INTRODUCTION

In this chapter, we explore the opportunities in FOSS for students to engage in the practice of argument from evidence. Argumentation involves the interplay of different positions. Good arguments are based on evidence derived from data, as well as sound reasoning. Ideally, these data come from students’ first-hand experiences, with additional information from teacher input and associated media. Sometimes the relevance or validity of evidence is questioned as a result of argumentation, requiring data collection methods or processes of analysis to be clarified or improved. Other times, the reasoning used in an explanation is further elucidated and successfully defended.

Jonathan Osborne, “Arguing to Learn in Science: The Role of Collaborative, Critical Discourse”

DEFINITION OF TERMS

Argumentation is a form of discourse, either verbal or written, intended to reach a conclusion or to codify and explain.

An argument is a discussion during which the merits of competing positions are presented and defended.

Positions are intellectual constructs, conclusions, and attempts to explain certain aspects of the way the world works.
THE ROLE OF ARGUMENTATION IN SCIENCE INSTRUCTION

What is an argument?
A scientific argument is not the stereotypical vociferous difference of opinion between two confrontational people. Scientific arguments usually do not involve raised voices, red faces, or personal attacks. However the history of science is enlivened with the occasional passionate confrontation between bellowing scientists, particularly when a community entrenched in a long-standing tradition is being challenged by a completely new insight. A scientific argument is a thoughtful, reasonably rigorous form of discourse intended to persuade others. An argument is usually initiated when one person lodges a claim, or states a position, which is challenged by another position. Defending a claim requires the development of a coherent case. A case might include a suite of evidence and a bank of reasoned conclusions.

Why argue?
Argumentation requires rigorous thought. Developing an argument often calls on the case builder to engage in critical thinking processes and metacognition. While developing the justification for a position, a person invariably finds himself or herself engaging in an internal dialog: Is this evidence sound? Is the reason I am asserting convincing? Is this a good argument? All of these processes draw the student into deeper thinking about the phenomena under study, and the most valuable outcome of the FOSS teaching experience is getting students to think deeply about science and utilize literacy skills. Argumentation is one tool for drawing students into a meaningful cognitive activity.

When should we engage in argumentation?
Most of the time the FOSS experience is driven or framed by a focus question. The investigation invites students to engage in a sequence of actions—a context in which students will determine the answer to the question. At times the questions and actions are designed to elicit a model. A scientific model is a coherent intellectual construct that has tremendous explanatory and predictive power. The cognitive path leading to a model is often rough and obscure, requiring a lot of cognitive surveying, hacking, and hewing to get there. Argumentation is one of the path finding tools—useful for working out some of the conceptual elements of an important model or scientific explanation. And once the learner has arrived at a serviceable model or explanation, it may be necessary to defend it when another student or team of students constructs a competing model or explanation.
Getting Started

According to Appendix F of the Next Generation Science Standards (NGSS), “Argument in science goes beyond reaching agreements in explanations and design solutions. 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” (13). The type of argumentation used in science and engineering requires a particular kind of classroom culture - a culture of talk.

Spend time developing norms that enable students to safely present and discuss ideas with their peers while seeking deeper, more nuanced understanding. These norms should be developed collaboratively at the beginning of the year and revisited as needed. Review the norms before discussions, remind students to follow them during the discussion and if necessary, debrief how well the class followed them following discussion. Providing speaking frames and prompts, as well as modeling appropriate discussion structures are also effective ways to develop and maintain a classroom culture conducive to argumentation.

In the process of constructing explanations and sharing designs, students may discover disagreement among their peers at the table. Conversations ensue. Explanations are refined as the merits of alternate ideas are debated in informal arguments or when the teacher structures a more formal argument within the class. Allowing students to revisit, revise, and elaborate previous explanations is a natural next step following scientific argumentation.

Teachers need to carefully consider when and how to initiate argumentation to support the learning of science content. Opportunities to engage students in argumentation, along with suggested strategies, are indicated in the FOSS Investigation Guide at specific points in the investigations. Often, there are unplanned opportunities or “teachable moments” that present themselves during the lesson where teachers may choose to encourage students to engage in argumentation around ideas that emerge spontaneously during discussion.

When you perceive an opportunity for students to engage in argumentation, enact a strategy to as seamlessly as possible guide the discourse into argumentation.

