Proven Science Programs

SEPUP
Issue-Oriented Science

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

How to Use It

Students are first asked to look for a relationship among a list of four or five words or phrases related to a topic and to cross out the one word or phrase that does not belong. Next, they are asked to circle any word or phrase that includes all the other words. (There may be more than one correct answer to a single word sort.) Finally, they must explain how the circled word or phrase is related to all the other words or phrases in the list.

Where It Is

Word sorts can appear as Analysis items in the Student Book and in the Teaching Steps in the Teacher Edition.

STUDENT SENSEMAKING

Issues and Science uses a variety of strategies to support individual student and collaborative sensemaking in the classroom, depending on the instructional needs of the activity. By facilitating student discussions and helping students generate relevant questions, compare results, and display scientific relationships, SEPUP's sensemaking strategies help students build coherent explanations about the natural world. Sensemaking approaches and strategies appear throughout the Teaching Steps in the Teacher Edition.

STRATEGIES TO FACILITATE SENSEMAKING

An important goal of *Issues and Science* activities is to facilitate connections between students' ideas and concept development through the sensemaking process. The strategies described below, along with other sensemaking suggestions, are embedded in appropriate activities throughout each unit.

Teacher's Note: Three literacy strategies previously described—the Anticipation Guide, Discussion Web, and Walking Debate—can also be sensemaking strategies, depending on their function within the activity.

ANALYZING MODELS

What It Is

Analyzing Models is a strategy that supports student analysis of the models used in an activity. Students develop parallel ideas between the model they are interacting with during class and the larger natural system the model represents.

Why to Use It

Models aid in scientific understanding by helping scientists and engineers visualize things they may not be able to see or directly test. This analysis helps students make constructive use of models during scientific investigations. It can also help students identify the strengths and limitations of a model.

How to Use It

Students complete a table that asks them to consider different aspects or parts of a model and identify which part of the real world it represents, how the model and the real world are alike, and how the model and the real world differ.

Where It Is

The Analyzing Models Student Sheet can be found in the Teacher Edition for the activities in which it is used. Sample student responses are also located in the Teacher Edition.

CONCEPT MAP

What It Is

A concept map is a visual representation of the relationship between ideas and concepts. Concept maps ask students to make and describe relationships between main ideas and subtopics and among the subtopics themselves.

