Session 3: *How Learning Happens and the Ocean-Atmosphere Connection*

Overview

This session probes into how learning happens - specifically, how learners construct an understanding of the world around them through experiences, social interactions, and making connections with their prior knowledge. Participants engage in a series of activities to gain a deeper understanding of the concept of the ocean as a heat reservoir and then apply that knowledge to explain the different temperatures found in coastal and inland places. Participants reflect on how the five foundational ideas on how people learn helped them learn the science content in the activity. The instructional model, the Learning Cycle is introduced to guide participants' thinking about the development of activities and experiences to support conceptual understanding and interest. Participants begin to explore what we mean by data and the various types of data and ways to collect data, while also thinking through the benefits and limitations of overly using one type of data in teaching. The homework assignment introduces participants to additional ideas from the current research on learning and has them collect real-time environmental data through a web-based data portal.

Session Goals

Theme	Goals
Climate Science Ideas	Understand that: ● the ocean covers 70% of Earth's surface, and all this water has a huge impact on temperatures on Earth. (OSS 1.3) ● average temperatures near the coast are moderated by the ocean. (OSS 1.3)
Using Data	Build on skills covered in previous sessions and explore ways to: ● Compare and contrast data sets and use patterns as evidence to support conclusions. ● Engage with and collect environmental data using a web-based portal of national estuarine observing data
Teaching & Learning	● Read & discuss how prior knowledge, the use of models, conversations with peers, and facilitation by the instructor, influence learning. ● Learn and apply the Learning Cycle instructional model.

Framework/ NGSS	Experience shifts in teaching and learning as described in the Framework for K–12 Science Education and NGSS.

Materials Needed

For the instructor

- 1 copy of HW2_WaterTemp_answers and learning goals Answer Key (used in Session 4)

For the class

- PowerPoint presentation
- Digital/data projector
- Whiteboard or flip chart paper and pens
- masking tape

For each participant

- 1 copy of The Learning Cycle
- 1 copy of How Learning Happens: Five Foundational Ideas
- 1 copy of What's up with Charleston and Waterloo? handout
- 1 copy of Data Skills used in working and teaching with data handout
- 1 copy of *Ocean as a Heat Reservoir* reading

For each participant for homework

- 1 copy of Key Ideas from the Literature: How People Learn
- 1 copy of Session 3 HW1_Environmental data Scavenger hunt
- 1 copy of Session 3 HW2_ Water temperature data search

For C. Activity: *Ocean as a Heat Reservoir (modified OSS 1.3 and 1.2)*

- 6 balloons
- 1 lighter
- Simulation: Heat Reservoirs (http://static.lawrencehallofscience.org/mare-sims/1-2-heat-reservoirs.html)

Preparation of Materials

1. **Duplicate handouts.** Make enough copies of the following handouts for

1 per participant:

- 1 copy of The Learning Cycle
- 1 copy of How Learning Happens: Five Foundational Ideas
- 1 copy of What's up with Charleston and Waterloo? handout
- 1 copy of Data Skills used in working and teaching with data handout
- 1 copy of *Ocean as a Heat Reservoir* reading

For homework

- 1 copy of Key Ideas from the Literature: How People Learn
- 1 copy of Session 3 HW1_Environmental data Scavenger hunt
- 1 copy of Session 3 HW2_Water temperature data search

For C. Activity: *The Ocean as a Heat Reservoir* **(modified OSS 1.3 and 1.2)**

1. **Set up projection system/review multimedia.** Set up and test the projection system to be sure all participants will be able to see items projected during the session. Spend a few minutes reviewing the Heat Reservoir simulation http://static.lawrencehallofscience.org/mare-sims/1-2-heat-reservoirs.html

2. **Prepare balloons.** Fill three balloons about halfway with air and tie them off. Fill three balloons with water (about halfway so they are the same size as the air balloons) and tie them off. Use one air and one water balloon to practice the demonstration; save the other two pairs of balloons for the class demonstrations. Place the lighter nearby.

3. **Practice the balloon demonstration.** Use the practice set of balloons to become familiar with the procedure: Hold the air balloon in one hand and the lighter in the other hand. Touch the flame to the balloon directly under the bottom of the balloon, not on the side of the balloon. It quickly pops. Do the same with the water balloon, touching the flame to the bottom of the balloon for about 30 seconds (or even more). It will not pop. To guide you, watch ~1 minute of the video, **Session 1.3 Oceans of Climate Change**, beginning at 1 minute, 13 seconds found at http://mare.lawrencehallofscience.org/curriculum/ocean-science-sequence/oss68-overview/oss68-resources/unit1http://mare.lawrencehallofscience.org/curriculum/ocean-science-sequence/oss68-overview/oss68-resources/unit1

Session at a Glance

Task	Description	Time (minutes)
A. Homework Reflection & Session Goals	Participants share the climate science ideas chart completed for homework. Session goals are introduced.	15
B. Quick Write & Research Discussion: *How Learning Happens*	Participants do a Quick Write to the prompt: How does learning happen? The instructor shares Five Foundational Ideas about how learning happens and participants reflect on and discuss the ideas with a small group.	20
C. Activity: *Ocean as a Heat Reservoir (modified OSS 1.3 and 1.2)*	Participants engage in an activity designed to model how educators can strategically address the Five Foundational Ideas about how learning happens, as well as reflect the phases of the instructional model called the learning cycle.	60
D. Discussion: *Debrief the Ocean as a heat Reservoir Activity*	The Ocean as a Heat Reservoir activity is debriefed; reflecting on how prior knowledge was accessed and the teaching and learning strategies that helped participants learn the climate science ideas.	10
E. Research Presentation: The Learning Cycle	The Learning Cycle instructional model is introduced. Participants determine which parts of the Ocean as a Heat Reservoir activities mapped onto which phase of the learning cycle.	10
F. Reflection: *the learning cycle Instructional model.*	Participants reflect on the learning cycle as an instructional model, including how it affected their own learning.	10
G. Presentation & Discussion: *Teaching with Data & Types of Data*	Participants reflect on how they use data in their lives as an introduction to the reasons why teaching with data is a core component of the course. Participants are exposed to a variety of types and ways data is collected, as well as benefits and limitations to using simulated data.	30

