beetles
Science and Teaching for Field Instructors

Student Activity Guide

Argumentation Routine

This activity helps students learn to be open-minded, and to participate in respectful discussion using evidence and reasoning. These are great life skills that any citizen of the world should have. They're also scientific argumentation skills. The ability to change one's mind based on evidence and reasoning, to see issues as complex, and to look at issues and claims from different perspectives are all scientific argumentation skills. Students also learn that absolute answers rarely exist. These skills and understandings are useful beyond science for anyone interested in figuring things out, and in talking with others about issues, particularly with those who have different perspectives and opinions.

This routine is a series of steps to help students develop scientific argumentation skills as they evaluate different claims based on evidence and reasoning. It can be used when competing claims come up during the discussion of a rich question, a complex issue, or while a group is trying to explain something puzzling or intriguing that they've found in nature.

Students will...

- **Use science discussion agreements during discussion.**
- **Examine and evaluate evidence and reasoning supporting each claim.**
- **Choose a claim, supporting it with evidence and reasoning.**

Grade Level:
Grades 5–8. Adaptable for younger or older students.

Timing:
30 minutes

Related Activities:
Fire Management Discussion, Most Successful Organism Discussion, NSI: Nature Scene Investigators, Case of the Disappearing Log, other Focused Explorations (that might inspire argumentation opportunities). Classroom activities: *Evaluating Evidence, Evaluating Sources.*

Materials:
Optional: A sign with argumentation sentence starters written out (see page 3).

Tips:
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

Setting:
An area with something puzzling and of interest to students for which the group has come up with two or more opposing claims. Or anywhere your group comes up with two or more claims during a discussion.

NEXT GENERATION SCIENCE STANDARDS

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Varies	Engaging in Argument from Evidence	Varies, but often Cause and Effect

For additional information about NGSS, go to page 12 of this guide.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Argumentation Routine

ACTIVITY OVERVIEW

Argumentation Routine	Learning Cycle Stages	Estimated Time
Introducing Science Discussion Agreements	Invitation	5–10 minutes
Students Discuss Initial Thoughts, Then Choose to Stand by a Claim	Exploration	10 minutes
Students State & Evaluate Evidence for Different Claims	Concept Invention, Application	10 minutes
Reflecting on the Experience	Application, Reflection	5 minutes
TOTAL		30–40 minutes

(About 5–10 minutes introducing discussion agreements can also happen at an earlier time.)

TEACHING TIPS

Field Card. On pages 16-17 of this guide is a pocket-sized version of this lesson that you can use in the field.

Read the Instructor Support Section. Beginning on page 10, you'll find more information about pedagogy, student misconceptions, science background, and standards.

Finding an argumentation opportunity and using the routine. An argumentation opportunity could be something you've planned ahead of time, such as an intriguing set of bones in a known location you guide students to "discover," or a question you've planned to pose to the group. The opportunity may also be unplanned, in the middle of an exploration when students come up with more than one explanation for a phenomenon, or during a discussion. As you explore nature with students, looking at intriguing things or making explanations about what you find, keep an eye out for a moment when two or more claims (e.g., this pile of bones is a rabbit vs. a squirrel; there were mushrooms growing on this branch before it fell vs. the fungi grew on it after it fell). You might also choose to pose a juicy question to the group, let them discuss it for a little while, then begin this routine to take the discussion deeper if students come up with more than one claim and seem interested in further discussion.

There's little value in students engaging in argumentation over something they're not interested in. Whether you're discussing a question or exploring an interesting "find," give students time to explore, discuss, and get interested in the topic before using the argumentation routine. Only use this routine if students are truly "fired up" and have a LOT to say about whatever you're discussing. If two or more claims show up but students don't really seem that interested in the topic, move on with the discussion without using this routine.

PREPARATION AND CONSIDERATIONS FOR SUCCESS

1. **Before the activity:**

- **Set students up for success with the activity by practicing skills of discussion.** If students don't arrive with skills to participate in discussions, build up to this routine with routines like *Walk & Talk* and *Turn & Talk*, and other activities that give students the chance to discuss ideas and build up their skills in discussing ideas, thinking together, and making explanations.
- **Set *yourself* up for success with the activity by practicing skills of leading discussions.** So much of the activity's success depends on the instructor's ability to flow with student interest and gently guide the discussion. Don't make this the first discussion you ever lead; if you're not experienced with leading discussions, start small, with routines like *Walk & Talk* and *Turn & Talk*, and use BEETLES resources on discussions to help you.
- **Choose a topic.** The question you choose for your students to discuss is a "make it or break it" choice for the success of the activity. See Example Argumentation Topics, page XX in the Instructor Support section for suggestions on how to choose an interesting and productive topic for your students to discuss.
- **Optional: Make sentence starter sign.** Make a sign using a manila folder or othe sturdy surfaces with argumentation sentence starters for students to use during the activity:
    - I think that ________ is evidence that supports this claim because ____________________.
    - I'd like to build on what ________ said about ________, and add ____________________.
    - I can see why you think ________, but I'd like to respectfully disagree, because ____________________.
    - I think the strongest evidence is ________, and it supports the ________ claim because ____________________.

