Science

The goal of science is the construction of theories that can provide explanatory accounts of features of the world. A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence and parsimony. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with the intermediary of a theory-based model for the system under study. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.

Engineering

Engineering design, a systematic process for solving engineering problems, is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depends on the criteria used for making evaluations. (Framework, p. 52)

See A Framework for K-12 Science Education, 2012, p. 67 for the entire text for Practice 6: Constructing explanations and designing solutions.
In the video below from BozemanScience.com, Paul Andersen explains how scientists modify theories by constructing explanations. He also discusses the cycle of design used by engineers to solve problems. He starts by defining a theory as a well-established explanation of a phenomenon that is refined over time.
https://youtu.be/rVSHsSCzt-A?list=PLi8HVli-fejYMV_aB3-hYUwR14W7Ouran
For more, refer to the Webinar on Constructing Explanations and Designing Solutions from the National Science Teachers Asssociation (NSTA) Learning Center.

Constructing Explanations & Designing Solutions Progression through Gradebands:

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. • Generate and/or compare multiple solutions to a problem.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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 the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. • Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Progression from NGSS Appendix F pgs. 11-12.

Activities

Four Conceptual Change Activities are included to help teachers and students Confront Beliefs:

Constructing Explanations Activity #1: Rope Tube

Constructing Explanations Activity #2: Balloons & Skewers

Designing Solutions Activity #1: Rope Tube

Designing Solutions Activity #2: Pringles Potato Chip Challenge

Also refer to Student Work in the Practice for real-life examples of how MPRES teachers have applied this Practice.
The purpose of the activities is to engage teachers in the Practice of Constructing Explanations and Designing Solutions. The emphasis is NOT on the activity itself, but rather the conceptual change related to the Practice. Consumers of this Toolkit are reminded to not get wrapped up in the activity, but rather continually reflect on the conceptual nature of the Practice to gain deeper understanding.
Since the activities are NOT lesson plans, in some cases only a brief explanation of the activity has been provided. Professional development facilitators should encourage learners to direct their own investigations and intervene only as needed to redirect.
To facilitate conceptual change throughout each activity, you should consider the following questions. These questions are also repeated at key points in each activity to assist you.

Awareness Questions:

1. From the background information, what new awareness do you have about constructing explanations & designing solutions?
2. How does this practice support constructing explanations & designing solutions?
3. In a 3 Dimensional classroom, who do you think needs to be constructing explanations & designing solutions?
4. What questions did the background information raise for you?

Expose Belief Questions:

1. What are your current beliefs about the constructing explanations and designing solutions practice?
2. What beliefs do you have from prior knowledge, education or professional development regarding this practice?
3. How well do you feel you meet the expectations of this practice as a teacher?

Debrief activities by focusing on the conceptual understanding of the practice using the prompts (Resolving Belief Questions, Extend the Concept Questions, and Go Beyond Questions) included on the left side of each activity page.