H. Homework	1. **Online Data Scavenger hunt.** Participants conduct their first foray into real-time environmental data in the form of a scavenger hunt on the NERR data portal where they search for specific patterns and information. 2. **Read Research on How learning happens.** Participants read articles from the research on learning and have an online discussion (optional) or record ideas about the ideas presented, and how they relate to them as learners and teachers.	5
	TOTAL: 2 hrs 40 mins	**160**

Optional / Additional Resources

Data Discussion: *Averaged vs. Raw*	Participants engage in a discussion about using averages and raw data with variation to look at relationships and patterns in science.	15 minutes

Session Details

A. Homework Reflection and Session Goals

Homework Reflection - Using climate science ideas to build an understanding of climate change

1. **Introduce class climate science Ideas chart**. Tell participants that as the course progresses and new climate science ideas are introduced and explored the group will be revisiting the individual Climate Science Ideas charts and this class chart to map their connections to climate change.

2. **Participants share Climate Science ideas and Climate Change Connections.** Ask for volunteers to share what the climate science ideas about ocean currents have to do with climate change. Record connections that participants share.

Introduce goals for Session 3.

1. **Project the Session 3 Goals slide.** Tell participants that in this session these are the goals for each of the four themes.
    - Climate science ideas - Understand that:
        - the ocean covers 70% of Earth's surface, and all this water has a huge impact on temperatures on Earth. (OSS 1.3)
        - average temperatures near the coast are moderated by the ocean. (OSS 1.3)
    - Using Data - Build on skills covered in previous sessions and explore ways to:
        - Compare and contrast data sets and use patterns as evidence to support conclusions.
        - Engage with and collect environmental data using a web-based portal of national estuarine observing data
    - Teaching & Learning - Read & discuss how prior knowledge, the use of models, conversations with peers, and facilitation by the instructor, influence learning. Learn about and apply the Learning Cycle instructional model.
    - Framework/NGSS - Experience shifts in teaching and learning as described in the Framework and NGSS.

B. Quick Write & Research Discussion: *How learning happens*.

1. **Show Quick Write Prompt.** Have participants spend about 2 minutes recording their ideas about the following prompt:

   How does learning happen? What are your ideas about what facilitates and supports learning?

2. **Introduce the research discussion.** Tell participants that the education field has learned many things about how people learn, in the last session they focused on the purpose and value of learning conversations, and they will now probe further into the idea of how learning happens by discussing the Five Foundational Ideas.

3. **Read and discuss five foundational ideas of learning.** Distribute the How Learning Happens-Five Foundational Ideas handout and tell participants that they will consider these ideas from the research, with particular reference to their own learning experiences. Tell them they will read the research and then discuss the following prompts with a partner.
   - What do you think each idea means?
   - How do these ideas apply to your experiences as a learner?

   How Learning Happens - Five Foundational Ideas:

   - Learning is an active process of engaging and manipulating objects, experiences, and conversations in order to construct a mental picture of the world (Dewey, 1938; Piaget, 1964; Vygotsky, 1986). Learners build knowledge as they explore the world around them, observe and interact with phenomena, converse and engage with others, struggle to make explanations, and make connections between new ideas and prior understandings.

   - Learning builds on prior knowledge, and involves enriching, building on, and changing existing mental models, where "one's knowledge base is a scaffold that supports the construction of all future learning" (Alexander, 1996, p. 89).

   - Learning that is situated in an authentic context, not in the abstract, provides learners with the opportunity to engage with specific ideas and concepts on a need-to-know or want-to-know basis (Greeno, 2006; Kolodner, 2006) and leads to deeper understanding.

- Learning occurs in a complex social environment, and thus should not be limited to being examined or perceived as something that happens on an individual level. Instead, it is necessary to think of learning as a social activity involving people, the things they use, the words they speak, the cultural context they're in, and the actions they take (Bransford, et al., 2006; Rogoff, 1998); knowledge is built by members in the activity (Scardamalia & Bereiter, 2006).

- Learning complex ideas deeply involves considerable mental effort and persistence, which requires learners' motivation and cognitive engagement to be sustained, i.e., for learners to be engaged in, or actively committed to, the experience, task, or activity (Fredricks, 2004). Engagement is multi-faceted and malleable, and affected by interactions between individuals and the context.

4. **Participants read individually and actively.** Tell participants they will have a few minutes to review the ideas on their own. They should underline ideas that seem important, circle ideas they wonder about and write questions in the margin. Encourage them to be ready to discuss the ideas with their partner, and also select one of the ideas that resonates with them and think about an example from their own past learning experiences where this has noticeably come into play.

5. **Partners discuss.** After a few minutes, ask participants to discuss the ideas with their partner, including an idea that resonated with them, and an example from their own past learning experiences.

6. **Display "How might these ideas apply to you as an educator" slide; whole class share out.** After about 5 minutes, display the slide, showing the bullets one at a time, and ask for volunteers to share out using one or more of the following prompts:
    - what did the idea mean,
    - what are some examples from past learning experiences
    - which of the foundational ideas resonated with them, and/or provoked the most interesting conversation.

    Lead a brief whole-class discussion and as participants share their ideas, remember to use the discussion map to facilitate a discussion. For each bullet, also add any additional, clarifying information to fill in the important points you would like to share with them.

7. **Synthesize the discussion.** After the whole class discussion, share some, or all, of the following:

- People construct understanding of complex ideas over a long period of time.
- Learners don't acquire concepts simply by having someone tell them the content, or even by doing hands-on activities.
- Learners must encounter multiple learning experiences that encourage them to:
  - question their assumptions;
  - engage in discussion about their ideas;
  - recall, make connections to and build on their prior knowledge;
  - apply their new understandings in different contexts;
  - want to learn.

