# Appendix A – Science and Engineering Practices (SEPs) and Subpractices

## Science and Engineering Practice (SEP) 1—Asking Questions

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means the capability to reason as described about given Disciplinary Core Ideas (DCIs) and Crosscutting Concepts (CCCs). No claim is made for “abilities” as decoupled from DCIs and CCCs.

1.1 Ability to ask and evaluate questions addressing phenomena of the natural world

1.1.1 Ability to ask questions that arise from careful observation of phenomena or unexpected results, to clarify and/or seek additional information

1.1.2 Ability to clarify, seek additional information, or both when needed

1.1.3 Ability to evaluate the given questions in terms of whether or not the answers to those questions would provide examples of a scientific theory (Note: Questions should be evaluated based on the level of thought required for answering them.)

1.2 Ability to ask and evaluate scientific questions arising from examining models, explanations, arguments to specify relationships between variables

1.2.1 Ability to ask questions that clarify and refine a model, or provide an explanation

1.2.2 Ability to ask questions that determine relationships, including quantitative relationships, between independent and dependent variables

1.2.3 Ability to ask and/or evaluate questions that challenge the premise(s) of an argument, or provide interpretation of a data set

1.3 Ability to ask and evaluate investigable questions

1.3.1 Ability to 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

1.3.2 Ability to evaluate a question to determine if it is empirically testable and relevant

## SEP 1E—Defining Problems

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

1E.1 Ability to ask questions about a design problem or the designed world

1E.1.1 Ability to ask questions to find more information about the designed world

1E.1.2 Ability to ask questions to identify, clarify, or refine an engineering problem

1E.1.3 Ability to ask or evaluate, or both, questions that challenge the suitability of a design

1E.2 Ability to define a design problem

1E.2.1 Ability to define a design problem that would lead to the development or improvement of an object or tool based on an understanding of science concepts and usability considerations

1E.2.2 Ability to define a design problem to develop an object, process, or system that takes into consideration criteria and constraints that include science concepts among other considerations

1E.2.3 Ability to define a design problem for a process or system with interacting components that takes into consideration criteria, constraints, and stakeholder perspectives that include scientific conceptual understanding

## SEP 2—Developing and Using Models

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

2.1 Ability to develop models

2.1.1 Ability to determine the components as well as relationships among multiple components, to include or omit, of a scientific event, system, or design solution

2.1.2 Ability to determine scope, scale, and grain-size of the model, as appropriate to its intended use

2.1.3 Ability to represent mechanisms, relationships, and connections to illustrate, explain or predict a scientific event

2.2 Ability to use models

2.2.1 Ability to use the model to collect evidence to reason qualitatively or quantitatively about concepts and relationships represented in the model

2.2.2 Ability to use the model to generate explanations and predictions about the behavior of a scientific phenomenon

2.2.3 Ability to use models to test and compare the effectiveness of different design solutions

2.3 Ability to evaluate and revise models

2.3.1 Ability to evaluate the model taking into account additional evidence or aspects of a phenomenon

2.3.2 Ability to revise models in light of empirical evidence to improve their explanatory and predictive power

## SEP 3—Planning and Carrying Out Investigations

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

3.1 Ability to clarify the goal of the investigation and identify the evidence needed to address the purpose of the investigation

3.1.1 Ability to describe the purpose of the investigation or formulate a question that can be investigated

3.1.2 Ability to identify relevant independent and dependent variables and to consider possible confounding variables or effects

3.1.3 Ability to describe what and how much data need to be collected to provide sufficient evidence to the purpose of the investigation

3.1.4 Ability to describe how the observations and/or collected data can be used as evidence for the phenomenon under investigation

3.2 Ability to develop, evaluate, and refine a plan for the investigation

3.2.1 Ability to decide how to measure and observe relevant variables, including considering the level of accuracy and precision required, and the kinds of instrumentation and techniques best suited to making such measurements to reduce both random and systematic error

3.2.2 Ability to describe detailed experimental procedure, including how the data will be collected, the number of trials, the experimental set up, and the equipment and tools required

3.2.3 Ability to compare and evaluate alternative methods to determine which design provides the evidence necessary to address the purpose of the investigation

3.3 Ability to collect the data for the investigation

3.3.1 Ability to use appropriate tools for accurate and precise measurements

3.3.2 Ability to make observations according to the investigation plan

3.3.3 Ability to evaluate the quality of data to determine if the evidence meets the goals of the investigation

## SEP 4—Analyzing and Interpreting Data

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

4.1 Ability to record and organize data

4.1.1 Ability to record information and represent data in tables and graphical displays

4.1.2 Ability to use appropriate digital tools for representing data

4.1.3 Ability to organize data in a way that facilitates analysis and interpretation

4.2 Ability to analyze data to identify relationships

4.2.1 Ability to use observational and/or empirical data to describe patterns and relationships

4.2.2 Ability to identify patterns (qualitative or quantitative) among variables represented in data

4.2.3 Ability to apply concepts of statistics and probability to data

4.2.4 Ability to consider limitations of data analysis

## SEP 5—Using Mathematics and Computational Thinking

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

5.1 Ability to develop mathematical and/or computational models

5.1.1 Ability to generate mathematical measurements and representations to describe characteristics and patterns of a scientific phenomenon and/or a design solution

