Supporting Students to Construct Scientific Explanations and Build Arguments

Description of Teaching Practice
In science, constructing explanations is a key part of scientific practice. Consequently, for the high-leverage practice of *explaining and modeling content* we focus on how teachers can support students to construct explanations rather than on teachers’ ability to explain content to students. Constructing explanations and supporting them with arguments are two closely related scientific practices which students should engage in. One goal of science is to create explanations for why or how natural phenomena occur. These explanations are developed and supported through a process of argumentation negotiating different interpretations of evidence. Science teachers must be able to support students to construct their own explanations and arguments by using the data they collect during investigations.

In the classroom, this entails teachers providing support for students to make sense of scientific phenomena by developing claims that answer investigation questions, transforming data that have been collected to serve as evidence for the claim, and identifying science principles or big ideas that can be used as reasoning to connect the claim and the evidence. Throughout this process, the teacher should provide support for students to engage in scientific argumentation as they work to develop the best explanation. The teacher provides tools and strategies for students to critique one another's claims, support their own claims with evidence, evaluate the relevance of data, and revise their claims or arguments based on other students’ input.

Advancing Justice
Students walk into science classrooms with a range of experience and/or comfort with engaging in scientific talk and writing, which is influenced by their prior personal, cultural, and academic experiences. The practice of supporting students in constructing explanations and building arguments positions teachers to anticipate and consider the diverse abilities of their students in relation to this practice. Teachers develop an understanding of the components of an evidence-based explanation (including claim, evidence, and reasoning), are supported in making the process of explanation construction explicit to students, and practice providing equitable feedback for student-developed explanations using rubrics.

Why Work on Supporting Students to Construct Explanation and Build Arguments?
When students are supported to construct scientific explanations and build arguments, they are engaging in two key science practices which can help them understand the process through which scientific knowledge is generated.

In addition, students can gain an improved understanding of science content when they work to generate their own explanations of phenomena. Discussing the strengths and weaknesses of opposing explanations through argumentation can lead to a deeper understanding of the science content behind phenomena.

How is Supporting Students to Construct Explanation and Build Arguments used in Classrooms?
In a lesson on energy transfer, a teacher might ask students to develop an explanation for what will happen after two substances of different temperature come into contact with one another. Students are responsible for making a claim that directly answers the question, and supporting that claim with evidence from the investigation (e.g., temperature data) and reasoning (e.g., scientific principles related to energy transfer). As students work together to answer the claim, the teacher might encourage students to engage with each other’s ideas. By helping students to critique, revise and reach consensus on their ideas, the teacher is supporting the scientific practice of argumentation.
Decomposition of Practice

The high-leverage practice of supporting students to construct scientific explanations and build arguments is different than the high-leverage practice of explaining and modeling content, practices, and strategies. Although teachers need to be able to clearly explain content, this high-leverage practice focuses on the work teachers do to support students in the crucial disciplinary work of constructing their own scientific explanations of phenomena, not on how well teachers explain content to students.

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<tr>
<th>Area of Work</th>
<th>Example of what this might involve</th>
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| 1) Supporting students to interpret evidence to construct explanations | • Giving opportunities for students to engage with scientific phenomena and ensure that students are able to collect appropriate and sufficient data they can use as evidence.  
• Using methods of representing data that will help students interpret them in support of an explanation. |
| 2) Helping students to support explanations with arguments | • Using the Claim-Evidence-Reasoning framework to scaffold students’ arguments.  
• Pressing students for evidence to support their claims.  
• Pressing students for reasoning that links their evidence to their claims. |
| 3) Supporting students to engage in argumentation | • Supporting students to question one another about their explanations.  
• Providing language for students to use as they interact.  
• Encouraging students to revisit their initial ideas about the investigation question, expanding upon or developing new evidence-based claims. |
| 4) Assessing students’ explanations and/or arguments | • Using rubrics that evaluate if students use sufficient evidence, if their evidence is appropriate, and if they use reasoning.  
• Having students compare their own explanations with explanations reflecting scientific understanding, via direct instruction, textbooks, models, etc. |

Supporting Novice Teachers

In working on this practice in teacher education, we focus on helping novice teachers develop clear definitions and accurate understandings of claim, evidence and reasoning to use in their classrooms. Like students, novice teachers may particularly struggle with reasoning. Further, we provide opportunities for them to explore and practice the work of supporting students in constructing explanations. We distinguish explanation from argumentation to emphasize the different purposes these practices serve, though with novice teachers, we don’t worry as much about this distinction. Finally, we help novice teachers to practice assessing explanations and/or arguments, allowing them to more deeply understand these practices and to become generally more comfortable using rubrics.

