

Session 2: Learning Conversations and Ocean Currents

Overview

This session focuses on learning conversations, the purpose and value in learning and ways to support students engaging in academic discussions. Participants explore ocean currents through multiple activities that include a hands-on investigation and observing a computer animation. They construct an explanation for what causes ocean currents and consider evidence-based responses to alternative explanations that are presented. Participants interpret and analyze data as a source of evidence and explore the benefits and limitations of using only simulated data vs. raw data to identify patterns. The session provides an opportunity to reflect on the role of conversation in meaning making, engagement in a research discussion on classroom conversations, and sharing of resources to support creating a classroom culture of talk and supporting students in reflective discourse.

Session Goals

Theme	Goals
Climate Science Ideas	Investigate ocean currents to understand: <ul style="list-style-type: none">● As denser water (colder and/or saltier) sinks and displaces water below it, the less dense water (warmer and/or less salty) is forced to rise to the surface. This is one way currents can form.● Currents spread heat energy throughout the ocean (OSS 1.8)
Using Data	Explore ways to: <ul style="list-style-type: none">● Assess benefits and limitations of using simulated data,● Orient to data visualizations to understand the details (e.g., scale) and context of the data, and● Connect observed data with prior knowledge.
Teaching & Learning	<ul style="list-style-type: none">● Experience and discuss the purpose and value of conversations in learning.● Examine some strategies and talk moves to support student engagement in academic discussions.

Framework/ NGSS	Identify and discuss some ways of supporting students in making scientific explanations.
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Materials Needed

For the class

- PowerPoint presentation
- Digital/data projector
- Whiteboard or flip chart paper and pens
- masking tape
- Model Ocean animations from OSS Session 1.8 available at <http://static.lawrencehallofscience.org/mare-sims/1-8-model-ocean-animation.html>
- Convection Current Demonstration video clip: http://mare.lawrencehallofscience.org/sites/mare.lawrencehallofscience.org/files/images/1-8_Convection_Current_Demonstration_v3.mp4
- Great Ocean Conveyer Belt animation clip: http://mare.lawrencehallofscience.org/sites/mare.lawrencehallofscience.org/files/images/thermohaline_assembled_640x360_mp4-h264.mp4
- WOCE Ocean Temperature with Depth image
- Class Climate Science Ideas chart

For each participant:

- 1 copy of Ocean Currents First Ideas
- 1 copy of Revised Ideas Ocean Currents
- 1 copy of Investigating Ocean Currents Worksheet
- 1 copy of Ocean Currents Cartoon
- 1 copy of *Discussion Map*
- 1 copy of *Strategies for establishing a culture of talk*
- 1 copy of *Sample Norms & Expectations*

- 1 copy of *Strategies to explore multiple ideas and seed argumentation*
- 1 copy of *Discussion Checklist (Goals and Instructor Prompts for Productive Discussion)*
- 1 copy of Climate Science Ideas handout
- 1 copy of Homework -Air Currents
- 1 copy of *The Gulf Stream Voyage: Using Real Time Data in the Classroom* (Hotaling, 2005)
- 1 copy of *Use of First-hand and Second-hand Data in Science: Does data type influence classroom conversations?* (Hugs & McNeill, 2008)

For each pair of students:

- set of molecule cards (also provided in Session 1)
- 2 paperclips (to hold molecule card sets)

For B. Activity: *Ocean Currents (modified OSS 1.7 and 1.8)*

- water
- 3 dishpans
- electric kettle or hot tap water
- cooler or ice chest
- ½ bag of ice
- 3 bottles of blue food coloring
- 3 bottles of red food coloring
- paper towels
- 3 cups of salt
- 4 plastic cups (1 oz)
- 2 clear plastic cups (9 oz)
- 8 cafeteria-style trays
- 8 self-sealing clear plastic bags (8" x 10")
- 8 tanks (1-1.5 gallon)
- 8 paper cups (8 oz)
- 8 pushpins
- 8 binder clips

- 8 red-colored pencils
- 8 blue-colored pencils
- 8 teaspoons
- scissors or paper cutter
- 8 sheets of blank white paper
- Ocean Currents Directions (stations 1,2,4,6)

For G. Research Discussion: *Talking & Learning*

1 set of the following research cards from the *Research Discussion: Talking and Learning* handout:

- Research Card #1: Conversations to Make Thinking Visible
- Research Card #2: Learning to Talk Science
- Research Card #3: Facilitation Approaches

Preparation of Materials

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

- Discussion Map
- Strategies for establishing a culture of talk
- Sample Norms & Expectations
- Strategies to explore multiple ideas and seed argumentation
- Discussion Checklist
- Ocean Currents First Ideas
- Revised Ideas Ocean Currents
- Investigating Ocean Currents Worksheet
- Ocean Currents Cartoon
- Climate Science Ideas handout
- Homework -Air Currents
- Homework readings:
 - *The Gulf Stream Voyage: Using Real Time Data in the Classroom* (Hotaling,

2005)

- *Use of First-hand and Second-hand Data in Science: Does data type influence classroom conversations?* (Hugs & McNeill, 2008).

2. Duplicate the Jigsaw Research Discussion Cards – Talking and Learning.

Prepare the Jigsaw Research Discussion Cards, 1 set per group of three:

- Research Card #1: Conversations to Make Thinking Visible
- Research Card #2: Learning to Talk Science
- Research Card #3: Facilitation Approaches

For B. Activity: Ocean Currents (modified OSS 1.7 and 1.8)

1. **Fill tanks.** Add enough tap water to each of the eight tanks so the water is 5–6" deep. Allow the water to come to room temperature.
2. **Make copies.** Make copies of the Ocean Current Directions (2 copies of the set of 4). Cut apart the Station direction sheets and place each inside a self-sealing plastic bag, or laminate them.
3. **Prepare the Stations:**
 - **Prepare the salt cups.** Fill 4 2-oz cups with salt.
 - **Prepare trays.** Place the following materials on each tray: 1 numbered Ocean Current direction sheet inside a plastic bag, 1 tank of room-temperature water, 1 paper cup, 1 pushpin, 1 spoon, 1 binder clip, 1 colored pencil, 1 bottle of food coloring, and 1 sheet blank white paper. Additional items - salt cups are listed in "What You Should Have" on individual Model Ocean direction sheets (Station # 4 and 6).
4. **Model Ocean animations.** Become familiar with the Model Ocean Animations at <http://static.lawrencehallofscience.org/mare-sims/1-8-model-ocean-animation.html>. It is optional to show these in the session, but familiarization will help the instructor support participant discussions about what they saw.