2. **During the activity:**

- **Throughout the process, encourage and facilitate dialogue.** Ask students what they think of each other's ideas; encourage respectful disagreement; encourage students to challenge evidence and reasoning; encourage students to change their minds in the face of new evidence or reasoning. Highlight students' positive participation, such as active listening, building on each other's ideas, sharing evidence and reasoning, changing their minds based on evidence, or asking each other questions.
- **Add content to further the discussion.** Add in content you know, a little at at a time, to stimulate and feed the discussion.

TEACHING NOTES

TEACHING NOTES

Instructor doing it "the wrong way." It can be effective and engaging for the instructor to act out how NOT to do each norm, and ask students to call out what they are doing wrong.

Science discussion agreements can vary." Use the agreements that make sense for you and your audience, and see the Instructor Support Section, page 10, for examples of more possible Agreements for Science Discussions

Student generated agreements. You can also ask students to come up with agreements for participating in discussion. This can give them more ownership over the agreements, but also might take more facilitation, and the addition of a couple of agreements by the instructor.

Introducing Science Discussion Agreements

1. **Before doing the Argumentation Routine, choose a time to introduce science discussion Agreements.** At some point during your field experience with students—either as a part of your overall introduction with students, before another discussion, or before the beginning of this activity—make time to introduce your students to science discussion agreements. If possible, it's well worth introducing science discussion agreements toward the beginning of a field experience to set a tone of discussion and collaboration for the group. This way, you can jump right into the Argumentation Routine when something interesting to discuss comes up.

2. **Explain & provide examples of agreements in an engaging manner.** Go over each agreement, keeping it interesting by acting out an agreement, asking students to discuss what they think each agreement means, or asking students to think of examples of what it looks like to follow the agreement. Try to strike a balance between thoroughly explaining each agreement and not dragging it out too long. If you notice it's becoming boring and long, then change things up: move around, go exploring, or shift gears in some other way, then come back to the agreements later. (Or go ahead and start the discussion then introduce each of the rest of the agreements during discussion when a student embodies one of them).

   Example of science discussion agreements. Below is a set of common science discussion agreements. Also included are examples of what an instructor might say and do to explain each one. Use agreement that work for you, and introduce them how you see fit.

   Listen actively and share ideas:

   - *What does a person who's actively listening look like and do?* [Listen to students' ideas, then act out a few examples of a person not actively listening, such as: looking bored, interrupting, fidgeting, etc. Act out a person who is actively listening, or ask a student to do this.]
   - *Let's talk about the "share ideas" part of this agreement. If people share ideas, we could have some really interesting discussions. If people don't share ideas, or if only a few people do, then discussion won't be very interesting. If you want interesting discussions, please share! And you'll feel more engaged if you share. Don't worry about having the right idea to share. Your ideas will make the discussion richer. We want to hear them. There is value in every idea on the topic we're discussing.*

   Share and ask for evidence:

   - *For science discussions, ideas have to be based on evidence. You can't just say something like, "I think an elephant made that mark," if it's not based on evidence. When you have an explanation, you need to share your evidence, like, "I think those marks on the bark may have been caused by squirrels, because I've seen squirrels here, and I've seen them run up and down trees before." And if someone shares an idea without evidence, feel free to ask for it politely, like, "what's your evidence for that?"*

Data: Factual information, such as observations, measurements, and test results.

Evidence: Data that help answer a question, form an explanation, or disprove an explanation.

Explanation: A nonfiction evidence-based story about how or why something in the natural world appears or happens. A scientific explanation must connect data or phenomena with accepted scientific knowledge.

Build on ideas of others:

- *It's not a real discussion if people just take turns sharing their own ideas without responding to each other. You've got to listen to other people's ideas, and sometimes build on them, such as "Building on what Rahul said about squirrels making the marks on that tree, I'd like to add that I've heard that squirrels build nests, and I wonder if maybe they use shredded-up bark for their nests."*

Keep an open, curious mind:

- *Have you ever been around someone who won't change their mind, even when the evidence goes against their idea? Pretty frustrating, huh? It's important in science discussions (and in life!) to keep an open mind. Some people seem to think that if they change their mind, it's a sign of weakness, but changing your mind can actually be a sign of open-mindedness, flexibility, and scientific thinking.*

Disagree respectfully to increase understanding:

- *A discussion is much more interesting when people share different perspectives, and when they feel free to respectfully disagree with each other. An important part of science is trying to figure out what might be wrong with each new idea, before you decide on which seems like the best idea. What might be some ways to disagree in a nonrespectful way?* ["You're wrong!" "That's stupid!" etc.] What might be some ways to respectfully disagree? ["I see your point, but I have a different idea." "I'd like to respectfully disagree, because..." etc.]

Pay attention to participation:

- *The more voices we get to hear in a discussion, the richer it is, and the more interesting perspectives we'll get. If you notice that you are talking a lot more than others, try speaking less. If you are not speaking much, try to speak up more. We don't want to put people on the spot, but we do want everyone to feel welcome and comfortable. Think about what you can do to make this a safe discussion space. We want a diversity of perspectives.*

TEACHING NOTES

Some useful definitions. "Evidence" and "explanation" are vocabulary most students are familiar with, and probably won't need definitions. But with very young students and/or English language learners, it may be worth formally defining evidence and explanation and providing examples. The important thing is for instructors to begin using these terms in the context of investigating something interesting to students.

