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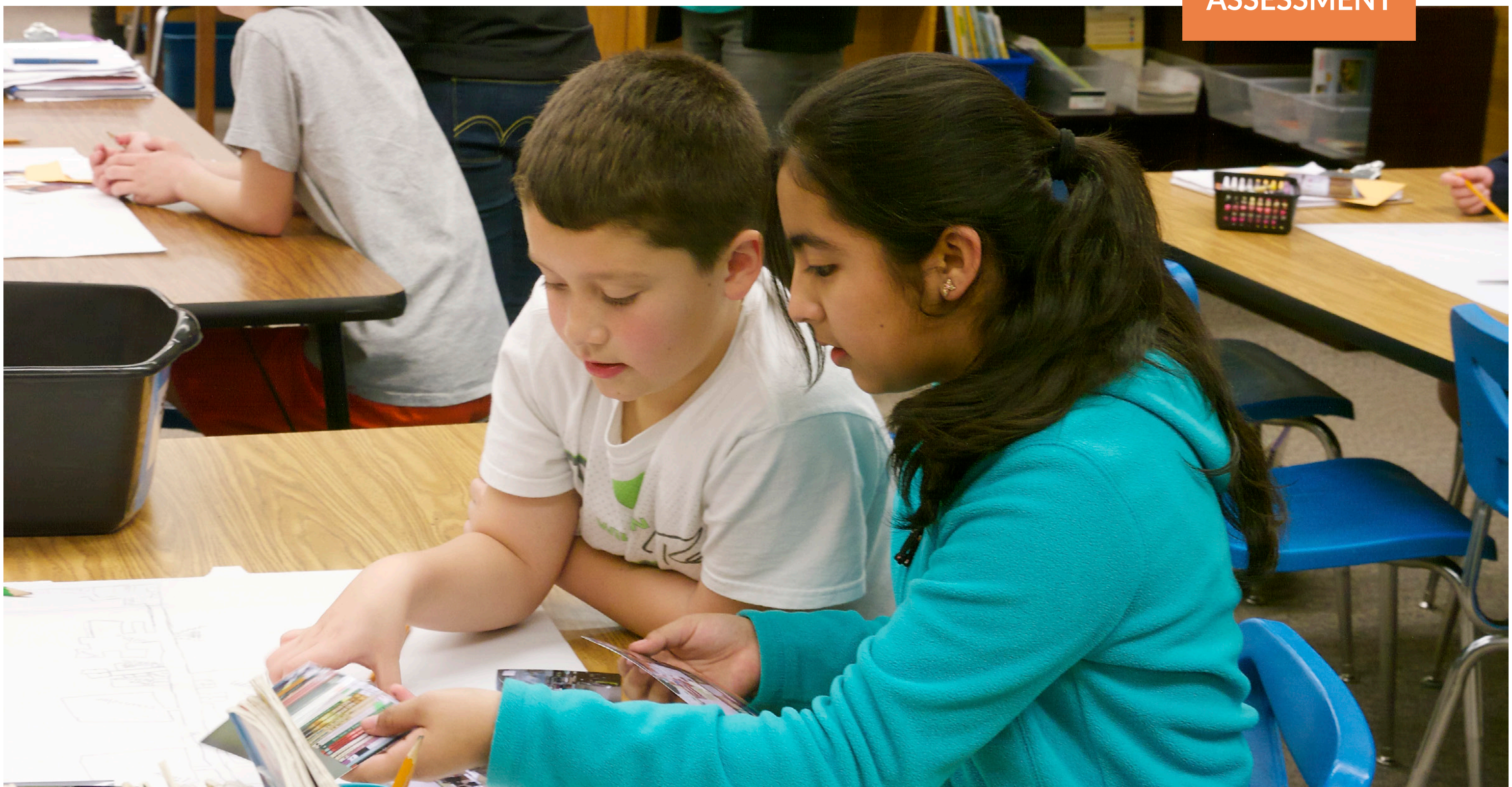
FORMATIVE ASSESSMENT



Steps to Designing a Three Dimensional Assessment

This five-step process is designed to help teams develop three-dimensional assessment tasks. Three-dimensional assessment tasks allow you to make inferences about students' integrated understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts.

The tool aims to provide guidance for developing multicomponent assessment tasks that is based on the conclusions and recommendations included in the National Research Council (2014) report, Developing Assessments for the Next Generation Science Standards.

This is a companion tool to the "Integrating Science and Engineering Practices into Assessments" tool, which suggests activity formats to help teachers create three-dimensional, practice-based assessments. That tool can be found at researchandpractice.org/ngsstaskformats.

