Focus on Inquiry

SEPUP News

Spring 2004 Lawrence Hall of Science University of California at Berkeley

SEPUP Provides Support for Guided and Open-Ended Inquiry

There are many approaches to inquiry. Inquiry can be very open-ended, with the student independently designing and constructing a procedure. In other situations, the inquiry can be guided by the curriculum or the teacher. According to *Inquiry and the National Science Education Standards* (NRC, 2000), all approaches to inquiry should contain five essential features. (*See right.*) Both the guided and open-ended inquiry in SEPUP materials typically include these features.

NSES Essential Features of Inquiry

1. Learners engage in scientifically oriented questions.
2. Learners give priority to evidence.
3. Learners formulate explanations from evidence.
4. Learners connect explanations to scientific knowledge.
5. Learners communicate and justify explanations.

SEPUP's approach to inquiry is based on a learning-cycle approach in which concepts are introduced through student exploration, enhanced by activities that build on students' initial ideas, and further developed and reinforced through discussion and analysis. In this approach, both guided and open-ended inquiry are used to facilitate learning.

Many SEPUP activities define the purpose of the activity and provide a comprehensive procedure. These guided inquiry activities provide students with an opportunity to investigate important science concepts that cannot be easily discovered through open-ended inquiry. During guided inquiry, students collect, test, evaluate, and apply scientific evidence. These processes address essential components of inquiry while providing a structure for student learning.

Activities found early in a module or course often contain this guided inquiry approach. For example, early in the *Investigating Food Safety* module, students investigating optimum conditions for yeast growth are provided with a challenge question, a step-by-step procedure, and a table to record data.

Other SEPUP activities provide less structure and require students to assume greater responsibility for collecting, recording, analyzing, and explaining data. This open-ended inquiry encourages students to develop their ability to ask and investigate questions, think critically, and gain a better understanding of the application of science to real contexts and even future careers. For example, later in the *Investigating Food Safety* module, students are asked to design and conduct an experiment to investigate the ability of chemicals to inhibit yeast growth. Students are expected to specify a purpose, construct a procedure, design a data table, explain their findings, and make conclusions.

SEPUP emphasizes six inquiry skills, all of which contribute to building conceptual knowledge. *(See below.)* All of these skills are distributed across SEPUP full-

Inquiry Skills Assessed in SEPUP

1. Designing investigations
2. Conducting investigations
3. Recording data and procedures
4. Analyzing and interpreting data
5. Communicating scientific information
6. Evaluating evidence

Continued on page 7

Inquiry and Hands-On Science with Oakland Teachers

SEPUP has partnered with the Oakland Unified School District to develop a series of mini-conferences on inquiry for high school science teachers.

Chemistry teachers conduct activities from the SEPUP module, "Waste Disposal: Computers and the Environment."

In the first set of sessions, biology, physics, and chemistry teachers discussed their ideas about inquiry and reviewed the definition of inquiry used by the National Science Education Standards (NSES).

They then focused on the five essential components of inquiry described in *Inquiry and the National Science Education Standards* (NRC, 2000). *(See above.)*

Continued on page 2

Director's Corner: Guided to Open Inquiry—A Continuum

One common myth about inquiry is the idea that inquiry can only take place when students generate a scientific question and develop their own investigations. This myth and others are addressed in a publication that I highly recommend to all teachers interested in inquiry: *Inquiry and the National Science Education Standards* (NRC, 2000; see complete reference below). I offer here some suggestions for using this valuable resource.

If you are a teacher who is looking at this book for the first time, you may want to begin with Chapter 2, which provides an introduction to inquiry and an overview that you can use to plan the range of inquiry activities throughout a unit or a course. The table on page 29 is especially helpful—you can use it to evaluate an activity for the five essential features of classroom inquiry (listed here on page 1). You may also wish to use it to evaluate where an activity falls on the continuum from a high degree of direction from the teacher (or instructional material) to a high degree of learner self-direction. As you plan instruction, you can begin with more guided variations to prepare students until they are ready for more open inquiry opportunities.

Chapters 3 and 7 also provide practical information for teachers. In Chapter 3, you may choose to read only those images of inquiry provided for the grade levels you teach. Chapter 7 addresses frequently asked questions such as "How can teachers cover everything in the curriculum if they use inquiry-oriented materials and teaching methods?" and "In inquiry-based teaching, is it ever OK to tell students the answers to their questions?"

I hope this resource will provide some answers to your own questions about inquiry and help you adapt inquiry activities to meet your instructional goals.

Dr. Barbara Nagle, Director

Selected Bibliography on Inquiry and SEPUP

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DiRanna, K., & Siegel, M.A. (2004). *Facilitating learning: The role of the teacher: Elementary Science Teacher Leadership (ESTL) 2.* Berkeley, CA: SEPUP, Lawrence Hall of Science, University of California, Berkeley. *www.sepuplhs.org.*

Linn, M., Lee, K., Levenson, J., Spitulnik, M., & Slotta, J. (2000). *Teaching and learning K–8 mathematics and science through inquiry: Program reviews and recommendations.* North Central Regional Educational Laboratory.

National Research Council. (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning.* Washington, D.C.: National Academy Press.

Snell, V., Baumgartner, L, & Seaver, D. (2000). Design and decision making. *The Science Teacher.* 67(6), 29–31.

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Inquiry and Oakland Teachers *continued from page 1*

Teachers engaged in discipline-specific activities and analyzed them to determine how they related to the five essential features of inquiry and to the continuum from guided to open inquiry. Further discussion focused on how activities could be modified to be more guided or more open based on students' prior experiences with inquiry. Experienced teachers offered suggestions on how to differentiate inquiry-oriented instruction for diverse student groups within a classroom.

Some teachers, especially those who have only been teaching for a short time, were relieved to discover that they are already incorporating more features of inquiry than they realized. They were optimistic that they will be able to modify instruction to incorporate additional inquiry features and provide a greater range of inquiry experiences. Teachers who had previous experience with the NSES essential features of inquiry appreciated the practical suggestions for achieving inquiry in the classroom.

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SEPUP Materials

SEPUP instructional materials include student books or pages, teacher's guides, and kits. The following are currently available:

Science and Sustainability: high school

Issues, Evidence and You: middle school (available both as year-long course and mega-modules)

Science and Life Issues: middle school (available both as year-long course and mega-modules)

12 SEPUP Modules: secondary school (kit includes CD-ROM and transparencies)

CHEM-2: Grades 4–6 (Spanish student pages also available)

All SEPUP materials are produced and distributed solely by Lab-Aids®, Inc. (800) 381-8003 www.sepup.com.

SEPUP Issues in the News: Using Current Events to Promote Inquiry

According to the National Science Education Standards, an inquiry approach to teaching encourages learners to formulate explanations based on evidence to scientifically oriented questions. Successfully engaging students immediately in the inquiry process is important, because it drives the remainder of the inquiry.

Current news events that introduce scientific issues can motivate students to learn more about the science that forms the background to these events. These news events can be used to generate scientific questions that lead directly to the science content.

Contaminated Lettuce

Scientists at the University of Arizona in Tucson are investigating whether the contaminant perchlorate moves through the food chain and can be found in vegetables, such as lettuce, from areas that use water contaminated with the substance. In 2000, perchlorate, one of the ingredients of solid rocket propellant leaked from a rocket fuel plant near Las Vegas, Currently, there is a concentration of 14 parts per billion of perchlorate in Lake Mead, the reservoir behind Hoover Dam. The contaminant has also traveled into the water of lower Colorado River, which is used as drinking water and to irrigate vegetable farms.

Issues, Evidence and You, Activities 14–20, "Investigating Groundwater." Students investigate contaminated drinking water.

Scientific questions to pursue:

- What is contamination?
- How do we know whether water is safe to drink?
- How does a contaminant travel from one place to the other in the ground?

England's Energy Plan

In 2003, the British government rolled out its new energy plan for the future. The plan outlines extensive use of renewable energy sources such as ocean wave, tidal and wind farms, and solar power by the year 2020. Notably absent were plans for significant use of nuclear power and coal. Great Britain has historically depended on coal as its main energy source, but government officials are turning to renewable energy sources to increase efficiency and reduce greenhouse gases.

Science and Sustainability, Activity 31.2, "Fuels for the Future." Students become familiar with different alternative energy sources and the trade-offs associated with each one.

Scientific questions to pursue:

- How is renewable energy different from non-renewable energy?
- What is energy efficiency?
- How do US energy sources compare to those of other countries?
- What energy choices are most sustainable?

Disappearing Lynx

It is estimated that there are only a few hundred Canadian lynx living in the US, mostly in Montana, Washington and Maine. This rare cat usually lives in mature forests with dense undergrowth but can also be found in more open forests, rocky areas or tundra. The reduction of the lynx population is a result of human habitat destruction and trapping. Since 1999, the Colorado Division of Wildlife has engaged in ongoing efforts to reintroduce lynx into Colorado. The success of this reintroduction has remained controversial for environmentalists.

Science and Life Issues, Activity 89, "Here Today, Gone Tomorrow?" Students investigate the extinction of endangered species.

Scientific questions to pursue:

- What are some of the consequences of extinction?
- Can people change the course of evolution?
- What steps are needed for a successful reentry of a species?
- Is an animal considered extinct if it can be found somewhere else in the world?

Making Soda Taste Better

In the past few years, scientists have been working on new plastics for soda containers that can improve the taste of soda by retaining the carbon dioxide longer. The new soda containers are made of polyester, replacing the traditional polyethylene packaging. The advantage of the improved polyester packaging is that it lasts longer and in turn can keep food fresher and extend the shelf life of many foods. In addition, polyester materials are easier to recycle than polyethylene containers.

Living with Plastics (SEPUP Module), Activity 1, "The Best Bottle." Students consider the materials used to make beverage containers.

Scientific questions to pursue:

- What is the difference between polyethylene and polyester?
- How is plastic recycled?
- What characteristics of polyester make it more desirable for soda bottles than polyethylene?
- Are there trade-offs in using polyester to make bottles?

Sample Activity: Learning Through Inquiry in SEPUP

The ultimate goal of inquiry-based lessons is to support student learning. It is often easy to forget that the inquiry lesson itself is only the first step to building knowledge. As stated in *Inquiry and the National Science Education Standards* (NRC, 2000), students must also "formulate explanations from evidence," "connect explanations to scientific knowledge," and "communicate and justify their proposed explanations." The role of teachers and good science curriculum is to assist students in accomplishing these tasks.

The four principles below can promote student learning through inquiry. We have used an activity from the Ecology unit of *Science and Life Issues*, SEPUP's life science middle school course, as an example of how to apply these principles.

1. Relate the science to students' prior knowledge.

Plan time to draw out and build on students' initial ideas. Help students confront their misconceptions by investigating alternative ideas, and require students to weigh the reasonableness of each idea.

For example, teachers can use Activity 83 to help students evaluate anthropocentric responses to organism behavior. People tend to look at animal behavior as a reflection of or reaction to their own presence. When the blackworms begin actively squirming, students often say things like "Oh, they're trying to get away from us." This is an excellent opportunity to have students look at the other variables affecting behavior. In the case of the blackworm, a less anthropocentric inference might be that the blackworms are searching for a substrate.

2. Emphasize the science focus of the lesson.

Emphasize the science concepts and processes that underlie the inquiry-based lesson and provide time for discussion and elaboration of scientific ideas. After initial discussion, it is often necessary to return to the Challenge to address the science focus of the lesson. Activity 83 focuses on the non-living components of a habitat and their potential effect(s) on population size, which are broader ecological concepts than blackworm habitat.

As an immediate follow-up to the Procedure, the teacher's guide recommends discussing how population size may vary as a result of changes to a habitat. The abiotic factors investigated in this activity may act as a limiting factor to the size of a population, and the phrase "carrying capacity" is introduced in a later activity in this sequence. Carrying capacity can be investigated by extending the activity and observing the blackworm population in a particular habitat over time.

3. Reflect on new knowledge.

Make sure students have the opportunity to reflect on the results of the inquiry. In SEPUP, analysis questions are intended to help guide this reflection and learning. Suitable habitat is determined by both living and abiotic factors. Analysis Question 2 provides students with an opportunity to connect this lesson to this more extended concept.

4. Use assessments to build understanding.

Take advantage of the variety of assessments embedded in SEPUP curriculum. In Activity 83, Analysis Question 3 is an embedded assessment opportunity. Students can be assessed on their ability to record or design a procedure using the SEPUP Assessment System. In addition to evaluating student understanding, assessments are a tool for finding out what your students think and then used as the basis for further instruction.

83 A Suitable Habitat

CHALLENGE

What are some of the important non-living characteristics of a habitat?

PROCEDURE

1. Fill the base of a petri dish with treated tap water (or spring water) and place 5 blackworms in it.
2. Observe how the blackworms respond over the next few minutes. Discuss with your group any behaviors that seem to be true of all or most of the blackworms.
3. As a class, discuss what type of data you could collect on the blackworms in order to determine which type(s) of material provides a good habitat for them.
4. Compare the different materials you can use to create a blackworm habitat. Record any similarities and differences in the physical characteristics of the different habitat materials.
5. With your group, design an experiment to investigate which type(s) of material provides a good blackworm habitat.

   When designing your experiment, think about the following questions:

   - What is the purpose of your experiment?
   - What variables will you keep the same?
   - How many trials will you conduct?
   - Will you collect qualitative and/or quantitative data? How will these data help you to make a conclusion?
   - What variable are you testing?
   - What is your hypothesis?
   - How will you record your data?
6. Record your hypothesis and your planned experimental procedure in your science notebook.
7. Make a data table that has space for all the data you need to record. You will fill it in during your experiment.
8. Obtain your teacher's approval of your experiment.
9. Conduct your experiment and record your results.

ANALYSIS

1. Based on your experiment, which type(s) of material provides a good habitat for blackworms? Explain how your experimental results support your conclusions.
2. Describe the non-living characteristics of a habitat.
   Hint: What non-living factors could affect whether organisms will survive and reproduce?
3. What could you do with your blackworms to investigate if a warm or cold habitat is better for them? Write a procedure that anyone in your class could follow to investigate this question.

SEPUP (2001) Science and Life Issues. *Ronkonkoma, NY: Lab-Aids®, Inc.*

SEPUP Instructional Materials Provide Range of Inquiry Opportunities

Five essential features of inquiry are described in Inquiry and the National Science Education Standards, (see page 1 of this SEPUP News) and teachers are encouraged to include each of these features in lessons ranging from more structured to less structured.

SEPUP materials are designed to cover this range for all the features. The table below focuses on one of these features: "Learners give priority to evidence," and shows how activities in each of the SEPUP curriculum products correlate with the continuum from more structured / more guided to less structured / more open-ended inquiry. There are similar correlations for the other four features.

GIVING PRIORITY TO EVIDENCE	More Structured ⟷ Less Structured	
	Learner is given data and told how to analyze it	**Learner determines what constitutes evidence and collects it.**
Science and Life Issues (Grade 7)	**4 Testing Medicines Scientifically** Students calculate and compare specific ratios from a set of provided data.	**64 Nature and Nurture** Students design and conduct an experiment to collect data to show whether light affects the color of Nicotiana seedlings.
Issues, Evidence and You (Grade 8)	**Water A4.2 Cholera Deaths** Students plot a set of given data on a map. They are then asked to describe any patterns shown by the mapped data.	**Energy C1.2 Drive a Nail** Students are given equipment and asked to develop and conduct an experiment to collect evidence showing how the mass and height of an object affect its energy.
Science and Sustainability (Grade 10)	**2.4 Where Have All the Otters Gone?** Students are provided with a food web with current population levels and are asked to describe what would happen if one population changed significantly.	**26.4 Catalysis Paralysis** Students are asked to determine how to use a set of materials to collect evidence showing the optimal temperature for the breakdown of lactose by lactase.
Solutions and Pollution (SEPUP Module) (Grades 7–10)	**Extension 8 Modeling Neutralization** Students illustrate different strength solutions using a visual model which they are given for acid and base solutions.	**10 Cleaning the Acme Wastewater** Students design and conduct an experiment to remove dissolved solids and neutralizes the wastewater.

Of Special Interest to SEPUP Attendees at NSTA

Robert H. Karplus Lecture

Dr. Herbert Thier, Founding Director of SEPUP, has been asked to present the Robert H. Karplus Lecture, which will be titled, "Redesigning Science Education: The Legacy of Robert Karplus." Herb worked with Professor Karplus and others to develop *SCIS* (*Science Curriculum Improvement Study*) in the early 1970s.

The talk will discuss Karplus' learning cycle and the role of his conceptual organizers, *interaction* and *systems*, in the National Science Education Standards and Project 2061. It will then consider *design* as another conceptual organizer which brings together science and technology education to better engage middle school students in their own learning and encourage a 21st century view of the role of science and technology in every citizen's life.

Panel on Inquiry: Lawrence Hall of Science Curriculum Projects

Staff from SEPUP, FOSS, and GEMS—three science programs at the Lawrence Hall of Science at the University of California that have been cited for their exemplary approaches to science instruction will join elementary and middle school teachers for a panel discussion on the essential elements of meaningful inquiry in science.

Participants will draw from their broad range of experience and research to discuss questions such as: What distinguishes hands-on lessons from inquiry? How can the difficulties in creating successful inquiry experiences be overcome?

The variety of approaches will provide both practical and theoretical insights into the use of inquiry in science education.

Many Thanks to SALI Evaluation Participants

We gratefully acknowledge the teachers and coordinators who were involved in the SALI evaluation pilot test last year (2002–2003), and the evaluation study this year (2003–2004):

Buffalo, NY: Kathy Burke, coordinator; Joan Bernobich, Jason Mayle, Kai Lewis

Charleston, SC: Carol Tempel, Rodney Moore, coordinators; John Patrick Shell, Kathy Missel, Christina Kleindt, Sandra Heidecker, Jacqueline Townsend, Karen Drawdy

Iowa City, IA: Jeanne Bancroft, coordinator; Jody Bandy, Lore Baur, Dan Hill, Linda Johnson, Mark Kluber, Dan Mascal, Edijoy Williams

Lemon Grove, CA: Samantha Swann, coordinator; Helen Copeland, Susan MacIntosh

Orinda, CA: Sue Boudreau, Karen Snelson

Temple, TX: Dr. Kathleen Coburn, coordinator; Sherry Newton

Vista, CA: Donna Markey

First 3 ESTL Guides Available

Download guides on integration, assessment, and facilitating teaching at: www.sepuplhs.org/profdev/educators/estlguides.html.

SEPUP and Inquiry *continued from page 1*

year courses, while one to two skills are emphasized in each of the SEPUP modules.

Support for developing these skills is provided in the student materials and in the teacher's guides. Guidance for improving and assessing inquiry skills are also a part of the SEPUP Assessment System, which includes rubrics for designing and conducting investigations (including recording procedures, organizing data, and analyzing data), communicating scientific information, and identifying and using evidence.

Different levels of inquiry are often supported by the teaching suggestions found in SEPUP teacher's guides. In cases where students need more guidance, the teacher's guide may contain a sample procedure that can be distributed to students who are not yet prepared for open-ended inquiry. For those students who are ready to be more independent, the teacher may incorporate suggestions that reduce the level of guidance. Teachers may implement these strategies differently based on their student populations, but the essential features of inquiry remain the same.

Teachers can help support learning through inquiry with classroom discussion and by prompting students to devise their own questions about a lab or investigation. Whether the lesson uses open-ended or guided inquiry, students should be able to answer the following questions:

- What is the purpose of the investigation?
- What type of data would be the most useful to collect?
- What is the best way to organize and display the data?
- What evidence does the collected data provide?
- Does the data support my hypothesis?
- What conclusions can be made from the data?
- How does my conclusion explain the data collected?

A Word from Lab-Aids

Mark Koker, Director of Curriculum and Professional Development

The Role of Professional Development

More than ever, science teachers and administrators are challenged to improve their school science programs. Of course, we believe that schools that adopt SEPUP are taking an important first step! But helping teachers acquire new knowledge and skills as they work in their SEPUP classrooms is vital to their continued professional development. At Lab-Aids, we now offer a variety of professional development workshops to help teachers make the most of their SEPUP implementation. We currently offer workshops on inquiry, assessment, and literacy support, which are briefly described below:

Inquiry

Over the years, a robust literature has developed that supports the use of inquiry-based approaches to teaching and learning. Support for inquiry can be found in the language of most national and state science education frameworks. But what does it look like in the classroom? How can teachers use inquiry techniques more effectively in their teaching? How do we assess student learning through inquiry?

Assessment

Assessing what students know and are able to do is increasingly important—in the classroom and at local, state, and national levels. Whether formal or informal, research suggests that high quality assessment can have a positive effect on student achievement. How can teachers develop and use assessment procedures that bridge the gap between theory and practice? What does it all look like in the classroom?

Literacy

Many science lessons are also language lessons. Science uses words we don't use in everyday life, like photovoltaics, allele, and lactase. Science has special meaning for words we do use in everyday life, like mole, power, wave, and field. And we use logical connectives (e.g., respectively, inversely) to describe the relationship between concepts. What strategies can teachers use to support reading, writing, speaking and media literacy within the science classroom?

For more information, visit us online at www.sepup.com, or call us at 800.381.8003.

SEPUP's New Middle School Course Thrives in Classrooms

After a successful semester of field testing SEPUP's new 6th grade course, SPIES (*Studying Processes and Issues in Earth Science*), field test teachers returned to Berkeley, CA in January for follow-up training. The teachers from schools in Winston-Salem, NC; Buffalo, NY; and Vista, CA will continue to use the 6th grade issue-oriented earth science curriculum through the rest of the school year.

While these teachers are enjoying SPIES in their classrooms this spring, the SEPUP team will be busy preparing the course for its second year of field testing and selecting the field test sites for 2004-05. Teachers from those sites will participate in a training conference in Berkeley in July.

SPIES teachers and developers take a break from the January training at the Lawrence Hall of Science.

SEPUP News

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Spring 2004

Calendar

Selected SEPUP Workshops

Check your program for the location of each presentation. Workshops marked with an * are sponsored by Lab-Aids®, Inc.

NSTA National Convention, Atlanta, GA

Thursday, April 1

3:30–4:30 p.m.	"Approaches to Inquiry: Successes and Challenges," Manisha Hariani (SEPUP), Sue Jagoda (FOSS), Carolyn Willard (GEMS), Elizabeth Stage (Director, Lawrence Hall of Science)
3:30–4:30 p.m.	"Science and Language—Links to Scientific Literacy," Marlene Thier

Friday, April 2

8:00–9:30 a.m.	"Mission: Find New Ideas for Tackling the Grade 7-9 EM Spectrum Standards—Look No Further!"*
10:00–11:30 a.m.	"Energy Education Strategies for Grades 7–9"*
12:00–1:30 p.m.	"Challenging Issues of Science and Sustainability for High School"*
2:00–3:30 p.m.	"What Should Inquiry Teaching and Learning Look Like in the Classroom?"*
4:00–5:30 p.m.	"Middle School Genetics Made Easy, Interesting, and Fun? No Way!"*

Saturday, April 3

8:00–9:30 a.m.	"Modeling and Applying Cell Biology in Middle School—Back to the Future!"*
10:00–11:30 a.m.	"Earth Science Materials for Grades 6–9 that Really Rock!"*
12:00–1:30 p.m.	"What Happens When You Mix Two Parts Gas with One Part Literacy?"*
3:30–4:30 p.m.	"Redesigning Science Education: The Legacy of Robert Karplus," (The Robert H. Karplus Lecture), Dr. Herbert Thier

NARST (National Association for Research on Science Teaching), Vancouver, BC

April 1	"Evolution of Life Science Assessments for Middle School," Dr. Barbara Nagle and Dr. Marcelle Siegel

AERA (American Educational Research Association), San Diego, CA

April 12	"Development of an Assessment Instrument for Middle School Life Science: Design Considerations and Consequences Related to Scoring Student Learning with Rubrics," Dr. Marcelle Siegel