8. **Quick Write - Segue into designing experiences.** Have participants do a quick write using the following prompt:

   Given what you know about how people learn, how would you design learning experiences to take all of these ideas into account to promote learning for all learners?

9. **Introduce activity focused on ocean as a heat reservoir and design of activities.** Point out that in this next part of the session, they will experience a series of activities designed to deepen their understanding of ocean-atmosphere connections. Tell participants that although one of their goals is to engage with the activities, and get "caught up" in the activities themselves, the most important objective is to reflect on the learning experience, especially noting the design of the experiences. Emphasize that as they engage with the activities they should think about:
   - How are you engaging with the materials in each activity to learn the content?
   - What seems to be the purpose of each activity?
   - Which of the Five Foundational Ideas of Learning are being addressed?

C. Activity: *The Ocean as a Heat Reservoir*

[**Note to Instructors:** *As with all sessions, the presentation to participants has been designed to "practice what we preach." The lesson plan itself has been set up to reflect a learning cycle approach to instruction. Through the session, the participants actually experience a version of the Learning Cycle model as they learn about it. It's important that the session and instructor provide the opportunity for participants to experience each phase of the model for themselves—resisting the temptation to dole out too much information too early. Rather, the instructor should set up the circumstances and allow the participants to bring up most issues, while strategically inserting appropriate information to help clarify and organize the participants' experience and learning].*

Two Balloons (Modified OSS 1.3 and 1.2)

1. **Introduce balloon demonstration.** Show participants 1 air-filled and 1 water-filled balloon and describe how you'll use a lighter to add heat energy to the balloons by applying a flame directly to the balloon.

2. **Display Thought Experiment: What do you think will happen to each of the balloons?** Ask them to first think about their predictions and then record their ideas, being sure to include the reasoning for their prediction. Share that you anticipate that some people may know the explanation well, and others will have bits and pieces of an explanation. Assure them that they won't show anyone what they write down, so they should write freely and their reasoning doesn't need to be in complete sentences. Tell them they'll have 1–2 minutes. Don't do a whole group share-out of their ideas yet.

3. **Begin the demonstration.**
    a. Hold up the air-filled balloon and ask for a show of hands— how many think it will pop? How many think it won't? Apply the lighter flame directly to the underside of the balloon. [*The balloon will pop immediately.*]

    b. Hold up a water-filled balloon and place the basin underneath. Urge participants to move back a little.

    c. Tell them you'll use a lighter to add heat energy to the balloon as before. With a show of hands, how many think it will pop? How many think it won't? Hold the lighter flame directly to the underside of the balloon for 30 seconds or more. [*The balloon will not pop*].

4. **Initiate Turn & Talk.** Display the question prompt: **Why did one balloon pop and the other one not?** Have participants share their ideas and reasoning with a partner for a couple of minutes. Listen in on and take note of what partners are saying to each other, because not everyone will share publicly but you'll want to reference their ideas later.

5. **Transition to Whole-Group Share.** Ask a few volunteers to share the ideas they discussed. Remember to encourage them to explain their reasoning and invite others to share additional or alternative ideas. Stay neutral. Don't provide an explanation of the phenomenon, but rather encourage participants to share ideas.

6. **Return to Thought Experiment.** Have participants return to their notes and draw a line under their first entries about predictions and reasoning for Two Balloons. Display the following prompts and have them record a second entry:

   a. What are you thinking now about why one balloon popped and the other one did not?

   b. What questions do you have now about the phenomenon?

   Tell them they have about 2 minutes to record their ideas. As they write, walk around and take note of what kinds of explanations and questions are emerging.

7. **Share group ideas.** Recapitulate community-generated ideas of which you became aware during the Turn & Talk, Whole-Group Share, and outcome of the reflective writing tasks.

8. **Initiate Small-Group discussions.** Display the following question and ask participants to discuss it within their small groups for 2 minutes.

   What additional information would be helpful to make an explanation for the balloon phenomenon?

9. **Create chart from Whole-Group Share.** Use the Discussion Map to guide a brief community share-out about what participants said they'd like to know. Record their ideas on chart paper in the form of questions about what additional information they need.

Introduce the Heat Reservoir animation (OSS 1.2)

1. **Introduce the Heat Reservoir animation.** Show the animation and describe what is displayed:
   - Two sealed bottles, one filled with air and the other filled with water.
   - Air and water molecules are visible in each bottle.
   - A light bulb provides the heat energy.
   - A thermometer above each bottle displays the temperature inside the bottle.

2. **Click the light bulb "on" and invite observations.** Invite participants to call out what they notice in the animation. The following points should come up.

   In everyday language:
   - ❑ Air molecules bounce around all over the bottles. They bounce around faster and faster over time. Temperature in the bottle increases.
   - ❑ Water molecules slowly begin to wiggle. They continue to wiggle over the 5 minutes. Temperature in the bottle doesn't change much.

   In the language of science:
   - ❑ In modeling how water and air molecules behave differently as they absorb heat energy,

the animation provides evidence that water is able to absorb much more heat energy before the temperature in the bottle (or balloon) increases.

3. **Expand the observations.** Ask participants to call out their ideas about the following questions and give information as needed:

   What is heat? [*The spontaneous transfer of (thermal) energy from hotter materials to cooler materials. (Remember, heat is a* <u>*process*</u>*, not an entity)*]

   What is temperature? [*A measure of a) how hot or cold something is (the internal thermal energy of a material), and b) the average kinetic (moving) energy of molecules or atoms in a sample of matter.)*].

   Which bottle contains more mass? [*The water bottle*]

4. **Initiate Small-Group discussions.** Ask the participants to discuss the following questions in their groups:

   Does this simulation add to or support your explanation? If so, how?
   Which of your questions haven't been answered?
   What new questions arise?

5. **Provide reading for further evidence.** Tell participants that, to support their explanations and answer some of their remaining questions, they may want or need to search for additional evidence. Distribute the **Ocean as a Heat Reservoir** handout and tell participants to use the Active Reading strategy to find evidence to support their explanations. Ask them to answer the following displayed questions.

   a. Why did one balloon pop and the other one not?
   b. How might this balloon activity be similar to what happens in the Earth system?

