Formative Assessment in the Science Classroom

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Time Frame 3 Hours

Essential Question(s)

What is formative assessment, and what does it look like in the science classroom?

Summary

Participants will actively engage in formative assessments and reflect on how formative assessment strategies can be used in their specific content area and with their students.

Learning Goals

1. Explore a variety of strategies that support formative assessment for the science classroom.
2. Identify the purposes and uses of formative assessment probes in science.

Attachments

- CER Claim Evidence Reasoning—Formative Assessment in the Science Classroom.docx
- CER Claim Evidence Reasoning—Formative Assessment in the Science Classroom.pdf
- Copy of 3Dimensions of Science Standards—Formative Assessment in the Science Classroom.pdf
- Formative Assessment Collaborative Slides—Formative Assessment in the Science Classroom.pptx
- HS LS2 6 AT Ecosystem Dynamics Functioning and Resilience Niangua Darter—Formative Assessment in the Science Classroom.pdf
- HS LS4 5 Student Work Samples 4 18 River Darter Dont Box In—Formative Assessment in the Science Classroom.pdf
- I Notice I Wonder—Formative Assessment in the Science Classroom.docx
- I Notice I Wonder—Formative Assessment in the Science Classroom.pdf
- Ice Cold Lemonade Probe—Formative Assessment in the Science Classroom.docx
- Ice Cold Lemonade Probe—Formative Assessment in the Science Classroom.pdf
- Justified List—Formative Assessment in the Science Classroom.docx
- Justified List—Formative Assessment in the Science Classroom.pdf
- Note Catcher—Formative Assessment in the Science Classroom.docx
- Note Catcher—Formative Assessment in the Science Classroom.pdf
- Presentation Slides—Formative Assessment in the Science Classroom.pptx

Materials

- Presentation slides (attached)
- CER (Claim, Evidence, Reasoning) handout (attached; one per participant)
- Note Catcher (attached; one per participant)
- Ice-Cold Lemonade Probe (attached; one per participant)
- Justified List (attached; one per participant)
- I Notice I Wonder (attached; one per participant)
- Ecosystem Dynamics, Functioning, and Resilience: Don't Box Me In (attached; one per participant)
- Example Student Data (attached)
- Don't Box Me In: Student Work Samples (attached; 4-5 student work samples per group)
- Sticky notes
- Chart paper
- Beakers (three per group)
- Water
- Rubbing alcohol
- Corn syrup
- Pencils (three per group)
- Paper towels

Engage

Presenter's Note: Setting Up

Prior to beginning this session, you will need to set up a few things.

1. Insert a photo of the Anchor Chart from Day 1 of the Formative Assessment Institute on slide 7 in the attached **Presentation Slides**. This chart lists the purposes that participants identified for formative assessment in the classroom.
2. Have handouts available on the table for participants as outlined in the Materials List above.
3. Prepare lab supplies for Explore activity 2 by filling beakers with three different liquids: water, rubbing alcohol, and corn syrup.
4. Set up sticky bars for activity 3.
5. Poster paper for activity 4.
6. Handouts for the activities.

Display **slide 4**. Briefly introduce yourself and welcome participants to the science-content-specific day of the Formative Assessment Institute.

Display **slide 5** and share the essential question for the session: *What is formative assessment, and what does it look like in the science classroom?*

Display **slide 6** and share the session objectives with participants:

1. Explore a variety of strategies that support formative assessment for the science classroom.
2. Identify the purposes and uses of formative assessment probes in science.

Display **slide 7** and remind participants of the list of purposes for formative assessment that they generated on day 1 of the institute. This list will be driving their work throughout the session today.

Display **Slide 8** and share the agenda for the session.

Display **slide 9** and review the information on the slide to set the context for the day's work with formative assessment probes. Point out to participants that all of the formative assessments that we have seen up to this point could be probes, but the way we are featuring them today is assessment **AS** learning.

Explore 1: Justified List

Display **slide 10** and share the Justified List formative assessment strategy. Explain that this strategy is similar to the Justified True/False formative assessment used on day 3.

Display **slide 11**. Ask participants to note for themselves which of the statements best apply to scientific theories and explain what a theory in science means to them based on the statements they selected.

