GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2209 | FINDERS, KEEPERS

MAPPING THE FLOOR OF THE GREAT LAKES

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **sound waves underwater** used to map landforms and how modern technology is helping update the maps of the terrain beneath the Great Lakes. Students will learn about the history of mapping the lakebed and the SONAR technology used by NOAA to upgrade our maps.

LESSON OBJECTIVES

- **Know** the history of our existing Great Lakes bathymetry
- **Understand** how modern technology is being used to map the bottom of the Great Lakes
- **Be able to** estimate the speed of sound in air

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

The existing bathymetry, or measurement data of the bottom of a body of water, for the Great Lakes is surprisingly old. What's more is that the methods used to develop the original maps of the lake floors was primitive, at best, in comparison to modern technology for doing the job. Currently, the National Oceanic and Atmospheric Association (NOAA) is looking to change that by using state of the art SONAR technology to map the bottoms of the Great Lakes. The result should be much more detailed maps of the lakes than ever before—likely yielding new information about lakebed features that we didn't even know were there.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- measurement in the metric system
- unit conversion calculations
- sound waves
- graphing
- linear equations (e.g., y=mx+b)
- temperature and kinetic molecular theory

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our full collection of lessons for more activities related to topics like these.

*****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Sound Waves in Water

- ESS2-2
- ETS1-2
- SEP-2
- SEP-3
- SEP-4
- SEP-5

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit or activate prior knowledge about echolocation
- Close reading of a video with a partner
- Teacher notes on SONAR and bathymetry
- Watch a segment from *Great Lakes Now*
- Class discussion to debrief the video
- Read about bathymetry
- Mathematically model correction factors using temperature
- Conduct an experiment to estimate the speed of sound in air

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at:
GreatLakesNow@DPTV.org

TEACHER BACKGROUND INFORMATION

by Great Lakes Now Contributor, Gary G. Abud, Jr.

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

Lake bottoms are easy to see in shallow clear waters, but how do scientists observe the floor of lakes and other bodies of water when the depth is too great to observe visually? They use another of their five senses—hearing—or at least devices that are able to 'hear' where the human ear can't.

Sound waves are a vibration of colliding particles that make up the substance through which the wave is traveling (e.g., air, water, etc.) As the particles collide—like bumper cars—one after another, they eventually reach a large object that pushes back on them in such a way as to create a vibration in the reverse direction—an echo—that can be sensed by a device as vibrations reach it.

Sound Navigation And Ranging (SONAR) is just over a century's old technology. This "listening" equipment was the result of prior scientific knowledge and discoveries, but the first working SONAR device was created by Canadian physicist Robert Boyle in 1917 to sense reflected vibrations.

Mimicking the echo-location of animals, SONAR technology emits a sound wave and measures the time it takes for the reflection of that sound wave to return back to the instrument from whatever it bounced off of. With knowledge of the speed at which sound travels, and a direct measurement of the time the emitted sound wave is traveling, SONAR makes possible the calculation of what distance away an object is from the device.

That means the longer it takes for the reflected sound to return, the farther the distance away the object is that reflected the sound wave from the SONAR. In this way, SONAR can observe things where visibility may not be possible—such as underwater terrain. You can see how this process works in this SONAR **video** from NOAA, including a visualization that shows how SONAR data is used to make nautical charts. Ships travel across the waters with their SONAR devices sending sound waves underwater. As they are reflected back off of whatever they hit beneath the water, the ship records the time it takes the sound wave to return and maps the time to calculate the distance and generate a **relief map** of the landscape below the water's surface.

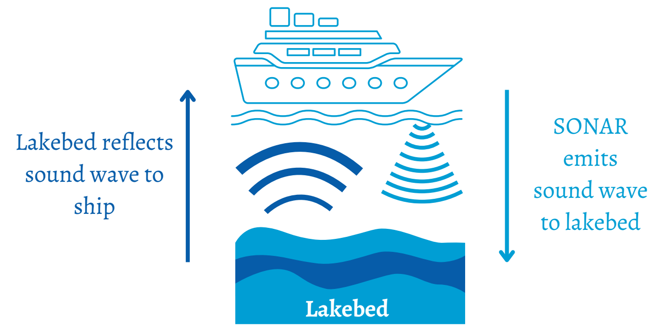


Image Credit: Gary Abud, Jr.

The process of mapping the depths of the bottom of a body of water—whether freshwater or saltwater—is known as **bathymetry**. And this measurement process was not always done using high-tech approaches. To determine the depth at different points under water, scientists used to drop a line with a lead weight down in the water until it struck the bottom and then measure the length of rope that was submerged.