   Tell them they'll have 5 minutes to read parts of the article they think will help them gain a deeper understanding and answer the focus questions.

   Active Reading Strategy:

   - Underline ideas you find interesting or that seem important.
   - Circle ideas you find confusing or have questions about.
   - Write your questions in the margins.

6. **Have participants discuss with others.** Invite participants to discuss their ideas with others (in a small group or with someone sitting near them) for about 2 minutes. Remind them to explain their reasoning and to support their explanations with evidence.

7. **Ask participants to revise their writing again.** Allow participants about 3–5 minutes to add another line below their previous explanations and to record their new thoughts underneath. Encourage them to compare and contrast their new entry with their previous ideas and explanations.
   a. Why did the air balloon pop?
   b. Why didn't the water balloon pop?
   c. What role does the concept of heat reservoir play in the larger Earth system?

8. **Lead a Whole-Group Share.** Display the following questions and ask each one aloud, one at a time. Facilitate a whole-community discussion using the Discussion Map—probe for evidence and encourage others to add to the explanations shared.
   - Why did one balloon pop and the other one not?
   - How do you think this is the same or different from what happens in the Earth system?

9. **Synthesize the discussion.** Summarize these main points as necessary:
   - ❑ The balloon filled with air popped because the matter inside the balloon (air) could not absorb much heat energy, so the heat energy quickly transferred to the rubber of the balloon. As soon as the rubber heated, it lost its integrity and failed.
   - ❑ The balloon filled with water did not pop because the matter inside (water) *was* able to absorb a lot of heat energy, which kept that heat energy from transferring to the rubber of the balloon.
   - ❑ In the Earth system, the vast ocean constitutes one large source of matter (water) into which heat energy is absorbed. Just like the water in the balloon, that oceanic body of water absorbing heat energy keeps the other things around it relatively cool. Just as the rubber remained cool when we heated the water balloon, on Earth the air remains relatively cool during the day because the ocean absorbs much of the Sun's heat energy. Conversely, if there were no ocean to absorb the Sun's heat energy during the day, the air would become very hot, as the rubber did on the air balloon.
   - ❑ Had the balloon demonstration shown us what happens when the heat energy is *released* from the air and water, as happens on Earth at night or in winter, we'd have seen that air cools down much faster than water. On Earth, the ocean moderates the climate of the whole planet.

10. **Display the key concepts from the activity.** Explain that the following key concepts are some of the big ideas that emerged from the Two Balloons activity.

- ❑ The ocean covers 70% of Earth's surface, and all this water has a huge impact on temperatures on Earth

- ❑ Water acts as a heat reservoir. Water can absorb a lot of heat energy before it changes temperature, and it holds onto the heat for a relatively long time before releasing that heat energy to the atmosphere as the water cools down.

- ❑ In absorbing and releasing heat energy, the ocean warms cold air and cools warm air. The heat reservoir of the ocean keeps air temperatures moderate all over the planet, not just in coastal places.

11. **Begin a Whole-Group Share.** Revisit the group chart (step 9) and lead a whole-community debrief. Use the following questions to facilitate the discussion:
    a. What questions have been answered?
    b. What questions remain?
    c. What additional questions should be added about the role of heat reservoir in climate change?
    d. Why is it important for me to understand this content?

Mystery of Temperatures in Two Cities. ***(OSS 1.3)***

1. **Project the slide–Charleston, Oregon and Waterloo, Iowa.** Tell participants they will use what they've learned about the ocean as a heat reservoir to solve a mystery about the temperatures in the two locations shown on the slide. Point out Charleston and Waterloo on the map. Tell participants that the two cities are located at about the same latitude (same distance from the equator). Both cities are also located at about the same altitude (height above sea level). Point out that the main difference between the two locations is that one of the cities (Charleston) is located on the Pacific Ocean, while the other is located inland and far away from the coast.

2. **Project slide, What's Up with Temperatures at Charleston and Waterloo? and go over the temperature chart.** Ask the following questions to help orient the participants to the data:
    - What data are being collected? [*air temperature*]
    - What units are being used? [*degrees celsius*]

- Is 25°C warm or cold? [*25°C is 77°F - slightly warmer than "room temperature"*]

Ask the following questions to help the participants begin to interpret the data:

- Which city is colder during the winter? [*Waterloo*]
- Which city is warmer during the summer? [*Waterloo*]
- Which city had the larger difference between winter and summer temperatures? [*Waterloo*]
- What other trends or patterns do you notice? [*answers will vary depending on what the participants are interested in and look at within the chart*]

3. **Turn and Talk; solve the mystery.** Ask participants to pair up and begin to synthesize the data by discussing why they think Charleston doesn't get as hot or as cold as Waterloo? After participant pairs have a minute or two to discuss the question, regain the attention of the whole group, and ask for their ideas. Encourage participants to use evidence to support their ideas. Invite participants to respond to one another by asking questions, agreeing and adding supporting evidence, or disagreeing and explaining why.

4. **If necessary, prompt participants to discuss how the ocean as a heat reservoir affects temperatures in Charleston, OR.** If participants have not yet brought up the idea of the ocean as a heat reservoir, ask, "How can what we learned about water as a heat reservoir help us make sense of why Charleston doesn't get as hot or as cold as Waterloo?" [*Because it takes longer for water to release heat, during the winter the ocean water gives off heat to the air, making the climate in Charleston warmer than if it were inland. During the summer, the ocean water around Charleston absorbs heat more slowly than the land, due to its high heat capacity. This and other factors result in the climate around Charleston being cooler than if it were inland.*]

5. **Explain why Charleston's temperatures are not as hot or as cold emphasizing evidence sources.** Key points to discuss:
    - Charleston is near the ocean and Waterloo is not. [*The evidence is the geographic location of the two cities in relation to the water by looking at the map.*]
    - Water is a heat reservoir. It warms up and cools off slowly. [*The evidence: water vs. air bottle investigation, molecule simulations, balloon demonstration, reading The Ocean: A Giant Heat Reservoir.*]
    - Temperature of the ocean water doesn't change very much from summer to winter. Therefore, in winter the ocean water warms the air in Charleston; in summer, the ocean cools the air in Charleston. [*This evidence comes from reasoning.*]

Connect the climate science ideas to climate change.

