Elaboration and Unpacking of the Practices

Grade 5, Measurement Target 1	Students are able to investigate and interpret data to draw or support conclusions about the structure and properties of matter, including whether or not matter is conserved, and to identify materials and mixtures based upon their properties or results of a reaction.		
	Developing and Using Models	**Using Mathematics and Computational Thinking**	**Planning and Carrying Out Investigations**
Practices[1]	• Students can use models to describe phenomena. **(5-PS1-1)**	• Students can measure and graph quantities such as weight to address scientific and engineering questions and problems. **(5-PS1-2)**	• Students can make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. **(5-PS1-3)** • Students can conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. **(5-PS1-4)**
Essential Knowledge and Skills	**5-PS1-1** • Students can use a model to describe phenomena. • Students can use a model to reason about a phenomenon. • Students can reason about the relationship of the different components of a model. • Students can select and identify relevant aspects of a situation or phenomena to include in the model. • Students can create a representation of a situation or phenomena. • Students can describe the connections between the model and the phenomena.	**5-PS1-2** • Students can use tools for observing, describing, measuring, recording, and graphing data. • Students can use observations, descriptions, measurements, recordings, and graphing to address questions. • Students can plot measurements and other data sets as a line plot on a graph to represent relationships between the data.	**5-PS3-3** • Students can make observations to collect data. • Students can make measurements to collect data. • Students can use data from an investigation as evidence for an explanation of a phenomenon or to support an explanation. **5-PS1-4** • Students can describe how an investigation relates to a question or hypothesis. • Students can plan investigations collaboratively[2] to produce data to serve as the basis for evidence. • Students can conduct investigations collaboratively to produce data to serve as the basis for evidence.

[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.

[2] Note: Students are asked to work collaboratively to plan and conduct investigations; for this age, we should not ask students to work independently in these areas.

Essential Knowledge and Skills Cont'd			• Students can plan investigations collaboratively using fair tests in which variables are controlled and the number of trials considered. • Students can conduct investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.
Evidence of a High Level of Performance	• Students can build and revise simple models and use models to represent events and design solutions.	• Students can collect quantitative measurements of a variety of physical properties and use computation and mathematics to analyze data and compare alternative design solutions.	• Students can plan and carry out investigations that include control variables and provide evidence to support explanations or design solutions.
Prerequisite Knowledge and Skills	• Knowledge of units and unit conversions among different-sized standard measurement units within a given measurement system • Knowledge of bar graphs and histograms • Knowledge of line graphs (Note: CCSSM[3] "Students solve problems involving information presented in line plots" beginning in grade 5) • Knowledge of how and when to use estimations • Knowledge of proportional reasoning skills (Note: Should not be included, as students learn proportions in grade 6, CCSSM[4]) • Ability to write		
Student Challenges	• Upper elementary and middle school students may not understand experimentation as a method of testing ideas, but rather as a method of trying things out or producing a desired outcome. [1] With adequate instruction, it is possible to have middle school students understand that experimentation is guided by particular ideas and questions and that experiments are tests of ideas. [2] Whether it is possible for younger students to achieve this understanding needs further investigation. [3] • When engaged in experimentation, students have difficulty interpreting covariation and noncovariation evidence. [4] For example, students tend to make a causal inference based on a single concurrence of antecedent and outcome or have difficulty understanding the distinction between a variable having no effect and a variable having an opposite effect. [5] • Upper elementary school students can reject a proposed experimental test where a factor whose effect is intuitively obvious is uncontrolled, at the level of "that's not fair". [6] "Fairness" develops as an intuitive principle as early as 7 to 8 years of age and provides a sound basis for understanding experimental design. This intuition does not, however, develop spontaneously into a clear, generally applicable procedure for planning experiments. [7] Although young children have a sense of what it means to run a fair test, they frequently cannot identify all of the important variables, and they are more likely to control those variables that they believe will affect the		

[3] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. Washington, D.C.: Author.
[4] Ibid.

	result. Accordingly, student familiarity with the topic of the given experiment influences the likelihood that they will control variables. [8] After specially designed instruction, students in 8th grade are able to call attention to inadequate data resulting from lack of controls. [9]
Common Core State Standards for Mathematics Connections	**MP.2** Reason abstractly and quantitatively. **(5-PS1-1), (5-PS1-2), (5-PS1-3)** **MP.4** Model with mathematics. **(5-PS1-1), (5-PS1-2), (5-PS1-3)** **MP.5** Use appropriate tools strategically. **(5-PS1-2), (5-PS1-3)** **5.NBT.A.1** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. **(5-PS1-1)** **5.NF.B.7** Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. **(5-PS1-1)** **5.MD.A.1** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems. **(5-PS1-2)** **5.MD.C.3** Recognize volume as an attribute of solid figures and understand concepts of volume measurement. **(5-PS1-1)** **5.MD.C.4** Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft., and improvised units. **(5-PS1-1)**
Common Core State Standards for ELA/Literacy Connections	**RI.5.7** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. **(5-PS1-1)** **W.5.7** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. **(5-PS1-2), (5-PS1-3)** **W.5.8** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. **(5-PS1-2), (5-PS1-3)** **W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(5-PS1-2), (5-PS1-3)**

[1] Carey, S., Evans, R., Honda, M., Jay, E., Unger, C. (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. *International Journal of Science Education, 11,* 514-549; Schauble, L., Klopfer, L.E., Raghavan, K. (1991). Students' transition from an engineering model to a science model of experimentation. *Journal of Research in Science Teaching, 28*, 859-882; Solomon, J. (1992). Images of physics: How students are influenced by social aspects of science. In Duit, R. (Ed.), *Research in physics learning: Theoretical issues and empirical studies* (pp. 141-154). Kiel, Germany: Institute for Science Education at the University of Kiel.

[2] Carey, S., Evans, R., Honda, M., Jay, E., Unger, C. (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. *International Journal of Science Education, 11,* 514-549; Solomon, J. (1992). Images of physics: How students are influenced by social aspects of science. In Duit, R. (Ed.), *Research in physics learning: Theoretical issues and empirical studies* (pp. 141-154). Kiel, Germany: Institute for Science Education at the University of Kiel.

[3] American Association for the Advancement of Science, Project 2061 (2001). Atlas for Science Literacy, 18.

[4] Kuhn, D., Amsel, E., O'Loughlin, M. (1988). The development of scientific thinking skills. Academic Press.

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

[6] Shayer, M., Adey, P. (1981). *Towards a science of science teaching.* London: Heinemann.

[7] Wollman, W. (1977). Controlling variables: Assessing levels of understanding. *Science Education, 61*, 371-383; Wollman, W. (1977). Controlling variables: A neo-Piagetian developmental sequence. *Science Education, 61*, 385-391; Wollman, W., Lawson, A. (1977). Teaching the procedure of controlled experimentation: *A Piagetian approach. Science Education, 61*, 57-70.

[8] Linn, M., Swiney, J. (1981). Individual differences in formal thought: Role of cognitions and aptitudes. *Journal of Educational Psychology, 73*, 274-286; Linn, M., Clement, C., Pulos, S. (1983). Is it formal if it's not physics? The influence of content on formal reasoning. *Journal of Research in Science Teaching, 20*, 755-776.

[9] Rowell, J., Dawson, C. (1984). Controlling variables: Testing a programme for teaching a general solution strategy. *Research in Science and Technological Education, 2,* 37-46; Ross, J.A. (1988). Controlling variables: A meta-analysis of training studies. *Review of Educational Research, 58*, 405-457.