Ask participants to form small groups. Groups should take a few moments to discuss their description of a scientific theory and develop a group consensus.

Justified List Answers

The correct answers are A, D, G, and I.

Display **slide 12** to show correct answers. Ask a few groups to share out their group consensus description of a theory. Proceed to **slide 13** to provide gravity and relativity as an example of law versus theory. Refer to the slide notes for an explanation of the difference to share with participants.

Explore 2: Triangle of Power

Display **slide 17**, and ask participants to offer explanations for the phenomenon they are observing.

After a few participants have shared their ideas, briefly describe what information their answers gave you about their prior knowledge.

Go to **slide 18** and have participants complete the activity using beakers containing three types of liquids (water, rubbing alcohol, and corn syrup), pencils, and paper towels. Assure participants that it's fine if they can't remember any technical information about waves. Their task is simply to develop the most reasonable explanation they can.

Have each group share out their explanations and models, and then proceed to **slide 19**. Validate any correct information participants shared and explain how the phenomenon demonstrates the relationship between frequency, wavelength, and the speed of light waves by using the Triangle of Power. A detailed explanation is provided in the slide notes.

Explain 1: Justified List

Go to **slide 14** and share the lesson Scientific Reason, Not Scientific Treason, which uses the Justified List strategy. Give participants a few minutes to review how the formative assessment strategy was used in the lesson, and then ask for volunteers to share out.

Display **slide 15** and briefly identify the three dimensions of the science standards, applicable to the Next Generation Science Standards (NGSS) and Oklahoma Academic Standards for Science (OAS-S). Dimensions 1 and 2 will be addressed in detail in upcoming activities, and dimension 3 will be used throughout.

Ask participants what they know about Using Phenomena to Drive Science Instruction, and then continue to **slide 16** and introduce the definition of a phenomenon. Use participants' shared prior knowledge to set the context that phenomena serve as anchors for science instruction generally, and formative assessment specifically. Several example phenomena will be used in subsequent activities.

Explain 2: Triangle of Power

Display **slide 20** and share What is a Wave? Unit: Lesson 2 (Not the Bermuda Triangle). This lesson uses the Triangle of Power strategy and has students come back to the phenomena shared at the start of the unit. Provide participants with time to look over the lesson, and then ask them to reflect on the questions and share their answers. Students' initial explanations (before and after the investigation) and drawn models are the primary formative assessment activities.

Display **slide 21** and highlight how the activity served to formatively assess student understanding of the Disciplinary Core Ideas. Continue to **slide 22**. As part of three-dimensional science instruction, it is important to incorporate all three dimensions of the standards into student learning experiences. Remind participants that cross-cutting concepts (CCCs) are broad scientific lenses used to help students make sense of what they are learning. Ask participants to identify which CCCs the formative assessment activity touched upon and why.

Cross-Cutting Concepts

There are many possible choices of CCCs present in the activity, but the most readily apparent include: patterns; systems and system models; and scale, proportion, and quantity.

Display **slide 23** and bring participants' attention to their **Note Catcher** handout. Allow them time to reflect on the assessment strategies that they have engaged with up to this point and for each one answer the following questions:

- *How was it used?*
- *How can I use it?*

Once participants have filled out their Note Catchers, allow time for a break before resuming the session with Explore activity 3.

Explore 3: Sticky Bars

Display **slide 24** and introduce participants to the Sticky Bars strategy. Set up the probe by noting that the giant sequoia tree pictured grows from a single seed from a pinecone.

Have participants consider the following question:

Question: Where did more of the matter come from?

Answer choices:

- Sunlight
- Water
- Soil
- Carbon dioxide
- Oxygen
- Minerals

Instruct participants to go to the chart on the board and place a sticky note above the choice that they believe to be the correct answer, creating a bar graph. Don't share the answer yet, but mention that few participants choose the correct option the first time.

Go to **slide 25** and play the Minds of Our Own video from timestamps 1:30-6:25. The correct answer to the probe (carbon dioxide) is explained in the video. After watching the video, ask participants what surprised them about this formative assessment experience. Make explicit for them that teaching science is about uncovering student pre-conceptions and using them to build new knowledge. Probes and phenomena can serve as valuable tools to make these pre-conceptions visible to us.

