multiplied 6 x 15º to determine that their longitude was 90º W of the Prime Meridian.

2. Try it yourself! Go to this NOVA website and click on "Play Find Your Longitude."

http://www.pbs.org/wgbh/nova/longitude/find.html

Now, imagine that you are Captain Lewis. With your sextant, you determine the precise moment the sun reaches its *zenith*, its highest point in the sky. This is exactly noon, local time. Using your chronometer that is set to Greenwich, England time, the Prime Meridian, you can calculate your longitude. Try these problems on your own.

a. It's 12:00 pm (noon), local time. Your chronometer shows that it's 7:00 pm in Greenwich. What is your longitude?
105º W Solution: 7 hours x 15º per hour

b. It's 12:00 pm (noon), local time. Your chronometer show that it's 6:20 pm in Greenwich. What is your longitude?

95° W Solution: 90° 6 hours x 15° per hour
+5° 20 minutes = 1/3 of an hour, 1/3 of 15°

c. It's 12:00 pm (noon), local time. Your chronometer show that it's 7:24 pm in Greenwich. What is your longitude?

111° W Solution: 105° 7 hours x 15° per hour
+5° 20 minutes = 1/3 of an hour, 1/3 of 15°
+1° 4 minutes = 1/15 of an hour = 1°

d. Super Challenge! It's 12:00 pm (noon), local time. Your chronometer show that it's 6:49 pm in Greenwich. What is your longitude?

102° 15' W Solution: 90° 6 hours x 15° per hour
+12° 40 min. since 1° = 4 minutes
+ 15' 1 min. since 1 min. = 1/4 of 1°

3. That wasn't so difficult. So…why did Lewis and Clark do so well with latitude and so poorly with longitude? Go to these web pages to find out.

http://www.lewis-clark.org/content/content-article.asp?ArticleID=1268
http://www.nps.gov/jeff/LewisClark2/TheJourney/Mapmaking.htm

In the space below, list as many reason as you can think of why Lewis and Clark's longitude calculations were often inaccurate.

The primary cause of miscalculated longitudes on the Lewis and Clark Expedition was inaccuracy in the chronometer. Lewis recorded in his journal several occasions when he failed to wind it, when it stopped running due to getting wet, or other unknown causes. In addition, finding the exact point of the sun's zenith, local noon (or other celestial observations that could be used to calculate longitude) was impossible with the equipment they had. Even being off by a few seconds in time could result in errors of several minutes of longitude. Other sources of error noted by historians include errors in the nautical almanac calculations, conditions of extreme heat or cold or low humidity that could have affected the sextant or octant and miscalculations on the part of Lewis and Clark.