Why to Use It

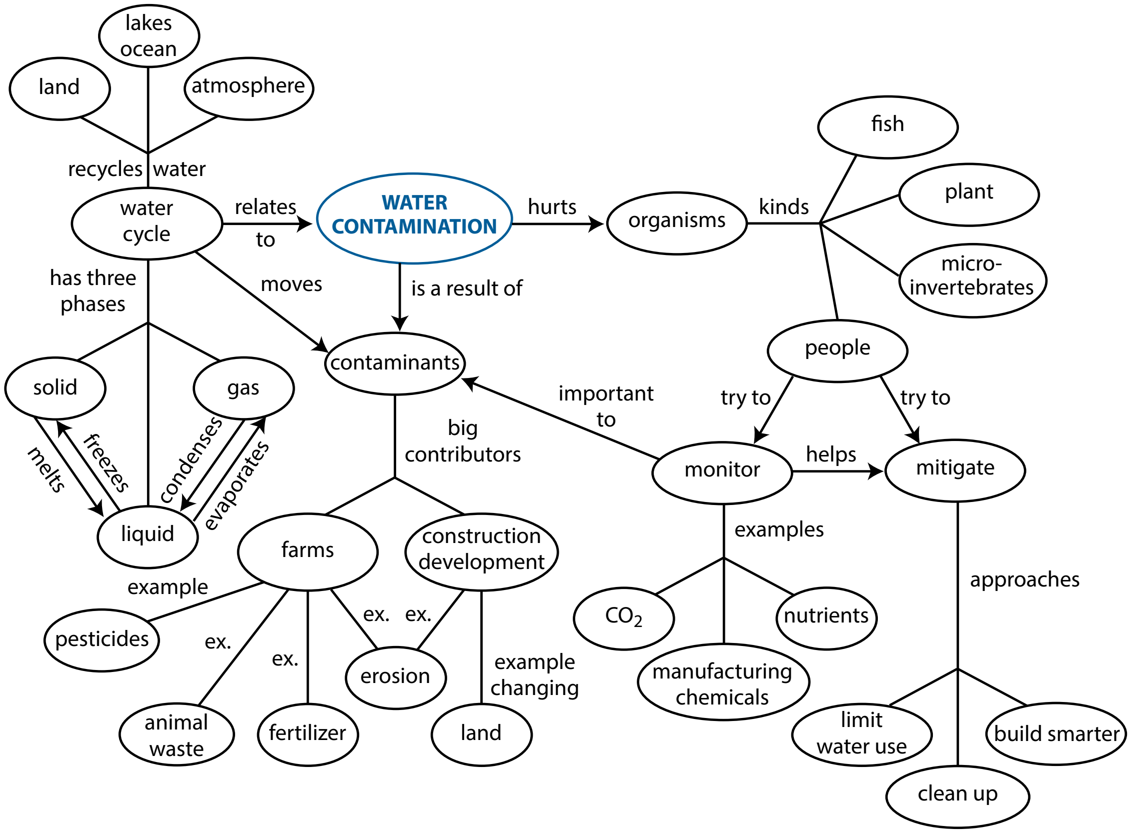
Concept maps demonstrate students' understanding of the connections between topics in a spatial manner. They also allow students to expand their knowledge related to a topic.

How to Use It

The main concept is written in the center of a page (or on the board), and students place subtopics around it, connecting lines between each subtopic and the main concept. On or near the line they've drawn, students add a brief description of the relationship between the two words.

The example on the following page is from an Analysis item in the LAND, WATER, AND HUMAN INTERACTIONS unit, where students are asked to draw a concept map for the earth processes of weathering, erosion, and deposition they are investigating in the unit.

Initially, students may find it helpful to have a list of words that must be included in the map or an incomplete concept map to fill in. Later, students might brainstorm words that should be included and make a list before beginning their



concept map. It may also be helpful to write each subtopic on an index card or sticky note so that students can physically manipulate them and lay out the map before transferring it to paper.

Where It Is

Concept maps are most often part of the Teaching Steps in the Teacher Edition; they may also be Analysis items in the Student Book. The Instructions for Constructing a Concept Map Visual Aid can be found in the Teacher Edition and in **Appendix E: Literacy Strategies** in the Student Book.

DISCUSSION STARTERS

What It Is

Discussion Starters are teacher prompts that encourage students to engage in productive discourse and support them in collaboratively constructing ideas from evidence.

Why to Use It

Clear and on-point discussions improve students' sensemaking while simultaneously allowing ideas to be student-generated. Student discourse improves when students can connect with, support, build on, and add to one another's ideas.

How to Use It

Teachers can use this strategy when facilitating a whole-class or group discussions. Some examples of Discussion Starters:

- "Who can repeat what Aishi just said or put it into their own words?"
- "Now that you have discussed this with your partner, what did your partner say?"
- "Why do you agree [or disagree]?"
- "What do people think about what Jamal said?"
- "Does anyone want to respond to that idea?"
- "Who can add to the idea that Omar is building?"
- "Who can explain what Bo means when she says that?"
- "Who thinks they could explain why Diana came up with that answer?"

Where It Is

Discussion Starters can be found in the Teacher Edition as part of the Teaching Steps.