Normals for classroom discussion

We promise to:

- Listen to others attentively
- Respond to classmates respectfully
- Challenge ideas — not individuals
- Speak clearly and loudly
- Ask classmates to speak up or clarify
- Include and encourage everyone to share ideas

Sample Chart of Classroom Norms, modified from Talk Science Primer (TERC) Sarah Michaels and Cathy O’Connor
Engage in Argument from Evidence

Following is a collection of general and specific strategies for focusing attention on specific aspects of argumentation. Teachers can select a general strategy to guide students through argumentation opportunities or select a specific strategy to develop one aspect of argumentation. In either case, teachers should reflect on the strategy used and refine their practice based on the needs of the students.

Students engage in argumentation in small groups when discussing ideas.
GENERAL STRATEGIES

The following strategies provide models for purposeful argumentation and can be utilized to develop general aspects of students’ argumentation skills.

**Questions and Prompts.** Ask probing and open-ended questions or give students interesting ideas to discuss. Examples are:

- Do you agree or disagree with Student X? Why?
- Does anyone have a different idea?
- What do you think about what Student Y just said?
- What makes you think that?
- Can you think of another reason that might have happened?
- What is your evidence?

**Teacher think-aloud.** Engaging in argument requires thinking and reasoning. Make the process visible to students by talking through the thinking processes you use to evaluate a claim or determine if the evidence is logical and relevant. Ask questions aloud, such as,

“What other possibilities are there? Is there other evidence that supports this claim?” or statements, such as “What he just said makes me think I only used one piece of evidence. I should include more evidence to make my argument stronger.

Modeling helps students understand what the expectations are and the structures that make argumentation a powerful thinking experience.

**Fishbowl.** To help students focus on the discussion moves necessary for argumentation, select a small group of students to engage in argument about a topic while the rest of the class observes. The small group makes a circle in the middle of the room and the rest of the class forms a larger circle around them. Give the observers a checklist of discussion moves they should be looking for as they watch, such as, listening to each other, building on the ideas of others, disagreeing with ideas respectfully, asking clarifying questions, etc. After the discussion, debrief with the whole class by asking what the observers noticed and how the small group felt their discussion went.
Engage in Argument from Evidence

Strategies for Grades K-2

The aspects of argumentation for K–2 as indicated in Appendix F of the NGSS are as follows.

• Identify arguments that are supported by evidence.
• Distinguish between explanations that account for all gathered evidence and those that do not.
• Analyze why some evidence is relevant to a scientific question and some is not.
• Distinguish between opinions and evidence in one’s own explanations.
• Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.
• Construct an argument with evidence to support a claim
• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

The following pages contain examples and strategies that can be utilized to develop each of these aspects of argumentation.

1. **Identify arguments that are supported by evidence.**

   In order to identify arguments, or positions, that are supported by evidence, young students need experiences with the concepts they are discussing. Students that are able to understand the position promoted by an argument will be better able to determine whether or not the position is supported by evidence.

   **Critique positions.** Present two positions to students on the board, one just stating a position, the other containing evidence to support a position. Clarify with students the position in both statements, such as the one’s below from *Insects and Plants*:

   Brassica plants need water to grow because Michael forgot to water his plant and it died.

   Brassica plants need light to grow.

   Have students discuss which position tells why the statement may be true. Then, have students think of evidence to show that plants need light to grow. When students have generated some ideas, return to the two statements on the board and add evidence to support the first position and additional evidence to support the second.

TEACHING NOTE

*It is not necessary to focus on all aspects of argumentation in each lesson. Select and modify strategies based on the needs of your students.*
Provide additional positions with and without evidence for students to critique and sort into those that are supported and those that are not.

<table>
<thead>
<tr>
<th>Supported by evidence</th>
<th>Not supported by evidence</th>
</tr>
</thead>
</table>

2. **Distinguish between explanations that account for all gathered evidence and those that do not.**

When helping students distinguish between explanations that account for multiple pieces of gathered evidence, consider where students are in their development of the concepts and whether they are aware of all gathered evidence.

**Making thinking visible.** During a whole-class discussion, collect items of student data they have been recorded which might help them answer a focus question. Write these data on the board or on chart paper. On another side of the board or another piece of chart paper, record a few explanations that students put forth and/or provide a few of your own. Make sure there is one example that contains robust evidence, one that contains sparse evidence, and one that is not supported by any data gathered in the investigation. Ask students to determine:

- Which explanations contain evidence?
- Which explanations do not contain evidence?
- Which explanation includes the most evidence?

To improve the other explanations, read through the potential evidence and ask students if the evidence supports the explanations. Model how to include those pieces of evidence in the explanations.