Move up, Move back, Step up, Step back. Another way the norm, "Pay attention to participation" is sometimes phrased is, "Step up, Step back," meaning that students who speak often should step back and listen more, while those who don't should step up and speak up. "Move up, Move back" is an option that is more inclusive of differently abled people. Choose the version you think will be best and easiest to remember for your group.

As an instructor, be aware of the demographics of your group and how that affects participation. Research has shown that male students, and in particular, white male students, tend to consistently be called on more often than other students. Try to call on more students of color and girls. If only a few students raise their hands every time there is an opportunity to share, try saying "I'm going to wait until we have a few more hands up," or "Let's first hear from anyone who has not spoken yet who would like to share."

Students Discuss Initial Thoughts, Then Choose to Stand by a Claim

1. **Through exploring nature, asking an interesting question, or sharing about a complex issue, look for an argumentation opportunity that's interesting to students.** Whether you're taking on a question or exploring an interesting "find," give students time to explore and discuss it before launching into the steps below.

TEACHING NOTES

Waiting for the "right time." This routine works best when there are two or more claims floating around in the group, AND when students are fired up and have a lot to say about each of those claims. It's usually pretty easy to tell when kids are fired up, because they'll all be excitedly talking when asked to "Think, Pair, Share." If it seems like there isn't excitement around the question/opposing claims, it might be best to introduce some evidence and see if students get more fired, up, or else move on with the discussion without doing this routine.

2. **When two (or more) claims come up during a discussion of a question or interesting find, point it out to the group.** For example:
   - *It seems like a few of us think these are rabbit bones, while others think they might be squirrel bones, and a couple of others think they might be from something else entirely.*
   - *From what you all just shared, it seems like part of the group thinks we should stop wildfires when they start, while others think we should let them burn sometimes.*
   - *Daniela just shared an interesting question: Is moss a type of lichen? Discuss with a partner whether you think moss is or is not a lichen.*

3. **Ask students to Think-Pair-Share about which claim they agree with at this point.** Ask students to think quietly for about 30 seconds about which claim they think is more true, and what makes them think so. Then, ask them to share their thoughts with a partner, then call on a couple of students to share their ideas with the whole group.

4. **After students have discussed their initial thoughts, choose spots for them to stand to show agreement with each claim, and tell the group to think about which spot they will go to (but not move to yet).** Point to a spot (e.g., some place on the ground near where the group is standing, or near something like a tree or a backpack) and tell students that's where they'll stand if they agree with claim A. Point to another spot and tell them that's where they'll stand if they agree with claim B. If you have more than two claims, make spots for them too. You might also choose to label each spot with a sign.

5. **Tell students to go stand in their chosen spot.**

6. **Ask students who are standing in the same spot to discuss with each other evidence and reasoning that supports their claim.**

7. **As students discuss these ideas in their claim groups, circulate and facilitate dialogue as needed.** Depending on where your students are with their discussion skills, you might need to step in to make sure multiple students are able to share their ideas and engage in discussion.

All materials created by BEETLES™ at The Lawrence Hall of Science.
Find the latest activities and information at http://beetlesproject.org.

8. **Optional: If you've chosen to use sentence starters, set them out now, explain what they're for, and make connections to science discussion agreements.** Explain to students that the sentence starters can help them figure out how to share their evidence, build off someone else's ideas, or show that they are thinking about multiple viewpoints.

9. **Ask students from each group to present some of their evidence and reasoning.** After students in claim groups discuss their ideas for a couple of minutes or so, ask students from each claim group to share their evidence and reasoning with the whole group.

Students State & Evaluate Evidence for Different Claims

1. **Explain that in science discussions and in life, it's important to consider all reasonable claims, then tell students to switch to another claim spot, and to discuss the evidence and reasoning supporting it.** Tell students that in science (and in life) you need to consider all reasonable claims, even if you don't agree with them at the time. Then, tell students to switch to a different position where they will think about and discuss evidence and reasoning that supports the different claim. Tell them to be ready to share out their ideas with the whole group.

2. **After students have had the chance to discuss ideas, ask a few individuals to share out evidence and reasoning that supports the claim in their new spot.** Ask especially for any new ideas that haven't been said yet.

3. **Optional: Introduce new evidence/information to the whole group.** If you have additional information/evidence to introduce that you think will help the conversation and understanding, now is a good time to introduce it. If you've noticed misconceptions that have popped up during the discussion so far, consider addressing them now by sharing evidence that contradicts the misconceptions.

4. **Gather everyone in a "neutral zone" to think about the strongest evidence they've heard so far for all the claims.** Gather everyone in a neutral zone. The neutral zone is any area that is not a claim spot so students can stand there thinking and discussing the choices open-mindedly without choosing a claim for the moment. Explain that now they'll focus on what they think is some of the strongest evidence they've heard so far for each claim.