The five steps described here are aimed at helping teams get started developing assessment tasks. Additional resources for developing rubrics for tasks and applying interpretive frameworks for interpreting student responses are under development. The four steps described here are:

Step 1: Define what you will assess by analyzing relevant sections of *A Framework for K-12 Science Education* and crafting learning claims.
Step 2: Brainstorm Possible Scenarios for Eliciting Student Understanding.
Step 3: Use Task Formats to Build Questions to Engage Students with the Scenario.
Step 4: Imagine the Range of Possible Student Responses to the Questions.
Step 5: Share, Review, and Revise.

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Step 1. Define what you will assess by analyzing relevant sections of *A Framework for K-12 Science Education* and crafting learning claims.

Assessment begins with defining what understandings you will assess. Most assessments start with defining the “content” to be assessed, focusing on only one dimension of proficiency, understanding of disciplinary core ideas. A three-dimensional assessment begins by defining understanding more broadly, as the integration of disciplinary core ideas, science and engineering practices, and crosscutting concepts.

The descriptions from the Framework of student expectations by grade band are the starting place for defining the understanding that should be assessed. The practices chapter (Chapter 3) and crosscutting concepts chapter (Chapter 4) highlight grade 12 endpoints and what is known about progressions across K-12. The disciplinary core ideas chapters (Chapters 5-8) include descriptions for what is expected that students know and can do by the end of grades 2, 5, 8, and 12.

Use the text to define a set of “learning claims” that you want to be able to make about what students know and can do. A claim is more than just a phrase that references a concept (e.g., “plate tectonics”). It’s a statement that comes directly from the Framework like “Plate tectonics provides a framework for understanding Earth’s geological history” (derived from 8th grade expectation for ESS2.B). The learning claims for a given assessment can include aims from a single disciplinary core idea or from multiple disciplinary core ideas. In states that have adopted NGSS, the performance expectations can form the basis for selecting relevant disciplinary core idea, practice, and crosscutting concept components. The claims can also derive from coherent bundles of standards that are being assessed together.

Original Framework Text	Claim
Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geological history. Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth’s crust. (DCI: ESS2.B) Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations. (DCI: ESS2.C) Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (SEP: Explanation) Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (CCC-Scale, Proportion, and Quantity)	Students can apply their understanding that plate tectonics, weathering, and erosion operate today as they have in the past to explain observable continental features, drawing on evidence presented in the form of models of the past developed by scientists to account for changes that are observable on different timescales.

Step 2: Brainstorm Possible Scenarios for Eliciting Student Understanding

Three-dimensional assessment tasks are multi-component tasks. That is, they have multiple questions that students can answer that pertain to a single scenario. Scenarios describe some aspect of a natural phenomenon to be explained or engineering design problem to be solved. Typically, more than one scenario can be used to develop evidence related to the claim(s) you have developed. Generating multiple scenarios allows you to evaluate which ones are better for eliciting student understanding. Consider following the criteria for assessment scenarios described in this resource, STEM Teaching Tool #26.

Write detailed descriptions of the scenarios you brainstorm. This will allow others to imagine just how the scenario might be used in a multi-component assessment to develop evidence related to the claim about students' understandings. Within the scenario, describe what explanation or model students must produce of the phenomenon represented in the scenario and how students will apply their understanding of the relevant disciplinary core ideas and make connections to crosscutting concepts. If the scenario is an engineering design challenge, then the solutions that student develop should require them to apply understanding of a science disciplinary core idea and make a connection to a crosscutting concept.

Claim	Possible Scenario
Students can apply their understanding that plate tectonics, weathering and erosion operate today as they have in the past to explain observable continental features, drawing on evidence presented in the form of models of the past developed by scientists to account for changes that are observable on different timescales.	The Ozark Mountains are a mountain range that sits in the middle of the North American plate. They are located in a region that today gets lots of rain and has an extensive river system. Scientists have compared isotopes in rocks there and in mountain ranges in California along the San Andreas fault [show data table with this data, along with pictures of Coastal Range and Ozark]. Students would use the data presented to come up with an explanation for how the mountain range could have formed there and what accounts for their shape. It would require them to apply their understanding of how plate tectonics can result in mountain building events, as well as knowledge that plates can move, to construct an explanation of how the mountains could have formed in the middle of the North American plate. To explain the rounded shapes of the Ozarks, they would need to invoke weathering and erosion as processes. They would need to also apply their understanding of how scientists model geophysical processes that take place on a very large timescale.

Step 3: Use Task Formats to Build Questions to Engage Students with the Scenario

Once you have chosen a scenario, you can use the task formats we have developed for each of the science and engineering practices named in the Framework to help you design specific questions for students—to assess specific parts of your learning claims from Step 1. The task formats are organized around the practices, because it is especially hard to develop assessments that require students to demonstrate not only their understanding of disciplinary core ideas but also their grasp of one or more practices. We encourage you to design assessment questions that engage students in a range of the science and engineering practices in ways that make sense for the scenario. Scenarios should be accessible to all students and connect to students' interests and experiences.