The practices of explanation and argumentation are closely related, often happen together, and can be difficult to disentangle. The goal of a scientific explanation is to answer questions about why something happens, and to improve our understanding of that phenomenon. There are many types of scientific explanations, but in general, students’ explanations in science should employ scientific “laws”, provide some form of causal account, apply statistical induction, or unify multiple phenomena under a single model. The kind of explanation that a teacher helps students construct will depend on the complexity of the phenomena and the students’ grade level. When constructing an explanation, scientists often engage in debates in which they refine claims until they reach a consensus. Consequently, students will also
engage in the two practices simultaneously. While the difference between the two is important, because of time constraints we do not work with our novice teachers on teasing out these subtle differences. Instead, we focus on ensuring that novice teachers support their students to include the essential elements of an argument (claim, evidence, and reasoning) as they work to develop an explanation.
The activities listed in this cycle need not be enacted in order, though it may make sense to go through the four quadrants sequentially. The most time-consuming of these for novices will be the field assignment where novices model for small groups in their classroom.

This cycle culminates with a full science lesson in the field that gives novice teachers the opportunity to engage in several high-leverage practices. For the purpose of practicing this high-leverage practice, we focus on the end of a science lesson when students use data to explain a scientific phenomenon and support that explanation with an argument. In the cases where teaching a full science lesson in the field is impossible, the simulated teaching experience, or Peer Teaching Assignment, provides novices the opportunity to practice eliciting and interpreting students’ ideas. The full lesson can also be modified so that novices only teach the portion of the lesson in the field that focuses on eliciting their initial ideas. For more on modifying the Enact portion of the learning cycle see the Science Lesson in the Field Assignment.

The claims-evidence-reasoning (CER) framework for explanations and arguments plays an important role in how we structure science lessons, and the learning cycle begins by making sure the novice teachers have a strong understanding of CER. In our program we use the book What’s Your Evidence? Engaging Students in Constructing Explanations in Science by Zembal-Saul, McNeill, and Hershberger as a resource, in particular with this high-leverage practice.
Learning Cycle Part 1: Introducing the Practice

Activity 1: Defining Claim-Evidence-Reasoning Activity
Novice teachers begin by learning about the Claim-Evidence-Reasoning (CER) framework for scientific explanations and arguments. The CER framework will be used throughout their lesson planning and instruction.

Novices are introduced to CER in the Defining CER Activity where they learn the definition of CER and analyze a teacher’s use of the framework. We typically use videos from What’s Your Evidence? however these may be substituted with another video of an experienced teacher.

Materials Used: Supporting Explanation and Argumentation PowerPoint
Defining CER Activity
What’s Your Evidence video 2.1

Activity 2: Claim-Evidence-Reasoning Rubric – Food Webs Activity
Novice teachers practice evaluating students’ use of CER in the CER Rubric – Food Webs Activity. Novices are also given an opportunity to construct their own claims supported by evidence and reasoning and they use rubrics to assess their explanations.

Materials Used: Supporting Explanation and Argumentation PowerPoint
General Rubric for Scientific Explanations Tool
CER Rubric – Food Webs Activity

Activity 3: Constructing Evidence-Based Explanations Activity
In the final part of the introduction to CER, novice teachers practice developing their own scientific explanations in the Constructing Explanations Activity. Novices are provided with a template to support their construction of the claim, evidence, and reasoning, which may also be used to support their students in develop explanations during the Explain+Argue element of the EEE+A framework.

Materials Used: Supporting Explanation and Argumentation PowerPoint
Constructing Evidence-Based Explanations Activity
CER Scaffolding Tool

Activity 4: Decomposing the Explain+Argue Element
Novice teachers begin learning about the purpose of the Explain+Argue element and its importance in helping teachers design and teach lessons that prioritize student sensemaking through investigations. The PowerPoint includes slides that introduce the Explain+Argue element and connect the element to high-leverage practices (e.g., supporting explanation and building arguments) and scientific practices (e.g., engaging in argumentation based on evidence).

Then, novice teachers watch a video exemplar of an experienced teacher leading students through the Explain+Argue element of an investigation-based lesson. As novices watch the video, they use the EEE+A Framework and the EEE+A Lesson Observation Form to monitor the teaching moves the experienced teacher uses (along with the purposes and outcomes of those moves) to support students to make sense of the scientific phenomenon.

Materials Used: EEE+A Framework Reference Tool
EEE+A Framework PowerPoint
EEE+A Lesson Observation Tool
What’s Your Evidence? videos 5.5 and 5.6

Activity 5: Facilitating Argumentation
Novice teachers learn about the importance of facilitating argumentation during whole-class investigation-based discussions. The PowerPoint includes slides that introduce the scientific practice of engaging in argumentation based on evidence and ways in which a teacher can facilitate different aspects of the argumentation process (e.g., evaluating arguments, counter-arguing, etc.).
Then, novice teachers watch a video exemplar of an experienced teacher facilitating an investigation-based discussion. As they watch the video, novice teachers use chart included in the *Facilitating Argumentation Activity* and the *Talk Moves Tool* to monitor and reflect on the talk moves and teaching moves the teacher uses to engage students in argumentation.