Taking measurements like this across the Great Lakes is how we developed our first maps of the bottoms of Huron, Ontario, Michigan, Erie, and Superior. But the limitations of that method left us with only a rough idea of what the lakebeds look like, and now modern SONAR technology is giving our bathymetric knowledge an upgrade.

There's just one problem: sound waves travel slower in colder water than in warmer water, because the vibrating particles have less energy to move at colder temperatures. So, since lake temperatures can vary, bathymetry techniques need to be able to mathematically account for temperature variances when using SONAR using what's known as a **correction factor**.

Correction factors are a way of consistently adjusting a measurement—usually by adding or subtracting a known quantity by which the original measurement is observed to be off—so that it can be as accurate as possible.

According to the National Oceanic and Atmospheric Association (NOAA), 80% of the world's sea floor remains unobserved and unexplored, Using modern SONAR technology that is starting to change. The result is that we will soon have highly-detailed maps and images of the bottoms of the Great Lakes to help us learn more about the environment and ecosystem of the waterways, as well as the mysteries that lie beneath their surface.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **echolocation**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **echolocation** that they already know about or that came to mind during this exercise.

Image Credit: Great Lakes Now

B. Close Reading a Video

Watch **this video about echolocation** in bats from PBS LearningMedia and then show them **this second video about echolocation** in aquatic animals.

Have students discuss with a partner:

- what was said?
- how was it said?
- why was it said?

Then have two sets of partners form a small group and make connections between their partner conversations about the videos and the ideas that came up during the warm up activity about things that came to mind about echolocation.

C. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come:

- Have students pair up to complete the online activity: **Underwater Frontiers: A Brief History of Seafloor Mapping** from NOAA.
- Debrief the activity with the whole class by asking them to write down one thing from this activity that they'd like to remember 10 years from now.
- Have them think pair share with a partner to elaborate on their ideas
- Invite a few students to explain their idea out loud with the whole group.

D. Background Information Notes

Explain that we are going to build on these ideas and learn more about echolocation technology—SONAR—in this lesson. Then proceed to give the notes from the **Teacher Background Information**.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing the use of SONAR to map the bottoms of the Great Lakes. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm…** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2209 of *Great Lakes Now* called **Mind the Map**.

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video the related to what we discussed earlier in this lesson during the warm up?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the video segment and what they discussed during the warm up activities earlier in the lesson about what they knew about **echolocation**

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT THE BENEFITS OF BATHYMETRY

The methods of mapping the floor of the Great Lakes have advanced by leaps and bounds over time. From lead sinker plumb line measurements to SONAR, the modern technology shaping Great Lakes bathymetry is nothing short of incredible.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Researchers Race to Understand What Lies Beneath the Great Lakes** by Kelly House from *Bridge Michigan*. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along.

Image Credit: Great Lakes Now

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group.

As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Based on the article, how might SONAR help the efforts to create updated maps of the Great Lakes lakebeds?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached.

Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

ACTIVITY 3: MEASURE THE SPEED OF SOUND IN AIR

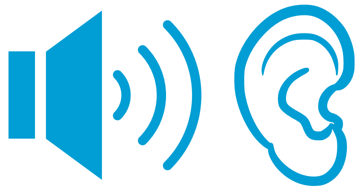


Image Credit: Gary Abud, Jr.

In this activity, students will conduct an experiment to estimate the speed of sound in air. Depending on the space available, this could be done as a whole-class activity or completed in small groups. Begin by asking students if they know the speed of sound in room temperature air. Some may know this fact while others do not. If no one knows, have someone do a quick web search and look it up. Once everyone knows the value (about 343m/s, or roughly 1 mi / 4.7s), ask students to turn and talk with a partner about what this value means. Elicit a few responses from the class. Guide them to focus on the fact that it is a speed of how much distance is traveled for every one second. Explain to them that they will be conducting an experiment to estimate the speed of sound in air today.

Show the QUEST video entitled **Speed of Sound from PBS LearningMedia** to the class and ask them to turn again afterward to their partner and summarize what they learned. After eliciting a few summary statements, explain that similarly to how the video showed a comparison between light and sound to estimate the speed of sound, they will perform a similar procedure.

Materials & Setup **(See the setup here!)**

- wooden blocks
- a stopwatch
- measuring tape or meter stick(s)

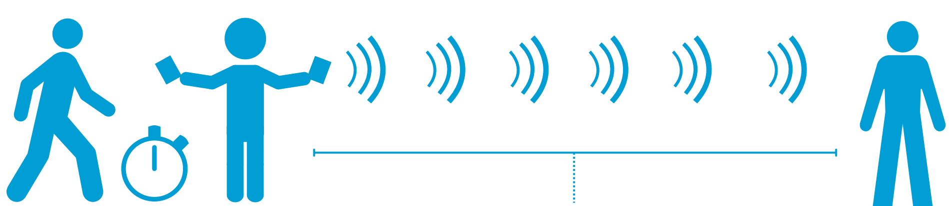
First, have one student take the wooden blocks and clap them together for everyone to hear. Ask a student how long did it take between the sound happening and them hearing the sound. (Basically no time at all.)