1. **Project Key Concept slide; participants connect Key Concepts to climate change.** Project the key concepts again and have participants record them on the Climate Science Ideas chart they received for homework in Session 2. Tell participants to then put ideas they have in the second column about what the concepts have to do with climate change.

Climate Science Ideas Chart

Climate Science Idea (key concept)	What does it have to do with climate change?
The ocean covers 70% of Earth's surface, and all this water has a huge impact on temperatures on Earth *Water acts as a heat reservoir. Water can absorb a lot of heat energy before it changes temperature, and it holds onto the heat for a relatively long time before releasing that heat energy to the atmosphere as the water cools down.* *In absorbing and releasing heat energy, the ocean warms cold air and cools warm air. The heat reservoir of the ocean keeps air temperatures moderate all over the planet, not just in coastal places.*	

2. **Share connections to climate change; complete class climate Science Ideas Chart.** After a few minutes, when participants have recorded their own ideas on their Climate Science Ideas handout, ask for volunteers to share out what they think the key concepts have to do with climate change. Record ideas on the class Climate Science Ideas chart.

D. Discussion: *Debrief the Ocean as a heat Reservoir Activity*

Quick Write

1. **Ask participants to think about the learning experience.** Explain that the Ocean as a Heat Reservoir activity modeled how a community of learners can work together to generate explanations for phenomena and build understanding of a concept. Now it's time to be metacognitive and analytical. Display the following prompts and ask participants to record some notes silently.
    - **How was prior knowledge accessed and connected in the activity?** [*participants were asked to make a prediction about a typically familiar scenario - the result of an air-filled balloon being touched by a flame. What would happen in the case of a water-filled balloon is possibly less familiar. Participants were also asked to predict the relative temperatures of an inland vs. a coastal city. Participants made adjustments to their thinking to reflect new evidence.*]

    - **What did you do to make sense of the two balloons activity?** (e.g., What kinds of experiences were you provided with to make sense of the ocean as a heat reservoir?) [*Demonstration, computer simulation and reading; opportunities to talk to peers to clarify thinking or get new ideas; small-group or partner discussions; low-stakes questions with no right or wrong answers to push thinking, e.g., "What surprised you? What made you reevaluate what you originally thought?"; finding evidence that supported or refuted original ideas; publicly sharing predictions created engagement.*]

2. **Display teaching and learning strategies they may have just experienced.** Tell participants you're going to read off a list of some teaching and learning strategies they might have encountered in the activities – some of which were mentioned in the discussion and possibly a few additional ones. Ask them to raise their hands if they found that they used that strategy in their own learning about the ocean as a heat reservoir during the activity. Read off the following list, and pause briefly after each one for participants to think and raise their hands.
    - Observing models and activity set ups
    - Listening to and talking with peers
    - Thinking on your own
    - Listening and talking with the instructor in the whole group
    - Overhearing other peers
    - Discussing and testing out ideas that agree or disagree with your own understanding
    - Asking new questions

- Explaining your ideas to peers or instructor
- Accessing and making connections to prior knowledge and experiences

Turn and Talk

1. **Application of ideas about how people learn.** Ask participants to look at their How Learning Happens- Five Foundational Ideas handout and turn to a neighbor to discuss where in today's session they engaged in one or more of these ideas. Encourage them to share details about how and what it helped them to learn.

2. **Lead whole group discussion.** After a few minutes, lead a whole group discussion about their ideas.

3. **Synthesis of the discussion and experience.** Remind participants that learners' understanding of complex ideas develop over long periods of time. Learners do not acquire concepts simply by having someone tell them the content, or even by performing a hands-on activity. In order to firmly grasp concepts, learners must encounter multiple learning experiences over time that encourage them to question their assumptions, engage in discussions with others about the ideas, make connections to and build on their prior knowledge, apply their new understandings in different contexts, and want to learn.

E. Research Presentation: *The Learning Cycle*

1. **Introduce instructional model.** Tell participants to consider the activities we just engaged in for learning about the ocean as a heat reservoir, not as individual activities, but rather as one extended learning experience with multiple opportunities for engaging in and learning the content. The entire activity was designed using an instructional model called the Learning Cycle. The Learning Cycle incorporates the five foundational ideas of learning into a model that can be used to support learning for all learners.

2. **Provide background about the model.** Tell participants that research indicates that the design of individual activities is highly important for deep learning to take place, but also of great significance is the sequence that learners engage with the activities.

- The Learning Cycle is a model that was developed to provide a method for organizing and delivering educational experiences that are consistent with what is known about how people learn.
- The Learning Cycle has been transformed and deepened through educational research on common components of good instructional models, as well as the work of cognitive scientists and researchers who study teaching and learning.

3. **Display Learning Cycle and describe phases.** Use the following information to briefly describe each phase.
   - **Invitation**: An invitation is a question, problem, observation, or demonstration that initiates the learning task. It should make connections between past and present learning experiences, anticipate activities and organize learners' thinking toward the learning outcomes of current activities. If learners are not engaged, they may not retain what they learn, and are probably only involved in rote learning.
   - **Exploration**: Learner is engaged in open-ended investigation of real phenomena, and can also involve some discussion about discoveries, results, ideas, and questions that arise. This can be through hands-on activity or through discourse and thought processes. It can be more or less structured, but the idea is that exploration should be driven mainly by the learner's interest and questions.
   - **Concept Invention**: The concept invention phase involves the active processing of the experience by the learner. Learners now review evidence and data gathered through exploration and try to make sense of it. With interest and attention focused, new ideas can be discovered and the learner can solve problems and begin to construct new meanings. When possible, learners should be free to invent and discuss their own understandings directly from their hands-on experiences, through discussion with their peers and with those with more knowledge.
   - **Application**: Armed with new ideas and concepts, the learner applies knowledge and abilities to different situations than those they have already encountered. Researchers agree that in-depth learning requires being able to transfer knowledge from familiar circumstances to novel ones.
   - **Reflection**: After trying out new ideas in different settings, learners reflect on how their original notions have been or need to be modified. They may also generate new questions that can initiate a new learning cycle.