5.1.2 Ability to use mathematical units, diagrams, and graphs to record and organize first-hand or given data from scientific investigations

5.1.3 Ability to create, evaluate, and/or revise a computational model or simulation of a scientific phenomenon, a design solution, or both

5.1.4 Ability to recognize that scientific computational models such as simulations are built on mathematical models that incorporate the underlying science principles being studied

5.2 Ability to conduct mathematical and/or computational analyses

5.2.1 Ability to use the results of computational models (e.g., graphical representation in a simulation) to identify the mathematical and/or computational representations to support a scientific explanation or a design solution

5.2.2 Ability to use computational models (e.g., simulations) to make predictions of a scientific phenomenon

5.2.3 Ability to use the results of computational models (e.g., simulations) to identify patterns in natural and/or design worlds

5.2.4 Ability to use critical mathematical skills to compare simulated effects in computational models to real world observations to identify limitations of computational models

5.2.5 Ability to use mathematical and statistical tools to analyze trends and patterns in data from scientific investigations

## SEP 6—Constructing Explanations

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

6.1 Ability to construct explanations of phenomena

6.1.1 Ability to construct quantitative and/or qualitative explanations of observed relationships

6.1.2 Ability to apply scientific concepts, principles, theories, and big ideas to construct an explanation of a real-world phenomenon

6.1.3 Ability to use models and representations in scientific explanations

6.2 Ability to evaluate explanations of phenomena

6.2.1 Ability to evaluate and revise a given explanation based on accepted scientific theory and/or data provided

6.2.2 Ability to use data to support or refute an explanatory account of a phenomenon

## SEP 6E—Designing Solutions

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

6E.1 Ability to solve design problems

6E.1.1 Ability to engage in a systematic, iterative process to solve design problems that result in structures or processes, or the plans for structure or processes

6E.1.2 Ability to generate multiple solutions for a design problem that meet design criteria and constraints

6E.1.3 Ability to construct a device or generate and/or implement a design (or redesign) solution

6E.1.4 Ability to apply relevant scientific knowledge and/or evidence in designing solutions

6E.2 Ability to evaluate and/or refine solutions to design problems

6E.2.1 Ability to compare or critique competing design solutions based on design criteria

6E.2.2 Ability to evaluate and/or refine (optimize) design solutions based on scientific knowledge or evidence

6E.2.3 Ability to optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing

## SEP 7—Engaging in Argument from Evidence

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

7.1 Ability to construct scientific arguments

7.1.1 Ability to develop scientific arguments that are supported by evidence/data

7.1.2 Ability to identify evidence/data that supports a claim

7.1.3 Ability to use reasoning to explain how relevant evidence/data supports or refutes the claim; the reasoning should reflect application of scientific concepts, principles, ideas

7.2 Ability to compare, evaluate, and critique competing arguments

7.2.1 Ability to evaluate arguments about a natural phenomenon based on scientific concepts, principles, and big ideas

7.2.2 Ability to respond to critiques from others by probing reasoning and evidence, and revising the argument

7.2.3 Ability to evaluate competing perspectives/claims using reasoning and evidence

## SEP 8—Obtaining, Evaluating, and Communicating Information

### Subpractices and Subpractice Assessment Targets

Note: “Ability” here means capability to reason as described about given DCIs and CCCs. No claim is made for “abilities” as decoupled from DCIs and CCCs.

8.1 Ability to comprehend and evaluate text in terms of its validity, reliability, and sources

8.1.1 Ability to recognize, interpret, and critique key ideas in scientific and engineering text, including a mix of words, symbols, tables, diagrams, and graphs

8.1.2 Ability to obtain relevant information through conducting searches in print and online sources and evaluate the reliability of the obtained information

8.1.3 Ability to summarize information from a single source and combine and synthesize information from multiple sources in order to address a question or solve a problem

8.2 Ability to engage in communication of science and engineering (especially regarding the investigations that they are conducting and the observations they are making)

8.2.1 Ability to produce written and illustrated text that communicates one’s own ideas

8.2.2 Ability to use appropriate combinations of language, models, and mathematical expressions to communicate one’s understanding or to ask questions about a concept, event, system, or design

Posted by the California Department of Education, June 2019