3. **Analyze why some evidence is relevant to a scientific question and some is not.**

After posing a question, ask students to think-pair-share what they will need to answer the question. For example, in *Insects and Plants* when asking students if a milkweed bug is an insect, students would identify characteristics of insects as evidence. Write these on chart paper to refer to later. The day after students have answered the question in their notebooks, review the initial list of ideas. Prompt students to think about a piece of evidence such as the small size of the milkweed bug. Ask if this piece of evidence is helpful, or relevant, in identifying the milkweed bug as an insect. Provide other pieces of evidence for students to determine if they are helpful in answering the question. Revise the list to indicate the agreed upon observations that qualify as evidence that supports their answers and those observations that do not.

<table>
<thead>
<tr>
<th>Is a milkweed bug an insect?</th>
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<tbody>
<tr>
<td>Helpful</td>
</tr>
<tr>
<td>6 legs</td>
</tr>
<tr>
<td>3 body parts</td>
</tr>
<tr>
<td>moves</td>
</tr>
</tbody>
</table>
4. **Distinguish between opinions and evidence in one’s own explanations.**

Conduct a mini-lesson on the difference between opinion and scientific evidence. **Opinions** are based on what a person believes to be true or feels should be true. **Evidence** is based on observation and scientific data. Give students a few prompts to generate explanations that might include an opinion, such as, “What is the weather today?” Generate a list of responses on the board such as, “The weather today is too cold; It’s just right for a picnic outside today; The air temperature here is 14°C; The sky is clear with a few high clouds.” Have students discuss in small groups, which statements are opinions and which are observations that could be used as evidence to support explanations. Underline statements that are opinions in red, evidence in blue. As an extension, students can play a game where they take turns making a statement for the rest of the group to determine if it is an opinion or evidence. Have students self-assess by reading their own explanations and determining if they have stated opinions or evidence. Students should end by describing the difference between opinion and evidence.

5. **Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.**

Engaging in argumentation requires that students not only formulate their own positions, but also that they focus their attention on other students’ positions. Primary students need lots of practice to develop these high-level discourse skills. Model and discuss what it looks like and sounds like when people listen to each other, show they understand or ask for clarification, and agree and disagree about ideas. As much as possible, give students the opportunity to discuss their ideas in pairs, small groups, and in whole class discussions. Make it a goal to move from the teacher generating questions and students answering to more student-centered discussions, where students are sharing and building on each other’s ideas. Use strategies such as having students ask each other questions and paraphrase what others are saying.

**Frames and prompts**

Provide sentence frames and prompts for students to use that will encourage active listening and productive talk. For example:

- I agree/disagree with … because …
- I have another idea …
- I am wondering what would happen if …
• Can you explain why you think …?
• Would it matter if …?

Post icons and/or use hand-signals for the different types of discussion moves (agree, disagree, build-on, question, etc.) to help students internalize the use of the moves in their own conversations. Include a debrief at the end of the process. Ask students how they think the discussion went. What made them think harder or share more during the discussion? How could it be better next time?

**A/B discussion protocol**

Use a discussion protocol, such as A/B partners to pair students who have differing ideas. The teacher should assign partners so each student has a different position. Have student A share his/her thinking while student B listens. Student B responds by paraphrasing what A said and then asking a question that helps the other think more deeply about his/her claim, such as “Why do you think that? What is your evidence?” or more specific questions such as,

• Why do you think we should put those seeds here?
• Why do you think cornstarch is a solid?
• How does your drawing show where sand comes from?

Students then switch roles. When both partners have shared, students should either reach a common position or agree to disagree and report back to the class.

6. **Construct an argument with evidence to support a claim**

In FOSS, students provide written explanations when answering the focus question. These explanations can be refined through argumentation. During discussion, students might present verbal statements during arguments. In both instances, students should construct their arguments by putting forth a claim and supporting evidence. For primary students this can simply be an answer to the focus question in the form, “I think ___ because ___.”

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Engage in Argument from Evidence-Draft-Can be used with permission.
Identify with color

When students begin to engage in argumentations, their positions will need development. One strategy to help students is to model how to write a position and then identify and code portions of the arguments using different colors. Gather students on the rug and write an argument statement on the board. Ask students which part of the statement is the claim. When all agree, underline the claim with one color marker, then model underlining the evidence statements with another color. As students develop in their writing skills, they can begin to use this strategy with their own writing.

Claim/Evidence card sorts

At the end of the investigation, write a few claim statements and a few evidence statements on sentence strips. Put the strips on a pocket chart to match up as a whole-group activity or give each small group a set to work on together. Students should first determine which statement strips are claims and which constitute evidence. Next, they should match the evidence statements with the claims supporting them.

7. Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

Students can also make claims about how well their engineering designs meet the proposed challenge. During and after engaging in designing and constructing activities, have students pause to think about what they are basing their decisions on and what the evidence is to support those decisions. For example, when constructing the highest tower possible, ask students about the materials are they choosing for the base. Why is the straw best placed at the top? Encourage students to cite evidence from what they have learned during the investigation, e.g., aluminum foil is flexible so it can be used to hold things together.

Design Show-Case

Conduct an exhibition of student-designed objects where students take turns explaining how they designed and built their objects, why they think it is effective for the purpose it was designed, and the evidence that supports their claim. Other students can ask questions and provide feedback on the effectiveness.
Strategies for Grades 3-5

Below are the aspects of argumentation for 3–5 as indicated in Appendix F of the NGSS.

• Compare and refine arguments based on an evaluation of the evidence presented.
• Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
• Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model by citing relevant evidence and posing specific questions.
• Use data to evaluate claims about cause and effect.
• Construct and/or support an argument with evidence, data, and/or a model.
• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

The first four aspects of argument work with students evaluating and distinguishing other’s arguments or self-assessment of their own arguments.

1. **Compare and refine arguments based on an evaluation of the evidence presented.**

In order to compare and clarify positions in an argument, students need to have knowledge about and experiences with a given phenomenon, including collecting and analyzing data to generate an argument. Once this is done, students can be engaged in different strategies to compare and refine their thinking using evidence to support their arguments.

**Critique two positions**

Present two positions to students on the board, both containing evidence from students’ collected data. One position should contain sufficient evidence to support the claim. The other position has a credible claim, but insufficient evidence or irrelevant data or a claim that is not supported or connected to the evidence presented.

Ask students to identify the evidence in both positions. Have students discuss which position has better evidence supporting the claim being made. Question students about how the evidence supports the claim. Have students work with a partner to refine the other position to incorporate stronger evidence.
Engage in Argument from Evidence

For example, when working in magnetic fields, provide two positions.

1. The size of the magnetic field increases when you add a second magnet. When you use one magnet, a paper clip can be attracted from 2 cm away. When you use two magnets, the same paper clip is attracted from 3 cm away.

2. The magnetic field gets bigger when you have more magnets. The paper clip is attracted from farther away.

Ask students to identify which argument has more convincing evidence and state why that evidence supports the claim. Ask students to refine the other position to incorporate stronger evidence.

2. **Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.**

When helping students distinguish among facts, reasoned judgment or conclusions, and speculation, consider the level of the concepts and determine which are widely accepted facts, which are still developing concepts, and which are typical speculations students might be expected to promote as explanations. These facts, reasoned judgments and speculations might appear as students’ claims during discussion or in writing. Teasing these out helps students learn the importance of developing valid, robust evidence.

**Sorting activity**

Write several facts, judgments, and speculations, on sentence strips, such as “Crayfish are animals.” “Crayfish use swimmerets for movement in the water.” and “Male crayfish are bigger than females.” Introduce one fact, one judgment, and one speculation on the board. Ask students to describe how each statement differs from the others. To sort these statements, guide the discussion with some questions, such as “Are there any statements that we all agree are true?” Identify these types of statements as facts. “Which statement do we think is probably true based on the reasoning we have done? [Judgments based on research findings] “Which statements seem like it might be possible but are not supported by evidence?” [Speculations] Provide students with additional statements to be sorted into facts, judgments, and speculations, such as “Crayfish have claws.” (fact), “Crayfish are territorial,” (judgment), and “Crayfish eat each other when they don’t have enough room to hide from each other.” (speculation)
3. **Use data to evaluate claims about cause and effect.**

When examining cause and effect claims, students need to process information (data from experience or from reliable text) in order to determine if the claim is valid. The source of information might be their notebook records or the FOSS Science Resources book, referenced to evaluate the claims.

**Multiple corners strategy**

Post three or four different variant claims regarding a phenomenon using a cause and effect statement without evidence, on a separate piece of chart paper. These claims could come from your assessment of student work identifying common understandings of the class. For example,

1. **The higher the starting position of a cart on a ramp, the farther the cart will travel.**

2. **The lower the starting position of a cart on a ramp, the farther the cart will travel.**

3. **The cart will always travel the same distance no matter where the cart starts.**

Place each claim poster in a different corner of the room. Divide the class so there is an even number of students at each claim. In the first round, have students write two points of data under the claim on the poster that either support or refute the claim. They should not identify whether the data supports or refutes the claim, just provide the data. The class then rotates to a different claim poster. In the second round, students verify that the data posted accurately represent the class findings and identifies whether the data support or refute the claim by writing “Supports” or “Refutes”. The class rotates one more time. At the last claim poster, students edit the claim for accuracy or revise the claim to best represent available information.

