Elaboration and Unpacking of the CCCs

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.	
	Scale, Proportion, and Quantity	**Cause and Effect**
CCCs[1]	• Natural objects exist from the very small to the immensely large. **(5-PS1-1)** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. **(5-PS1-2)**, **(5-PS1-3)**	• Cause and effect relationships are routinely identified, tested, and used to explain change. **(5-PS1-4)**
Essential Knowledge and Skills	**5-PS1-1** • Natural objects vary in size (very small to the immensely large). **5-PS1-2** • Matter can change, but, the total mass of the substances is the same. • Matter is conserved. **5-PS1-2 and 5-PS1-3** • Physical quantities (mass, time, temperature, and volume) can be measured. • Physical quantities are measured using standard units. • Measurements of physical properties can be used to describe physical quantities.	**5-PS1-2** • Matter flows and cycles (e.g., water going back and forth between Earth's atmosphere and its surface). • Matter can be transported into, out of, and within systems. **5-PS1-4** • Cause and effect relationships may be identified. • Cause and effect relationships may be tested. • Cause and effect relationships may be used to explain change.
Evidence of a High Level of Performance	• Students can develop a model to describe that natural objects and observable phenomena exist from the very small to the immensely large. • Students measure and graph quantities such as weight, time, temperature, and volume to provide evidence that regardless of the type of change that occurs to a substance or a mix of substances, the total weight of matter is conserved. • Students make observations and measurements to identify materials based on their properties.	• Students identify and test causal relationships and use these relationships to explain change. • Students conduct an investigation to determine whether the mixing of two or more substances results in new substances.

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

Relationships to Practices[2]	• Scale, proportion, and quantity are essential considerations when deciding how to model a phenomenon. • Relationships between variables (e.g., flow of energy and matter) can be explained by writing mathematical models or equations.	• Observations and data describe cause and effect relationships. • When students perform the practice of “Planning and Carrying Out Investigations,” they often address cause and effect.
Prerequisite Knowledge and Skills	• Ability to use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects • Ability to recognize that objects may break into smaller pieces, be put together into larger pieces, or change shapes	• Ability to explain that events have causes that generate observable patterns
Student Challenges	• Elementary and middle school students may think everything that exists is matter, including heat, light, and electricity. [1] Alternatively, they may believe that matter does not include liquids and gases or that they are weightless materials. [2] With specially designed instruction, some middle school students can learn the scientific notion of matter. [3] • Middle school and high school students are deeply committed to a theory of continuous matter. [4] Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed as basically continuous substances under certain conditions. [5] • Students at the end of elementary school and beginning of middle school may be at different points in their conceptualization of a "theory" of matter. [6] Although some 3rd graders may start seeing weight as a fundamental property of all matter, many students in 6th and 7th grade still appear to think of weight simply as "felt weight"—something whose weight they can't feel is considered to have no weight at all. Accordingly, some students believe that if one keeps dividing a piece of Styrofoam, one would soon obtain a piece that weighed nothing. [7] • Students of all ages show a wide range of beliefs about the nature and behavior of particles. They lack an appreciation of the very small size of particles; attribute macroscopic properties to particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles. [8] Despite these difficulties, there is some evidence that carefully designed instruction carried out over a long period of time may help middle school students develop correct ideas about particles. [9]	

[1] Stavy, R. (1991). Children's ideas about matter. *School Science and Mathematics*, *91*, 240-244; Lee, O., Eichinger, D.C., Anderson, C.W., Berkheimer, G.D., Blakeslee, T.S. (1993). *Changing middle school students' conceptions of matter and molecules. Journal of Research in Science Teaching, 30*, 249-270.

[2] Stavy, R. (1991). Children's ideas about matter. *School Science and Mathematics, 91*, 240-244; Mas, C.J., Perez, J.H., Harris, H. (1987). Parallels between adolescents' conceptions of gases and the history of chemistry. *Journal of Chemical Education, 64*, 616-618.

[3] Lee, O., Eichinger, D.C., Anderson, C.W., Berkheimer, G.D., Blakeslee, T.S. (1993). Changing middle school students' conceptions of matter and molecules. *Journal of Research in Science Teaching, 30*, 249-270.

[4] Nussbaum, J. (1985). The particulate nature of matter in the gaseous phase. In R. Driver, E. Guesne & A. Tiberghien (Eds.), Children’s ideas in science (pp. 124–144). Milton Keynes, UK: Open University Press.

[2] These are meant to be examples; not an exhaustive list of connections to the practices. Additional Practices Building to the PEs can be found on the website for the Next Generation Science Standards.

[5] Pfundt, H. (1981). The atom-he the final link in the division process or the first building block?. *Chemica Didactica, 7*, 75-94.

[6] Carey, S.; Gelman, R. (1991). Knowledge acquisition: Enrichment or conceptual change?. In Carey, S. (Ed.), *The Epigenesis of Mind: Essays on Biology and Cognition* (pp. 257-291). Hillsdale, NJ: Lawrence Erlbaum Associates; Smith, C., Snir, J., Grosslight, L**.** (1987). *Teaching for conceptual change using a computer modeling approach: The case of weight/density differentiation*. (Technical Report). Cambridge, MA: Harvard University, Educational Technology Center. ERIC No. ED 291 598.

[7] Carey, S.; Gelman, R. (1991). Knowledge acquisition: Enrichment or conceptual change?. In Carey, S. (Ed.), *The Epigenesis of Mind: Essays on Biology and Cognition* (pp. 257-291). Hillsdale, NJ: Lawrence Erlbaum Associates

[8] Children's Learning in Science. (1987). *Approaches to Teaching the Particulate Theory of Matter*. Children's Learning in Science Project, Leeds: Centre for Studies in Science and Mathematics, University of Leeds.

[9] Lee, O., Eichinger, D.C., Anderson, C.W., Berkheimer, G.D., Blakeslee, T.S. (1993). Changing middle school students' conceptions of matter and molecules. *Journal of Research in Science Teaching, 30*, 249-270.