Developing and Using Models (SEP2)

Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. (NRC Framework 2012, p. 58)

Developing and Using Models (SEP2)

Elementary Sample Student Actions

Develop and Use a Model

- ❏ Students distinguish between a model and the actual object, process, and/or events the model represents.
- ❏ Students compare models to identify common features and differences.
- ❏ Students identify limitations of models. [3-5]
- ❏ Students develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).
- ❏ Students collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. [3-5]
- ❏ Students develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. [3-5]
- ❏ Students develop and/or use models to describe and/or predict phenomena. [3-5]
- ❏ Students develop a simple model based on evidence to represent a proposed object or tool.
- ❏ Students develop a diagram or simple physical prototype to convey a proposed object, tool, or process. [3-5]
- ❏ Students use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. [3-5]
- ❏ Students test two different models of the same proposed object, tool, or process to determine which meets criteria for success. [3-5] (SEP3)

Revise and Refine a Model

- ❏ Students revise and refine a model based on new data, evidence, or information.

Secondary Sample Student Actions

Develop and Use a Model

- ❏ Students describe the system that is being modeled.
- ❏ Students make decisions about the type of model they will create (e.g, a diagram, illustration, physical creation, or computer animation) to represent a phenomenon or system.
- ❏ Students define and clearly label all of the essential variables or factors (components) within the system being modeled.
- ❏ Students describe unobservable mechanisms (if applicable) identified in a model.
- ❏ Students describe the relationships among the variables or components of a model. (SEP6)
- ❏ Students evaluate, when appropriate, the boundaries and limitations of the model.
- ❏ Students compare models to identify common features and differences.
- ❏ Students use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world.
- ❏ Students ask questions that arise from observations and predictions of a model. (SEP1)
- ❏ Students explain a science concept using a model as a representation of a phenomena or system under study. (SEP6)
- ❏ Students use a model as the basis of an explanation or to make predictions about how the phenomena or system will behave in specified circumstances. (SEP6)
- ❏ Students use a model to discuss cause & effect or structure & function relationships or interactions between variables or components of a system.
- ❏ Students use a model to discuss the stability or instability of system components and how they change over a period of time.

	❏ Students discuss the benefits and drawbacks of a model or different models (that they have created or that was created by others). ❏ Students apply a model to a related example and then revise the model to reflect new information. [3-5] ❏ Students evaluate a model by comparing predictions to the real world and then adjust the model accordingly. [3-5] ❏ Students design a test of a model to ascertain its reliability. [3-5]	❏ Students develop a complex model that allows for manipulation and testing of a proposed process or system. ❏ Students develop a diagram or simple physical prototype to convey a proposed object, tool, or process. ❏ Students develop and/or use mathematical or computational representations (e.g., equations, graphs, spreadsheets, computer simulations) to depict and describe the relationships between system components. (SEP4) **Revise and Refine a Model** ❏ Students revise and refine a model based on new data, evidence, or information. ❏ Students ask questions to clarify and/or refine a model. (SEP1) ❏ Students modify a model, based on evidence, to match what happened when a variable or component of a system is changed. (SEP3) ❏ Students discuss the benefits and drawbacks of a model or different models (that they have created or that was created by others). ❏ Students apply a model to a related example and then revise the model to reflect new information. ❏ Students evaluate a model by comparing predictions to the real world and then adjust the model accordingly. (SEP3) ❏ Students revise a model to show relationships among variables, including those not observable but predict observable phenomena. ❏ Students design a test of a model to ascertain its reliability. (SEP3)

Sample Prompts and Questions for Developing and Using Models (SEP2)

Develop and Use a Model (SEP2)

- What is the purpose of this model?
- What is the model trying to represent? What object, process, or event does this model represent?
- What system or part of the system is being modeled?