**Materials Used:**
- Facilitating Argumentation Activity
- Talk Moves Tool
- Supporting Explanation and Argumentation PowerPoint
- What’s Your Evidence? video 5.7

**Activity 5: Preparing to Peer Teach the Explain+Argue Element**

Once novice teachers are familiar with the CER framework and how to facilitate argumentation, they plan the Explain+Argue portion of a science lesson (see *EEE+A Framework Overview*) for their peer teaching (simulated teaching). Novice teachers will have already planned and simulated teaching the Engage and Experience portions of the plan (see *Eliciting and Interpreting Students’ Thinking about Science and Setting up and Managing Small Group Work*) and they should continue using the same *Instructional Planning Template* plan. Novice teachers complete the *Identifying Big Ideas in Science Tool* to develop a deeper understanding of the scientific phenomena of focus. Then, novice teachers can use tools like the *CER Scaffolding Worksheet* and *General Rubric for Scientific Explanations* to develop materials for this portion of the lesson. The *Talk Moves Tool* and *Facilitating Argumentation Activity* can be used to help novices script their language for this element. The peer teaching assignment is used to support practice with multiple high-leverage practices and is included as part of the learning cycles for those HLPs as well.

**Materials Used:**
- Peer Teaching Assignment
- Peer Teaching PowerPoint
- Alternative Ideas Tool
- Instructional Planning Template Tool
- Identifying Big Ideas in Science Tool
- Equity Leverage Points Tool
- CER Scaffolding Tool
- General Rubric for Scientific Explanation Tool
- Talk Moves Tool
- Consideration Cards for Planning Science Lessons Tool
- Interpreting What Students Say or Do Tool
- Monitoring Tool
- Science Practices Scaffolding Continuum Tool

**See Also:**
- Leading Discussion Resource Guide
- Eliciting and Interpreting Resource Guide
- Adapting Curriculum Materials Resource Guide
- Norms and Routines Resource Guide

**Learning Cycle Part 2: Preparing for the Practice**

**Activity 7: Peer Teaching the Explain+Argue Element**

In this class session, novice teachers simulate teaching the Explain+Argue element of the science lesson they planned in the previous session to a small group of novice teachers and a teacher educator. The novice teachers and teacher educator use the *EEE+A Lesson Observation Form* to provide feedback to one another.

**Materials Used:**
- Peer Teaching Assignment
- Peer Teaching Assignment PowerPoint
- EEE+A Lesson Observation Tool
Learning Cycle Part 3: Enacting the Practice

Activity 8: Science Lesson in the Field
In the field, novice teachers teach a full science lesson that follows the EEE+A framework. As with the Peer Teaching Assignment, novices create their lesson plans using the Instructional Planning Template and can use the CER Scaffolding Worksheet and General Rubric for Scientific Explanation to develop materials and the Teacher Talk Moves tool and Facilitating Argumentation Activity to plan what they will say and do during the discussion.

As with the Peer Teaching Assignment, the Science Lesson in the Field Assignment supports the development of several high-leverage practices. It can be used as a culminating activity to give novice teachers practice integrating each of these HLPs.

Materials Used:
- Science Lesson in the Field Assignment
- Science Lesson in the Field Assignment PowerPoint
- Alternative Ideas Tool
- Instructional Planning Template Tool
- Identifying Big Ideas in Science Tool
- Equity Leverage Points Tool
- CER Scaffolding Tool
- General Rubric for Scientific Explanation Tool
- Talk Moves Tool
- Consideration Cards for Planning Science Lessons Tool
- Interpreting What Students Say or Do Tool
- Monitoring Tool
- Science Practices Scaffolding Continuum Tool

See Also:
- Leading Discussion Resource Guide
- Eliciting and Interpreting Resource Guide
- Adapting Curriculum Materials Resource Guide
- Norms and Routines Resource Guide

Learning Cycle Part 4: Analyzing the Enactment of the Practice

Activity 9: Full Science Lesson Reflection
After completing their full lesson in the field, novice teachers reflect on their experience and analyze the video of their enactment. While the assignment supports multiple HLPs, novice teachers can focus on their enactment of the Explain-Argue element to assess how well they supported students to construct explanations and build arguments. Novices can use the Facilitating Argumentation Activity to identify when and how well they used strategies to support students. The reflection is typically assigned as homework, but can also be adapted to happen in class.

Materials Used:
- Science Lesson in the Field Assignment
- Instructional Planning Template Tool
- Teacher Talk Tracker Tool
- Science Practice Scaffolding Continuum Tool