Science and Engineering Practice: Asking Questions and Defining Problems

Asking questions is essential to developing scientific habits of mind. Even for individuals who do not become scientists or engineers, the ability to ask well-defined questions is an important component of science literacy, helping to make them critical consumers of scientific knowledge. Engineers must be able to ask probing questions in order to define an engineering problem.

What is the difference between asking questions (science) and defining problems (engineering)?[1]

Asking Questions	Defining Problems
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 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.

What grasp of these practices should students gain in middle school?[2]

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.

How can I support students in refining the questions they have and sharpening their definition of engineering problems?

- Ask students about **specific aspects** of the phenomenon or design challenge.
- Ask students to **select** questions they can investigate.
- Introduce **new dimensions** of the problem or situation to consider after an initial brainstorm.
- Use **talk moves** to help students refine questions for different purposes
    - Is there a way we could phrase our question, so that we can investigate it in class?
    - How could you investigate that question?
    - In your question, what are the independent and dependent variables?
    - If that's your investigation, what question can that answer?
    - What new questions do you have, after today's investigation?
    - What questions could you ask to identify the assumptions of this model?

Sources:

[1]National Research Council. (2012). *A Framework for K-12 Science Education.* Washington, DC: National Academies Press. pp. 50, 54.
[2]Achieve, Inc. (2014). *Appendix F: Science and Engineering Practices within the NGSS.* Washington, DC: Author.

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