5. **Tell students to take turns sharing the strongest pieces of evidence they've heard for each claim.** Students will take turns saying things like, "I think the strongest evidence for XX claim is XX." You might have them go and stand in the claim spot as they describe the strongest evidence for that claim.

TEACHING NOTES

Discussion agreements reminder. Remind students of the discussion agreements you shared earlier, and ask them to include their evidence when they share their ideas.

Introducing language of uncertainty. At some point, to encourage good science talk, ask students to respectfully agree or disagree with each other's ideas, and to use "language of uncertainty." When a learner begins a statement with "Maybe," "I wonder if," or uses other language of uncertainty, point this out to the group. Explain that it's a good example of how you talk in science, and it shows openness to the possibility that there may be a better explanation. Bring the "Language of Uncertainty Sentence Starters" (page 37) and hold it up during the discussion to help students form their sentences.

Letting it flow. Don't be totally rigid with this process. If you've landed on a really juicy question, you might go back and forth a bit here, encouraging students to switch back and forth between claims as people share evidence if they are finding their minds changed often. Keep things moving, and switch things up if it's dragging.

TEACHING NOTES

6. **Encourage students to do this for multiple claim spots.**

7. **Prepare students to get creative where they stand next to represent their current opinion; they could stand between two claims, closer to one, in a new spot to represent a new claim, etc.** For example:
   - Next, you'll stand wherever you want based on your best understanding of everyone's evidence and reasoning. I'd like to challenge you to get creative with where you stand. You could choose to stand in one claim spot, if that represents your thinking, but you might choose to stand between two spots, or in the neutral zone, or in more than one spot somehow, or closer to one claim than another. Or you might choose to come up with a new claim, or something else you think of.

8. **Tell all students to stand in the spot representing their current opinion, and ask a few students to share their evidence and reasoning.** After students stand in the spot that represents their current opinion, ask a few of them to explain why they are standing where they are, and how it represents their thinking. In particular, make sure to call on students who are standing in more creative spots to make sure new ideas are heard.

9. **After students have shared ideas about their current opinion (but BEFORE their interest drops), wrap up the discussion by briefly summarizing what the group has talked about.** Briefly trace how the group's ideas evolved during the discussion. For example:
   - First, most of the group agreed with ________________ claim, but then when we learned about some different evidence like ________________, a lot of the group changed their opinions. Now it seems like most in our group think ________________, but a few think ________________.

10. **Ask students what additional evidence (that they don't have) might help them choose one claim or another.**

    ▶ *Is there some kind of evidence you wish you had that would help you be more certain of which claim to choose?*

11. **If you have relevant information about what students were discussing that you think would be useful now, share it.** For example, if you have knowledge about current practices for managing the environmental issue students were discussing, that could be very interesting and useful. Keep in mind that sometimes it's better to leave some questions unanswered if it generates curiosity and student empowerment.

Reflecting on the Experience

1. **Explain that the world is complex, and while we often seek absolute answers, solutions or explanations are rarely simple.** There's rarely only one cause for something we observe, or one solution to a problem. It's important to develop the ability to consider multiple claims and perspectives instead of becoming attached to the simplest answer.

2. **Optional: Share one of these quotes:**
   - "We don't know what the answer is when we start, and that not knowing can be pretty uncomfortable—we're not used to that—but that's actually the point. We want to embrace ambiguity. We want to give ourselves the permission to explore lots of different possibilities so that the right answer can reveal itself."
     —Patrice Martin, Creative Director and Co-Lead IDEO.org
   - "I think what human beings need is to be able to laugh at the absurd, hold on to ambiguity, and learn to love nuance, instead of making everything one or the other, and structurally, so much of the Internet and online publishing doesn't have room for any of that."
     —Tavi Gevinson, writer, editor, and actress
   - "The test of a first-rate intelligence is the ability to hold two opposing ideas in mind at the same time and still retain the ability to function."
     —F. Scott Fitzgerald, writer
   - "Most people like to believe something is or is not true. Great scientists tolerate ambiguity very well. They believe the theory enough to go ahead; they doubt it enough to notice the errors and faults so they can step forward and create the new replacement theory. If you believe too much, you'll never notice the flaws; if you doubt too much, you won't get started. It requires a lovely balance."
     — Richard Hamming, mathematician

3. **Explain that science works hard to try to figure out the best explanations based on all available evidence.**

   ▶ *The discussion you just had was a lot like scientists might have. Scientists try to consider (and test) all evidence and explanations in all possible ways, deciding which is best, but keeping an open mind to the possibility of another, better explanation coming up.*

4. **Encourage students to keep trying to be open-minded, and to talk about this, and other issues and claims.** Encourage students to keep open minds about the issue they've discussed, and to try to look at evidence and reasoning from different perspectives with other issues and claims they encounter. Encourage them also to try to listen to and talk to others about claims and issues in ways that are not adversarial or oppositional, but that work toward deeper understanding.