ELICIT, PROBE, AND CHALLENGE QUESTIONS

What It Is

Elicit, Probe, and Challenge is a sensemaking strategy that helps students construct scientific concepts through discussion. There are three types of questions posed by the teacher:

- *Elicit questions* are designed to help teachers learn about students' thinking and their ways of making sense, and to engage students in the lesson by helping them see the connections between their own ideas and what they will investigate.
- *Probe questions* are directed to students who have already provided an answer or offered an idea to help those students further explore and clarify their ideas.
- *Challenge questions* help students push their thinking and develop a deeper understanding. Elicit, Probe, and Challenge questions may be used at the start of a new topic, throughout the lesson, and when soliciting student predictions.

Why to Use It

By using the three types of questions sequentially throughout an activity, teachers can foster students' sensemaking ability and move their ideas toward more scientific, evidence-based understandings.

How to Use It

When introducing a new topic to the class, use Elicit questions to draw out students' prior knowledge. Some examples:

- "How do you know if something is living?"
- "What determines how rapidly chemicals will interact?"
- "Why aren't there elephants living in the wild in Chicago?"
- "What is the relationship between temperature and energy?"
- "How does your body maintain its internal environment while experiencing external stress?"

Use Probe questions for students who have already provided an answer in order to gain a better understanding of their thinking around the topic. Some examples:

- "What do you mean when you say, 'It moves'?"
- "Tell me more about how you think that happens."
- "Let me know if I'm correct or if I get something wrong. Are you saying . . . ?"
- "Can you say more about the water and the rocks?"
- "Explain more about what you mean by, 'It's the wrong environment.'"
- "What evidence supports your idea?"
- "Can you give us an example?"

Use Challenge questions to push students, either individually or in a group discussion, to think further, make predictions, reconsider their thinking, or make a new connection. Some examples:

- "Does it always work that way, or are there some exceptions?"
- "How does your idea take into account the example of the zebra mussel?"
- "What if it had been a copper cube instead?"
- "What would the map look like if there was more erosion on the cliff?"
- "In what ways could this device be used for another purpose?"
- "Does this new information change what you thought about how the circulatory system works?"

Where It Is

Elicit, Probe, and Challenge questions are suggested in the Teaching Steps of the Teacher Edition for the relevant activity.

SCIENCE NOTEBOOKS

What It Is

The science notebook is an informal place for students to record their ideas and develop new constructs that aid in their sensemaking. In their notebooks, students bring together their ideas as they make sense of the unit issue and phenomena.

Why Use It

A science notebook allows students to authentically engage in the practices of science. It supports students' efforts to process ideas, ask questions, keep track of data during investigations, and build their scientific observation and writing skills. Students can also use the science notebook to keep complete records of their data and investigations.

How to Use It

When introducing science notebooks, model how students should record information. The Keeping a Science Notebook Visual Aid has guidelines for how to keep good records, including the purpose, background, hypothesis, experimental design, data, and conclusion for an investigation.

Where It Is

The Student Book regularly prompts students to use their science notebooks, particularly during Procedures. The Keeping a Science Notebook Visual Aid is included in the Teacher Edition for the activity in which the science notebook is introduced; it can also be found in **Appendix E: Literacy Strategies** in the Student Book.

FACILITATING GROUP WORK

In an issue-oriented science and engineering program, group work is critical. Establishing classroom guidelines for group interactions can facilitate students' ability to collectively make sense of disparate events or integrate multiple sources of information. Students who are able to listen to one another, participate and share work equally, and respect other people's ideas and opinions are better able to contribute to the development of new ideas and understandings. Teachers can use the strategies described below to support and develop positive and constructive group interactions so that students can constructively work together to make sense of science and engineering concepts.

EVALUATING GROUP INTERACTIONS

The Evaluating Group Interactions Student Sheet helps students improve their group interaction skills by having them evaluate the ability of their group members to work together. The sheet guides students in self-assessing their interactions when working in groups and identifying ways to improve their interactions as a group. Teachers may also use the sheet as a framework to discuss the criteria and expectations for successful group work. The Evaluating Group Interactions Student Sheet can be found in the Teacher Resources.