4. **Distribute the Learning Cycle handout.** Distribute the handout and give the participants just a few minutes to read it over.

5. **Project Activity Design and Learning Cycle Slide.** Draw participants' attention to the elements of the Ocean as a Heat Reservoir activities that fit with the Learning Cycle model. Ask participants to identify the parts of the Learning Cycle in the lesson that they just experienced.
   - **Invitation**: *The description of the demonstration and initial question about what will happen to the two balloons. A phenomenon is introduced and learners are challenged to gather evidence to construct an explanation.*
   - **Exploration:** *Participants discuss their ideas in pairs and small groups, a whole group discussion is facilitated to explore thinking and identify what additional information is needed to solve the mystery.*
   - **Concept Invention:** *Instructor provides information about how water and air molecules behave as the absorb heat energy with an animation; checks participant understanding with questions about heat and temperature definitions and asks participants to connect animation to the two balloons; then provides a reading to support their explanations and answer some of their remaining questions.*
   - **Application:** *Participants apply their understanding of the ocean as a heat reservoir to explain a real-world scenario of temperature differences in two cities, one inland and one coastal.*
   - **Reflection:** *Revise thinking regarding why one balloon popped and the other one didn't and how they think this is the same or different from what happens in the Earth system; generating and addressing their own questions throughout.*

6. **Connect the structure of Session 3 with the Learning Cycle model.** Draw participants' attention to the third column on the ppt slide. Describe how the pieces of the session were also designed with the learning cycle in mind.
   - **Invitation**: The initial questions posed at the beginning of the session - How does learning happen? Given what you know about how people learn, how would you design learning experiences to take all of these ideas into account and promote learning for all learners?
   - **Exploration:** Active Learning activities (Ocean as a Heat Reservoir and Debrief Discussion) to explore ideas and assumptions.
   - **Concept Invention:** Research Presentation on the Learning Cycle model and discussion of how it supports learning.

- **Application:** The current and following activities. Applying the Five Foundational Ideas about Learning to the Ocean as a Heat Reservoir activity. Further applications will occur in subsequent sessions in this course.
- **Reflection:** Opportunity coming up.

7. **Discuss how the Learning Cycle can be used.** Point out that the Learning Cycle can be an extremely valuable tool for designing learning experiences. Things to consider:
   - When a lesson is ineffective, it's often because concepts and vocabulary have been introduced before exploration.
   - The learners aren't interested yet, and have little context for the concepts.
   - The learners are given the opportunity to explore, but not to engage, in concept invention, which is a missed opportunity for them to try to make sense of their experience.
   - Some otherwise great activities lack the opportunity for application or reflection, which can result in lessening the impact of the experience.

   The Learning Cycle model is an excellent planning tool, and it can also help guide the many on-the-spot decisions educators must make during instruction.

Optional: Additional information you might want to share with participants.

1. **Explain how science is often presented**. Point out that it's very common for science topics to be presented to learners <u>without</u> giving the learner:
   - A chance to really engage in discovery. For example, an educator might introduce concepts and new vocabulary at the start of an activity, and then ask learners to merely follow a procedure or view a demo where those concepts are demonstrated and essentially nothing new is learned.
   - An opening invitation and free exploration phases. Learners have much less opportunity to activate relevant prior knowledge and become interested in the concepts. Moreover, merely delivering the information removes the engagement and educational impact of discovering ideas for themselves.

   Share how it is often possible to reformat "traditional" science activities into lessons that follow a more effective learning cycle approach.

F. Reflection: *the learning cycle instructional model*

1. **Think about prompts.** Ask participants to think for 1-2 minutes about themselves as a learner and respond to the following prompts:
    a. What do you feel are the pros and cons about the way the science content in the Ocean as a Heat Reservoir was presented?
    b. Which stage(s) of the learning cycle do <u>you</u> find has the greatest impact on <u>your</u> learning? Why do you think that?
    c. What questions do you have about the learning cycle?
    d. Describe a traditional science activity example that could be reformatted to follow a learning cycle approach.

2. **Share ideas**. Ask participants to share their ideas with a partner. After a few minutes of sharing, ask a couple of volunteers to share their ideas about the prompts with the entire group. Encourage others to participate in the discussion. Remember to do the following to engage participants in the discussion:
    - Listen to their responses
    - Maintain neutral response
    - Ask them to provide explanations, evidence, or clarifications to elaborate on their thinking. Suggested probing questions:
        - What makes you think that?
        - What evidence do you have to support your ideas?
        - What do you mean? Can you explain that in another way?
    - Invite others to react and respond to the ideas shared. Suggested probing questions:
        - Can anyone add something to that comment?
        - Who would like to share an alternative idea?
        - Does anyone disagree with that comment?
    - Reference and cross-reference their comments as you facilitate the discussion to encourage participants to think about and respond to one another's ideas.

G. Presentation & Discussion: *Teaching with Data & Types of Data*

1. **Homework Reflection.** Let participants know that you'll be switching the focus for the remainder of the session to teaching with data, an important aspect of science learning. Have students reread their data reflections that they did for homework and think about one aspect that

really resonated with them. After a few minutes gather everyone's attention again.

2. **Opening Discussion.** Remind participants that a key aspect of doing science is interacting with data, and that it would be helpful to share as a group our ideas about what data means to us. Ask participants to share how they would define data, and write down their definitions and ideas on the board. Encourage input from everyone by using discussion prompts "Does anyone have a different idea?" or "Something additional to add?"