   ▶ *Being able to listen to others, to weigh evidence for different claims, and to change your mind are essential for collaborating with others. Let's keep finding interesting things to explore and think about by discussing our ideas and working towards deeper understanding.*

5. **Ask students to Walk & Talk about a few of the following reflection questions:**

   ▶ *What helped you learn in that activity?*

   ▶ *What was it like to participate in a discussion in which we considered different perspectives, and included respectful disagreement?*

   ▶ *If you changed your mind during that discussion, what helped you change it?*

TEACHING NOTES

Using the Tavi Gevinson quote. This quote is great (and is by a young woman who writes for teens!), but includes two potentially hard (but very appropriate for the concept at hand!) words that may need unpacking: "ambiguity" and "nuance." The last part of the quote can lead into helping students apply what they've just experienced to issues with Internet discussion, which may help make it relevant to their lives. If you don't want to go there, you might choose to shorten it by cutting it off after "one or the other."

TEACHING NOTES

Do you know what the pirate's favorite BEETLES activity is?

Arrrrrggg-umentation Routine, of course!

See BEETLES Fire Management Discussion for a full activity guide to leading a discussion about wildfires.

Instructor Support

Example Argumentation Topics

Plan ahead about when you might want to use this routine. Below are examples that might come up during an exploration (based on something your group finds), useful questions to keep in your pocket that tend to be productive, and some BEETLES activities that we know often lead to a good opportunity for argumentation.

Questions that might come up during exploration:

These are examples of questions and claims that could come up during an exploration, or could be posed by students:

- How do newts breathe underwater? (Three claims: newts have gills, newts have lungs, and newts breathe through their skin.)
- Is this carcass from an elk or a buffalo?
- Is this pile of bones from a squirrel, rat, or some other small mammal?
- Are these holes from an insect, a bird, or something else?
- Is moss a lichen, a plant, or something else?

Useful questions to keep in your pocket:

These questions tend to be juicy and interesting for students to think about:

- Should people try to eliminate all mosquitoes (or poison oak, or ticks, etc.)?
- Should people reintroduce X organism (wolf, grizzly, etc.) to this area?
- What could be a policy of what should be done to encourage more salmon in this creek?
- Should people feed wildlife?
- What are the competing management approaches to important environmental issues from your area?
- Should humans stop wildfires from burning?

Argumentation topics that might arise in BEETLES activities:

Some BEETLES activities have opportunities for argumentation. This routine can be used as a part of discussions in the following activities: Bark Beetle Exploration, and Fire Management Discussion. Supporting critical thinking. As students engage in argumentation, they develop skills in critical thinking that help them decide whether a claim is true, false, or somewhere in between. Critical thinking skills are important in school, in a wide range of work settings, and beyond, because they enable a person to identify biases and misinformation, evaluate assumptions, and reach well-reasoned conclusions about complex problems or questions. But many students (and adults) struggle with critical thinking and are eager to reach "correct" answers quickly. By breaking down the process of argumentation, having students consider one claim at a time, giving them time to gather as much evidence as they can in support of different claims, and encouraging them to challenge each other's reasoning, you support them in developing important critical thinking skills.

Teaching Knowledge

Evaluating evidence. It may be useful to give students a framework for evaluating the strength of evidence for different claims. You can evaluate evidence based on the size of the assumption, the quantity of evidence, and the quality of the source. You could ask students to think about how clear the link is between their evidence and their claim (size of the assumption). If their claim is that a mouse was killed by a bobcat, seeing a bobcat catch the mouse is much stronger evidence than just finding a dead mouse on the trail. You could also ask them to think about how much evidence they have supporting a claim (quantity of evidence). You could also ask students to think about where their evidence is from and how trustworthy their source is (quality of source)—is it a field guide? A firsthand observation? A TV show? See the BEETLES classroom activities, *Evaluating Sources* and *Evaluating Evidence* for more on the topics of quality of source and size of assumption. See the BEETLES field activities, *Tracking*, or *What Lives Here?* or the professional learning session *Evidence & Explanations* for more on evaluating evidence.

Encourage participation from all learners, but don't require equal participation from all. Just because some learners aren't speaking doesn't mean they're not engaged. Some learners will happily talk in pairs, but will be reluctant to speak in a larger group. With some encouragement and a non-intimidating question you may get a quieter person to share, but by forcing participation you could embarrass them and shut them down further.

Using agreements for science discussions. Science discussion agreements can vary., so use what makes sense for you and your audience. Below are some additional potential agreements that you could also choose to use:

- Listen actively and share ideas.
- Share and ask for evidence.
- Keep an open, curious mind.
- Disagree productively.
- Work toward a deeper understanding.
- Everyone participates.
- Support claims with evidence.
- Challenge ideas, but respect the person.
- Revise and rethink often.

The importance of using discussion agreements. A program leader told us they noticed certain staff were doing well with discussions, while others were struggling. They realized that those who were doing well were using science discussion agreements, and those who were struggling were not.

Pacing for this activity. This activity requires careful attention to student interest and energy by the instructor. Any phase of the activity can be shortened if the group is lacking interest, or lengthened if they are deeply engaged. Discussion without engagement achieves very little, so don't force

TEACHING NOTES

If you're interested in learning more about discussion agreements, check out:

Michaels, S. and O'Connor, C (2012). Talk Science Primer. TERC: Cambridge, MA.