DEVELOPING COMMUNICATION SKILLS

The Developing Communication Skills Student Sheet is an additional tool to help students effectively participate in class discussions. It promotes positive classroom discourse by suggesting how students might appropriately express disagreement, seek clarification, or build on one another's ideas. The suggestions are presented in the form of sentence starters that students can use to initiate a conversation and express their ideas. Teachers can gradually incorporate this strategy into group work by introducing one sentence starter at a time to elicit students' ideas. The Developing Communication Skills Student Sheet can be found in the Teacher Resources, and in **Appendix E: Literacy Strategies** in the Student Book.

GROUP INTERACTIONS SCORING GUIDE

Teachers may want to use the Group Interactions Scoring Guide to evaluate students on their group interaction skills during an activity. This scoring guide is intended to provide formative student feedback rather than summative scores. The Group Interactions Scoring Guide can be found in the Teacher Resources.

ASKING QUESTIONS IN THE LEARNING ENVIRONMENT

Teachers pose questions in the classroom for a variety of reasons. Although teachers are often looking for a specific response, SEPUP teachers also pose more open-ended questions to assess what students are thinking, to help students build conceptual understanding, and to help them relate what they have learned to new situations. These questions relay an important message to students that science is more than memorization of facts, that their ideas are important, and that they can learn collectively from one another.

Most SEPUP activities include suggested questions for teachers to ask at different stages of an activity. For example:

- In the **Get Started** section of the lesson, the Teaching Steps suggest questions to elicit students' ideas and get them thinking about the specific topic. This helps create an environment that is both knowledge- and learner-centered.
- As students **Do the Activity**, the questions suggested in the Teaching Steps can serve as a formative assessment to help gauge students' understanding and better guide the classroom discussion.
- To help students **Build Understanding** at the end of the activity, suggested questions in the Teaching Steps and Analysis items support students' sensemaking by helping them draw conclusions from their investigations, connect their new ideas to previous knowledge, and/or revise their earlier ideas.

Students' own questions are a critically important part of the process of sensemaking. As students make connections to the content, they formulate questions to fill the gaps in their knowledge. Two specific approaches embedded in SEPUP units, described below, are designed to facilitate this process and to engage students in their ability to ask questions that lead to learning.

DRIVING QUESTIONS BOARD

In the first few activities of each unit, the teacher works with students to establish a Driving Questions Board, which allows students to connect their own ideas and questions to the anchoring phenomenon and unit issue. Connecting the unit content to students' interests and experiences engages students and creates a shared sense of purpose (Weizman, Shwartz, & Fortus, 2008, 2010).

Teachers should initiate the Driving Questions Board after students have engaged with the anchoring phenomenon or unit issue, usually in the first activity of the unit. Typically, the teacher introduces the anchoring phenomenon and unit issue as suggested in the Teacher Edition. Students then generate their own related questions. This can be done on sticky notes, index cards, or chart paper, or electronically. The teacher then facilitates the grouping of similar questions into categories, and helps students frame them as driving questions for each learning sequence of the unit, as described in the **Phenomena, Driving Questions, and SEPUP Storyline** overview (which can be found in the back of the Teacher Edition).

The unit's anchoring phenomenon and unit issue, along with suggested driving questions for the learning sequences, are provided on laminated cards that can be placed on the Driving Questions Board. The suggested questions may be modified as appropriate, based on the classroom discussion, as long as they are similar in scope and will help students connect their own ideas to the learning goals for the sequence.

As students progress through the unit, they routinely revisit the Driving Questions Board, in particular as they complete instructional sequences. Students identify the questions that have been answered with evidence and reasoning from the unit and add any new questions that arise. When questions are outside the scope of the unit, they can be placed to the side in a "parking lot," and some students might wish to investigate them independently.

EVALUATING QUESTIONS

Evaluating Questions is a teacher support tool to help students generate scientific questions, thus encouraging their investigations to follow a path that aligns with the broader driving questions of the unit. The teacher begins by providing examples of questions that vary in how useful they are to a particular inquiry. For example, when investigating water quality students could compare the question, "Which liquids best dissolve solids?" to the question "Do you drink tap water?" Students then practice generating scientific questions, and they examine the questions they generated and a sample from the Student Book. Using the Evaluating Questions Student Sheet to guide their work, students evaluate to what degree these questions can be answered by evidence and/or opinion. Through this process, students become more proficient at posing well-defined scientific questions that can only be answered with empirical evidence. The Evaluating Questions Student Sheet can be found in the Teacher Edition for the activities in which it is used.

ELICITING STUDENTS' PRIOR KNOWLEDGE

Students come to science instruction with a diverse set of conceptions concerning natural objects, phenomena, and events, which are often based on students' lived experiences; these conceptions cut across age, ability, gender, and cultural boundaries. Students may also have misconceptions and nonscientific beliefs that they learned in other domains of knowledge. If there is a contradiction between students' previous knowledge and the new idea being presented, students may need support in resolving this conflict.

Of course, not all of students' prior knowledge will be incorrect or deficient. SEPUP's instructional design reflects research suggesting that teachers should first uncover students' existing alternative conceptions, if any, and then encourage students to confront what they think they know (Odden & Russ, 2019). *Issues and Science* activities allow students to reconcile and integrate their new knowledge and their previous conceptions through reflection and discussion. Students have ample opportunities to use their prior knowledge to build understanding and make sense of the world. Students also encounter situations and experiences that lead them to revise their original ideas, if needed, and develop a conceptual change. Teachers should consider students' experiences and understandings as something students can build on in order to learn the science or engineering concept being presented.

For example, in the opening activity of the Earth's Resources unit, students make observations about a variety of natural resources, such as a piece of copper, a rock with fossils, a vial of fresh water, and a sample of oil shale. In groups, students discuss how valuable they think each sample is and what makes it more or less valuable. This activity specifically elicits students' prior knowledge, which gives them a construct on which to add the concepts of renewable and non-renewable resources. In the subsequent activity, students again share their ideas about resource use before being presented with more information about resources and consumption in relation to population growth. Analyzing the new data challenges students to go further with and possibly revise their initial ideas to make sense of disparate events.

Although SEPUP uses many strategies to support the integration of old and new ideas, two in particular address sensemaking through the practice of constructing explanations.

COMPARING EXPLANATIONS

The Comparing Explanations Student Sheet presents two explanations or models to students: one reflecting a typical understanding based on incorrect knowledge or a misconception, and one reflecting a newer understanding based on evidence from the investigation. First, students predict which explanation makes the most sense to them. Next, they review the scientific evidence they have gathered thus far in the unit. Working in pairs, students compare the evidence to each explanation, and determine which explanation is best supported by the science. Finally, students return to their predictions and reflect on how their initial ideas may need to be revised. The Comparing Explanations Student Sheet can be found in the Teacher Edition for the activities in which it is used.

TALKING DRAWING

Talking Drawing is a strategy that allows students to visually communicate and compare their previous knowledge to their newly acquired concepts. Before students begin a learning activity, they complete the first task on the Talking Drawing Student Sheet: "Close your eyes and think about [a particular concept or hypothesis]. Now, open your eyes and draw what you imagined." After students have completed the learning activity, they create a new drawing that represents their more developed conceptual understanding. Students then share their drawings with a partner and discuss how their ideas changed. This opportunity to verbalize their revised impressions encourages students to reflect on how their understanding has changed and reinforces their new understanding. The Talking Drawing Student Sheet can be found in the Teacher Edition for the activities in which it is used.

INTEGRATING ENGINEERING DESIGN

Issues and Science promotes engineering practices by integrating them into activities in a variety of ways. For example, teachers may use the ANALYZING AND INTERPRETING DATA (AID) Scoring Guide to assess students when they are testing the performance of a device, or use the Group Interactions Classroom Rubric to assess students as they collaboratively refine a prototype to optimize their solution. Teachers can accomplish the NGSS performance expectations for engineering and promote design thinking among students by using SEPUP supports during the SEPUP Engineering Design Process, as outlined in the diagram on the next page.

While most SEPUP science teachers are proficient in supporting students who are engaged in scientific inquiry, they may want direction for guiding students through the engineering-focused activities. This diagram helps teachers identify what they can expect from students during different steps in the SEPUP Engineering Design Process.

Engineering Design Process in the Classroom

Students are engaged in:

- defining a successful solution or design
- clarifying what is not the problem
- developing criteria and constraints

NGSS SEP: Asking Questions and Defining Problems

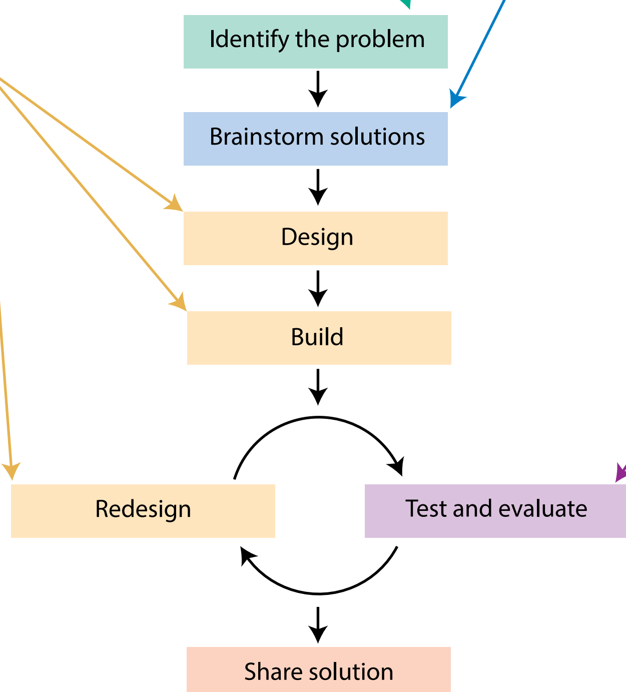
SEPUP support: COM Scoring Guide (ASSESSMENT)

Students are engaged in:

- generating potential solutions, initially without evaluating those ideas
- researching scientific information that supports various solutions
- narrowing down a list of possible solutions to those that are most likely to meet the criteria and constraints

NGSS SEP: Obtaining, Evaluating, and Communicating Information

SEPUP support: Facilitating Group Work (SENSEMAKING)



Students are engaged in:

- designing prototypes for testing
- considering the material properties involved
- using test results to inform a redesign
- combining the best aspects of multiple designs to optimize performance

NGSS SEPs: Developing and Using Models, Constructing Design Solutions

SEPUP support: MOD, and ENG Scoring Guides (ASSESSMENT), Facilitating Group Work (SENSEMAKING)

Students are engaged in:

- recording data from testing
- analyzing test results for strong performance
- using data to indicate redesign improvements

NGSS SEPs: Developing and Using Models, Using Mathematics and Computational Thinking, Analyzing and Interpreting Data, Planning and Carrying Out Investigations

SEPUP support: ENG, and AID Scoring Guides (ASSESSMENT), Facilitating Group Work (SENSEMAKING)

Students are engaged in:

- presenting their design ideas
- explaining the evolution of the design
- comparing designs across teams
- using evidence to argue for particular design attributes
- weighing the trade-offs of designs

NGSS SEPs: Engaging in Argument from Evidence; Constructing Explanations; Obtaining, Evaluating, and Communicating Information

SEPUP support: ARG, EXP, and COM Scoring Guides (ASSESSMENT), Oral Presentations (LITERACY)

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