3. **Quick Write - Data in Our Lives**. Ask the participants to take 3 minutes to write anything that comes to mind with respect to the following prompt:
    a. How do you use data in your life? *If they are struggling, use the following prompts to provide further direction:*
        i. Where do you find data?
        ii. What role does data play in your daily life?
        iii. How do you use data to make decisions in your life?

4. **Quick write debrief**. After the 3 minutes ask for volunteers to share one or more ways that they use data in their life. As participants are sharing some comments, ask other participants to add to the list of ways that data are used in their lives. If the participants talk about a specific type of data or way that data are collected, capture that on the board or flip chart paper for later.

5. **Introduce why teaching with data is important**. Explain to the participants that understanding:
    - what is involved in using data,
    - how data are used in science, and
    - good pedagogy for teaching with data

    are all necessary skills that will make them much more effective science teachers.
    Data enhanced learning experiences can:
    - Prepare students to address real-world complex problems;
    - Develop students' ability to use scientific methods, including consideration of the values and ethics of working with data;
    - Teach students how to evaluate critically the integrity and robustness of data or evidence and of their consequent interpretations or conclusions; and
    - Provide training in scientific, technical, quantitative, and communication skills.

6. **Define data literacy.** Tell participants that data literacy can be defined as - the ability to ask and answer meaningful questions by collecting, analyzing, and making sense of data encountered in

our everyday lives.

7. **The importance of increasing data literacy.** Explain to participants that increasing data literacy is important for two reasons:

    1) in our increasingly data-driven society, data literacy is an important civic skill to be developed in our learners, and

    2) learners can engage in more meaningful learning experiences by using data to connect school subjects with real-world events.

    Engaging with data in classroom experiences, learners move beyond simply learning facts to beginning to acquire skills in inquiry, critical reasoning, argumentation and communication. Additionally, building students' data literacy is imperative to increasing students' ability to interact with data, a key component of successfully implementing NGSS in classrooms.

Types of Data

1. **Discuss "Types of Data"**. Using the "Types of Data" slide, explain to participants that a lot of time will be spent talking about data and how to teach middle school students effectively about using data. Therefore it is important for everyone to have the same understanding of what is meant by data. Briefly describe the different types of data as shown on the slide:
    a. **Raw data** = Actual data that are collected using instruments/equipment/models that have **not** been averaged or "cleaned-up" in order to demonstrate an overall concept. Although these data may not clearly demonstrate the concept, they do tend to quite accurately represent the natural variability in a system. Examples of using raw data include, data charts and graphs that are populated with data collected/created from a demonstration or scientific investigation.
    b. **Simulated data** = Representations of data manipulated to clearly emphasize and demonstrate a particular scientific concept with minimal confusion. For example, simulated data are often seen in textbook graphs and diagrams representing the idealized version of science concepts. Scientific simulations and models also use simulated data.

2. **Exploring "Ways Data are Collected/Created".** Using the "Ways Data are Collected/Created" slide, briefly describe the different ways that data are collected/created and could be used in school science:
    a. **Learner-generated data** = are measured and/or calculated by learners as part of an activity or laboratory experience.
    b. **Real/near real-time data (RTD)** = are data collected on an ongoing basis that can be retrieved as they are collected, or shortly thereafter, to study current conditions or events.

Learners can use RTD to compare local conditions to global conditions or to view current real-world events as RTD allows learners access to types of information and a scale of information that would be too expensive or impossible to measure by the learners.

c. **Archived data** = are older data (> 30 days old) that are important and necessary for long-term reference. Learners can use these data to compare the past to the present, study conditions during historical events, or use when RTD are not available. Learners can use archived data to practice pattern recognition or recognize trends over time.
d. **Local Ecological Knowledge (LEK)** = a body of placed-based knowledge of the processes, properties, constituents and/or functioning of local ecosystems that is acquired by living, working and/or being immersed in a specific natural place. LEK is often used as a way to differentiate from "expert" ecological knowledge acquired through more formal means of knowledge transfer and/or research. LEK and "expert" forms of knowledge are not mutually exclusive and many practitioners have rich bodies of both expert and local ecological knowledge.
e. **Traditional Ecological Knowledge** = a body of knowledge or awareness of natural systems related to Local Ecological Knowledge, LEK, but that is generally rooted in deeper and longer-term traditional or cultural practices associated with a group or community of people and their interactions with the natural world. One form of traditional ecological knowledge is Indigenous Knowledge, which has been attributed to the knowledge of Native/Indigenous peoples throughout the planet and has become an important body of knowledge regarding long-term change in living systems.

3. **Turn and Talk: types of data used in the sessions**. Tell the participants to do a turn and talk, using the prompt: what types of data have they used thus far in the class? E.g., the type of data and the way in which the data was collected.

4. **Share out**. After a couple of minutes, regain the attention of the group and have volunteers share out some of their ideas. As volunteers share their responses, encourage other groups that talked about the same type of data or way it was collected to join in the conversation.

5. **Summarize.** Summarize the ideas presented. Highlight that in the second session they used both raw and simulated data in their work, and that the raw data were professionally-collected from the eWOCE project while the simulated data were in the Ocean Conveyor Belt simulations.

6. **Learner-generated data.** Explain to participants that learner-generated data are a common way that data are collected and used in science classrooms. This kind of data achieves many desired

outcomes such as allowing students to collect their own data: learners obtain a strong sense of context for the data, including where the data come from and how they were collected; and it provides experiences in using various tools to collect data.

7. **Describe simulated data**. Explain to participants that the use of textbook examples (diagrams, graphs, etc.) of scientific concepts, that are made up of simulated data, are also often used in science classrooms. Simulated data removes confusing outliers and small-scale variability to allow a clear pattern to emerge, which can help a learner grasp a new concept. However, there are also some limitations and potential misconceptions that can arise when using mostly simulated data.

8. **Benefits and limitations of using simulated data in the classroom.** Ask the participants to work in small groups to brainstorm a list of benefits and limitations of using simulated data in their classroom instruction about science and data.