Penuel, W. R., Moorthy, S., DeBerger, A., Beauvineau, Y., & Allison, K. (2012). "Tools for Orchestrating Productive Talk in Science Classrooms." *The Future of Learning: Proceedings of the 10th International Conference of the Learning* Sciences (ICLS). Sydney, Australia: International Society of the Learning Sciences.

TEACHING NOTES

any part if it's not working.

Considering different points of view. Giving students time to discuss evidence that supports opposing claims, in addition to evidence that supports their initial claim choice, gives them an important opportunity to challenge initial assumptions and think critically about which claim is best supported by evidence.

Language of science. Science is about coming up with the best explanation for all the available evidence. It's also about being open-minded to other explanations that could be better. In science, nothing is ever "proven." That's why scientists tend to use language of uncertainty when discussing ideas and explanations. Try to use sentence starters like, "Maybe…" "I wonder if…" "That evidence makes me think…" "The evidence seems to show…" and encourage students to phrase their statements in similar language. Writing these sentence starters on a board or card may provide additional support for English language learners.

Conceptual Knowledge

In this activity, conceptual knowledge will be different depending on whatever claims the students are arguing about. The instructor doesn't need to be an expert on the topic of discussion for *Argumentation Routine* to be successful, but some knowledge of the topic is useful so the instructor can facilitate a productive discussion. The instructor should be ready to encourage students by asking a productive question or offering a bit of content at a critical point in the discussion. Often there is a point when students can't find out any more information just by looking more, and a key question will remind students to remember what they have already observed and to use the information available to them. For example, if students are engaging in argument about whether or not moss is a lichen, an instructor who is familiar with their structural differences could say, "A few of us have argued that moss is a type of lichen because lichen and moss both grow on trees. If we look at the structure of the lichen and compare it to the structure of the moss, what evidence can we see that supports the claim that moss is a lichen? What evidence can we see that supports the claim that moss is not a lichen?" If the instructor doesn't know what distinguishes moss from lichen, it can be more challenging to come up with productive questions like this.

But asking a pointed question or sharing a small piece of information is different from just telling students everything about an object or answering a question right away without leaving any space for discussion or debate. A statement like, "Broad, flat teeth are often used for grinding plants. Do these teeth look like plant-grinders?" informs, then invites students to observe more and better support their claims with evidence and reasoning. On the other hand, making a conclusive statement like, "This animal skull is from an animal that eats plants because the teeth are broad and flat for grinding up those plants," defeats the purpose of the activity by shutting down the opportunity for thinking and debate.

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the "three-dimensional" learning that is called for in the Next Generation Science Standards (NGSS). Three dimensional learning weaves together Science Practices (what scientists do), Crosscutting Concepts (thinking tools scientists use), and Disciplinary Core Ideas (what scientists know). Students should be exploring and investigating rich phenomena, and figuring out how the natural world works. The abilities involved in using Science Practices and Crosscutting Concepts —looking at nature and figuring things out, using certain lenses to guide thinking, and understanding ecosystems more deeply—are mindsets and tools students can take with them and apply anywhere to deepen their understanding of nature. And, they're interesting and fun to do!

In *Argumentation Routine*, students use the Science Practice of *Engaging in Argument from Evidence* to make sense of a natural phenomenon. The Crosscutting Concepts students use to make sense of the phenomenon will be different depending on what the phenomenon is, but Cause and Effect will often be appropriate. Similarly, the specific Disciplinary Core Ideas students learn about will vary depending on what they are discussing.

Featured Science and Engineering Practices

"Engaging in the practices of science helps students understand how scientific knowledge develops...It can also pique students' curiosity, capture their interest, and motivate their continued study." -National Research Council, A Framework for K-12 Science Education. Focus on these science practices will help to ensure a more scientifically literate public who will be better able to make thoughtful decisions.

Engaging students in *Engaging in Argument from Evidence*. The *Framework for K-12 Science Education* highlights the importance of reasoning and argument in deciding which is the best explanation for a natural phenomenon. According to the Framework, engaging in argument is critical to students' understanding of the culture of science. Scientific knowledge evolves as scientists uncover new evidence and engage in argument about competing claims. That's why scientific argumentation is central to building scientific knowledge.

When investigating an intriguing find in nature or an interesting question, students often hold on to their initial ideas, or on the flipside, are unsure of what to think and eager to be told the "right" answer. *Argumentation Routine* is structured to support students in considering multiple claims and evaluating evidence in support of a variety of claims. It encourages students to think critically about their initial ideas, and to change their minds if the evidence leads them to new conclusions. Don't miss the opportunity for students to reflect on their discussion and what made them change their minds, or to point out that their discussion was similar to a discussion scientists might have. Keep probing students' claims about phenomena, asking them to critique each other's explanations based on the available evidence and sharing why they agree or disagree, so they begin to internalize the practice of engaging in argument from evidence, and recognize it as a transferable skill.

TEACHING NOTES

About the Next Generation Science Standards (NGSS). The development of the Next Generation Science Standards followed closely on the movement to adopt nationwide English language arts and mathematics Common Core standards. In the case of the science standards, the National Research Council (NRC) first wrote a Framework for K-12 Science Education that beautifully describes an updated and comprehensive vision for proficiency in science across our nation. The Framework-validated by science researchers, educators and cognitive scientists-was then the basis for the development of the NGSS. As our understanding of how children learn has grown dramatically since the last science standards were published, the NGSS has pushed the science education community further towards engaging students in the practices used by scientists and engineers, and using the "big ideas" of science to actively learn about the natural world. Research shows that teaching science as a process of inquiry and explanation helps students to form a deeper understanding of science concepts and better recognize how science applies to everyday life.
In order to emphasize these important aspects of science, the NGSS are organized into three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas (DCI's). The DCI's are divided into four disciplines: Life Science (LS), Physical Science (PS), Earth and Space Science (ESS) and Engineering, Technology and Applied Science (ETS).

Read more About the Next Generation Science Standards at http://www.nextgenscience.org/ and http://ngss.nsta.org/

TEACHING NOTES

Other Crosscutting Concepts. Depending on the phenomenon students discuss, there may be opportunities to point out other Crosscutting Concepts. For example, if students are discussing whether or not a particular structure of an organism is an adaptation, they may be thinking about how the structure might function to help the organism survive. This could be an opportunity to discuss how scientists use Structure and Function to make sense of the natural world.

Featured Crosscutting Concepts

Crosscutting concepts are considered powerful thinking tools for how scientists make sense of the natural world. The seven "big ideas" listed as crosscutting concepts are: Patterns; Cause & Effect; Scale, Proportion & Quantity; Systems and System Models; Energy & Matter: Flows, Cycles and Conservation; Structure & Function; and Stability & Change. These concepts may sound familiar, as they are quite similar to the themes referred to in science literacy documents as being important ideas that unify all disciplines of science and engineering.

Learning science through the lens of Cause and Effect. When scientists make explanations for how or why something happens, they're thinking about the connection between cause and effect. Much of what we can observe of the natural world are the "effects" of many potential "causes." Holes in a piece of wood (effects) may be from woodpecker beaks (cause). Understanding cause and effect relationships leads to a deeper understanding of the world, which is helpful in making predictions and scientific explanations about what might happen as a result of similar conditions in the future.

- In *Argumentation Routine*, if students engage in argument about an intriguing "discovery" (like where a piece of scat or pile of bones came from), they will likely be thinking about what might have caused the effects they observe.
- If students engage in argument about a question, such as "Should we let wildfires burn or should we stop them right away?" they may use cause and effect relationships to make sense of competing claims. For example, they may be thinking about what effects an unstopped wildfire might cause for the ecosystem.
- Students are not explicitly introduced to the language of "cause and effect" in this activity, and won't necessarily connect what they're doing in the moment to this "thinking tool" that's often used by scientists. They may not realize that this is a useful lens or mindset that they themselves can use anytime they are trying to make sense of something.
- Listen for instances of students using cause and effect thinking as they discuss evidence in claim groups and as they share their evidence and reasoning for particular claims as a whole group. Then, as the opportunity arises, explicitly point out that analyzing cause and effect relationships is an approach scientists also use when trying to decipher the mysteries of the natural world, or when deciding how to best approach an environmental problem. This will help students recognize the usefulness of this Crosscutting Concept.

Performance Expectations

No single activity can adequately prepare someone for an NGSS performance expectation. Performance expectations are examples of things students should be able to do, after engaging in multiple learning experiences or long-term instructional units, to demonstrate their understanding of important Disciplinary Core Ideas and Science Practices, as well as their ability to apply the Crosscutting Concepts. They do not represent a "curriculum" to be taught to students.

In *Argumentation Routine*, students build foundational skills that help prepare them for any of the many performance expectations that involve argumentation, including the following:

5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water.

5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.

5-ESS1-1: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

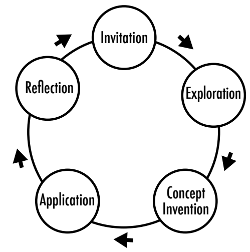
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Activity Connections

The main goal of *Argumentation Routine* is to help students develop skills in scientific argumentation, such as coming up with, examining, and evaluating evidence and reasoning to explain different claims about a natural phenomenon. If students observe and engage in argument about an intriguing "find," using *I Notice, I Wonder, It Reminds Me Of* before *Argumentation Routine*, this will give them practice with making observations and asking questions. Some other BEETLES student activities are focused on making explanations from evidence, and could provide more opportunities for students to practice scientific argumentation. These activities include *NSI: Nature Scene Investigators, Case of the Disappearing Log, Fire Management Discussion, What Lives Here?,* and other *Focused Explorations*. Two BEETLES classroom activities could help prepare students for argumentation before an outdoor science experience: *Evaluating Sources* and *Evaluating Evidence*.

TEACHING NOTES

Reading the codes in NGSS. Each standard in the NGSS is organized as a collection of performance expectations (PE) for a particular science topic. Each PE has a specific code, provided here so that they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K - kindergarten, 1 - first, 2 - second,etc...MS - middle school, and HS - high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that is addressed by the PE, and the last digit identifies the number of the PE itself.



Within a sequence of other activities, this activity could serve as the exploration, concept invention, or application, depending on how it is used.

FIELD CARD

Cut out along outer lines and fold along the centerline. This makes a handy reference card that will fit in your pocket.