4. **Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.**

During discussions of explanations about phenomena, students have an opportunity to critique the work of fellow classmates. Initially, this process should be structured by the teacher to ensure norms for discourse are honored and all students participate. As the year progresses, the discussions should be managed by students with minimal guidance from the teacher.
Engage in Argument from Evidence

A/B discussion protocol

Use a discussion protocol, such as A/B partners to pair students together and critique each other’s procedures, explanations, or models. The teacher should assign partners so the two students have divergent points of view. Have student A share his/her thinking while student B listens. Student B responds by asking clarifying questions, such as

- Why did you decide to put those seeds here?
- What happens if you increase the height?
- How does your model explain the effect of atmospheric pressure on the crushed bottle?

Poster sharing

Have groups write their procedure, explanation, or model on chart paper and post them around the room. Groups visit other posters with self-stick notes and pencils in hand. As the groups read the posters of others, they write questions such as “What is your evidence?” or “What does this part of the model show?” Groups return to their own posters and edit their original thinking based on peer feedback.

5. Construct and/or support an argument with evidence, data, and/or a model.

In FOSS, students provide written explanations when answering focus questions. These explanations can be refined through argumentation. During discussion, students might present these orally. In both instances, students should construct their arguments providing evidence, data, and models.

Revision with color

When students begin to engage in argumentation, their position will need development. One strategy is to have them write their position and then identify and code portions of their arguments using different colors. Students can underline their claim in one color and evidence statements with another color. More sophisticated arguments might use a third color to underline the description of a model. This can help students identify aspects of their constructed position and determine if any elements are missing or need refinement. Another variation is to have students add new information using one color and correct information is another.
Four corners

Using assessment data, determine a few claims or explanations the class is promoting about a particular phenomenon. Write each claim at the top of a poster. Divide the poster in half with a vertical line and write the words “statements in support” on one side and “statements against” on the other side. Hang the posters around the room and divide the class into four groups. Have each group go to one poster. The group reads the claim and agrees with it, or disagrees. Then the group provides thoughts, evidence, or models to support their agreement or disagreement. Additionally, they could consider statements people with the other point of view would write and add those to the poster. Groups rotate through each of the four posters evaluating the different claims. After finishing the posters, groups can review the statements for and against each claim. The teacher should question students in efforts to nudge the thinking towards the best representation of the fundamental knowledge intended by the investigation. Students then revisit their own arguments. They can refine their thinking about the topic by committing their arguments, including models, in their science notebooks.

6. Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

In designing and engineering a solution to a problem, students consider the criteria and constraints framing the problem. When evaluating a solution, student use evidence to make decisions to declare success or head back to the drawing board.

Student-Generated Checklist

Begin a class discussion by asking for one of the criteria that defines a satisfactory solution to a particular problem and write it on the board. Have students provide examples of what meets that particular criterion and what does not meet the criterion. In doing so, students are identifying specific evidence that will assist in determining the merits of a solution. Repeat this process with additional criteria and acknowledging constraints by having students list the evidence they should see. Once this checklist has been created, have students consider the proposed solution. Ask students to identify the evidence for the first criteria or constraint on the checklist. Does the evidence meet the criterion or not? Encourage students to work in pairs to continue to work through their checklist. When finishing, ask the pairs to make a claim about the merit of the solution and provide specific evidence to support their claim.
CONNECTIONS TO COMMON CORE ELA STANDARDS

Engaging in argument from evidence is a critical science and engineering practice for supporting sense-making. Sense-making happens primarily through language. The Common Core ELA standards describe “argument literacy” as fundamental to being educated and therefore, include argumentation in all four strands – reading, writing, speaking and listening, and language – Kindergarten to 12th grade. Appendix A describes the “special place” of argument in the standards for English language arts as well as the content areas:

*In science, students make claims in the form of statements or conclusions that answer questions or address problems. Using data in a scientifically acceptable form, students marshal evidence and draw on their understanding of scientific concepts to argue in support of their claims. Although young children are not able to produce fully developed logical arguments, they develop a variety of methods to extend and elaborate their work by providing examples, offering reasons for their assertions, and explaining cause and effect. These kinds of expository structures are steps on the road to argument. In grades K–5, the term “opinion” is used to refer to this developing form of argument.*

- Appendix A. Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects

The Venn diagram on the next page shows argumentation at the convergence of the science, math, and ELA practices and underscores how important the ability to “construct valid arguments from evidence and critique the reasoning of others” is to preparing students for college and careers of the 21st century. Following are the ways to support student engagement in the science practice of argumentation within the four strands of the ELA common core standards.