There are between four and eight possible task formats for each of the science and engineering practices. Having multiple task formats to choose from allows for variety in assessment questions. The formats vary in how challenging they are likely to be for students, too. Some require students to construct knowledge with very little support from the prompt. Others could be used to build questions where students select from available responses (multiple choice).

Each scenario is likely to rely on multiple formats to develop specific questions for students to answer, because 3D tasks are multi-component tasks. The examples below illustrate how you can use the format as a guide to develop specific questions.

Possible Scenario	Questions (Using Task Formats)
The Ozark Mountains are a mountain range that sits in the middle of the North American plate. They are located in a region that today gets lots of rain and has an extensive river system. Scientists have compared isotopes in rocks there and in mountain ranges in California along the San Andreas fault [show data table with this data, along with pictures of Coastal Range and Ozark]. Students would use the data presented to come up with an explanation for how the mountain range could have formed there and what accounts for their shape. It would require them to apply their understanding of how plate tectonics can result in mountain building events, as well as knowledge that plates can move, to construct an explanation of how the mountains could have formed in the middle of the North American plate. To explain the rounded shapes of the Ozarks, they would need to invoke weathering and erosion as processes. They would need to also apply their understanding of how scientists model geophysical processes that take place on a very large timescale.	*Analyzing and Interpreting Data (5a)* Scientists look at the data from rocks and conclude that the Ozarks are much older than the mountains of the Coastal Range mountains. What evidence supports their conclusion? Why do scientists need evidence from the presence radioactive isotopes support conclusions about the age of rocks? *Asking Questions (1b)* Scientists hypothesize that the Ozarks once looked more like the Coastal Range. What is a question that scientists could pose about processes happening today in the Ozarks that they could investigate to test their hypothesis? What evidence would scientists need to gather to answer this question? *Engaging in Argument from Evidence (1b)* One group of scientists thinks the Ozarks are just a worn down plateau, like the Berkshires in Massachusetts [show picture]. Others think there was once a plate boundary there that caused the mountains to form. For each of these claims, what pattern of evidence could scientists look for to support or refute their claims? What geophysical process would explain the pattern of evidence they found?

Step 4: Imagine the Range of Possible Student Responses to the Questions

An important step in developing an assessment is imagining how students might respond to each of the questions. Ideally, the prompts elicit complete explanations that provide support for the claims developed in Step 1. In developing hypothetical student responses, you may decide that the prompts are not specific enough to elicit the student response that is needed to support the claims. You may also discover the scenario is not adequate for eliciting student responses. At this point, you may need to revise the prompts, the scenarios, or both to bring all four elements— claims, scenarios, application of task formats, and hypothetical student answers—into closer alignment.

It is valuable to imagine how a range of students might respond to each of the prompts. This will help you eventually develop rubrics for tasks. Especially important is to consider how well the questions allow emerging bilingual students ("English Language Learners") to engage with the science content. Also important is to imagine yourself as a student when writing the response, because it can help you refine your prompts to elicit better what students know and can do. It can be useful to think about typical responses you might get at different levels of correctness (e.g., limited, partial, full understanding).

Questions	Hypothetical Student Response
Asking Questions (1b) Scientists hypothesize that the Ozarks once looked more like the Coastal Range. What is a question that scientists could pose about processes happening today in the Ozarks that they could investigate to test their hypothesis? What evidence would scientists need to gather to answer this question?	Question that Scientists Could Pose "They could ask a question about whether the mountains are getting taller or shorter." "How are weathering and erosion changing the shape of the Ozarks?" "What is water doing to the Ozarks?" Evidence They Would Need to Gather "About what's happening to the tops of mountains" "They could look at how much sediment and rock is coming down in the streams from the tops of mountains" "They could take pictures over time" (incorrect response)

Step 5: Share, Review, and Revise

Assessment design requires many cycles of developing, testing, and revising tasks to ensure that you are getting an accurate picture of what students know and can do. Sharing your initial tasks with a colleague and asking them for constructive feedback on how to improve them is a good way to begin. It is also helpful to pilot test assessments with a small number of students to feed that actual student response data into the revision process. Carefully reviewing alignment of the different elements presented here—claims, scenarios, application of task formats, and hypothetical/actual student answers— and also testing tasks with students as part of classroom instruction can reveal to you ways that tasks can be improved.

A key is to be ready to revise your initial tasks, even when you've put a lot of work into them. Often, the challenge is not with our students but with the questions that we ask. It is difficult to develop tasks that allow all students to show what they know and can do. Yet it is imperative to do so in order to create fair, valid assessments of students' three-dimensional science proficiency. Also, once you test them with students, your hypothetical student responses can be replaced with actual student responses, along with ideas for how to address problematic aspects of student responses.

Claims	Scenarios	Questions (Using Task Formats)	Hypothetical / Actual Student Responses

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