5. **Prepare to project video and animation.** Cue up the video and animation.
 - a. Convection Currents Demonstration video clip:
http://mare.lawrencehallofscience.org/sites/mare.lawrencehallofscience.org/files/images/1-8_Convection_Current_Demonstration_v3.mp4 (use a browser other than Chrome)
 - b. The Great Ocean Conveyor Belt animation clip:
http://mare.lawrencehallofscience.org/sites/mare.lawrencehallofscience.org/files/images/thermohaline_assembled_640x360_mp4-h264.mp4

Immediately before the session:

1. **Prepare three kinds of water.** Prepare about 4 cups of each type of water:
 - a. **Cold water.** Place ice and 4 cups water in a dishpan. Use enough ice so that the water is very cold, but there is still plenty of liquid water.
 - b. **Hot water.** You need water, which feels hot to the touch, but not so hot it burns. If there is hot tap water, place it in a dishpan. If not, heat water in an electric kettle and unplug before class begins.
 - c. **Room-temperature water.** Have on hand about 4 cups of room-temperature tap water.

Session at a Glance

Task	Description	Time (minutes)
A. Homework Reflection and Session Goals	Participants discuss their observations, ideas, and questions from the homework reading and video. The session goals are shared.	15
B. Activity: <i>Ocean Currents (modified OSS 1.7 and 1.8)</i>	Participants engage in a series of activities designed to help them gain a deeper understanding of density and ocean currents. Participants observe and explain model ocean currents, then interpret an animation and a video that introduces the concept of convection currents as they build an understanding of global ocean currents and how they move heat energy around the world.	55
C. Activity: <i>Looking at Raw vs Simulated Data of Ocean Currents</i>	Participants brainstorm what variables were needed to make the Great Ocean Conveyor Belt model. Participants then engage with authentic ocean temperature data at depth to compare their predictions with actual data, and discuss the pros and cons of using actual/raw vs. simulated data (an animation) to teach concepts to middle school students.	20
D. Activity: <i>Discussing Multiple Ideas about Ocean Currents</i>	Participants apply their ideas to explain ocean currents, then consider alternative explanations - and discuss why one idea is a better explanation than the others, using evidence they have gathered, and reasoning.	25
E. Discussion: <i>What helped us make sense of ocean currents?</i>	Participants reflect on what helped them to construct their understanding of currents in the ocean system and consider the role of talk.	10

G. Research Discussion: <i>Talking & Learning</i>	Participants engage in a jigsaw discussion about talking and learning. They include their own reactions to and questions about the information and lead a discussion on the topic within their group. Resources to support learning conversations are introduced (the Discussion Map, teacher moves, talk moves, and strategies for discussion).	30
H. Homework	<ol style="list-style-type: none"> 1. Read and respond to reflection prompts. <ul style="list-style-type: none"> • <i>The Gulf Stream Voyage: Using Real Time Data in the Classroom</i> (Hotaling, 2005) OR • <i>Use of First-hand and Second-hand Data in Science: Does data type influence classroom conversations?</i> (Hugs & McNeill 2008) 2. Density-driven currents. Predict how air currents might flow during the day and at night. 3. Climate Science Ideas. Complete Climate Science Ideas handout ready to share in next session. 	5
	TOTAL: 2 hrs 40 mins	160

Session Details

A. Homework Reflection and Session Goals

1. **Show slide of Session 1 homework prompts.** Remind participants that in the last session they were provided a reading and a video link and asked to respond to prompts. Ask participants to think about the ideas and questions they had:
 1. Describe two examples of how the conceptual shifts described in the reading may be meaningful to teaching science in schools? And/or to your own teaching practice?
 2. Given the new vision for K-12 science teaching and learning, what questions do you have?

2. **Participants turn and talk about homework prompts.** Ask participants to turn and talk with a partner for 1-3 minutes about their responses to these prompts.

3. **Share out.** Ask for volunteers to share out some of the big ideas or questions they were discussing.

4. **Share Session 2 goals.** Show the slide of Session 2 goals and explain that in this session participants may notice all four of the course themes interwoven into the session, as they explore *Learning Conversations & Ocean Currents*.

- **Climate science ideas** - Investigate ocean currents to understand:
 - As denser water (colder and/or saltier) sinks and displaces water below it, the less dense water (warmer and/or less salty) is forced to rise to the surface. This is one way currents can form
 - Currents spread heat energy throughout the ocean (OSS 1.8)
- **Using Data** - Explore ways to:
 - Assess benefits and limitations of using simulated data,
 - Orient to data visualizations to understand the details (e.g., scale) and context of the data, and
 - Connect observed data with prior knowledge
- **Teaching & learning** - Experience and discuss the purpose and value of conversations in the learning. Examine some strategies and talk moves to support student engagement in academic discussions
- **Framework/NGSS** - Identify and discuss some ways of supporting students in making scientific explanations, as described in the Framework and NGSS.

B. Activity: *Ocean Currents (modified OSS Sessions 1.7 and 1.8)*

Introduction

1. **Turn and talk about currents.** Project slide of World Ocean Surface Currents. Tell participants that patterns of currents at the surface of the ocean are a phenomenon that they

will be trying to explain in this session. Provide each participant with an Ocean Current First Ideas handout. Ask, “What do you know about what causes freshwater and ocean water to move around Earth?” Tell participants to take 1-3 minutes to jot down their ideas on the handout. Have participants briefly talk to a partner about their ideas and any questions they have.