**Speaking and Listening Standards K-5**

The anchor standards for speaking and listening (SL) directly support argumentation in science and engineering. Students:

- Participate in a range of conversations and collaborations building on other’s ideas and expressing their own (SL 1)
- Integrate and evaluate information (SL 2);
- Evaluate a speaker’s point of view, reasoning and use of evidence (SL 3)
- Present information, findings, and supporting evidence (SL 4)
These standards progress from kindergarten to grade 12 making it imperative that students starting in Kindergarten have many opportunities to share their ideas and provide evidence to support them. As students progress through the grades, those discussions will become more complex as they become adept at formulating well reasoned claims, listening to each other, building on, and critiquing the ideas of others. The aspects of argumentation shared in Appendix F of NGSS indicate a similar progression across grade levels. When facilitating argumentation in whole group discussion, emphasize that the goal is for everyone to participate and learn. It is not a competition of ideas, rather a co-construction of knowledge during a sense-making discussion the class as a whole is attempting to achieve.

Commonalities Among the Practices in Science, Mathematics and English Language Arts

Based on work by Tina Cheuk ell.stanford.edu
Writing Standards K-5

One of the major shifts in the writing standards is the focus on writing arguments. Though referred to as “opinion” pieces in K-5, the intent is to develop students’ ability to support claims with clear reasons and relevant evidence in grades 6th-8th. First graders state an opinion and supply a reason. By grade 5, students write opinion pieces supporting a point of view with reasons and information. (W 1) Students also draw evidence from informational texts to support analysis, reflection, and research. (W 9) Giving students opportunities to wrestle with their developing science ideas by routinely writing in their notebooks (W 10) supports both transition to formal writing and providing students with a starting place for sharing their ideas is oral discussions. Students are also putting these literacy skills to practice when they answer the focus questions and when writing responses to assessment questions.

Reading Standards K-5

Make sure to allow ample time for students to read and discuss articles in the FOSS Resources book and other relevant texts. (See FOSSweb.com for recommendations.) The FOSS Investigations Guide describes opportunities for students to cite textual evidence, draw inferences (RI 1) and to explain how an author uses reasons and evidence to support points in a text (RI 8). After conducting investigations and gathering data, facilitate close readings of the corresponding articles. The information students glean from the text and the graphics helps them put the pieces of the conceptual framework together. The more access students have to relevant science and engineering information, the better prepared they will be to craft claims backed up with sound scientific and engineering ideas in addition to their own observational data.

Finding Evidence from the Text

<table>
<thead>
<tr>
<th>Question, claim, or prompt:</th>
<th>Evidence: What does the text say?</th>
<th>Explanation of Evidence: What does it mean?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Page #</td>
<td>How does it support what your idea?</td>
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</table>
**Language Standards K-5**

Throughout their years of science learning, students will acquire and use thousands of new science-specific and general academic vocabulary words (L 6). Argumentation activities can help students deepen their understanding of key vocabulary by examining word relationships and nuances in word meaning (L 5). One example is partner or small group construction of a concept map. Give students 6 to 10 of the most important words they have been exploring in their investigation. Write each word on a sticky note and have students work together to clarify their understanding of each word/concept and then organize them in a coherent way on a large piece of paper. Students then discuss how the words relate to each other and agree on a final presentation of the words and an explanation as to how they are related. By developing a deeper understanding of key vocabulary, students can be clearer and more precise in their arguments.

**Crafting a language objective**

In order to deepen students’ understanding of the content and further develop their language skills, the teacher crafts a language objective. This language objective merges the science and the ELA practices in a meaningful way. The teacher considers these questions:

1. **What are the science concepts students will learn?** (Disciplinary Core Ideas)
2. **How will students learn?** (Science and Engineering Practices and Crosscutting Concepts)
3. **How will students communicate what they are learning?** (ELA skills)

Based on these questions, the teacher crafts this language objective:

*Students will*

- state whether they think a seed is alive or not alive,
- present evidence to support their claim orally,
- evaluate the arguments of others,
- communicate whether they agree or disagree or add on to the ideas of others, and
- reflect in writing on how their thinking changed.

This language objective can be expanded even further to meet the needs of English learners (ELs) as described in the next section.
Engage in Argument from Evidence

Accelerating English-Language Development

*Students must read, write, and visually represent as they develop models and construct explanations. They speak and listen as they present their ideas or engage in reasoned argumentation with others to refine their ideas and reach shared conclusions. These science and engineering practices offer rich opportunities and demands for language learning.*

(NGSS Appendix D)

**Culture of equity**

Establishing and maintaining a culture of talk in the classroom where the voices of all students are respected and valued is key to fostering robust and equitable academic discourse. This means allowing flaws in student’s models, procedures, designs, and explanations to surface as well as limitations in their English language proficiency (ELP). The classroom culture should convey a spirit of shared thinking and discovery in which *all* students feel encouraged to ask each other questions, push for further explanations, and refute the claims of others, regardless of their ELP levels. Engaging in argument from evidence provides emergent bilingual students with the opportunity to hear examples of the type of discourse they are expected to produce.