Ask the class what would happen if the sound were far away. (More time in between making the sound and hearing it.) Ask them what would it mean if there were a 1 second delay between seeing the blocks clapped together and hearing the sound it produced. (That would be the distance the sound traveled in 1 second.) Ask the same question about a 0.5 second delay. (Half the distance sound travels in 1 second.)

Next demonstrate for the class with the student who is clapping the blocks that if they strike the blocks once every second, then you would know something specific about the sound based on where the blocks were in their hands. (Make sure they move their arms far apart between every clap.) Point out that with a frequency of every second, when the blocks are together the sound occurs, when the blocks are far apart that is 0.5 seconds and when the blocks return back together 1 second has passed.

Then, engage them in a discussion of a procedure that would allow the class to measure how far sound travels in 0.5 seconds and then have them extend their thinking to how they could use that to estimate the distance sound travels in air in 1 second. Once a procedure is established, have the class conduct the experiment (at least 5 trials so they can average their measurements) and collect the data to estimate an approximate value for the speed of sound in air.

Last, have them compare their estimated value to the known value of the speed of sound in air. Engage the whole group in a discussion of what made the estimate closer to, or farther away from, the accepted value. How did temperature play a role? How could the procedure be improved for better accuracy in measurement?



distance at 0.5s is used to calculate distance traveled in 1s

Student with stopwatch tells partner to clap the blocks every second on the second as they move away from the observer

They continue moving away until the observer hears the sound when the blocks are seen are farthest apart. That notes the distance the sound travels in 0.5s.

ACTIVITY 4: MATHEMATICALLY MODELING CORRECTION FACTORS

In this activity, students will complete a graphing exercise to learn how correction factors work in mathematical modeling. They will use this activity in order to understand how the NOAA technology used to map the Great Lakes terrain can correct its measurements to adjust for temperature variance in the water and accurately determine the lake depths using SONAR.

Materials Needed:
- graph paper
- bathroom scales

Begin by having a few students volunteer to step on the bathroom scale and record their weight. Have students consider the situation of taking someone's weight at the doctor's office when they go in for a checkup. Point out that at different times of the year people may wear more/less clothing into their appointment.

Ask them to think about and discuss how doctors could account for clothing when taking weight. Elicit a few responses and lead them to focus on having a set of rules to adjust the scale reading to approximate the accurate weight of a person with clothes on (e.g., light clothing/shoes might be 1-2lbs and heavy clothing/shoes might be 3-4lbs). Have them suggest a mathematical way to account for clothing/shoes in measuring a person's weight. (This should generate an equation of some sort that takes away an amount of weight based on clothing.) Have some new volunteers step on the scale and record their weights. Using the equation the group came up with, estimate the volunteers' weights by adjusting for clothing.

Explain that this is the concept behind a correction factor. Inform them that they will be conducting an experiment in groups to measure their weight and determine a correction factor equation that accounts for clothing and shoes.

***Teaching Tip:** if a student does not feel comfortable disclosing their weight, have them look up the weight of famous athletes to include in their data.*

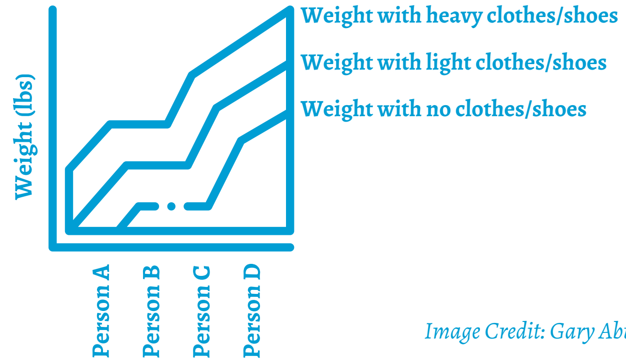


Image Credit: Gary Abud, Jr.

First, have students in groups take their individual weights and record them.

Next, have students estimate weights of the clothing/shoes they are wearing and come up with a set of rules that describes how much weight different categories of clothing accounts for. (**Note: if appropriate, students could remove their shoes and weight their shoes alone on the scale for reference.)*

Then, have students make a scatter plot of their group weight data with clothing included. Once the scatter plot is made, they should add a line of best fit. Have them make a second plot and line of best fit on the same graph for the weight data that corrects for the clothing.

