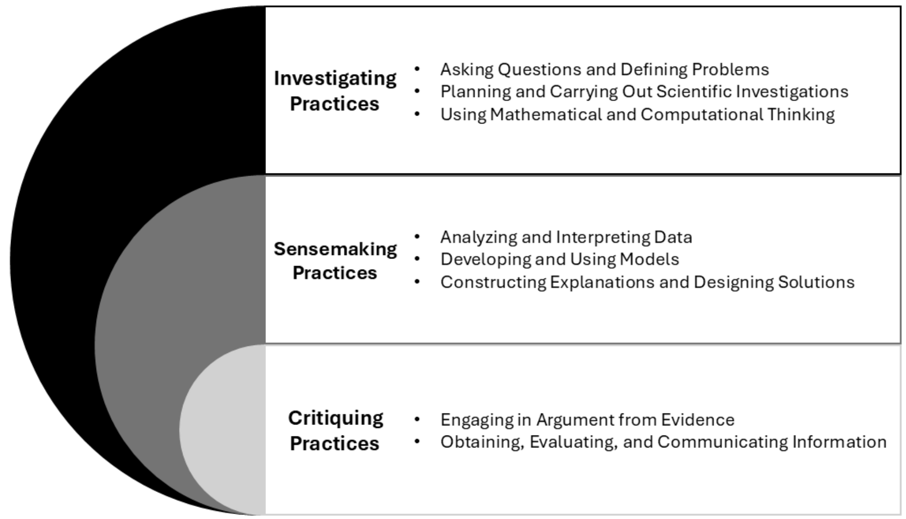
Using Science and Engineering Practices in Elementary Science Classrooms

Organizing Science and Engineering Practices to Support Student Reasoning

One approach to organizing Science and Engineering Practices (SEPs) is to demonstrate how they support students' conceptual understanding. In a three-dimensional science classroom, students investigate phenomena or problems to make sense of the natural and designed worlds while also critiquing their own and others' understandings. Thus, SEPs can be organized into three groups:

- **Investigating Practices:** Asking Questions and Defining Problems, Planning and Carrying Out Scientific Investigations, Using Mathematical and Computational Thinking
- **Sensemaking Practices:** Analyzing and Interpreting Data, Developing and Using Models, Constructing Explanations and Designing Solutions
- **Critiquing Practices:** Engaging in Argument from Evidence and Obtaining, Evaluating, and Communicating Information



There is no single "correct" way to group or order SEPs for instruction; SEPs are designed to overlap and interconnect. When developing learning and assessment experiences, one practice may lead to another or include aspects of another practice. It is important for students to recognize the connections among the SEPs. SEPs are more than just skills, they are the tools students use to develop their understanding of phenomena or problems. Learning and assessment experiences must include opportunities for students to engage in authentic sensemaking experiences. While the skills of the SEPs are necessary, they are not sufficient on their own for comprehensive science learning and assessment.

The following general strategies support classrooms where SEPs are thinking tools that guide students as they observe, question, and explain the world around them:

- Use phenomenon-based instruction so students can observe and "figure out" as they move through the learning process.
- Develop a classroom culture of inquiry and evidence.
- Create opportunities for students to actively engage in doing science, not just learning about it.
- Use SEPs daily to assist in "figuring out" phenomena.
- Use SEPs to guide class investigations and discourse.
- Connect SEPs across lessons to show their relationships to one another.
- Support student reflection on how they use SEPs to build understanding.

Building on these general strategies, teachers can deepen student engagement and understanding by tailoring their approach to each of the eight SEPs. The following sections provide specific, actionable example strategies for each SEP, offering practical ways to support student use of SEPs as tools for thinking, investigating, and making sense of phenomena and problems in science classrooms.

Investigating Practices

Science and Engineering Practice	Example strategies to engage students in practices	Crosscutting Concepts that often align to the practice

Asking Questions and Defining Problems
 	
Students ask questions to learn more about the natural and designed worlds. They wonder how things work, why things happen, and what they can do to solve problems. These questions guide their investigations and help them explore ideas in a meaningful way.
	• Present a phenomenon and related questions. Students sort the questions into examples and nonexamples of scientific questions.
	• Present a phenomenon/problem, then ask students to formulate descriptive and scientific questions.
	• Students observe a phenomenon/problem three times:
	  ○ first observation: just observe,
	  ○ second observation: record and/or discuss what they are observing,
	  ○ third observation: generate wonderings (questions).
	• Model the development of scientific questions emphasizing the need for data from investigations to answer the question.
		• Patterns
		• Structure and Function

Science and Engineering Practice	Example strategies to engage students in practices	Crosscutting Concepts that often align to the practice

Planning and Carrying Out Scientific Investigations
 	
Students make observations, collect data, and test ideas to find answers to their questions. Through hands-on experiences, students learn how to gather evidence and use it to explain what they observe.
	• Present a phenomenon/problem, a question, and an investigation plan. Students complete the investigation and collect data.
	• Students work collaboratively to develop investigative plans. Facilitate a whole group discussion to select one investigative plan to follow.
	• Present several procedures (for example: varying number of trials, different materials, different types of data tables, etc.) to students. Ask students to critique the procedures based on the phenomenon/problem the procedures are attempting to address.
	• Compare collected data across student groups (can be in the same class or across classes).
	• Present a phenomenon/problem, then ask students to:
	  ○ develop questions,
	  ○ evaluate observation and/or measurement methods to answer those questions, and
	  ○ conduct an investigation.
		• Cause and Effect
		• Systems and System Models

Science and Engineering Practice	Example strategies to engage students in practices	Crosscutting Concepts that often align to the practice
Using Mathematical and Computational Thinking Students use numbers and tools to make sense of the natural and designed worlds. They count, measure, and look for patterns in data to help explain what they observe. By organizing information and using simple math, students build stronger explanations and solve problems more clearly.	• Present multiple objects, then ask students to: ○ construct grade-appropriate quantitative attributes (for example: measurements of heights, etc.) of the objects and ○ display their data using graphs. • Present a text description of a phenomenon/problem and measured quantities, then ask students to: ○ develop a grade-appropriate equation/algorithm that corresponds to the text description and ○ describe how the equation/algorithm represents the text. • Present a text description of a phenomenon/problem, measured quantities of data, and a grade-appropriate mathematical equation, then ask students to ○ make a prediction about the phenomenon/problem that the equation can support and ○ develop a claim for the prediction, using the equation as evidence. • Present students with a proposed object or tool. Students claim if qualitative or quantitative data are the best to determine if the object or tool meets success criteria. Facilitate a whole-group discussion around the claims.	• Patterns • Scale, Proportion, and Quantity

Sensemaking Practices

Science and Engineering Practice	Sample strategies to engage students in practices	Crosscutting Concepts that often align to the practice
Analyzing and Interpreting Data Students examine data to find meaning in what they observe. They organize information using charts, drawings, or graphs to observe patterns and make sense of their investigations. This supports them in explaining what happened and sharing their ideas with others.	• Provide groups of students with a data table and sentence strips with various statements about the patterns in the data. Groups decide if each statement is an accurate or inaccurate description of the data. • Model how to construct graphs. Describe what decisions must be made when creating a graph and the reasons for one choice or another. • Students support and justify their ideas by referring to data. • Present recorded observations of the natural world. Ask student to describe a pattern or relationship they can infer from the observations. • Describe an investigation, the phenomenon, and one or more recorded observations. Ask students to: ○ organize, represent, and analyze the data, ○ use grade-level appropriate mathematics to analyze patterns in the data, ○ draw conclusions supported by their analyses, and/or ○ compare how the representations and analyses help them identify patterns in the data.	• Patterns • Scale, Proportion, and Quantity • Systems and System Models

Science and Engineering Practice	Sample strategies to engage students in practices	Crosscutting Concepts that often align to the practice