(Quinn, Lee, Valdés, 2012)

**Language demands of argumentation**

To help students meet and ultimately benefit from the language demands of argumentation, it is important to have a language objective for the lesson in addition to a toolkit of strategies that will provide opportunities for all students to participate. First, consider the analytical or cognitive tasks required to meet the language objective, in this case, argumentation about whether something is living or nonliving. For English learners, the teacher needs to consider which corresponding receptive (what students need to do to comprehend others) and productive (how students will generate communication) language functions students will need in order to successfully accomplish those analytical tasks.

**Analytical tasks:**

- Distinguish between a claim and supporting evidence or explanation
- Analyze whether expressed evidence supports or contradicts a claim
- Analyze how well a model and evidence are aligned
- Construct an argument

(CCSSO 2015)
The **receptive language functions** are what students do in order to **comprehend** written and oral arguments made by others. They include: identifying, distinguishing, comparing, evaluating, and reflecting on the words and their meaning and synthesizing them into a concept.

The **productive language functions** are how students **communicate** their claims, evidence and reasoning in support of and against the arguments of others. This includes: structuring and ordering written or verbal reasoning for a position; selecting and presenting key evidence and reasoning to support or refuting claims; questioning or critiquing arguments of others; suggesting alternative reasoning, refining one’s own thinking, and negotiating differing conclusions.

Here’s an example of what a third grade teacher might consider as she prepares for the wrap-up of a lesson on seeds from the *Structures of Life* module. Students take positions on whether a seed is alive or not. The content objective is for students to deepen their understanding of what characterizes a living organism. They engage in the practice of argumentation by **comparing** and **refining** propositions based on an **evaluation** of the evidence **presented**. Two differing claims are presented to students:

1. A seed is alive.
2. A seed is not alive.

The cognitive task for students is to **analyze** whether evidence supports or contradicts a claim that has been promoted as true. To support students engaged in this task, the teacher considers the language functions required:

**Receptive:** First the students need to understand the concepts of “seed” and “alive.” Students will need to comprehend the evidence presented by others and determine its relevancy. This requires **identifying** the connection (*Is there evidence to support the claim?*), **comparing** it to their own ideas (*Does this connection make sense to me?*), and **evaluating** the strength of the evidence (*Is this argument valid?*).

**Productive:** Students will need to communicate orally the evidence they think supports their claim and why. They will also need to **ask questions**, **request further explanations** and **refine** or change their own thinking if presented with persuasive evidence for a differing position.

This further refinement of what students need to tackle, not just the content of living and nonliving, but also what skills students need to have in order to listen and communicate their explanations and positions. Having these identified allows for better differentiation during instruction.
Differentiation

To address the varying levels of her students, the teacher breaks down the language objective into three categories:

**Emerging:** State evidence that supports the claim and negotiate the relevancy and strength of the evidence with others using sentence frames, [e.g. “A seed is ...(alive, not alive) because ... I agree with ... because ...”] as well as open responses.

**Expanding:** State evidence that supports the claim and negotiate the relevancy and strength of the evidence with others using an expanding set of learned phrases, (e.g., I think… My evidence is … I agree with … because … I respectfully disagree with … because...) as well as open responses and provide counter-arguments, (e.g., Why do you think … means …? I have a different idea …).

**Bridging:** State evidence that supports the claim and negotiate the relevancy and strength of the evidence with others using a variety of learned phrases (I think… My evidence is …) as well as open responses and provide counter-arguments and elaborate on the ideas of others, (e.g., Why do you think … means …? Have you considered …? What you said reminds me of …)

**Strategies Toolkit**

The next step is to think about scaffolds to make sure all students can participate in the discussion. For this example, the teacher decides to use the **Put yourself on the line** strategy. She will have students make a line with those that agree strongly that a seed is alive on one end, those who agree strongly that a seed is not alive on the other end, and those that are open to both ideas or not quite sure, somewhere along the middle of the line. Students will have to discuss their reasoning with the people near them and decide where they are on the continuum.

In addition to the scaffolds for argumentation outlined previously in this chapter, the teacher also considers ways to specifically support her emergent bilingual students in producing the complex oral language needed for argumentation:

1. **Pairing students up and assigning roles.** Make pairs based on their opposing claims. Student A argues for a position and Student B argues against.