Explain 3: Sticky Bars

Display **slide 26** and share the lesson What's a GMO?, which uses the Triangle of Power strategy and has students come back to the phenomena shared at the start of the unit. Give participants time to look over the lesson, and then ask them to reflect upon the questions and share their answers.

Display **slide 27** and highlight how the activity served to formatively assess student understanding of the Disciplinary Core Ideas. Continue to **slide 28**. Remind participants that science and engineering practices (SEPs) are the actions students take in order to engage with science content and learning experiences. Ask participants to identify how SEPs have been used in the formative assessment activities thus far.

Science and Engineering Practices

Arguments could be made for most of the SEPs, but developing models, carrying out investigations, and constructing explanations are the most well-supported. Depending on how much prior knowledge students have about waves, using mathematics and computational thinking might also be supported.

Explore 4: B-D-A (Before-During-After)

Display **slide 29** and introduce participants to the B-D-A (Before-During-After) strategy. Continue to **slide 30**. In groups, have participants consider the **Ice-Cold Lemonade Probe** and draw before, during, and after pictures a sheet of chart paper to help explain their reasoning. Have participants share their posters with the whole group.

Continue to **slide 31**. Show participants the There's No Such Thing as Cold video from timestamps 0:38-1:58. Ask participants how the B-D-A strategy allows us to see their understanding of the scientific concept of thermal transfer. Explain that by asking learners to illustrate how the system is changing, we can better see whether they understand the mechanism behind the phenomenon. We can also determine whether they know the direction of thermal energy flow in the system.

Explain 4: B-D-A (Before-During-After)

Display **slide 32** and highlight how the activity served to formatively assess student understanding of the Disciplinary Core Ideas. Though the standard does not explicitly address atomic motion, this formative assessment uncovers student thinking about and understanding of that mechanism, which underpins both the DCIs.

Ask participants where in a lesson they could use this particular probe. Display **slide 33** and briefly address the placement of probes in a science lesson, explaining how a probe's placement depends on its purpose.

Explore 5: Claim, Evidence, Reasoning (CER)

Go to **slide 34**. Introduce the Claim-Evidence-Reasoning (CER) strategy and ask participants whether they have used it. If anyone has, let them explain the strategy. Clarify, validate, or add to their explanation as necessary. Display **slide 35**. Direct participants to the NOAA Billion-Dollar Weather and Climate Disasters website. Allow participants time to explore the data set and develop a claim supported by evidence from the website for how severe weather events have changed over time.

Facilitator's Note: Exploring Data

A laptop or tablet is preferred for accessing the website, but it can be accessed on a smartphone as well. The easiest way to explore the data is from the Mapping tab, but the Time Series and Events tabs also provide straightforward data.

Have a few participants share their claims and supporting evidence. Point out that they did not yet get to the scientific principles necessary to support their claims and evidence. Show **slide 36** and ask them what their next steps would be at this point with students.

Explain 5: Claim, Evidence, Reasoning (CER)

Display **slide 37** and share the lesson Feelin' The Phenomena. Give participants time to look over the lesson, and then ask them how the CER strategy supports formative assessment as learning. If participants previously indicated that they have used CERs before, ask them to share a specific example of how they used it for formative assessment or how they *could have* used it for formative assessment. Before continuing on, highlight for participants that this activity was an example of how data can be used to illustrate a phenomenon, which is a rarely-used but valuable approach.

Facilitator's Note: CER

An initial explanation, like we've seen in previous formative assessments, is valuable for seeing the ideas, misconceptions, and ways of thinking about material, but it also provides a scaffold for the learning to come. The CER strategy allows students to continuously revise their thinking and strengthen their explanations as they learn more about the concept

Display **slide 38** and highlight how the activity served to formatively assess student understanding of the Disciplinary Core Ideas.

Explore 6: I Notice, I Wonder

Display **slide 39**. Introduce the context of the three-dimensional assessment task. Have participants complete an I Notice, I Wonder activity for the Niangua River Darter task.

Display **slide 40** to provide some background for the Niangua River Darter assessment before moving on to analyzing student work samples. Display **slide 41** and give participants some additional time to look over the student work samples (ideally 4-5 samples per group). Have participants add to their I Notice, I Wonder chart and, if possible, answer some of their previous "wonders" from when they looked at the blank task.