Investigating Currents

1. **Introduce Ocean Currents Activity.** Tell participants that in the last session in the Mystery of the Floating Balloons activity, they observed how water of different relative densities behaved. However, the water they worked with was contained in a balloon. In the next investigation, they’ll get a chance to explore what might happen when water of one density meets directly with water of another density.
2. **Introduce investigation stations.** Tell participants that in order to learn more about what causes ocean currents, they will take part in an investigation of currents at four different model ocean stations around the room.
 - There are 2 sets of the four different stations.
 - Each station is unique and has its own directions to follow.
 - The first group who goes to a station is the setup group—they will create the current.
 - Groups that stop by at the station after the setup group will observe what happens after the current has been flowing.
3. **Define currents.** Explain to participants that a term they can use for the moving water at the different stations is a current. A current is a huge amount of water flowing in the same direction over time and a long distance. The flow of a river or movement of water in the ocean are both kinds of water currents. There are also air currents—wind that blows consistently in the same direction.
4. **Project Instructions and worksheet slide; explain activity directions.** Tell participants that they will make observations at the stations by recording what they see with words and a drawing on their Investigating Ocean Currents Worksheet. Explain some important directions and points to keep in mind:

- At your first station, carefully follow directions on the model ocean directions sheet—you are the setup group creating a current that the whole class will observe. Place the blank sheet of white paper under the tank so everyone can better observe the results.
- Leave the currents alone once they are set up. Do not disturb or stir the water in a tank.
- Food coloring is what allows you to see if there is a current and what direction it is moving. Food coloring stays with whatever kind of water it's mixed with.
- When a group finishes its first investigation (the current is set up and all group members have recorded the results), the group may move to another model ocean station. Don't go to a crowded station and don't go to a station where the first group has not yet finished setting up and recording the investigation.

5. **Explain procedure.** The model ocean directions sheets tell the setup group what they should have and what they need. Point out the locations where participants can obtain their supplies.

- *Directions.* Follow directions exactly. Some stations require you to add something to the water in the cup.
- *Cups and pushpin hole.* Be sure the pushpin gets stuck into the side of the cup, not the bottom. When the cup is placed in the tank, the hole in the cup has to be underwater so water will come out of the hole. Leave the pushpin in the cup until the directions say to remove it. Try not to crush the cups.
- *Binder clip.* Attaching the cup to the tank with a binder clip means to attach the cup to the inside of the tank. The cup will float and tip over if it isn't attached with the clip.

6. **Explain Investigating Currents Worksheet handout.** Provide each participant with an Investigating Ocean Currents Worksheet. Ask participants to look at the data table and notice the four different model ocean stations listed in the lefthand column. Point out the next three columns for recording (1) their predictions, (2) the data of their results in words, and (3) the data of their results in a drawing.

7. **Demonstrate showing results in a drawing using color.** Explain that participants will use a colored pencil to show which way the colored water (current) travels. Tell participants that it's not critical for the pencil color to match the water color at the stations. Participants will simply use a colored pencil to draw arrows that indicate the direction the colored water is flowing. The colored pencils can also be used to show the different colored layers that may form. Quickly make an example sketch on the board to show how to record results.

8. **Make predictions together for Station #1.** Tell participants that before starting the investigations, they will make predictions for one of stations as a group.
 - Stand near station #1 and show the materials. Say, "This tank contains room-temperature water, and the cup with a pushpin stuck in the side will have colored hot water in it."
 - Ask participants to talk in their groups about what they think will happen when the pushpin is removed. Ask, "Where will the colored hot water go?" "Will it flow along the bottom of the tank, across the top, or will it just flow everywhere?" Tell them to discuss their ideas and reasoning with their groups for one minute.
 - Have participants record their predictions and reasoning for Station #1 on the Investigating Ocean Currents Worksheet.

Run the model ocean stations

1. **Start investigations.** Emphasize that it is not important for them to visit all the stations, but they should discuss their ideas and questions at each station they visit. Assign each group to their first station and let them get started.

2. **Facilitate as groups work.** Circulate around the room, reminding participants to write down their predictions for their first station, unless the prediction was already recorded with the whole class. Remind them to record their data in words and with a drawing. Facilitate participants' understanding, by asking what happened and encouraging them to explain the results to you and to the group. Challenge them to use the words molecules and density in their explanations.

3. **Groups circulate to other stations.** When a group finishes setting up, observing, and recording the results of their initial investigation, tell them to look for another station that is free, and go there with their entire group. Remind participants to carefully collect data on the currents at each station they visit, then write and draw the results. (As groups circulate, you may need to walk around to different stations to top off the cups so the current will keep running)
4. **Complete the investigations.** Have participants visit as many stations as time allows (8-10 minutes is sufficient). Give a two-minute warning for groups to complete recording at a last station.

Explaining the model ocean Stations

1. **Introduce the explaining model ocean stations activity.** Tell participants that they first will discuss the model ocean station for which they were the setup group (their first station). Later, pairs from different groups will meet and share their explanations.
2. **Establish group goals.** Let groups know about the two goals for their five-minute meeting:
 - Agree as a group on how their current moved. (Remind participants that the current was the colored water in their model.)
 - Discuss why they think the current moved the way it did. Their reasoning should include describing the water's movements, and, using what they know about molecules and density as evidence. They may refer to the balloon investigation from Session 1, the key concepts, and/or a set of Molecule Cards to help with their explanation for the way the current moved.
3. **Small groups discuss.** Circulate (and distribute molecule cards as needed) as participants discuss the results and listen to their conversations. Be prepared to answer questions or clarify concepts, but don't tell them what caused the specific current at a particular station. Encourage use of the Molecule Cards.
4. **Regroup participants into new groups.** Regain participants' attention and tell them that you will now assign them to new groups so they can share their results with others. Ask

- participants in each group to split into two pairs. Create new foursomes by seating two pairs from different station groups together. Have participants bring their Investigating Ocean Currents Worksheet with them to the new group.
5. **Pairs share in new groups.** Explain that each pair will tell what kind of water was in their station’s cup, and describe how the current acted. They’ll also explain why they think that happened, using the words *density* and *molecules*. They may use the Molecule Cards to illustrate. Give the groups about 2-4 minutes to share with each other. After groups share, send everyone back to their seats.
 6. **Emphasize the key concept.** Regain the class’s attention and emphasize that all the stations were about density. Say, “All the stations you have been discussing illustrate the key concept we learned that denser substances sink below substances that are less dense.”
 7. **Optional: Recap with two ways water can get denser.** Remind everyone that denser water has more “stuff” or matter in the same amount of space. Ask participants to recall the two ways that water can have more “stuff” in the same amount of space:
 - **Water gets colder.** The molecules in cold water are closer together than in hot water, so cold water is denser than hot water. If you compare cold water and hot water in the same amount of space, there is more “stuff” or matter in the cold water.
 - **Salt is added.** Mixing salt with water introduces more “stuff” or matter into the same amount of space, so it is denser. Freshwater has only water molecules; salt water has water molecules and salt molecules.
 8. **Revisit balloon investigation statements.** Go back to the chart of statements made during the *Mystery of the Floating balloons* activity in Session 1. Read the statements aloud. Ask if participants have any new information to add. Record their thoughts on the chart. [*At this point, participants may add that water increases in density as temperature decreases and as salinity increases, that salt water sinks below freshwater, and that colder water sinks below warmer water. They might also add that salinity seems to trump temperature.*]

Explaining Ocean Currents

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1. **Turn and Talk; project image of the Amazon River Basin.** Ask participants the question, “*When warm freshwater from a river flows into the cold, salty ocean, do you think the freshwater flows to the bottom, stays near the top, or do the fresh and salt water mix together quickly?*” Then have them turn and talk to a partner to explain their thinking and share their questions.

2. **Class discusses the river prompt.** Draw pictures of the three possibilities on the board using a cross-section side view of the river and ocean meeting—one of the river water sinking below the ocean water; one of the river water sitting on top of the ocean water; and one of the river and ocean water mixing.
 - Have a volunteer share which of these claims they think is most likely based on the available evidence from their investigations.
 - Write down the evidence they cite next to the corresponding drawing. Make sure to push for reasoning as well—why does the evidence they are citing count as evidence for that particular claim?
 - Ask if anyone wants to build on the first volunteer’s ideas. If not, ask if anyone wants to share evidence and reasoning for a different claim.
 - Record the evidence and reasoning for each claim next to its accompanying picture.
 - Finally, summarize the group’s discussion.

3. **Re-visit image of World Surface Currents.** As participants revisit the image of the world surface currents, provide the following questions:
 - How might your understanding of density be connected to ocean currents?
 - Where might we find the densest ocean water and where might we find the least dense ocean water?
 - Where might we expect ocean currents to sink? And where might we expect them to rise?

4. **Reflect on Model Ocean Currents.** Ask participants to record understandings and any questions they have about ocean currents on the Ocean Currents First Ideas handout, using both words and pictures.

Convection Currents

- 1. Introduce Convection Current Demonstration video.** Introduce the video demonstrating what happens when hot and cold water come into contact with each other.
 - Tell participants that the video shows what is happening in the container from a side view, so that we can observe currents below the surface.
 - Explain that in this setup, a tank of freshwater is placed on top of two containers.
 - The container under the left side of the tank contains hot water and the container under the right side contains ice-cold water.
 - This means that the water in the tank is warmer on the left side and colder on the right side.
- 2. Describe addition of coloring; participants make predictions.** Tell participants that room-temperature red food coloring will be added to the left side of the tank, and room-temperature blue food coloring will be added to the right side, so that they can track any movement. Have the participants predict what will happen and remind them to state their reasoning for their predictions.
- 3. Project video.** As the video is playing, encourage participants to use the word density in their answers to the following questions. Questions to ask the group:
 - What is causing the red-colored water to rise? [*The water on the bottom of that side of the tank is very warm and less dense, so the red-colored water heats up and rises.*]
 - What is causing the blue-colored water to move along the bottom? [*The blue-colored water moves to replace the space that the rising red-colored water used to occupy; therefore, it moves along the bottom toward the left side of the tank.*]
- 4. Turn and talk.** Ask participants to turn and talk to a neighbor for the following question:
 - What do you think is causing the blue-colored water to rise when it gets to the left side of the tank? [*It warms and becomes less dense when it is near the container of hot water.*]
 - Now explain your thinking in terms of energy and matter (the movement of water molecules) in this model.

5. **Introduce convection currents; project key concepts.** After a few minutes, explain that when the warm water (carrying heat energy) rose because it was less dense, the cold water (with less heat energy) flowed toward the left side of the tank to replace the water that was rising. Then the cold water got warmer (gained heat energy) and rose because it was less dense. As the red-colored water moved toward the right side of the tank, the water cooled (released heat energy) and, as it became more dense, it sank. This created a current in the tank as the water moved up, down, and around, making a circle. Tell the participants that this circular kind of current, powered by temperature and density differences, is called a convection current, in which both matter and energy are moved.
 - ❖ As denser water (colder and/or saltier) sinks and displaces water below it, the less dense water (warmer and/or less salty) is forced to rise to the surface. This is one way currents can form.
 - ❖ Currents spread heat energy throughout the ocean.