2. **Rehearsal time.** Give students time to practice presenting their arguments with one another before the whole-group discussion.

3. **Provide linguistic supports and starter language.** Make explicit the sentence frames or starters students should be using to present their arguments, make counter-arguments, and elaborate on the other’s idea.
4. Writing before speaking. Have students write out their argument before presenting. (The reverse—speaking before writing—also gives students the opportunity to practice using complex language orally in preparation for writing.)

(Modified from Zwiers, O’Hara, Pritchard, 2014)

Here are other strategies (adapted from Zwiers et al.) for generating the complex oral language production necessary for argumentation:

**Augmenting Argumentation in Lines or Circles**

Students either face each other in two parallel lines or in an inner circle facing the outer circle. On the signal, students take turns presenting their argument to the student in front of them. When time is called, one of the lines or circles moves one step over so that each student has a new partner. This time, students share their arguments and include additional ideas (claims, evidence, or reasoning) from their previous conversation.

**Agree/Disagree Improv**

Students form pairs. One is the “director” and the other, the “speaker.” The director states a claim, (e.g., a seed is alive). He/she claps her hands and says “Agree!” The speaker states evidence that supports the claim. After hearing at least two pieces of evidence in support of the claim, the director claps and exclaims, “Disagree!” The speaker uses transition words that are written on the board (e.g., However, … On the other hand …, In contrast, …, Now, let’s consider …, Another way to look at it is …) to offer evidence that refutes the claim. If needed, students can make a T-Chart in their notebook ahead of time to write down their ideas for and against the claim. The discussion can continue going from agree to disagree and should end with the director deciding whether they think the evidence is stronger in support of the claim or in refuting the claim. Partners can switch roles using the same claim or offer a new claim to discuss. As a variation, during a whole-class discussion, the teacher can call on students by saying their name and “Agree,” or “Disagree,” or “Add on.” Students must use the transition words in their statements.

**Interview Grids**

Students write down an argument (claim and evidence/reasoning) and then make a line under it in their notebooks. They move about the room when they hear the signal and find new partners to share their arguments. In pairs, they listen, then draw a line under the previous entry in their notebook, write the name of their partner, and then briefly paraphrase what their partner said. Each time they meet up with a new partner they should borrow and use the language, ideas, and
evidence of their previous partners. Their responses should become stronger (often longer) with better supporting evidence and examples. Encourage students to make their statements clearer and with more precise terms and linked, organized, complete sentences.

**Reflecting on Learning**

Success with argumentation is achieved when students find themselves deep in academic discussions, passionate about their ideas, and genuinely engrossed in the ideas of others. They use what they know, what their classmates offer, and what they are wondering about, to construct new connections that help them make sense of science and engineering phenomena. It’s important that during this endeavor, students are aware of their own learning process—that their ideas change as they communicate, obtain, and process new information. Make time for students to reflect on this process. Many teachers periodically end their science talks with a debrief of how students felt about the discussion. Students can also reflect on their learning by writing in their notebooks. Here are some prompts students can use to inspire their musing:

*Today, I learned ___ by ___.*

*I used to think ___, however, now I think __.*

*My thinking about ___ has changed because ___.*

*What helped me learn about ___ was ___.*

*I think I learn best when ___.*

*Next time, I will ___.*
Summary

It may take several seasons to become fluent in argumentation. The moves at first will be calculated and may feel exploratory and contrived; it will probably take a lot of exercise for a coherent suite of argumentation moves to become an intuitive dimension of your practice. And why marshal the energy to develop this skill? For the same reason we encourage pushing your practice in a whole host of new pedagogical directions—to achieve the first goal of the FOSS program: Scientific literacy for all students. Scientific literacy is in part knowledge of the objects, materials, organisms, and systems present in the natural world. Secondly, scientific literacy includes knowledge of the principles that govern the interactions within the natural world. Those are the two dimensions of knowledge of the natural world, but that has to be augmented with knowledge in the natural world. Scientific literacy requires that humans behave in ways compatible with and sustainable in the natural world. This requires that students transform knowledge into understanding. Understanding is appropriate application of knowledge in context. This will call on our students to demonstrate the invisible dimensions of their science education; the ability to transfer their sense-making ability to situations where human civilization interfaces with natural systems. This kind of cultural sense-making will manifest itself through productive scientific arguments in decisions regarding global citizenship. Students will be critical of proposed positions and will be able to make, we hope, informed decisions based on good solid sense-making and a reasonable expectation that evidence will be provided to support positions and claims.
Engage in Argument from Evidence

References:


