INTRODUCTION—GRADE 8

In FOSS, sense-making discussion is a prominent part of active investigation. The sense-making discussion follows the context setting, activity, data acquisition and management, and is a critically important part of the analysis process. The following vignette describes a sense-making discussion.

In the Electromagnetic Force course, students explored net force in Investigation 1 by pushing and pulling objects and measuring force in Newtons. In Investigation 2, students explored the force of magnetism by testing properties of magnets and various materials. In Part 3 of the investigation, students explored the force needed to break apart two attracted magnets when the magnets had varying distance between them. They determined that the force of attraction between magnets decreases over distance. Next they tested multiple magnets to determine how their force of magnetism increases as magnets are added to the system. Students recorded the “jump distance” of a paperclip, how far a paperclip moved, as a measure of the strength of the magnetic force applied. Then, they developed and recorded a model of the magnetic field of multiple magnets based on their experimental results. At this point in the investigation, the teacher asks...
students to bring their notebooks and form a discussion circle, standing shoulder to shoulder next to someone from another group. Partners discuss the question posed on the class notebook, a chart stand placed within the circle. They think about what happened to the jump distance as they added more magnets. One student shares their group’s data under the document camera as their partner describes how the data supports their claim. Some students agree and others ask questions. One student records their model on the chart paper. The teacher listens and asks questions to guide the discussion, encouraging communication between all students, careful to facilitate rather than lead. Students add to the model and others compare their own data. They review their notebook entries and cite findings from the experiment as they develop their explanations. Collaboratively, the class begins to make sense of the data to develop a model that explains the phenomenon. Before returning to their seats and responding to the focus question individually in their notebook, students summarize their models with a partner.

A sense-making discussion, like the one described above, has two purposes. First, it helps students review and confirm information accrued from the active investigation, and organize information for processing. It is more than just sharing what they did or observed; more importantly, it is analysis—finding connections and relationships in the data in an effort to construct conceptual knowledge. Second, this discussion helps students organize and communicate their thinking in collaboration with their peers. The sense-making discussion allows all students to develop conceptual models about phenomena and prepares them to respond to or build on their responses to the FOSS focus question.

If your students have had sense-making discussions in their FOSS elementary experience, they will be prepared to jump right in with a little encouragement. They may be able to maintain fruitful discussion for a longer time than their younger counterparts, but may be more distractible. You might find that as you grow comfortable with giving students more ownership of their own learning in this setting, both you and they will want more opportunities than those suggested in the Investigations Guide. Use your intuition. In addition, middle school presents challenges with multiple classes throughout the day. The next section provides suggestions on how to set up class notebooks for each of your classes.

This chapter describes a professional learning process to enhance your abilities to facilitate sense-making discussions of science phenomena with grade 8 students. This chapter will be most useful after you have taught a FOSS course.
Planning and Preparing for Sense-Making Discussions

PLANNING AND PREPARING FOR SENSE-MAKING DISCUSSIONS

We have identified six planning steps to prepare for a sense-making discussion. We will describe each step and then provide a typical planning schematic that summarizes the process. At the end of this chapter is one sample of a model sense-making planning guide for each grade 8 course.

1. Review the Investigations Guide

Look closely at the disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCs) associated with a particular lesson. These are stated on the first page of the investigation and discussed in the Teaching and Learning about... section. Review the guiding questions for the investigation (on the first page and in the at-a-glance chart), the Scientific and Historical Background, and the Teaching and Learning about... section for cognitive engagement that is critical for student understanding. Note relevant questions or talking points in these sections, and pay particular attention to common emerging conceptions that can be used to generate argumentation.

INVESTIGATION 2 – The Force of Magnetism

SCIENTIFIC and Historical Background

We tend to take magnetic phenomena for granted because magnets are all around us. Refrigerator doors are notorious gathering places for multitudes of little magnetic doodads, and magnets are at work behind the scenes keeping refrigerators and almost dozen scientists closed. Compasses, loudspeakers, and electric motors all use magnets. The magnet on the refrigerator door and the one used in this investigation are permanent magnets. Magnets that can be turned on and off have a different magnetic pedigree, and they are the subject of Investigation 3. The guiding question for this investigation is how can we describe magnetic force?

For many years permanent magnets were made of iron. Magnet technology has made tremendous strides in the past several decades, and modern magnets are stronger and less susceptible to losing their magnetism than their iron predecessors. New alloys like alnico (aluminum, nickel, and cobalt) make very powerful, long-lasting magnets, and magnets made from a powdered iron oxide called ferrite are not only strong but versatile, because magnetic ferrite dust can be put in a ceramic or rubber matrix and molded into an endless variety of sizes and shapes.

The doughnut-shaped magnets used in this investigation are ceramic ferrite magnets. The ferrite-infused ceramic liquid is poured in a mold, subjected to a magnetic field to align the tiny ferrite particles in the orientation desired, and fired to lock the ferrite particles in place.

The strongest consumer permanent magnets are called neodymium magnets. They are manufactured from an alloy composed of the rare earth element neodymium, iron, and boron (Nd_{2}Fe_{14}B). Neodymium magnets are often used by welders to hold steel pieces in place while they work. These magnets are so strong that they can be dangerous if handled carelessly. A pinch of skin caught between two neodymium magnets can be seriously damaged.

What Happens When Magnets Interact?

Magnets interact with objects in two ways; they either stick to the object or they do not. Magnets stick only to other magnets and a select few metals. The most common metals that stick to magnets contain iron, nickel, and cobalt, either pure or in alloy. Nickel and cobalt are quite rare on earth, but for everyday components, if a magnet sticks to an object that is not itself a magnet, chances are good that the object is made of iron or an iron alloy, such as steel.

The Scientific and Historical Background provides information about the content developed during the sense-making discussion.
INVESTIGATION 2 — The Force of Magnetism

TEACHING AND LEARNING about Magnetism

Developing Disciplinary Core Ideas (DCI)

• PS2.A: Forces and motion

Magnetism

The Force of Magnetism

Exposing Crosscutting Concepts (CC)

• Patterns: Magnetic patterns are related to the nature of microscopic and atomic-level structure. Patterns can be used to identify cause-and-effect relationships.

• Cause and effect: Magnetic force induces temporary magnetism in magnetic materials.

• Systems and system models: Magnetic force creates a magnetic field.

Connections to the Nature of Science

Scientific knowledge assumes order and consistency in natural systems. Science assumes that object and event in natural systems occur in consistent patterns that are understandable through measurement and observation. Science carefully considers and evaluates anomalies in data and evidence.

Connections to Engineering, Technology, and Applications of Science

Interdependence of science, engineering, and technology: Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. Science and technology affect each other forward.
When you hold two magnets, you can actually feel the magnets either pulling toward each other or pushing each other away, depending on how they are oriented. The agent responsible for the pull or push is the magnetic force. This force can cause motion, and where there is motion, there is energy. The potential energy of a magnetic object placed in a magnetic field, such as a paper clip placed near a permanent magnet, transfers to kinetic energy when the magnetic force is stronger than the force of friction, and the paper clip slides toward the magnet.

The strength of the force of attraction (or repulsion) between two magnets is the product of several variables. Most important are the native strengths of the magnetic fields produced by the magnets and the distance between them. The general rule is the stronger the magnets, and the closer they are together, the stronger the force acting between them.

The greater the distance between two magnets, the weaker the force of attraction. As the distance between magnets approaches infinity, the force of attraction approaches, but never reaches, zero.

**Vocabulary**

- Attract
- Compass
- Gravitational force
- Induced magnetism
- Magnet
- Magnetic field
- Magnetism
- Permanent magnet
- Pole
- Potential energy
- Repel
- Temporary magnet

**Conceptual Flow**

In this investigation, students explore the phenomenon of magnetism. The guiding question is how can we describe magnetic force?

The conceptual flow starts in Part 1 when students test magnets to learn about their properties. They use multiple magnets with a compass and conclude that opposite magnetic poles attract and like magnetic poles repel. The force of magnetism is an invisible force, similar in some ways to gravitational force, which is always attractive.

In Part 2, students consider how a magnetic field spreading from a magnet explains properties of magnetism. They start by considering how a permanent magnet can induce magnetism in a steel object and create a temporary magnet. They make a preliminary model to describe the phenomena they observe. Using various tools and a reading, students collect more information about magnetic fields and add to their model.

In Part 3, students describe the force exerted by a magnet in terms of its potential energy. They conduct an experiment to measure how the force of magnetism decreases as distance from the magnet increases, and another experiment to consider how the force of magnetism increases as magnetic fields from multiple magnets overlap.

**Teaching and Learning about Magnetism**

Knowing where concepts are addressed and how they are related helps determine what ideas to pursue during the discussion and which ones can be addressed during the next part.
2. Identify When and Why to Have the Discussion

Most investigation parts have a step where the class discusses the body of acquired information. The step may not always instruct you to organize students in a circle, but that is generally advisable. The sense-making discussion may be contained within a step, or may take place over several steps. Consider doing this when students have acquired sufficient experience and information and are ready to think about and construct explanations about a phenomenon. A sense-making discussion should happen after data acquisition to help students organize their thoughts and make evidence-based claims, ultimately preparing them to explain experimental findings, develop a conceptual model, or to answer the focus question. For middle school, plan about 10–15 minutes for the sense-making discussion. This time will vary from day to day and class to class depending on the students’ ability to focus and have fruitful discussion.

To illustrate this process, we will use an example from the Electromagnetic Force Course, Investigation 2, The Force of Magnetism. The page below shows the location of the sense-making discussion after the data collection.

During the sense-making discussion, the role of the teacher is to facilitate the discussion. The teacher asks questions, listens to students, and adjusts depending on the discussion. In the Investigations Guide, certain steps have detailed questions to help students analyze data. Other steps help to identify important ideas that need to come out during the discussion. Review those questions and the important ideas and plan additional scaffolding questions that will guide students toward the desired understandings (DCIs).

17. Have a sense-making discussion

After students review what they observed in terms of net force and energy, gather the class for a sense-making discussion, in a circle if possible. Have students take their notebooks to the circle. Review class norms for discussion, and encourage students to build on each others’ ideas and to ask clarifying questions of each other. Ask the Recorder from one group to share the group’s data on chart paper so the entire class can see. Discuss what it shows about how magnetic fields add together to affect the force of magnetism. Have other groups share their data and discuss patterns they notice. Ask students to summarize their findings.

- What happened to the jump distance that the paper clip moved when you added more magnets? [It increased significantly between one magnet and two magnets, less so when we added a third or fourth magnet.]
- What happened to the force of attraction when you added more magnets? [The force was stronger with each additional magnet, but the second magnet added more force than the third or fourth.]
- What evidence do you have that the force increased? [The jump distance increased.]
- Why do you think the force increased so much with the second magnet, and only a little with the third or fourth magnet? [Accept all ideas.]

18. Continue the discussion with distance

Continue the sense-making discussion, asking students to turn to a partner to ponder that last question. Give them a few minutes to come...
3. Plan What to Ask and What to Listen For

There are different levels of questions that will facilitate the discussion. If data have not been shared prior to the sense-making discussion, start with data questions. Plan on asking for observations and have students display those observations in the class notebook. After asking questions about observations, plan questions targeted to the content (disciplinary core ideas) that build on complexity.

Other questions should utilize a crosscutting concept. For example, “What pattern of motion leads to night and day?” Some of these questions might be found in the Scientific and Historical Background and the Teaching and Learning about . . . section. The focus question might be an analysis question. Generating this list of possible questions to ask during the sense-making discussion keeps the discussion focused and students engaged. See the list of teacher-generated sample questions for the vignette from Electromagnetic Force in the sidebar.

In addition to the questions, develop a list of the ideas or responses to these questions. This is what you will listen for during the discussion. Look at the What to Look For section for that part for possible anticipated responses, including common emergent conceptions.

Some teachers identify the What to Listen For first and then develop questions to elicit those ideas. Be certain the questions and the desired ideas match the goals or outcomes for the lesson. See the list of teacher-generated responses to questions in the sidebar.

### What to Ask

- How does magnetic force affect a paper clip?
- How do multiple magnetic fields affect the force of magnetism?
- The paper clip was resting on the table. What caused it to move?

### What to Listen for

- Magnetic force attracts the steel paper clip, overcoming friction.
- Magnetic fields appear to be additive; the force of magnetism increased when there were several magnets.
- The jump distance increased significantly between one magnet and two magnets, less so when we added a third or fourth magnet.
- The force was stronger with each additional magnet, but the second magnet added more force than the third or fourth.
- When magnetic fields are added together, the force of attraction increases.
- The farther magnets have less effect on the force of attraction.

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### SESSION 3  45–50 minutes

**FOSS**

Sense-Making Discussions for Three-Dimensional Learning—Grade 8
4. Plan for Adjustments

Since students might address ideas before questions are asked, there is not always a linear line of questions and answers. The sense-making discussion is not a question-and-answers session, but rather a student discussion about the data, managed but not directed by the teacher. Having a list of the ideas you are listening for helps determine if students’ ideas are heading in a productive direction.

**Scaffolding questions.** If the discussion needs to be further guided or redirected, adjust as necessary using scaffolding questions. As part of your planning, develop questions to scaffold the discussion, and be prepared to redirect the discussion if it is heading in an unproductive direction. Use questions that ask for data to support students’ conclusions. It is always helpful to ask students to support their thinking or the thinking of others with supporting data (evidence).

**Application questions.** Next, plan application or extending questions. In some contexts, these questions connect student thinking to the guiding question for the investigation, bigger ideas, or a new context. For example, “Why is it important for engineers and scientists to know what the exact acceleration of gravity is?” or “How are humans affecting evolution?” When appropriate, revisit the phenomenon or guiding question for the investigation and raise culturally relevant questions that connect concepts to students’ experiences. Look at the Wrap-Up/Warm-Up section for some of these questions. These questions push students’ conceptual models. At times it is appropriate for students to be thinking about these application questions well after the sense-making discussion takes place.

**Other instructional strategies.** Depending on the focus crosscutting concepts and science and engineering practices, other instructional strategies can be incorporated into the discussion. For example, the teacher can provide a claim that differs from the claim students are making in the discussion. This claim serves as a critical competitor, an argumentation strategy designed to fine tune the students’ claim. Additionally, a cause-and-effect chart could be made to help students look at specific relationships between variables. Examples of instructional strategies can be found in the Science and Engineering Practices and Crosscutting Concepts and Integration chapters. The next-step strategies found in the Assessment and Science Notebooks in Middle School chapters can also be incorporated into sense-making discussions when appropriate.

**NOTE**
Ways to adjust the discussion include:
- Using scaffolding questions
- Using application questions
- Using other instructional strategies
- Using talk moves
SENSE-MAKING DISCUSSION PLANNING GUIDE

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Questions and What to Listen For

**Steps 16–20:** Have a sense-making discussion

What to ask

- How does magnetic force affect a paper clip? (Analyzing and interpreting data; energy and matter)
- How do multiple magnetic fields affect the force of magnetism? (Constructing explanations; energy and matter)
- What evidence do you have that the force increased? (Step 17) (Analyzing and interpreting data; energy and matter)
- Why do you think the force increased so much with the second magnet, and only a little with the third or fourth magnet? (Step 17) (Constructing explanations; patterns)

What to listen for

- Magnetic force attracts the steel paper clip, overcoming friction.
- Magnetic fields appear to be additive; the force of magnetism increased when there were several magnets.
- Distance increased significantly between one magnet and two magnets, less so a third or fourth magnet.
- Magnetic fields are added together, the force of attraction increases.
- The farther magnets have less effect on the force of attraction.

Scaffolding questions

- The paper clip was resting on the table. What caused it to move?
- What evidence was there of kinetic energy? Of potential energy? (Step 16)
- What happens if an object is very far from a magnet?
- The third and fourth magnet you added were farther from the paper clip than the first few magnets. Are the effects of those magnets' magnetic fields stronger than the first magnets? (Step 18)

Application questions

- Based on your model of magnetic fields, how far do you think a paper clip would move if you used five magnets? Six? Seven? Eight? (Step 20)
- How might you introduce competing magnetic fields on a paper clip in opposite directions? Explain.

These are questions that help students process the data to extract meaning.

These are the intended responses to the content questions. As these ideas come forward, talk moves are used to engage all students.

These are questions to ask if students need guidance when processing data and the intended responses are not being heard.

These questions are designed to extend knowledge beyond the discreet experience for the lesson.
**Talk moves.** Talk moves serve to help all students communicate with each other and advance their models. Several talk moves are possible. Two talk moves can be used to help begin a sense-making discussion.

- Use partner talk when starting the discussion or when there is a lull in the action. Always start the group discussion with a quick “turn and talk to your neighbor.” This will loosen students up and give them oral practice. This move is very beneficial for students who need more support with language. It often makes sense to have students stand next to and talk with someone they did not work with in their group. You can also use a protocol such as an A/B partner talk dyad or a group sentence starter (see the Science-Centered Language Development in Middle School chapter for more information). Let students know how long the partner discussion will be and the importance of listening and responding to each other.

- Wait time often works well with students. Initially some students might find these discussions very uncomfortable, but don’t interrupt this struggle too soon. Students need time to process, reflect, and mount the courage to speak up.

Some talk moves are most useful when adjusting the discussion so students discuss the ideas of others. *Talk Science Primer* explains how talk moves progress from pushing individual thinking, to listening to others, to deepening reasoning, and to engaging with others’ reasoning. Try to move beyond having students listening to others just so they know when it is their turn to talk. Students should work to listen actively and critically and link their ideas to the ideas of others. As you prepare for using the talk moves, start with just a few. *Talk Science Primer* describes two examples that are very effective talk moves to use when students start thinking about analysis and application questions. The first one is Say More and Explain What Someone Else Means; the second move is to Agree/Disagree and Why. Using Asking for Evidence or Reasoning is an effective talk move in which students are asked to reference specific observations or explain a line of thinking.

Talk moves should be considered thoughtfully and selectively, and applied strategically to get students engaged in productive discourse.
5. Consider Language and Vocabulary

Sometimes it is advisable to formally develop precise vocabulary during the sense-making discussion. At other times, students develop those vocabulary words in the context of active investigation. Having these vocabulary words in mind and publicly displayed in the classroom can be helpful. Some teachers use a classroom word wall; others write relevant words on the board or chart paper visible during the discussion. If students are not using academic science vocabulary, adjust the discussion by asking them to rephrase statements, using the academic vocabulary.

With English learners, provide sentence frames to share data or share their thinking. This could become a focus during the discussion. For example, give a sentence starter, such as “What I hear you saying is ______,” when a student is responding to other students. Incorporate accommodations and modifications as necessary to provide all students equal access to and participation in the discussion. See the Access and Equity chapter for more information on ways to support all students.

6. Use a Class Notebook

Students should bring their science notebook and a pen or pencil to the sense-making discussion. It is helpful to develop a class notebook for use during the discussions. This can be a composition notebook used with a document camera, or chart paper on a stand where everyone can access it. This class notebook serves as a central, visible location for students to share their data and refine their thoughts. You might have one notebook for each class, or you can label each page with the class number for later reference.

Think about what data should be recorded in the class notebook for display during the sense-making discussion. Try to find time for a few students to record their data. This could be done during the initial partner talk or when students are collecting their data during the active investigation. Allow students to use the class notebook when discussing data. The class notebook can be used to reorganize data to determine patterns or describe cause-and-effect relationships.

The teacher might interact with the class notebook to model a particular data processing technique or call attention to a specific detail.

Sentence frames. These samples can be posted as a scaffold as students learn and practice their reasoning and participation skills.

- I think ______, because ______.
- I claim ______; my evidence is ______.
- I agree with ______ that ______.
- My idea is similar/related to ______’s idea.
- <Name> shared ____ with me.
- We decided/agreed that ______.
- Our group sees it differently, because ______.
- We have different observations/results. Some of us found that ______. One group member thinks that ______.
- We had a different approach/idea/solution/answer ______.
CONDUCTING A SENSE-MAKING DISCUSSION

Gathering in a circle is optimal for sense-making discussions. Students should stand shoulder to shoulder so everyone can see each other and the class notebook chart stand or front screen where notebooks are projected. You should be part of the circle. Depending upon the need for the class notebook, you might stand near it, but not next to it. One goal of the circle is to remove you from the position of “teacher” and the one who “runs” the discussion and has all the answers.

Additionally, you should encourage students to look at and talk to each other rather than to you.

Work with students to generate a list of their responsibilities and ways they should contribute to the conversations. Examples are displayed on the posters shown here.

Make sure students have visual access to the established class norms, sentence frames, word wall, class notebook, equipment photo cards, and, when appropriate, a reference set of the materials used during the investigation.

Frequency

The goal is to address challenging content or consider the focus or guiding question with a rich sense-making discussion several times in each course. You will find suggestions in the Investigations Guides in the context of the investigation called out by a note in the sidebar. Do not limit yourself to these instances. Rather, take your lead from the students. When they are struggling with a concept, you might find it the perfect opportunity to prepare for a sense-making discussion.
Don’t feel you need to do this as a new FOSS user. Branch out as you develop your facilitation skills and students develop their participation skills. In some parts, especially in life science modules, students will discuss data from long-term observations. While this might add additional time, having a rich sense-making discussion will go a long way to improving students’ conceptual understanding and decrease the need for next-step strategies.

**Your Role during the Discussion**

Move to the location in your classroom where everyone can gather in a circle, preferably without furniture or other visual distraction in the circle. Bring your planning documents that contain the list of questions and what to listen for to the discussion. If you have any additional materials, such as a chart, or equipment, bring those as well. If students need to see any projected material, make sure they can see the projection screen.

Begin by reviewing with students the discussion norms. These should be on posters hanging on the wall near the sense-making circle. Revisit these as necessary during the discussion, especially if some students are dominating or avoiding the conversation. When you form your circle, make sure there are no “double parkers,” that is, students positioned outside the circle standing behind others.

Your biggest role in the discussion is to ask, listen, and adjust. Ask your first planned question and listen to student responses and compare those to the What to Listen For you anticipated. Determine if students have provided a sufficient response, a partial response, such as one that does not contain evidence, or a response that is not accurate. Make a decision what to do next based on that response.

If students are on track, you might use a talk move such as “turn and talk with your partner, do you agree or disagree with the idea <student’s response>”.

If the response is only partially developed, you might use a talk move such as “who can add more to what <student name> said?” or “what data do we have that supports <student’s response>?”.  

If a particular student response is not accurate, you can use wait time to see if another student poses a question or adds to the conversation, ask a scaffolding question, or provide a sentence frame. Make adjustments in order to have all students engage with the question you asked.
These two pages show the connection between the sense-making planning guide and how this discussion might unfold in the classroom. Since each discussion will be different, this is provided as a sample.

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**Questions and What to Listen For**

**Steps 16–20:** Have a sense-making discussion

**What to ask**

- How does magnetic force affect a paper clip? (Analyzing and interpreting data; energy and matter)
- How do multiple magnetic fields affect the force of magnetism? (Constructing explanations; energy and matter)
- What happened to the jump distance that the paper clip moved when you added more magnets? (Step 17) (Using mathematics and computational thinking; patterns)
- What happened to the force of attraction when you added more magnets? (Step 17) (Constructing explanations; energy and matter)
- What evidence do you have that the force increased? (Step 17) (Analyzing and interpreting data; energy and matter)
- Why do you think the force increased so much with the second magnet, and only a little with the third or fourth magnet? (Step 17) (Constructing explanations; patterns)

**What to listen for**

- Magnetic force attracts the steel paper clip, overcoming friction.
- Magnetic fields appear to be additive; the force of magnetism increased when there were several magnets.
- The jump distance increased significantly between one magnet and two magnets, less so when we added a third or fourth magnet.
- The force was stronger with each additional magnet, but the second magnet added more force than the third or fourth.
- When magnetic fields are added together, the force of attraction increases.
- The farther magnets have less effect on the force of attraction.

**Scaffolding questions**

- The paper clip was resting on the table. What caused it to move? (Step 16)
- What happens if an object is very far from a magnet? (Step 18)
- The third and fourth magnet you added were farther from the paper clip than the first few magnets. Are the effects of those magnets’ magnetic fields on the paper clip as strong as the first magnets? (Step 18)

**Application questions**

- Based on your model of magnetic fields, how far do you think a paper clip would move if you used five magnets? Six? Seven? Eight? (Step 20)
- How might you introduce competing magnetic fields? That is, could magnetic fields ever pull on a paper clip in opposite directions? Explain.
Content questions include data analysis, constructing explanations, and engaging in argumentation, using crosscutting concepts when appropriate.

**COLOR KEY**

- ASK
- LISTEN
- ADJUST
- Scaffolding
- Talk moves

**ASK**

- Ask content question.

**LISTEN**

- Inaccurate analysis of data
- On track conceptually; no evidence
- Sufficient from many students

**ADJUST**

- Wait time
- Add on/say more
- Clarify answer with partner.

- Agree/disagree and why with partner
- Ask for evidence.
- Was all content discussed by all students?

- Ask scaffolding question.
- Reference data in class notebook.
- End discussion and have students answer focus question individually.

**Scaffolding**

- Ask scaffolding question.

**Talk moves**

- Provide sentence frame.

- Provide claim-and-evidence frame.

**Decision**

- Was all content discussed by all students?

**Student action**

- Listen and compare responses to “what to listen for.” What type of response was given?

**Talk move**

- Ask additional question.

**Instructional strategy**

- Provide claim-and-evidence frame.

**Sense-Making Discussions for Three-Dimensional Learning—Grade 8**

**Decision Map**—This is for an introductory sense-making discussion.
Before asking the next question on the list, decide what other ideas on the What to Listen For list came forward. If so, revisit the idea by saying something like, “An idea that <student’s name> mentioned was <student’s idea>” before asking the related question. This places value on student ideas and makes the conversation appear more student centered.

Continue asking your planned questions, listening and comparing to the what to listen for, and adjusting as needed until all the ideas come forward. Before moving on to the application questions, have students discuss the focus question. As time and student attention permits, ask the planned application questions following a similar sequence of ask, listen, and adjust. Application questions can be asked in a separate discussion as a wrap-up after students answer the focus question or at the start of the next lesson as a warm-up.

**After the Discussion**

After a sense-making discussion, you want students to write about their new knowledge in their science notebooks. After they answer or revise the focus question in their notebooks, you can review a sample of responses for embedded assessment. See the Assessment chapter for more information on embedded assessment. It’s okay to let some incomplete ideas or student questions linger when you know that the next lesson will continue to address those ideas. Resist resorting to telling students the answer as this rarely results in students adjusting their conceptual models. Instead, think of additional questions or experiences, such as engaging in argument, to address areas that warrant further consideration.

Last, and most important, have fun! Enjoy the intellectual struggle. This is the part where you never know what ideas students may trot out. Some discussions will be rich and rewarding, and others might not go so well, but it’s important to reflect on your practice and make incremental adjustments as needed to keep students striving to understand.
SENSE-MAKING SAMPLES—GRADE 8

On the next 3 pages are examples of sense-making discussion planning guides from the FOSS Next Generation Courses recommended for grade 8—Heredity and Adaptations, Electromagnetic Force, Gravity and Kinetic Energy, Waves, and Planetary Science. As you read the Investigations Guide to prepare for instruction, you will see a teaching note in the sidebar with red text, which tells you to refer to this chapter. The red-text teaching notes are found in the copyright latest FOSS Investigations Guide, which is available to registered users on FOSSweb.

The three samples in this chapter are offered as examples, and should be customized to meet the needs of your students. There is one sample per course. As you become proficient facilitating sense-making discussions, you can use the template to create new planning guides for other discussions. A blank template of the Sense-Making Discussion Planning Guide can also be downloaded from FOSSweb.