Developing and Using Models
 	
Students create and use models to represent ideas about the natural and designed worlds. These models (for example: drawings, physical objects, simple diagrams, etc.) support them in understanding how things work, making predictions, and explaining their thinking to others.
	• Provide students with an example of a scientific model and a nonexample (for example a labeled diagram). Students compare the two, emphasizing that the scientific model shows how the phenomenon occurs while the nonexample does not.
	• Present students with two models of the same phenomenon. Ask students to compare the models to identify common and unique components, relationships, and mechanisms.
	• When discussing the "scientifically accepted model," critique it as a class together rather than presenting it as the "right answer." Facilitate student understanding toward the scientifically accepted model throughout the learning experience.
	• Invite the co-construction of models that make sense to the class, including opportunities to create rival models.
	• Facilitate discussions of the benefits and drawbacks of a variety of models, including student-generated models. Use a variety of representations of model components. Emphasize that all models have benefits and drawbacks.
	• Present a textual description of a phenomenon and ask students to develop a model explaining it by applying their understanding of a disciplinary core idea.
	• Present students with a model of a scientific process or system. Ask students to:
	  ○ label the components, interactions, and mechanisms and/or
	  ○ write a description of what is shown
		• Structure and Function
		• Scale, Proportion, and Quantity
		• Stability and Change
		• Energy and Matter
		• Systems and System Models

Science and Engineering Practice	Sample strategies to engage students in practices	Crosscutting Concepts that often align to the practice
Constructing Explanations and Designing Solutions Students use their understanding and observations to explain how or why something happens. They build ideas based on evidence and share their thinking with others. When solving problems, students design simple solutions and test their ideas to see what works.	• Describe a phenomenon and relevant evidence (for example: from a media source). Ask students to write an evidence-based account of the causes of the phenomenon. • Describe a phenomenon, a related set of evidence, and an explanation that includes scientific principles. Ask students to identify which pieces of evidence support components of the explanation. • Describe a phenomenon and related qualitative/quantitative data/observations. Ask students to develop an explanation about the mechanisms for the phenomenon using the data as evidence.	• Structure and Function • Stability and Change • Energy and Matter • Systems and System Models

Critiquing Practices

Science and Engineering Practice	Sample strategies to engage students in practices	Crosscutting Concepts that often align to the practice

Engaging in Argument from Evidence
 	
Students share their ideas and listen to others as they make sense of the natural and designed worlds. They use evidence from observations and investigations to support their thinking, compare explanations, and decide what makes the most sense based on what they have learned.
	• Present two different arguments related to a phenomenon, one with evidence and one without. Ask students to identify the argument that is more scientific. Ask them to defend their choice.
	• Describe a phenomenon. Ask student to:
	  ○ articulate a claim about the phenomenon,
	  ○ identify evidence that supports the claim, and
	  ○ articulate the scientific principle(s) that connect each piece of evidence to the claim.
	• Present a claim about a phenomenon. Ask students to identify the evidence that supports the claim.
		• Cause and Effect
		• Energy and Matter

<table>
<tr><th>Science and Engineering Practice</th><th>Sample strategies to engage students in practices</th><th>Crosscutting Concepts that often align to the practice</th></tr>
<tr><td>Obtaining, Evaluating, and Communicating Information

Students gather information from books, media, and observations to learn about the natural and designed worlds. They think about what makes information useful and reliable. By writing, drawing, and talking students share what they have learned and explain their ideas to others.</td><td>• In small groups, students read text that includes evidence and science ideas about a phenomenon. Ask students to annotate the text (for example: underline evidence and star science ideas).
• Provide 2 or more texts on the same topic. Ask students to compare the texts, focusing on how well the author defends their claim. Students decide which is the most persuasive text.
• Present a grade-appropriate text set related to a phenomenon. Ask students to:
○ synthesize information from across texts and/or
○ compare information from across texts to determine which are the most relevant to explaining the phenomenon and/or
○ ask questions about the phenomenon based on combined information from relevant texts and/or
○ construct and explanation of the phenomenon based on combined information from the relevant texts.
• Present a textual description of a phenomenon or of an investigation of a phenomenon. Ask students to use multiple scientific texts to communicate about the phenomenon to a given or student selected audience.</td><td>• Patterns
• Structure and Function</td></tr>
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Tips for Using Science and Engineering Practices

SEPs are essential tools that engage students in the practices of science and engineering, helping them actively build and apply knowledge. However, their power lies in not just naming them, but in how they are used to support student thinking. When SEPs are embedded meaningfully into instruction, they become cognitive tools that guide students through investigating, sensemaking, and critiquing ideas about the world around them. This requires intentional planning and consistent opportunities for students to engage with SEPs in varied and authentic contexts.