Facilitator's Note: Assessment Task Context

The Niangua River Darter assessment task (AT) was one of several ATs developed with and vetted by rural Oklahoma teachers over the course of a three-year grant. The ATs address all three dimensions of the science standards in an integrated way, asking students to engage in SEPs in order to make sense of the DCIs through the lenses of CCCs.

While it might superficially resemble a summative assessment, it was designed to be used strictly as a formative assessment by teachers in a variety of (primarily) collaborative ways to support learning. In many cases, teachers chose to use the AT more like an instructional activity rather than as a stand-alone performance task where students applied their learning. The full context of the project is here: https://learn.k20center.ou.edu/science-resource/1934

Go to **slide 42**. Ask participants the following questions:

- What do you notice about the assessment task overall?
- What do you notice about student answers?
- How could this assessment be used for learning?

Highlight that the AT is designed in such a way that the task should be assessed holistically. Often, students' answers are comprehensive only when viewed across an entire task, particularly when the components of a task are scaffolded.

Explain 6: I Notice, I Wonder

Display **slide 43** and highlight how the activity served to formatively assess student understanding of the Disciplinary Core Ideas.

Go to **slide 44**. The questions posed on the slide are frequently asked by teachers. Pose them to participants to get their ideas.

Possible Participant Responses

1. Grades should not be given for formative assessments.
2. Formal documentation isn't always necessary for formative assessment. Assessment can often be accomplished through discussions: engaging with students one-on-one, listening to peer discussions, or asking student groups probing questions.
3. There are many possible answers to this question. Two of note:
    - When formative assessments are used as learning, students often don't realize they are being assessed at all because the assessment is embedded within the work.
    - Framing formative assessment as something students are doing for themselves (i.e., figuring out what they understand) rather than something they are doing for the teacher can be motivating for many students, as they are often willing to be more candid about their understanding when they know they won't be penalized for it.

Go to **slide 45**. Have participants return to their Note Catcher handout. Provide them with time to reflect on the assessment strategies that they have engaged with in this portion of the session and answer the following questions:

- *How was it used?*
- *How can I use it?*

Extend

Display **slide 46** and ask participants to choose one of the formative assessment strategies that has been covered during the institute and create an assessment in their content area. Consider grouping participants into content-specific areas and providing time for the assessments to be created in collaboration.

Evaluate

Transition to the evaluation **slide 47** and ask participants to complete the K20 TREK Rapid Feedback form. Within the feedback, ask them to list two strategies they plan to implement in the next month.

Research Rationale

Analyzing the current skill level of students in a classroom at any given time and determining the best course of action for ensuring they all meet the target learning goals can be a challenge even for seasoned teachers. The idea of using formative assessment to meet the individual needs of students is not a new topic. In fact, researchers as far back as Benjamin Bloom have shown that one-to-one tutoring is the most effective form of instruction because of the tutor's ability to pinpoint misconceptions and provide immediate feedback and correctives (William, 2011). Despite continued research backing up the claims that formative assessment can enhance student success, teachers might continue to struggle in their efforts to use the full array of formative assessment practices available. The question then becomes what can teachers do to effectively improve and enhance their use of formative assessment in the classroom environment?

Resources

- Annenberg Learner. (n.d.). Lessons from thin air. Retrieved October 14, 2021, from https://www.learner.org/series/minds-of-our-own/2-lessons-from-thin-air/
- It's Okay To Be Smart. (2015, January 19). There's no such thing as cold [Video]. YouTube. https://www.youtube.com/watch?v=Akd7MMRKDwc
- K20 Center. (n.d.). Claim, evidence, reasoning (CER). Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f506fc09
- K20 Center. (n.d.). Feelin' the phenomena. 5E Lesson. https://learn.k20center.ou.edu/lesson/415
- K20 Center. (n.d.). I notice, I wonder. Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f507d1a7
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- NOAA National Centers for Environmental Education. (2021). Billion-dollar weather and climate disasters. https://www.ncdc.noaa.gov/billions/
- Wiliam, D. (2011). What is assessment for learning? *Studies in Educational Evaluation*, 37(1), 3-14. doi:https://doi.org/10.1016/j.stueduc.2011.03.001