Argumentation Routine

Introducing Science Discussion Agreements

1. Before Argumentation Routine, choose a time to introduce science discussion agreements.
2. Explain & give examples of agreements in an engaging manner.
3. Example of science discussion agreements:

- **Listen actively and share ideas:**

  ▶ *What does a person who's actively listening look like and do?*

  ▶ *If people share ideas, we could have really interesting discussions. If people don't share ideas, or if only a few people do, then discussion won't be very interesting. If you want interesting discussions, please share! Don't worry about having the right idea to share. Your ideas will make the discussion richer.*

- **Share and ask for evidence:**

  ▶ *For science discussions, ideas have to be based on evidence. You can't just say something like, "I think an elephant made that mark," if it's not based on evidence. And if someone shares an idea without evidence, feel free to ask for it politely, like, "What's your evidence for that?"*

- **Build on ideas of others:**

  ▶ *It's not a real discussion if people just take turns sharing their own ideas without responding to each other. You've got to listen to other people's ideas, and sometimes build on them, such as "Building on what Rahul said about squirrels making the marks on that tree, I'd like to add that I've heard that squirrels build nests, and I wonder if maybe they use shredded-up bark for their nests."*

- **Keep an open, curious mind:**

  ▶ *Have you ever been around someone who won't change their mind, even when the evidence goes against their idea? Pretty frustrating, huh? It's important in science discussions (and in life!) to keep an open mind. Some people seem to think that if they change their mind, it's a sign of weakness, but changing your mind can actually be a sign of open-mindedness, flexibility, and scientific thinking.*

- **Disagree respectfully to increase understanding:**

  ▶ *A discussion is much more interesting when people share different perspectives, and when they feel free to respectfully disagree with each other. An important part of science is trying to figure out what might be wrong with each new idea, before you decide on which seems like the best idea. What might be some ways to disagree in a nonrespectful way?* ["You're wrong!" "That's stupid!" etc.] *What might be some ways to respectfully disagree?* ["I see your point, but I have a different idea." "I'd like to respectfully disagree, because..." etc.*]*

- **Pay attention to participation:**

  ▶ *The more voices we hear in a discussion, the richer. If you notice you are talking a lot more than others, try speaking less. If you are not speaking much, try to speak up more. We don't want to put people on the spot, but we do want everyone to feel welcome and comfortable. Think about what you can do to make this a safe discussion space. We want a diversity of perspectives.*

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Students Discuss Initial Thoughts, Then Choose to Stand by a Claim

1. Look for an argumentation opportunity *that's interesting to students*.
2. When 2 (or more) claims come up during a discussion of a question or interesting find, point it out.
3. *Think-Pair-Share* about which claim they agree with at this point.
4. After students have discussed initial thoughts, choose spots for them to stand to show agreement with each claim, and tell the group to think about which spot they will go to (but not move to yet).
5. Tell students to go stand in their chosen spot.
6. Ask students who are standing in the same spot to discuss with each other evidence & reasoning that supports their claim.
7. As students discuss in claim groups, facilitate dialogue as needed.
8. Optional: Set out sentence starters, explain what they're for, & make connections to science discussion agreements.
9. Ask students from each group to present some of their evidence and reasoning.

Students State & Evaluate Evidence for Different Claims

1. Explain that in science discussions & life, it's important to consider all reasonable claims, then tell students to switch to another claim spot, & to discuss the evidence & reasoning supporting it.
2. After students discuss ideas, ask a few to share out evidence & reasoning that supports the claim in their new spot.
3. *Optional:* Introduce new evidence/information to the whole group.
4. Gather everyone in a "neutral zone" to think about the strongest evidence they've heard so far for all the claims.
5. Students take turns sharing the strongest pieces of evidence they've heard for each claim.
6. Encourage students to do this for multiple claim spots.
7. Prepare students to get creative where they stand next to represent their current opinion.
8. Tell all students to stand in the spot representing their current opinion, & ask a few students to share their evidence & reasoning.
9. After students have shared ideas about their current opinion wrap up discussion by briefly summarizing what the group has talked about.
10. Ask students what other evidence (that they don't have) might help them choose one claim or another.
11. If you have relevant information about what students were discussing that you think would be useful now, share it.

Reflecting on the Experience

1. Explain that the world is complex, and while we often seek absolute answers, solutions or explanations are rarely simple.
2. *Optional:* Share this or other quote:
   - "We don't know what the answer is when we start and that not knowing can be pretty uncomfortable—we're not used to that—but that's actually the point. We want to embrace ambiguity. We want to give ourselves the permission to explore lots of different possibilities so that the right answer can reveal itself." —Patrice Martin, Creative Director and Co-Lead IDEO.org
3. Explain that science works hard to try to figure out the best explanations based on all available evidence.
4. Encourage students to keep trying to be open-minded, & to talk about this, other issues, & claims.
5. *Walk & Talk:*

   ▶ *What helped you learn in that activity?*

   ▶ *What was it like to participate in a discussion in which we considered different perspectives, and included respectful dis-agreement?*

   ▶ *If you changed your mind during that discussion, what helped you change it?*

ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

www.beetlesproject.org

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

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