- What are the variables or components in this model? How are they represented?
- How are the different variables or components related or connected?
- How can you model this pattern? How can you make a model to explain this pattern?
- What are some ways this model works well or fits well?
- What are some limitations of this model? What is not included in this model?
- Is there anything about what the model is representing that is really complex?
- How does the model or process of modeling help you simplify and think about what is happening?
- How does the model help you “zoom in” or “zoom out” to think about what is happening?
- How does the model allow you to imagine what is hidden so you can think about what is happening?
- How does the model help you slow down or speed up what is happening so you can think about what is happening?
- Were there moments when you thought you understood what was happening, so you tested your ideas with your model to see if you were right?
- How can we model how this structure works?
- How can we model the flow of energy ? How can you model the cycling of matter?
- How can you model this system?
- How can you model how this system is changing?
- How can you make a model that helps you understand nature at this scale?
- What model will explain this cause and effect relationship?
- How does this model help you predict what might happen next?
- How are these two models similar? How are they different?

Revise and Refine a Model (SEP2)

- How does the model you have support the prediction you are making?
- In light of new data we have collected, how would you revise or refine your model?
- What is the benefit or drawback of this model? How might it need to be revised?
- How can we test the model against what happens in the real world?
- What are some ways this model does not work well or fit well? How might it need to be revised?
- Is there anything about what the model is representing that is really complex? How can the model be revised to better represent a complex idea?
- Does the model help you simplify and think about what is happening? If not, how might the model need to be revised?
- Does the model help you “zoom in” or “zoom out” to think about what is happening? If not, how might the model need to be revised?
- Does the model help you slow down or speed up what is happening so you can think about what is happening? If not, how might the model need to be revised?
- Does the model allow you to imagine what is hidden so you can think about what is happening? If not, how might the model need to be revised?

K-12 Progression for Developing and Using Models (SEP2)			
K-2	**3-5**	**MS**	**HS**
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.	Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
Distinguish between a model and the actual object, process, and/or events the model represents. Compare models to identify common features and differences.	Identify limitations of models.	Evaluate limitations of a model for a proposed object or tool.	Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. Design a test of a model to ascertain its reliability.
Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. Develop and/or use models to describe and/or predict phenomena.	Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. Use and/or develop a model of simple systems with uncertain and less predictable factors. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
Develop a simple model based on evidence to represent a proposed object or tool.	Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. Use a model to test cause and effect relationships or interactions concerning the	Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and/or use a model (including mathematical and computational) to

	functioning of a natural or designed system.		generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

from NGSS Appendix F: Science and Engineering Practices in the NGSS

Assessment Task Formats for Developing and Using Models (Science)	
Format	**Task Requirements for Students**
1	Present students with a scenario that describes a phenomenon using text, images, video, and/ or data, then ● Ask student to develop a model that represents amounts, relationships, scales, or patterns in the natural world, or ● Ask students to create a simple model based on evidence from the scenario to represent an object or tool.
2	Present students with a scenario that describes a phenomenon using text, images, video, and/ or data, and with two different models for that phenomenon, then ● Ask students to compare the two models to identify common features and differences and ● Ask students to revise one of the models and justify their revisions with disciplinary core ideas.
3	Present students with a scenario that describes a phenomenon using text, images, video, and/ or data and a question or problem related to the phenomenon, then ● Ask students to develop a model with components, interactions, and mechanisms that answers the question or demonstrates a solution to the problem, and/or ● Ask students to develop a version of their model that shows what will happen if a variable or component changes, and/or ● Ask students to write an explanation for the phenomenon or the problem, using the model as supporting evidence.
4	Present students with a scenario that describes a phenomenon using text, images, video, and/or data, and includes an illustration or drawing of a scientific process, then ● Ask students to label the components, interactions, and mechanisms in the model, and ● Write a description of what is shown in the drawing.
5	Present students with a scenario that describes a phenomenon using text, images, video, and/or data and a question or problem related to the phenomenon, then ● Ask students to develop a model that generates data, and ● Ask students to write an explanation or explain a solution using data generated from the model.
6	Present students with a scenario that describes a phenomenon using text, images, video, and/ or data and a question or problem related to the phenomenon, then ● Ask students to develop at least two types of models, and ● Ask students to write an explanation or explain a solution using evidence generated from more than one type of model.
7	Present students with a scenario that describes a phenomenon using text, images, video, and/ or data and a model to describe or predict something related to the phenomenon then ● Ask students to develop a test to understand the reliability of the model, and ● Revise the model to improve its reliability.

From STEM Teaching Tool #30, Integrating Science Practices into Assessment Tasks