Last, have them compare their two best fit lines. What they should notice is that these lines have the same slope but different y-intercept values, and on the graph one line should be shifted up/down from the other. This difference amounts to the correction factor for clothing.

Finally, combine all of the data from all the groups for a class set. This could be done by averaging their correction factors to generate an estimated mathematical model for the whole class that would allow them to have an equation that corrects for clothing no matter who is being weighed. **Note: If appropriate, the teacher can step on the scale to test the correction factor the class determined.*

Help students make connections between this correction factor and how the SONAR device on NOAA ships correct for water temperature and sound speed when doing bathymetry.

ACTIVITY 5: MAPPING TERRAIN USING PLUMB LINES

In this activity, students will model the original bathymetry techniques used to map the floors of the Great Lakes.

Materials Needed:

- Aluminum quarter-sheet baking tray (or similarly-sized container
- Full sheet of graph paper with 1" x 1" squares
- Hole puncher
- Play Dough
- Wooden skewers
- Ruler
- Colored pencils
- Tape

Remind students that originally, when the Great Lakes floors were mapped, they used lead lines (retractable ropes with lead weights on the end) to lower down into the lake at different points to measure the depths. Inform students that they will be modeling this technique by mapping the terrain of a model lakebed using a technique similar to what was originally used to map the floors of the Great Lakes. Provide all the supplies they need to complete the activity.

First, have students flatten out some Play Dough to cover the bottom of the tray. Have them build it up in different areas so as to create land forms in the tray of different depths. Have them punch holes at the intersection of the lines on the graph paper before taping the graph paper over the top of the tray to cover it completely.

Teaching Tip:

Demonstrate the plumb line depth measurement technique from the paper to the bottom of skewer for the class before they begin mapping their model lakebeds.

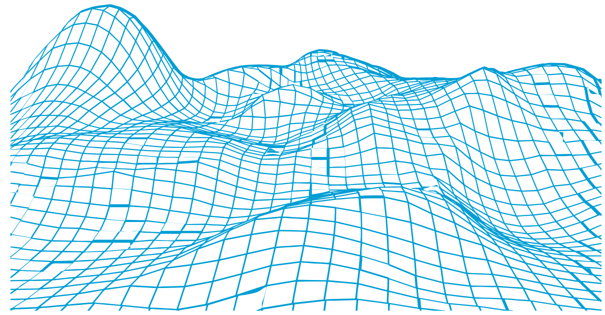


Image Credit: Gary Abud, Jr.

If multiple sheets need to be combined to cover the tray, be sure to tape them together so that the graph lines are continuous between each sheet. After the trays are prepared, have groups trade trays with one another so that they do not have their own. These trays serve as model lakebeds.

Next, give groups time to discuss how they could use their supplies to map the depth of the Play Dough lakebed. After discussion time, elicit some responses from the whole group and ensure that everyone understands that by dropping a straight line (e.g., a plumb line) until it hits the bottom that they can measure the depth and map depths along the grid.

Then, allow students time to take and record their measurements at each of the holes in the graph paper. Once they have finished, they should create a bathymetry map of their model lakebed using colored pencils and generate a legend to show which colors indicate which depths. A colorful gradient map should result.

Last, have groups uncover their lakebeds and compare the terrain with the bathymetry map that they made of it. Have them discuss with the other group (the one who created and traded their Play Dough lakebed) how accurate was their map, what limitations the technique had on the map making, and how the technique could be enhanced for improved accuracy in measurement.

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

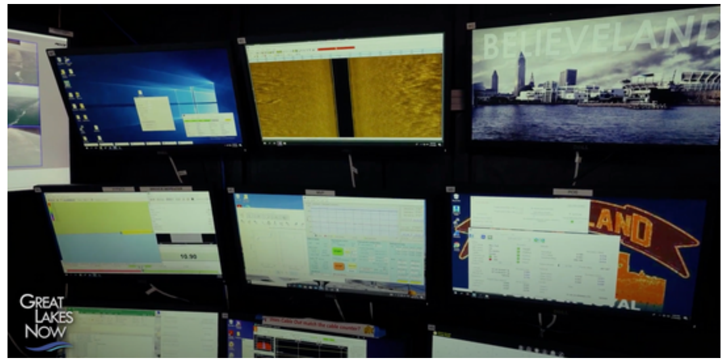


Image Credit: Great Lakes Now

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

***Teaching Tip:* Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

NAME: ______________________________

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: ______________________

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: ______________________

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: ______________________

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed

NAME: ______________________

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea