Asking Questions & Defining Problems

Science

Science begins with a question about a phenomenon, such as "Why is the sky blue?" or "What causes cancer?" and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered.

Engineering

Engineering begins with a problem, need, or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the nation's dependence on fossil fuels may engender a variety of engineering problems, such as designing more efficient transportation systems, or alternative power generation devices such as improved solar cells. Engineers ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints. (Framework, p. 50)

See A Framework for K-12 Science Education, 2012, p. 54 for the entire text for Practice 1: Asking questions (for science) and defining problems (for engineering).

In the video below from BozemanScience.com, Paul Andersen explains how asking questions is the first step in both science and engineering. Questions allow scientists to direct inquiry with a goal of understanding the phenomena in the Universe. Questions allow engineers to define problems that require solutions.

Asking Questions & Defining Problems Progression through Gradebands:

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested. • Ask questions based on observations to find more information about the natural and/or designed world(s). • Ask and/or identify questions that can be answered by an investigation. • Define a simple problem that can be solved through the development of a new or improved object or tool.	Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships. • Ask questions about what would happen if a variable is changed. • Identify scientific (testable) and non-scientific (non-testable) questions. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • Use prior knowledge to describe problems that can be solved. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions ○ that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. ○ to identify and/or clarify evidence and/or the premise(s) of an argument. ○ to determine relationships between independent and dependent variables and relationships in models. ○ to clarify and/or refine a model, an explanation, or an engineering problem. ○ that require sufficient and appropriate empirical evidence to answer. ○ that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. ○ that challenge the premise(s) of an argument or the interpretation of a data set. • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions ○ that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. ○ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ○ to determine relationships, including quantitative relationships, between independent and dependent variables. ○ to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Progression from [NGSS Appendix F pgs. 4-5](#).

Activities

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

- Asking Questions Activity #1: Balloons and Skewer
- Asking Questions Activity #2: Lake Cabin Mystery
- Asking Questions Activity #3: Rope Tube
- Defining Problems Activity #1: Heat Transfer
- Defining Problems 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 Asking Questions and Defining Problems. 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 only intervene as needed to redirect.

The second component of this Practice is defining problems in engineering. People are faced with challenges everyday that can be solved through engineering. These challenges usually present themselves as a PROBLEM, a NEED or a DESIRE. The identification and verbalization of a problem leads to its successful solution. A component of that solution is the identification of constraints on the challenge. These may include time, money, other resources, equipment, manpower and more. In the Defining Problems activities, a PROBLEM, a NEED and a DESIRE are presented and students are to define the problem and identify the constraints. This Practice is not about finding and designing a solution; that’s a different Practice. The engineering design process is introduced in these activities, but ONLY the ASK step is the focus for this practice. The steps of the engineering design process include ASK, IMAGINE, PLAN, CREATE, IMPROVE (2006, Museum of Science, Boston).

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 asking questions?
2. In a 3-Dimensional classroom, who do you think needs to be asking questions
3. What questions did the background raise for you?

Expose Belief Questions:

1. What are your current beliefs about this practice?
2. In what ways do you think you are using this practice?
3. What challenges do you see to using this practice?

Debrief the **Asking Questions activities** by focusing on the conceptual understanding of the practice using the following prompts.

Resolve Belief Questions:

1. In what ways did this activity change your beliefs about asking questions in science?
2. How can discrepant events be used to generate questions in science?
3. What discrepant events do you currently use and HOW do you use them?
4. What other strategies can be used to help students generate questions?

Extend the Concept Questions:

1. How do you currently help students ask question in your

classroom?
2. By using science notebooks and having students write questions in their notebooks, the creation of a personal habit of asking questions can be developed. What are your thoughts about this approach?
3. Review a recent lesson you taught and evaluate the effectiveness of engaging students in asking questions.

Go Beyond Questions:

1. Ask a colleague to observe one of your lessons OR video yourself teaching and reflect on your application of this practice.
2. Use the EQuiP Rubric for Lessons & Units: Science (PDF format) to evaluate a recent science lesson you taught.

Debrief the **Defining Problems activities** by focusing on the conceptual understanding of the practice using the following prompts.

Resolve Belief Questions:

1. In what ways did this activity change your beliefs about defining problems in engineering?
2. How difficult was it to define the problem?
3. What clarity was brought to the problem once the problem was defined?
4. How difficult was it to identify the constraints?
5. What clarity was brought to the problem once constraints were identified?

Extend the Concept Questions:

1. How do you currently help students to define problems in engineering in your classroom?
2. Review a recent lesson you taught and evaluate the effectiveness of defining problems in engineering.

Go Beyond Questions:

1. Share lessons in which you could implement the practice of defining problems.
2. Ask a colleague to observe one of your lessons OR video yourself teaching and reflect specifically on defining problems and identifying constraints.
3. Use the EQuiP Rubric for Lessons & Units: Science (PDF format) to evaluate a recent science lesson you taught.

Additional Activity Resources

- Ice Balloons from Scholastic.com (Elementary level K-3)
- How Much Gas…Pop Rocks Expander from SteveSpanglerScience.com (Intermediate level 4-5)