Elaboration and Unpacking of the Practices

Grade 8, Measurement Target 2	Students are able to develop and interpret models and use mathematical representations and scientific information to make claims about how waves transfer energy and information through various materials.		
	Using Mathematics and Computational Thinking	**Developing and Using Models**	**Obtaining, Evaluating, and Communicating Information**
Practices[1]	• Students can use mathematical representations to describe and/or support scientific conclusions and design solutions. **(MS-PS4-1)**	• Students can develop and use a model to describe phenomena. **(MS-PS4-2)**	• Students can integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. **(MS-PS4-3)**
Essential Knowledge and Skills	**MS-PS4-1** • Students can use mathematical representations to describe scientific conclusions. • Students can use mathematical representations to support scientific conclusions. • Students can use mathematical representations to describe design solutions. • Students can use mathematical representations to support design solutions.	**MS-PS4-2** • Students can use a model to predict phenomena. • Students can use a model to describe phenomena. • Students can develop a model to predict phenomena. • Students can develop a model to describe phenomena. • Students can identify appropriate aspects of a given phenomenon to include in a model. • Students can explain the relationships among the components of a model. • Students can create an accurate representation of a given phenomenon. • Students can describe the relationship between a given phenomenon and a model of that phenomenon.	**MS-PS4-3** • Students can interpret qualitative scientific information in written text. • Students can interpret qualitative scientific information in media and visual displays. • Students can integrate qualitative scientific information from different sources. • Students can use integrated qualitative scientific information to clarify claims and findings. • Students can cite evidence and draw inferences from text. • Students can determine the central ideas or conclusions of a text. • Students can compare and contrast the information from multiple sources. • Students can draw evidence from informational texts to support analysis, reflection, and research.

[1] These are the primary Practices associated with the Performance Expectations for this Measurement Target. Additional Practices Building to the PEs can be found on the website for the Next Generation Science Standards.

<table>
<tr><td>Evidence of a High Level of Performance</td><td>• Students can design and use mathematical representations to support a solution to a problem.</td><td>• Students can create a model to represent a given phenomenon and use the model to describe and predict aspects of the phenomenon.</td><td>• Students can interpret and evaluate qualitative data from different sources and justify conclusions using data.</td></tr>
<tr><td>Prerequisite Knowledge and Skills</td><td colspan="3">• Knowledge of units and unit conversions
• Knowledge of ratio relationships
• Ability to interpret qualitative data
• Ability to represent proportional relationships
• Knowledge of linear relationships</td></tr>
<tr><td>Student Challenges</td><td colspan="3">• Typical student beliefs about mathematical inquiry include the following: There is only one correct way to solve any mathematics problem; mathematics problems have only one correct answer; mathematics is done by individuals in isolation; mathematical problems can be solved quickly or not at all; mathematical problems and their solutions do not have to make sense; and that formal proof is irrelevant to processes of discovery and invention. [1] These beliefs limit students' mathematical behavior. [2] Further research is needed to assess when and how students can understand that mathematical inquiry is a cycle in which ideas are represented abstractly, the abstractions are manipulated, and the results are tested against the original ideas. We must also learn at what age students can begin to represent something by a symbol or expression, and what standards students use to judge when solutions to mathematical problems are useful or adequate. [3]
• Prior to instruction, or after traditional instruction, many middle and high school students continue to focus on perceptual rather than functional similarities between models and their referents, and think of models predominantly as small copies of real objects. [4] Consequently, students often interpret models they encounter in school science too literally and unshared attributes between models and their referents are a cause of misunderstanding. [5] Some middle and high school students view visual representations such as maps or diagrams as models, but only a few students view representations of ideas or abstract entities as models. [6]
• Only a few middle and high school students think that models are useful in developing and testing ideas and that the usefulness of a model can be tested by comparing its implications to actual observations. [7]
• Middle school and high school students accept the idea that scientists can have more than one model for the same thing. [8] However, having multiple models may mean for them that one could have literally a different view of the same entity, or that one could emphasize different aspects of the same entity—omitting or highlighting certain things to provide greater clarity. Students are rarely aware that there could be different models to explain something or to evaluate alternative hypotheses. They find multiple model use in school science confusing and rarely use multiple models to think about phenomena; even if they do, the idea that one model is "right" and "real" persists. [9] Students may know that models can be changed, but changing a model for them means (typical of high school students) adding new information or (typical of middle school students) replacing a part that was made wrong. [10]</td></tr>
<tr><td>Common Core State Standards for Mathematics Connections</td><td colspan="3">• MP.2 Reason abstractly and quantitatively. (MS-PS4-1)
• MP.4 Model with mathematics. (MS-PS4-1)
• 6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1)
• 6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1)
• 7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-PS4-1)
• 8.F.A.3 Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS4-1)</td></tr>
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Common Core State Standards for ELA/Literacy Connections	• **RST.6-8.1** Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text. **(MS-PS4-3)** • **RST.6-8.2** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. **(MS-PS4-3)** • **RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (**MS-PS4-3)** • **WHST.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(MS-PS4-3)** • **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. **(MS-PS4-1), (MS-PS4-2)**

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[2] Schoenfeld, A. (1985). *Mathematical problem solving. Mathematical problem solving.* New York: Academic Press.

[3] American Association for the Advancement of Science. (2001). Atlas of science literacy (Vol. 1). Washington, DC: Author.

[4] Grosslight, L., Unger, C., Jay, E., Smith, C. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts. *Journal of Research in Science Teaching, 28*, 799-822; Treagust, D., Chittleborough, G., Mamiala, T. (2002). Students' understanding of the role of scientific models in learning science*. International Journal of Science Education, 24*, 357-368; Schwarz, C., White, B. (2005). Metamodeling knowledge: Developing students' understanding of scientific modeling. *Cognition and Instruction, 23*, 165-205.

[5] Coll, R., France, B., Taylor, I. (2005). The role of models and analogies in science education: Implications from research. *International Journal of Science Education, 27*, 183-198; Harrison, A., Treagust, D. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching science. *Science Education, 80*, 509-534.

[6] Grosslight, L., Unger, C., Jay, E., Smith, C. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts*. Journal of Research in Science Teaching, 28*, 799-822.

[7] Grosslight, L., Unger, C., Jay, E., Smith, C. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts. *Journal of Research in Science Teaching, 28*, 799-822.

[8] Grosslight, L., Unger, C., Jay, E., Smith, C. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts*. Journal of Research in Science Teaching, 28*, 799-822.

[9] Harrison, A., Treagust, D. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching science. *Science Education, 80*, 509-534; Harrison, A., Treagust, D. (2000). A typology of school science models. *International Journal of Science Education, 22*, 1011-1026.

[10] Grosslight, L., Unger, C., Jay, E., Smith, C. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts*. Journal of Research in Science Teaching, 28*, 799-822.