## Asking Questions in Science
& Defining Problems in Engineering

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<tr>
<th>AWARENESS Framework Rationale</th>
<th>Science</th>
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<td>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.</td>
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<th>Engineering</th>
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<td>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.</td>
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See [A Framework for K-12 Science Education](https://wwwERA/), 2012, p. 54 for the entire text.

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<tr>
<th>AWARENESS QUESTIONS</th>
<th>1. From the background information, what new awareness do you have about asking questions?</th>
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<td>2. In a 3-Dimensional classroom, who do you think needs to be asking questions?</td>
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<td>3. What questions did the background raise for you?</td>
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<tr>
<th>EXPOSE BELIEFS</th>
<th>Asking Questions and Defining Problems Podcast</th>
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<td><a href="https://wwwera/">NGSS @ NSTA</a>.</td>
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| EXPOSE | 1. What are your current beliefs about this practice? |
| BELIEF QUESTIONS | 2. In what ways do you think you are using this practice?  
| CONFRONT BELIEFS | 3. What challenges do you see to using this practice? |

| Conceptual Change Activities: |
| 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 |

**Developing Conceptual Understanding of the Asking Questions Practice Activities Background**

The purpose of the following 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. Three activities have been provided to engage in each Practice.

Since the following activities are NOT lesson plans, in some cases only a brief explanation of the activity has been provided. The facilitator should encourage the learners to direct their own investigations and only intervene as needed to redirect.

**Asking Questions #1: Balloons and Skewers**

General Objective: To provide an opportunity for learners to ask questions in science by observing a phenomenon and experiencing that phenomenon.

The facilitator does the following:

1. Show a balloon and a skewer.  
2. Blow up balloon.  
3. Ask what happens when a sharp object and a balloon come into contact.  
4. When people say that the balloon pops, then pop the balloon.  
5. Blow up a 2nd balloon. Say something like, “Wouldn’t it be interesting if I could push the skewer through the balloon without popping it?” Do it as you say it.
6. Let learners observe the skewer in the balloon. Solicit questions from learners and encourage them to record those questions in their notebooks.
7. You can help learners differentiate between researchable questions and testable questions. Researchable questions are those that can be looked up in a resource such as a dictionary or a web search. Testable questions are those that can be tested to determine the answer.
8. Have learners write questions in their notebooks.
9. Lead a discussion of the questions that have been written. Encourage learners to ask deeper questions.
10. Pass out balloons and skewers to everyone.
11. Assist learners as needed.
12. Once everyone has been successful, have students revisit their questions and answer them. Share with the full class.

The balloons and skewers activity is an example of a discrepant event. Discrepant events usually involve a phenomenon that is counterintuitive and creates cognitive dissonance for the learner. They are excellent ways to help learners ASK their own questions based on the phenomenon observed. The role of the presenter is to generate opportunities for the learners to ask questions. If learners are utilizing science notebooks, science journals or other personal record-keeping tools, student-generated questions should be put in the notebooks. Not only should learners be encouraged to ask questions, but they should be expected to find answers to their own questions as well.

Link to the Balloons & Skewer Lesson

Other Discrepant Events

Discrepant Event Podcast

Science Notebooks podcast

Asking Questions #2: Lake Cabin Mystery

Give everyone a copy of the Lake Cabin page. Learners may ask the facilitator YES or NO questions only. Learners are encouraged to take notes as the questions are answered. Once a learner BELIEVES they have a solution to the problem, they are NOT to give the solution, but instead are encouraged to ask and answer their own question in a statement. An example might be, “I believe the tracks leading into the woods were made by the person after they left the garage.” Learners should be encouraged to create statements for questions that have NOT been asked previously to avoid repetition of questions/answers. Facilitator Answer Sheet.

Asking Questions #3: Rope Tube

General Objective: To provide an opportunity for learners to ask questions in science by observing a phenomenon and experiencing that phenomenon.

The facilitator does the following:
1. Using the rope tube, demonstrate that the ropes are all connected to each other. [Rope Tube podcast](#).
2. After students have observed the operation of the rope tube, solicit questions from students.
3. You can help students differentiate between researchable questions and testable questions. Researchable questions are those that can be looked up in a resource such as a dictionary or a on a web search. Testable questions are those can that be tested to determine the answer.
4. Have students write questions in their notebooks.
5. Lead a discussion of the questions that have been written. Encourage students to ask deeper questions.

The purpose of this activity is ONLY to generate questions. The rope tube is also used with the Science & Engineering Practices of Developing and Using Models, Constructing Explanations and Designing Solutions and Arguing from Evidence.

The Rope Tube is another example of a discrepant event. Refer to the discrepant event resources above.

Links to possible solutions to the Rope Tube. In addition to the solution shown here, the ropes can also be connected with a washer, paper clip or knots.

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<tr>
<th>RESOLVE BELIEFS</th>
<th>Debrief the activity(ies) by focusing on the conceptual understanding of the practice using the following prompts:</th>
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| 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?  
2. 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 to evaluate a recent science lesson you taught. |

**Developing Conceptual Understand of the Defining Problems Practice Activities Background**

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 following 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).

Since the following activities are NOT lesson plans, in some cases only a brief explanation of the activity has been provided. The facilitator should encourage learners to direct their own investigations and intervene only as needed to redirect.

**Defining Problems Activity #1: Heat Transfer**

1. Give students a copy of the [Heat Transfer](#) sheet. The full case study is available [here](#). After students have read the narrative, have them write a statement that DEFINES THE PROBLEM and then list the CONSTRAINTS of the challenge.
2. After students have finished, lead a discussion of what was written.

**Defining Problems Activity #2: Pringles Potato Chip Mailing Challenge**

1. Show the students a single Pringles potato chip. Tell them that they have been requested to ship a single chip through the mail. Engage the students in a question/answer discussion that lead them to DEFINE THE PROBLEM and then determine the CONSTRAINTS of the challenge. Do NOT tell them the constraints ahead of time, lead them to the constraints through the discussion. Use the [Pringles Chip Challenge](#) as a facilitator guide.
2. After students have finished, lead a discussion of what was written.

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| **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 to evaluate a recent science lesson you taught.

### Learning Progressions for Asking Questions

**Elementary:** Students should be encouraged to ask questions in ALL areas of science. This includes text information, observation of phenomena and conclusions they draw. The use of science notebooks to record question and answers should be encouraged.

**Middle School:** Students continue to ask questions, but focus should be on higher level. Questions should be higher order, including comprehension, application, analysis, synthesis and evaluation.

**High School:** Students should be proficient at asking relevant empirical questions for explanations, models, engineering problems and challenge the context of an argument or the feasibility of a design (Framework, p. 55).

### Learning Progressions for Defining Problems in Engineering

**Elementary:** Students should be introduced to defining simple engineering problems. They should be able to identify patterns, constraints and the specifics of simple solutions as well as determine the need or desire to be met through the engineering design.

**Middle School:** Students continue to define engineering problems. The identification of features, patterns and contradictions in defining engineering problems should be emphasized. They need to be able to clearly define constraints and specifications for an engineering design solution.

**High School:** Ask questions about the need or desire to be met in order to define constraints and specifications for a solution (Framework, p. 55).

See p. 4 Appendix F Science and Engineering Practices in the NGSS for a more thorough grade band progression.

### Additional Activity Resources

- [Ice Balloons](#) (Elementary level K-3)
- [How Much Gas... Pop Rocks Expander](#) (Intermediate level 4-5)
- [How to Make a Compass](#) (Middle level 6-8)
- Ditch Water Activity (High School level 9-12)