6. **Discuss video model's limitations as compared to ocean.** Briefly, have participants share their ideas about how the video model is like and unlike the ocean.
 - The video model is much smaller; it is freshwater, not saltwater; different temperatures of water are not colored differently; ocean water is cooled and warmed from the surface, not the seafloor; the model doesn't receive heat energy from the Sun; and the model doesn't have wind or waves.
 - If no one mentions it, emphasize that a big difference between the model and the ocean is that ocean water is cooled and heated from the surface, not the seafloor. Most of the heat energy that warms the ocean comes from the Sun. Cooling of the ocean water also happens on the surface.

Introduce the Great Ocean Conveyor Belt

1. **Introduce the Great Ocean Conveyor Belt.** Project the conveyor belt animation and tell the participants that this large circulation pattern in the ocean is called the Great Ocean Conveyor Belt. This network of currents cycles water between surface currents and deep currents (below 500m), and everywhere in between. Describe the following features on the video:
 - White lines show currents flowing on and near the surface (0M to 400m-500m) of the ocean
 - Blue-gray lines show deep currents (> 500m deep). Dense (cold and salty) water
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sinks in the Northern Atlantic and the Southern Ocean.

- Deep water comes to or near the surface in multiple places throughout the world (e.g., Indian Ocean, North Pacific Ocean).

Emphasize that most of the white lines shown are actually currents flowing near the surface of the ocean. Remind participants that Earth is heated unevenly by the Sun: it's warmer at the equator and colder at the poles.

2. **Discuss animation.** As the animation plays, ask questions about what they observe and about how they would explain those observations, based on what they have learned. During the video, participants can discuss their observations with the person next to them. As The Great Ocean Conveyor Belt plays, guide conversations with the following:
 - Where does the warm ocean surface water near the equator go? [*It will travel along the surface or near the surface toward the poles.*]
 - What would you expect to happen to the warm water from the equator once it reaches the colder regions near the poles? [*It would cool off and sink because it would be more dense.*]
 - Where does cold, dense water from east of Greenland go? [*It sinks and moves in currents along the bottom of the Atlantic Ocean.*]
3. **Describe water at the poles.** When the animation ends, remind participants that this network of surface, near-the-surface, and deep currents is called the Great Ocean Conveyor Belt and it begins with water sinking near the poles. Ask, “**what would be two reasons water is dense and sinks near the poles?**” [*(1) it is very cold and (2) when the ocean water freezes into sea ice or evaporates, the salt is left behind in the ocean, causing the remaining water to become saltier*]. For these reasons, the water near the poles is really cold and really salty, which makes it really dense.

C. Activity: *Looking at raw vs. simulated data of ocean currents*

1. **Think about making of current simulation model.** Share with participants that in order to make the animation, scientists first had to build a model simulation of the ocean currents included in the animation.

- a. Have participants take two minutes to individually write down their thoughts about what assumptions scientists made about how the Earth works and/or what information had to be included in the mathematical model to make the simulation of the ocean currents, and thus the animation.
- b. Remind participants that this is just a brainstorming session, so they shouldn't worry about getting the "right" answer or editing what they write down.

2. Discuss making of current simulation model.

- a. After two minutes, have participants share out some of their brainstormed ideas of assumptions or information, and record ideas on chart paper or whiteboard.
- b. Highlight for the participants that brainstorming what data/variables and assumptions need to be included in the mathematical model are the first steps that need to be taken to develop a mathematical model and is a good way to help others to understand what goes into a mathematical model.
- c. If necessary, remind participants to think about what data/variables about the ocean water conditions that scientists could use to understand the pattern of the thermohaline circulation currents. [*Thermohaline currents are those caused by differences in salinity and temperature.*]

[Note to Instructor - Some example data/variables would be: water temperature, water salinity, water density, latitude, longitude, depth, etc. Some example assumptions would be: the Earth is spinning, denser water sinks, colder and more salty water is denser, currents form at different depths in the water column, etc.]

3. **Make predictions about a temperature at depth profile.** If it doesn't come up, tell participants that looking at temperature at depth could provide useful information for the mathematical model. Ask the participants to make a prediction of what a depth profile of temperature (ocean temperature from the surface to the seafloor) throughout the Atlantic Ocean (from the north to the south pole) would look like (e.g., where would the cold water be, where would the warm water be, etc.) if they were to look at actual (raw) data from the ocean. Have each participant write down their prediction.

4. **Introduce the "WOCE Ocean Temperature with Depth" slide.** Explain that the World
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Ocean Circulation Experiment (WOCE) was the largest internationally coordinated oceanographic program ever conducted. Scientists went out to sea and made measurements of the ocean throughout the globe from 1988 until 1998. **Note** - It may be helpful for some students to have a printed version of the visualization. If so, this would be a good time to pass it out to each participant.

- a. Since this is a new type of visualization, orient the participants to the data by going over the x and y axis, the units, and the scale.
 - b. Explain that potential temperature is temperature with pressure effects removed. This is important because changes in pressure can also influence temperature.
 - c. Before moving on, make sure that participants understand what they are looking at in terms of the data in the visualization.
 - d. Ask if anyone has any clarifying questions.
5. **Think-Pair-Share to look for patterns.** Ask participants to take a moment to notice what patterns or trends they see in the actual data. After a minute, have participants pair up and talk about how their predictions did or did not line up with the raw data from the Atlantic Ocean from July 1988-April 1989.
6. **Share partner discussion.** After a few minutes, regain the attention of the class and have volunteers share out with the class what they were discussing with their partner about the actual data from the Atlantic Ocean (as opposed to the simulated data from the Ocean Conveyor Belt simulation). Encourage other partner groups to build on the conversation by commenting, adding something new, or discussing a different conclusion from their partner discussions. As the conversation slows down, remind participants that scientists collect data from multiple locations over long periods of time to learn about large-scale patterns like the Great Ocean Conveyor Belt that they can use to make their mathematical models a more accurate representation or simulation of reality.
7. **Turn and Talk.** Have the participants turn to their neighbor one more time to discuss the benefits and limitations of only using the “Great Ocean Conveyor Belt” animation slide when discussing these patterns with their students.
- Benefits are: it presents the data in 3D representation of the 3D world, it summarizes the overall pattern, it uses schematics (arrows) to focus the user on the pattern.

- Limitations are: it does not include information about the depth that the water is at, it oversimplifies the pattern, it could lead to the misconceptions that the water only moves one way or that there are road sign-like arrows in the ocean.

Other Kinds of Ocean Currents

1. **Briefly introduce other kinds of ocean currents.** Tell participants that the Great Ocean Conveyor Belt is only one kind of current in the ocean. The uneven heating of Earth not only sets the ocean in motion, but it also causes wind patterns to form across the planet. Wind plays a major role in moving the surface water of the ocean around the planet. It is the wind that sets the surface waters in motion, but the spinning of Earth and the location of the continents also affect the direction of surface currents.

D. Activity: *Discussing Multiple Ideas about Ocean Currents*

1. **Introduce Revised Ideas.** Distribute the Revised Ideas Ocean Currents handout and tell participants that they will now take a few minutes to consider the diagram at the bottom. They should draw arrows on the diagram to show one place where water would sink, another place where it would rise, and any other water movements they want to include. They can add labels to help explain why the water moves the way it does.
2. **Project slide and distribute handout of Ocean Currents Cartoon.** Ask the participants to consider each of the ideas presented in the concept cartoon, first individually, then with a partner. Ask them to consider the following questions:
 - Which of the ideas is most similar to what you drew in your investigation notebook in step 1 above? How is it the same and in what ways does it differ? What evidence do you have to support your ideas?
 - What would you say to each of these kids? And what evidence do you have to back up your ideas?
 - Do you agree with any of the kids? If so, who? Why?
 - If you don't completely agree with anyone, how would you change their responses to be more accurate? What is your evidence that your ideas are more accurate?

Remind participants that understanding why the wrong answer is wrong is just as important

as understanding why the right answer is right.

3. **Discuss different claims.** Lead a whole group discussion with the participants, by asking, **“Which of these claims, if any, is most likely the best explanation? What is your evidence?” “How does the evidence support the claim?”** Remember the following:
 - Listen to their responses
 - Ask participants to provide explanations, evidence, or clarifications to elaborate on their thinking. Suggested probing questions:
 - What makes you think that?
 - Please give an example from your experience.
 - What do you mean?
 - Remember to stay neutral in your reaction to participants’ comments.
 - 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 opinion?
 - 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.

4. **Summarize the whole group discussion.** If necessary, summarize the group understanding about which explanation is most likely the best explanation supported by evidence and reasoning.
 - Marcus’s explanation, “The cold fresh water from the ice will sink to the bottom because it is more dense than the water around it. The water near the equator will rise up because it is warmer.” has a misunderstanding that the cold water that sinks at the poles is cold fresh water. The water at the poles sinks because it is cold and salty (saltier than the surrounding water because when ice is formed from ocean water, it leaves behind the salt).
 - Tim’s explanation, “The cold salty water in the poles will sink because it is more dense than the water around it. It’s really salty and really cold. And the cold water rises as it comes near the equator cause it gets warmer.” shows that Tim understands why the ocean water sinks at the poles, but does not show that he understands why

the water rises as it moves towards the Equator and how the water at the Equator moves towards the poles.

- Talya’s explanation, “The water moves around in a big circle. The warm water rises, and the cold water sinks, and it just keeps going.” shows that she understands on a phenomenological level that the water moves in a circular motion, but she does not include an explanation of the role of relative densities with different temperatures and salinities.
- Jamal’s explanation, “I think that the cold salty water at the poles sinks, and then it warms as it moves along the bottom toward the equator and mixes with warmer water. But then the water at the surface near the equator moves toward the poles again because that water sank” offers a more complete explanation of how the relative densities of water with different temperatures and salinities cause convection currents that drive this movement of heat energy around the Earth.

5. **Strategy to explore multiple ideas.** Tell participants that a concept cartoon, such as the Ocean Currents cartoon, is a strategy that can be used to explore multiple ideas with learners, and that a handout describing other strategies will be introduced later in this session.

E. Discussion: *What helped us make sense of ocean currents?*

1. **Participants do a Turn and Talk.** Remind participants that during the ocean current activity they, as a community of learners, constructed an understanding of the scientific concepts. Ask participants to be metacognitive about their learning experience, i.e., to “think about thinking.” Tell participants to turn and talk to a neighbor about the following prompts:
 - How did you learn the science ideas about ocean currents? More specifically, what was the role of talk?
 - What is it that makes conversations important for learning?
2. **Facilitate a whole group discussion.** This discussion builds on participants’ conversations with the goal of sharing ideas and identifying characteristics of conversations that support learning.

3. **Summarize the role of conversation in learning?** Ask participants to share their responses to: What is it that makes conversations important for learning? Participants may share ideas such as:
 - Arguments can be helpful to clarify ideas
 - Opportunity to realize what one knows and doesn't know
 - Organizes ideas about a topic
 - Reiterates or rephrases information to make it understandable
 - Opportunity to articulate first thoughts on a topic
 - Opportunity to add ideas into the mix and build off of one another
 - Mechanism to help remember what one knows about a subject
 - Helps create learners' own understanding of ideas
 - Allows for disagreements and sharing of multiple viewpoints
 - Opportunity to share in a "safe" environment
 - Provides opportunity for everyone to contribute and be included

F. Research Discussion: *Talking and Learning*

1. **Introduce discussion on talking and learning.** Tell participants that they will take a look at what the research can tell them about talking and learning.
2. **Introduce Jigsaw.** Ask participants to work in small groups. Tell them each small group will receive a few research cards. Each card features a piece of information from research about talking and learning. Each member of their group is responsible for carefully reading one of the cards. Then they will take turns explaining the information from their card to their small group and have a discussion about what the information means. Like a jigsaw puzzle, each member of the team is in charge of one of the "pieces."
 - Research Card #1: Conversations to Make Thinking Visible
 - Research Card #2: Learning to Talk Science
 - Research Card #3: Facilitation Approaches
3. **Each member leads a brief discussion about one research card.** During this discussion, each member should hold onto, and be in charge of their research card. After each group

member shares the information from their research card, they should also tell the group their thoughts about the card. They should continue the sharing and discussing process until you tell them to stop. They should also invite group members to discuss the topic on the card, including:

- Anything they find confusing about it.
- Questions or issues they have about the topic on the card.
- How teaching science might be structured to take this information into account.

4. **Start jigsaw.** Project a slide with the jigsaw instructions and prompts. Then break participants into groups of 3 (it's okay to have a group of 2 or 4 if your class doesn't divide into 3). Have participants get started on the jigsaw. Give them about 15 minutes to read and discuss in their small groups.

5. **Large group share (modeling discussion map).** After about 15 minutes of small group discussion, ask each group to share out any issues, ideas, or questions that came up during their small group discussion. Model the use of a discussion map (as follows) during this discussion so that you can refer to it in the next section.

6. **Model the discussion map.** Use the following prompts and strategies to facilitate a discussion. Ask a broad question: *What issues, ideas, or questions came up during your small group discussions?* (call on one group to share)
 - Listen to their responses and thinking.
 - Challenge participants to provide evidence or explanation.
 - What makes you think that?
 - What is your evidence for that comment?
 - Can you say more about that?
 - Please explain what you mean.
 - Remember to stay neutral in your reaction.
 - Encourage participants to provide alternative opinions or ideas, and react and respond to the ideas shared (Remember to continue to ask for evidence to support their thinking). Suggested probing questions:
 - Did other groups discuss similar ideas? Would anyone like to add

something to that comment?

- Does everyone agree?
- Would someone like to share an alternative opinion?
- Does anyone have a different idea of viewpoint?
- Connect back to the main topic. Suggested probing questions:
 - Do you think one type of discussion might help facilitate learning more than another? If so, which one?
 - How might the types of questions vary as the educator uses the different facilitation approaches —Giving information; Checking for understanding; and Thinking out loud?

7. **Summarize the discussion.** Summarize the discussion, including the following:

- Point out that none of these facilitation approaches are intrinsically good nor bad; their merits and demerits derive from the reasons for and ways they are used to support and achieve intended goals.
- In teaching science, there's often a tension between directing the conversation to communicate the views of science and being an equal contributor to the conversation to encourage and facilitate everyone to voice their views.
- The opportunity for learners to talk and share their thinking is necessary for learning science, but learning science also requires understanding and speaking the language of science, which educators need to model for learners. It's important for learners to have the opportunity both to make explicit their everyday ideas and to apply and explore newly-learned scientific ideas through talk and other actions *for themselves*.
- The fundamental point here is that “meaningful learning involves making **connections** between ways of thinking and talking...between everyday and scientific views.” For instance, an educator may begin with **Thinking Out Loud** to give learners a chance to express their everyday views in order to motivate and encourage them to be engaged, to legitimize their ways of thinking, and probe their prior knowledge. The educator may then shift to **Checking for Understanding** to draw out more of learners' thinking and

guide the expressions of their understanding toward scientific views. The educator may then transition into **Giving Information** to model how to voice and connect learners' everyday ideas in scientific language, and then finish with more **Thinking Out Loud** to give learners the opportunity to practice using scientific language.

- 8. Explaining rationale behind jigsaw activity.** Tell participants that this type of jigsaw activity is meant to encourage collaboration and discussion in small groups. Having each member responsible for the information on their card, and leading the discussion about that information, can help keep everyone involved in the discussion, and prevents any one person from dominating the group.

Setting up Learning Conversations

- 1. Explain need for conditions to support learning conversations..** Tell participants that although learning conversations are very important, creating the conditions to support such conversations is critical to making them effective. Many things need to happen in order to engage students in productive learning conversations.
- 2. Share the conditions to support learning conversations.** Share the following list of conditions to support learning conversations with participants and tell participants that they will receive handouts that address each of these areas.
 - Norms established to support a culture of talk
 - Questions that encourage divergent thinking
 - Student understanding of what constitutes evidence and reasoning
 - Classroom discussion structures that encourage debate and equal participation (e.g., science seminars, science talks, Socratic seminars)
 - A teacher's command over facilitation and questioning strategies
 - Strong command over the science content

Learning Conversation Resources

[**Note to Instructor:** *If there is not time to introduce these resources through a presentation, as described here, distribute the handouts and have participants read them for a homework assignment.*]

1. **Introduce the culture of talk handouts.** Pass out one copy of the *Strategies for establishing a culture of talk* and the *Sample Norms & Expectations* handout to each participant. Tell participants that these two handouts focus on strategies for establishing a culture of talk within the classroom so that students feel comfortable sharing and challenging ideas. Remind participants that in the first session, you established norms for discussion, which were intended to help create a safe and equitable environment for discussions. The sample norms handout will provide some examples of types of norms they might wish to establish in their own classrooms.
2. **Introduce the checklist handout.** Pass out one copy of the *Discussion Checklist (Goals and Instructor Prompts for Productive Discussion)* handout to each participant. Tell participants that this handout provides suggestions for different questions or prompts a teacher might provide depending on their instructional goal in the moment. For example, if a teacher had a goal of helping learners listen carefully to others, (s)he might ask, “Who can rephrase or repeat that?” Tell participants that having an understanding of various goals they might have as a teacher during a discussion is fundamental to high quality facilitation of learning discussions.
3. **Introduce the exploring multiple ideas handout.** Pass out the *Strategies to explore multiple ideas* handout to each participant. Tell students that asking questions that encourage divergent thinking is crucial to engaging students in learning conversations. Not all discussions need to engage students in arguing from evidence, but a real discussion does provide opportunities to consider multiple perspectives. This handout shares several strategies for having students consider multiple ideas—both generated by the students and by the teacher, including the Concept Cartoon strategy they experienced earlier this session.

Engaging in Argument from Evidence

1. **Introduce Engaging in Argument from Evidence.** Tell participants that engaging in argument from evidence, is one of the Science and Engineering Practices described in the Framework and NGSS, and is one type of learning conversation.
2. **Briefly describe the SEP Engaging in Argument from Evidence.** Read the following

description of argumentation from NGSS:

Argumentation is a process for reaching agreements about explanations... Reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon... Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits.

Ask participants, during the ocean circulation concept cartoon activity:

- A. What structure(s) supported the consideration of multiple claims and sources of evidence? *[Possible responses: having four cartoons (claims) to choose from; talking to peers about the claims; having peers share evidence in the whole group discussion]*
- B. What structure(s) supported all participants' engagement in the discussion? *[Possible responses: starting with a small group discussion; teacher encouraging multiple perspectives to be shared during whole-group discussion]*
- C. What structure(s) supported all participants' understanding of the conclusion(s) reached at the end of the discussion? *[Possible response: instructor summarizing at the conclusion of the discussion]*

- 3. For further exploration of Argumentation (optional).** (If time) Introduce participants to the Argumentation Toolkit website where they will find additional strategies and tools for promoting argumentation in the classroom, and a series of instructional videos of teachers using them in their classrooms. (<http://www.argumentationtoolkit.org/index.html>).

Discussion Map

- 1. Introduce the discussion map.** Tell participants that researchers have studied effective strategies for facilitating discussions, and have developed the idea of a “discussion map” to reflect how skilled discussion leaders tend to guide and encourage discourse. This map can be applied to discussions with any age group.
- 2. Display discussion map.** Project the *Discussion Map* and read each step aloud:

- Ask an open-ended (broad) question that invites students to share their ideas
 - Listen to responses and thinking
 - Challenge learners to provide evidence or explanations
 - Remain neutral
 - Encourage alternative opinions or ideas
 - Connect back to the main topic
 - Help to organize and summarize the ideas
3. **Point out importance of listening carefully after each response and following learner's thinking.** Explain that these steps represent a useful *sequence* to facilitate a conversation, but they don't specify exactly what the educator says. It is necessary to listen carefully to each learner's response and encourage them to articulate their ideas in full. The purpose is to allow learners to express themselves, make connections between their ideas, and challenge them to organize and reconsider their thinking in relation to what they and others say. The most important factor in facilitating discussions is following (and guiding) the natural flow of the exchange of ideas.
4. **Staying neutral is important.** Tell participants that it is important to be non-judgmental in their responses. Keep a "poker face," and refrain from saying "right!" to the response they expect and hope to hear. An educator's neutrality encourages learners to contribute their own viewpoints, which is critical for constructing meaning. Encourage participants to take their time when leading discussions, to pause after questions and comments, and encourage their learners to explain their reasoning.
5. **Relate discussion map back to research discussion.** Pass out the *Discussion Map* handout to each participant. Explain that the debrief of the research discussion utilized the discussion map. Display the Discussion Map Example and review how they followed the discussion map.
- **Pose an open-ended (broad) question:**
 - What issues, ideas, or questions came up during your small group discussion?
 - **Listen to response and thinking.**
 - **Challenge learners to provide evidence or explanation.**

- What makes you think that?
 - What is your evidence for that comment?
 - Can you say more about that?
 - Please explain what you mean.
 - **Encourage alternative opinions or ideas.**
 - Did other groups discuss similar ideas? Would anyone like to add something to that comment?
 - Does everyone agree?
 - Would someone like to share an alternative opinion?
 - Does anyone have a different idea or viewpoint?
 - **Connect back to the main topic.**
 - Do you think one type of discussion might help facilitate learning more than another? If so, which one?
 - How do you think an educator might view his/her role when facilitating each type of discussion— giving information, checking for understanding, and thinking out loud?
6. **Discussion Map modeled throughout course.** Point out that most of the discussions in this and the previous course session were facilitated using this map as a guide. This Discussion Map model is well-suited for an educator who seeks to facilitate learners in constructing their own conceptual understanding. It allows:
- Diverse ideas to emerge
 - Learners to compare evidence for varying points of view
 - Learners to articulate what they are thinking and why they think it
7. **Describe flexible use of Discussion Map.** Explain to participants that the Discussion Map idea is very useful, but it's not intended to be a full description of discussion-leading strategies. It works best when used as a flexible model to guide discussions, rather than a rote procedure to be followed step-by-step. Often each step can involve multiple learner responses, and learner-to-learner responses, without the teacher intervening between each response.

H. Homework

1. Thinking about how to use data in our teaching

1. **Read.** Read either

- *The Gulf Stream Voyage: Using Real Time Data in the Classroom* (Hotaling, 2005)

OR

- *Use of First-hand and Second-hand Data in Science: Does data type influence classroom conversations?* (Hugs & McNeill 2008).

2. **Reflect.** Reflect on aspects of teaching with data that are discussed in the paper you read in terms of:

- What resonated with you for yourself as a learner?
- What resonated with you for your thoughts on teaching with data?
- What are potential challenges that students may encounter when learning with data?

2. Density-driven currents. Draw arrows to show direction of air currents.

Distribute the Air Currents handout. Predict how air currents might flow during the day and during the night and show your thinking with arrows and words on the Air Currents handout. (Consider your understanding of what causes ocean currents).

3. Using climate science ideas to build an understanding of climate change

1. **Introduce climate science Ideas chart.** Provide each participant with the Climate Science Ideas handout. Show participants that the key concepts learned from the ocean currents activity have been entered into the Climate Science Ideas column.

2. **Connecting Climate Science ideas and understanding of Climate Change.**

Explain to participants that they should reflect on these climate science ideas and in the second column on the chart, record how the ideas might be connected to climate change. Explain that they will have an opportunity to share their ideas and hear some of the other ideas in the group in the next session.