Teachers can support this process by modeling SEPs as thinking tools, encouraging their use in discourse, and providing time for reflection on how SEPs shape understanding. When students are given repeated authentic opportunities to use SEPs, they begin to see the practices not as isolated skills, but as powerful processes through which to explore and make sense of science.

To support this instructional shift, the following four approaches—**exploration, comprehension, evaluation, and foundation**—offer practical and flexible ways to incorporate SEPs into teaching, learning, and assessment. Each approach highlights a different function SEPs can serve in the classroom and provides a pathway for deepening student engagement and sensemaking.

- **Exploration:** Using SEPs to examine and investigate phenomena or problems, helping students develop a deeper understanding.
- **Comprehension:** Using SEPs to clarify scientific concepts and processes, enabling students to build on existing knowledge and create new explanations.
- **Evaluation:** Using a SEP to assess and refine scientific ideas and methods.
- **Foundation:** Using a SEP to establish common practices, language, purposes, or meaning. Students learn when and why to apply SEPs.

Exploration: How can SEPs help us see new things about this phenomenon or problem?	Comprehension: How can SEPs help us to make sense of a phenomenon or problem?	Evaluation: How can SEPs help us to evaluate and refine our understanding of a phenomenon or problem?	Foundation: Do we know when, why, and how to use the SEPs?
Supporting sensemaking: Focuses student thinking to support productive learning.	**Supporting sensemaking:** Serves as a frame for "putting the pieces together" to explain phenomena/problems.	**Supporting sensemaking:** Strengthens the knowledge structures students build around science concepts.	**Supporting sensemaking:** Deepens student understanding of why SEPs are useful tools used by scientists to understand, interpret, and communicate.
Within instruction, look for: • Students observe phenomena closely and pose their own questions or ideas about what they notice, leading to further investigation. • Students engage directly with materials, systems, or representations to explore how or why something happens, using evidence from their exploration to build understanding.	**Within instruction, look for:** • Students engage with diverse examples and contexts for SEPs. • Students use SEPs to support deeper understanding of Disciplinary Core Ideas.	**Within instruction, look for:** • Students use SEPs in the beginning of a unit when encountering an anchor phenomenon and use SEPs throughout the unit to evaluate their understanding of science concepts. • Students engage in SEPs to evaluate and critique their own and peers' scientific understanding.	**Within instruction, look for:** • Students co-construct the procedures for SEPs and how they are used to understand, interpret, and communicate. • Students have opportunities to discuss and/or reflect on which SEP(s) they used to make sense of something and why that particular SEP was useful.

Exploration: How can SEPs help us see new things about this phenomenon or problem?	Comprehension: How can SEPs help us to make sense of a phenomenon or problem?	Evaluation: How can SEPs help us to evaluate and refine our understanding of a phenomenon or problem?	Foundation: Do we know when, why, and how to use the SEPs?
Within a task, look for: • The task driving question explicitly uses a SEP. • Explicit use of SEPs in prompts.	**Within a task, look for:** • Prompts use SEPs to scaffold sensemaking – either by requiring use of multiple SEPs and/or using one SEP at multiple levels of complexity.	**Within a task, look for:** • Tasks ask students to revisit their initial explanations or models and revise them based on new data or peer feedback. • Tasks prompt students to evaluate the strengths and limitations of an investigation, model, or explanation and suggest improvements.	**Within a task, look for:** • Students have opportunities to explain and/or reflect on which SEP(s) they used to make sense of something and why that SEP was useful.

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