9. **Share out.** After a couple of minutes, regain the attention of the participants and have groups list their top benefit and limitation of using simulated data. As the groups share out, ask other groups if they agree, disagree, or have something else to add to the statements made. Record the ideas on the board.

10. **Summarize simulated data discussion.** If not mentioned, explain to the participants that while there are lots of benefits to teaching with simulated data, if it is the only kind of data used then it can provide a false sense of certainty to science, as all variability and complex interactions have been removed, and can present science as deterministic rather than probabilistic.

Scope of Data in the Course.

1. **Introduce scope of data in course**. Explain that teaching with data is an extremely worthwhile way of teaching science and something that is integral to truly embracing NGSS - key to all of the Science & Engineering Practices is a comfort with and use of data - but it is also something that comes with time, practice, and experience. Therefore, this course is designed to focus on increasing the participants':
   - Overall comfort with working with different kinds of data and data visualizations – any visual form of looking at data – tables, graphs, figures, charts, images, maps, etc.
   - Ability to teach the concepts of science and the results of working with data in terms of the probability of a pattern/relationship rather than a determined/proved pattern/relationship.

- Confidence in teaching effectively with real/near real-time data (which is rarely used, but has huge potential for exposing students more broadly to the process of science through engaging with the data).
- Success in helping your future students engage with data in ways that they can orient to the data to understand what is there, can interpret the data to understand what does the data show, and can synthesize the data to understand what does the data pattern/trend/relationship allow them to explain or understand more fully.

2. **Introduce Data Skills handout.** Give the Data Skills used in working and teaching with data handout to each participant and explain that the course has been designed to repeatedly provide opportunities to strengthen their knowledge of and skills in working with these key data skills. These skills can be categorized into four sections: a) prior to having a data visualization, b) data orientation, c) data interpretation, and d) data synthesis. These final three categories are the different levels of engaging with the data and will be explored more deeply in the next session.

H. Homework

1. **Online Data Scavenger hunt and Data Collection.** Participants conduct their first foray into real-time environmental data in the form of a scavenger hunt using the National Estuarine Research Reserve (NERR) data portal. They will begin by searching for basic data about the reserves and how these vary geographically (Homework Handout #1), then generate graphs of water temperature throughout the year at four reserves located across the country (Homework Handout #2). Encourage your participants to work with a partner (or partners) on this homework assignment. Students will bring in water temperature graphs to interpret in class during the next session (a copy of these graphs is also provided with Session 4 materials in case your students can't print it out or don't bring a copy). Goals of the homework activity are:
    a. Have students become familiar with navigating the NERR Central Data Management Office (CDMO) web portal;
    b. Collect air temperature data from eight reserves, plot temperature on a bar graph, and draw conclusions regarding air temperature and distance from equator (Ocean as a heat reservoir);
    c. Use the interactive map and CDMO graphing tool to generate graphs of water temperature at four reserves representing a broad geographic scope; and
    d. Build the basic skills that will allow students to navigate through online data portals and investigate data-based questions for their final project.

2. **Read research on how People Learn.** Participants read research on learning and have an online discussion about the different ideas presented, and how those ideas compare to their experiences as learners. Distribute *Key Ideas from the Literature: How People Learn* Research Discussion handouts. Provide them with the following prompts to respond to:
    a. Describe what you think are the most important ideas from each section.
    b. How can the ideas about learning described in the reading be useful and relevant to you as a learner?
    c. When you teach, how might you use what you know about how people learn to help your learners to ***make sense*** of the science?

Optional / Additional Resources

Data discussion: *Averaged vs. raw data*

[**Note to instructor**: *An important aspect of science is that we look at the full range of data, not just the average of the data. Scientists both physically look at the data to understand the variation, or range, within their data as well as run statistics on their data to learn how the variation in the data influences what they can and cannot say from the data. However if we do have multiple data points, we often teach our students how to calculate the average and ask them to plot it. While this practice promotes their understanding of how to calculate an average, if unfortunately removes key information in the data that indicates what you can say about the observed pattern. This activity provides an opportunity for participants to experience the loss in depth of understanding of the data when you only look at averages.*]

1. **Introduce discussion.** Tell participants that they will take a few minutes to look more closely at temperatures recorded at Charleston, OR. This was the coastal location they were comparing with the inland location in an earlier activity in this session.

2. **Explain natural variation in raw data**. Using the "Natural Variation" slide, point out that they are looking at raw air temperature data collected every 15 minutes from the same location (South Slough NERR site in Charleston, OR) that they used in the mystery temperatures activity earlier. Have the participants describe the pattern that they see in the temperature data from this location.

3. **Turn and Talk: Comparison of raw vs. averaged data**. Using the "Natural Variation vs. Average" slide, explain that participants now are looking at the averaged data from the same

location over the same time period, with daily averages (center) and monthly averages (right) illustrated. Have the participants turn and talk about how they would describe the pattern that they see in the temperature data from the averaged data rather than the raw data. Have them think about:

   a. Do your descriptions change when looking at the averaged data only? [*An expert data user would say yes because there is a wider range of data points in the raw vs. averaged data. A novice data user would often say yes because the raw data goes up and down a lot but the averaged data only goes up and down a little bit.*]
   b. Do your conclusions change about the relationship/pattern of how temperature varies over time when looking at the averaged data only? [*An expert data user would say no because the increased temperatures in the summer months can be seen across all three figures, but their confidence in the pattern varies between the raw and averaged data. A novice data user would often say yes, because the raw data has more going up and down and the averaged data does not go up and down as much.*]
   c. Does the range of temperature values change when looking at averaged data only? [*yes*]

4. **Whole group discussion.** After a few minutes, regain the attention of the group and have partners share highlights from their conversations. As participants share, ask others if they talked about something similar or different and if anyone has anything else to add.

5. **Summarize Average vs. raw data.** As the conversation slows down, highlight that in science it is important to look at averaged data as well as the raw data that is full of natural variability in order to get a broader sense of the patterns and how confident you can feel in the patterns. If there is a large amount of variation around the average, then you can lose a lot of information about the situation if you only look at the averaged data.