### Grade 8 Sense-Making Discussion Opportunities

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<thead>
<tr>
<th>Instructional opportunity</th>
<th>Disciplinary Core Idea</th>
<th>Science and Engineering Practices</th>
<th>Crosscutting Concepts</th>
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<tbody>
<tr>
<td><strong>Heredity and Adaptation</strong></td>
<td>Inv. 1, Part 2, Step 26</td>
<td>LS4.A: Evidence of common ancestry and diversity</td>
<td>Analyzing and interpreting data; engaging in argument from evidence</td>
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<tr>
<td></td>
<td>Inv. 2, Part 2, Step 20</td>
<td>LS3.A: Inheritance of Traits; LS3.B: Variation of Traits</td>
<td>Constructing explanations</td>
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<tr>
<td></td>
<td>Inv. 3, Part 2, Step 18</td>
<td>LS3.A: Inheritance of traits; LS3.B: Variation of traits; LS4.A: Evidence of common ancestry and diversity; LS4.B: Natural selection; LS4.C: Adaptation</td>
<td>Developing and using models; constructing explanations; engaging in argument from evidence; obtaining, evaluating, and communicating information</td>
</tr>
<tr>
<td><strong>Electromagnetic Force</strong></td>
<td>Inv. 2, Part 3, Step 17</td>
<td>PS2.B: Types of interactions</td>
<td>Analyzing and interpreting data; using mathematics and computational thinking; constructing explanations</td>
</tr>
<tr>
<td></td>
<td>Inv. 4, Part 1, Step 13</td>
<td>PS3.C: Relationship between energy and forces</td>
<td>Developing and using models; constructing explanations</td>
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<tr>
<td></td>
<td>Inv. 4, Part 2, Step 28</td>
<td>PS3.B: Conservation of energy and energy transfer; ESS3.A: Natural resources</td>
<td>Constructing explanations; engaging in argument from evidence; obtaining, evaluating, and communicating information</td>
</tr>
<tr>
<td>Instructional opportunity</td>
<td>Disciplinary Core Idea</td>
<td>Science and Engineering Practices</td>
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<tr>
<td></td>
<td>Inv. 2, Part 2, Step 8</td>
<td>PS2.B: Types of interactions</td>
<td>Analyzing and interpreting data; using mathematics and computational thinking</td>
</tr>
<tr>
<td></td>
<td>Inv. 3, Part 1, Step 16</td>
<td>PS3.A: Definitions of energy; PS3.B: Conservation of energy and energy transfer; PS3.C: Relationship between energy and forces</td>
<td>Developing and using models; analyzing and interpreting data</td>
</tr>
<tr>
<td></td>
<td>Inv. 4, Part 1, Step 18</td>
<td>ETS1.B: Developing possible solutions; ETS1.C: Optimizing the design solution</td>
<td>Analyzing and interpreting data; engaging in argument from evidence</td>
</tr>
<tr>
<td>Waves</td>
<td>Inv. 2, Part 1, Step 12</td>
<td>PS4.A: Wave properties</td>
<td>Developing and using models; analyzing and interpreting data; constructing explanations</td>
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<tr>
<td></td>
<td>Inv. 3, Part 3, Step 8</td>
<td>PS4.B: Electromagnetic radiation</td>
<td>Analyzing and interpreting data; constructing explanations</td>
</tr>
<tr>
<td></td>
<td>Inv. 4, Part 2, Step 13</td>
<td>PS4.C: Information technologies and instrumentation</td>
<td>Analyzing and interpreting data; using mathematics and computational thinking</td>
</tr>
<tr>
<td>Planetary Science</td>
<td>Inv. 1, Part 3, Step 5</td>
<td>ESS1.A: The universe and its stars</td>
<td>Analyzing and interpreting data</td>
</tr>
<tr>
<td></td>
<td>Inv. 2, Part 1, Step 21</td>
<td>ESS1.B: Earth and the solar system</td>
<td>Developing and using models; constructing explanations</td>
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<tr>
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<td>Inv. 5, Part 1, Step 24</td>
<td>ESS1.C: History of planet Earth</td>
<td>Analyzing and interpreting data; constructing explanations</td>
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<td>Inv. 6, Part 2, Step 7</td>
<td>ESS1.B: Earth and the solar system</td>
<td>Constructing explanations</td>
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<tr>
<td></td>
<td>Inv. 9, Part 1, Step 13</td>
<td>ESS51.A: The universe and its stars</td>
<td>Analyzing and interpreting data</td>
</tr>
</tbody>
</table>
SENSE-MAKING DISCUSSION PLANNING GUIDE

Course: Heredity and Adaptation

Investigation 3: Evolution, Part 2: Natural Selection

Guiding question: How can we explain the diversity of life that has lived on Earth?

Focus question: How do populations change over time?

NEXT GENERATION SCIENCE STANDARDS

<table>
<thead>
<tr>
<th>Focus DCI(s)</th>
<th>Focus SEP(s)</th>
<th>Focus CCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inheritance of traits (LS3.A); Variation of traits (LS3.B); Evidence of common ancestry and diversity (LS4.A); Natural selection (LS4.B); Adaptation (LS4.C)</td>
<td>Using models to synthesize multiple lines of evidence; constructing explanations about diversity of life on Earth; engaging in argument using evidence to explain conclusions; obtaining and communicating information from multiple sources.</td>
<td>Patterns; cause and effect, systems and system models; stability and change</td>
</tr>
</tbody>
</table>

Questions and What to Listen For

Steps 17–18: Answer the driving question for the course; Have a sense-making discussion

What to ask

➤ **How can we explain the diversity of life that has lived on Earth?** (Step 17) *(Constructing explanations; systems and system models, stability and change)*

➤ **How do the observations that you and scientists have made provide evidence for your explanation?** *(Obtaining, evaluating, and communicating information; patterns)*

➤ **What evidence have you included in your model or explanation for the diversity of life that has existed over time?** *(Engaging in argument from evidence; cause and effect)*

➤ **What is the theory of evolution?** (Step 18) *(Developing and using models; systems and system models)*

What to listen for

• We make observations in *paleontology*: the fossil record reveals relationships between ancient and modern organisms.

• We make observations in *heredity*: all life has DNA. Mutations can happen to genes on the DNA and be passed on to offspring via sexual or asexual reproduction.

• We can see *variation* in populations as a result of mutations in DNA and because of sexual reproduction.

• Organisms that have *adaptations* suited to an environment have a greater chance of surviving to reproduce.

• *Natural selection* occurs when changes in the environment lead to changes in the traits in populations.

• If populations become separated by geography or behavior, over time, they can become new species, a process called *speciation*.

Scaffolding questions

➤ **What patterns from the fossil record point to relationships between ancient and modern organisms?**

➤ **What evidence from the fossil record demonstrates how life has changed over millions (and billions) of years?**

➤ **What role do inheritance and genetics play in the diversity of life?**

➤ **How do mutations in DNA and inheritance lead to variation?**

➤ **What factors lead to natural selection?**

➤ **What kind of time frame are we thinking about when we think about how life has changed over time?**

Application questions

➤ **Will life continue to change in the future?**

➤ **How are environmental pressures such as climate change affecting evolution?**

➤ **How are humans affecting evolution?** (This is a leading question to the next Part.)
SENSE-MAKING DISCUSSION PLANNING GUIDE

**Course**: Electromagnetic Force

**Investigation 2**: The Force of Magnetism, **Part 3**: Force over Distance

**Guiding question**: How do humans use energy?

**Focus question**: What factors affect the force of attraction between magnets?

### NEXT GENERATION SCIENCE STANDARDS

<table>
<thead>
<tr>
<th>Focus DCI(s)</th>
<th>Focus SEP(s)</th>
<th>Focus CCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of interactions (PS2.B)</td>
<td><strong>Analyzing and interpret data</strong> to determine if magnetic fields combine; <strong>using mathematics</strong> to make precise measurements and compute averages; <strong>constructing explanations</strong> to describe the cause for a phenomenon.</td>
<td>Patterns; energy and matter</td>
</tr>
</tbody>
</table>

### Questions and What to Listen For

**Steps 16–20**: Have a sense-making discussion

**What to ask**
- How does magnetic force affect a paper clip? (**Analyzing and interpreting data**; energy and matter)
- How do multiple magnetic fields affect the force of magnetism? (**Constructing explanations**; energy and matter)
- What happened to the jump distance that the paper clip moved when you added more magnets? (Step 17) (**Using mathematics and computational thinking**; **patterns**)
- What happened to the force of attraction when you added more magnets? (Step 17) (**Constructing explanations**; energy and matter)
- What evidence do you have that the force increased? (Step 17) (**Analyzing and interpreting data**; energy and matter)
- Why do you think the force increased so much with the second magnet, and only a little with the third or fourth magnet? (Step 17) (**Constructing explanations**; **patterns**)

**What to listen for**
- Magnetic force attracts the steel paper clip, overcoming friction.
- Magnetic fields appear to be additive; the force of magnetism increased when there were several magnets.
- The jump distance increased significantly between one magnet and two magnets, less so when we added a third or fourth magnet.
- The force was stronger with each additional magnet, but the second magnet added more force than the third or fourth.
- When magnetic fields are added together, the force of attraction increases.
- The farther magnets have less effect on the force of attraction.

**Scaffolding questions**
- The paper clip was resting on the table. What caused it to move?
- What evidence was there of kinetic energy? Of potential energy? (Step 16)
- What happens if an object is very far from a magnet? (Step 18)
- The third and fourth magnet you added were farther from the paper clip than the first few magnets. Are the effects of those magnets’ magnetic fields on the paper clip as strong as the first few magnets? (Step 18)

**Application questions**
- Based on your model of magnetic fields, how far do you think a paper clip would move if you used five magnets? Six? Seven? Eight? (Step 20)
- How might you introduce competing magnetic fields? That is, could magnetic fields ever pull on a paper clip in opposite directions? Explain.
SENSE-MAKING DISCUSSION PLANNING GUIDE

**Course**  
Gravity and Kinetic Energy

**Investigation 1:** Acceleration, **Part 3:** Acceleration of Gravity

**Guiding question:** How are speed and acceleration alike and how are they different?

**Focus question:** What is gravity?

**NEXT GENERATION SCIENCE STANDARDS**

<table>
<thead>
<tr>
<th>Focus DCI(s)</th>
<th>Focus SEP(s)</th>
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<tbody>
<tr>
<td>Forces and motion (PS2.A); Types of interactions (PS2.B)</td>
<td>Analyzing and interpreting data to provide evidence for phenomena; Using mathematics and computational thinking to calculate the rate of fall of a falling object using graphs.</td>
<td>Patterns; scale, proportion, and quantity; systems and system models</td>
</tr>
</tbody>
</table>

**Questions and What to Listen For**

**Steps 13–16:** Have a sense-making discussion

**What to ask**

- *What patterns do you notice in the time (t) column? (Step 13)* (Analyzing and interpreting data; patterns)
- *What patterns do you notice in the position (x) column? (Step 13)* (Analyzing and interpreting data; patterns)
- *How did you calculate the speed of the falling ball? (Step 13)* (Using mathematics and computational thinking; scale, proportion, and quantity)
- *What patterns do you notice in the speed (v) column? (Step 13)* (Analyzing and interpreting data; patterns)
- *What data don’t follow the patterns you have identified? (Step 14)* (Analyzing and interpreting data; patterns)
- *What caused the ball to accelerate? (Step 15)* (Analyzing and interpreting data; systems and system models)

**What to listen for**

- The pattern in the time column is that the time increased by 0.0333 seconds in each frame.
- The pattern in the position column is that the position increased with each frame, but didn’t increase by the same number each time.
- The pattern in the speed column is that the speed increased with each frame, but not by the same number each time. It seems to be increasing more each time. The ball is speeding up.
- Based on the data, there is error in the measurement. This might be due to software, video clarity, other sources.
- Gravity caused the ball to accelerate.

**Scaffolding questions**

- *Was the ball moving at a constant speed or was it accelerating? (Step 15)*
- *How can you tell? (Step 15)*

**Application questions**

- *Gravity is an attractive force that acts between objects. What objects are attracting and pulling to make the ball fall? (Step 16)*
- *Why is it important for engineers and scientists to know what the exact acceleration of gravity is? (Step 16)*
### Sense-Making Discussions for Three-Dimensional Learning

#### SENSE-MAKING DISCUSSION PLANNING GUIDE

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<td><strong>Investigation 3:</strong> Light Waves, <strong>Part 3:</strong> Color</td>
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</tr>
<tr>
<td><strong>Guiding question:</strong> How do electromagnetic waves interact with matter?</td>
<td></td>
</tr>
<tr>
<td><strong>Focus question:</strong> What makes objects appear as different colors? (Student-generated)</td>
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#### NEXT GENERATION SCIENCE STANDARDS

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<tbody>
<tr>
<td>Electromagnetic radiation (PS4.B)</td>
<td>Constructing explanations about the electromagnetic spectrum.</td>
<td>Patterns; cause and effect; energy and matter</td>
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</table>

#### Questions and What to Listen For

**Steps 8–9: Have a sense-making discussion**

**What to ask**

- **Constructing explanations:**
  - How can we use the electromagnetic spectrum to explain color? (Constructing explanations; cause and effect; energy and matter)
  - How did using the filters help you determine which colors of light were absorbed or reflected? (Constructing explanations; cause and effect)
  - What colors of light are absorbed by white objects? Reflected? (Constructing explanations; patterns, cause and effect)
  - What colors of light are absorbed by black objects? Reflected? (Constructing explanations; patterns, cause and effect)
  - What statements can you make about the relationship between the color of objects and which colors they absorb or reflect? (Step 8) (Constructing explanations; patterns)

**What to listen for**

- White objects reflect all colors of light and absorb no colors of light.
- Black objects reflect no colors of light and absorb all colors of light.
- An object of a particular color reflects light of that color and absorbs other colors.
- Different wavelengths of light appear to the human eye (brain) as different colors.

**Scaffolding questions**

- How do light waves travel from a light source to your eye?
- What happens if the light waves from a source pass through a filter on the way to your eye?
- Light waves reflect off the objects that you see. Where do those light waves originate? (Step 4)
- What does reflect mean, when we are talking about waves? (Step 5)
- What does absorb mean, when we are talking about waves? (Step 5)

**Application questions**

- When you look at grass, why do you only see green and not all the other colors of the Sun's light? (Step 9)
- When you look at <name of object>, what color is being reflected to your eye? What colors are being absorbed by the object? (Step 9)
- You wish to paint a room white. Using your understanding of color, explain why so many shades of "white" exist.
- What do wave frequency and wavelength have to do with color? (In preparation for Response Sheet—Investigation 3.)
SENSE-MAKING DISCUSSION PLANNING GUIDE

<table>
<thead>
<tr>
<th>Course</th>
<th>Planetary Science</th>
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<tbody>
<tr>
<td>Investigation 2:</td>
<td>Earth/Sun Relationship, Part 1: Day and Night</td>
</tr>
<tr>
<td>Guiding question:</td>
<td>What causes day, night, and seasons?</td>
</tr>
<tr>
<td>Focus question:</td>
<td>What causes day and night?</td>
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NEXT GENERATION SCIENCE STANDARDS

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<tr>
<th>Focus DCI(s)</th>
<th>Focus SEP(s)</th>
<th>Focus CCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth and the solar system (ESS1.B)</td>
<td>Developing and using models to demonstrate Earth’s rotation; Constructing explanations that demonstrate understanding of the Earth/Sun system.</td>
<td>Patterns; systems and system models; cause and effect</td>
</tr>
</tbody>
</table>

Questions and What to Listen For

**Step 21: Have a sense-making discussion**

**What to ask**

- How does the Earth/Sun system result in night and day? (Step 21) (Constructing explanations; systems and system models, cause and effect)
- What pattern of motion leads to night and day? (Constructing explanations; patterns)
- How can you model the rotation of Earth? (Developing and using models; systems and system models)
- How can you model darkness and light (night and day) on Earth? (Developing and using models; systems and system models)

**What to listen for**

- The Sun lights up Earth during the day.
- The area on the back side of Earth is in shadow, night.
- The shadow is from Earth itself, not from the shadow of another object in space.
- Perspective is important. From our perspective, it appears that the Sun rises and sets; it reality, Earth’s rotation is what causes night and day.
- The part of Earth experiencing day or night is continually changing because of Earth’s rotation.
- One complete rotation of Earth requires 24 hours, one day.

**Scaffolding questions**

- Use the questions from notebook sheet 6, Day/Night Think Questions, as scaffolds for a complete explanation.

**Application questions**

- Explain the difference in the night and day experience on a planet that rotates and a planet that does not rotate.
- Is the night/day pattern important for life on Earth? Explain.
- Would life exist over all of Earth if Earth did not rotate? Explain.
- Do you think the Sun rotates? Would it affect Earth if it either does or doesn’t?