THE SCIENCE EDUCATION FOR PUBLIC UNDERSTANDING PROGRAM (SEPUP):

A SHORT HISTORY OF ISSUE-ORIENTED SCIENCE

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SUMMARY

From its offices at the Lawrence Hall of Science, at the University of California, Berkeley, the Science Education for Public Understanding Program (SEPUP) has produced science instructional materials for elementary, middle, and high school use since 1987. Primary support for this effort has been provided by development grants from the National Science Foundation (NSF) and by grants from private foundations and industry, including early support from Dow Chemical, Union Carbide, Hewlett-Packard, the Exxon-Mobil Foundation, and others.

All SEPUP programs highlight the science concepts and processes associated with current personal, societal, and environmental issues. All are research-based and inquiry-oriented, and are available in supplementary and full year formats. Use of SEPUP materials supports the ongoing reform of school science programs advocated by many national, state, and local groups. Historically, this includes Project 2061's Benchmarks (AAAS), National Science Education Standards (NRC/NAS). More recently, the middle level units were revised and updated for the Next Generation Science Standards (NGSS) and provide full support for the Middle Level Performance Expectations of the NGSS (NGSS Lead States, 2013).[2] SEPUP materials are used today in school systems from Florida to Alaska[3], and have been adopted in several states. Based on sales data and conservative estimates of repeat use, we estimate that over 8.5 million students have used SEPUP. What began as a small program in northern California in 1986 is now widely used in the United States and abroad.

Over the years, many internal and external studies have attempted to document the impact of SEPUP. These are available in summary form at www.sepuplhs.org and https://lab-aids.com/evidence-impact. In the main, these efforts have shown that the educational impact of SEPUP is positive and cumulative. We continue to seek additional evidence of the impact of SEPUP on students and teachers.

This paper is intended as a general introduction to SEPUP. It will cover SEPUP development and early influences, the elements of SEPUP instructional design, the role of laboratory or material-centered activities in SEPUP, use of research on student alternative frameworks, the SEPUP

[2] See www.sepuplhs.org.

[3] A partial list of cities that have used, or are currently using SEPUP programs, includes Buffalo, Denver, San Diego, Scottsdale AZ, New York, Chicago, Las Vegas, Winston-Salem, Charleston SC, Portland OR, Cedar Rapids IA, and others; SEPUP programs have been state-adopted in Kentucky, North Carolina, Michigan, Indiana, Georgia, Utah, West Virginia, and others.

approach to decision-making, our efforts to assess what students know and are able to do as a result of SEPUP, some strategies to incorporate literacy and technology in our materials, a short summary of the NGSS redesign efforts, and SEPUP's future plans.

The following table shows major SEPUP instructional development and teacher enhancement efforts. For more detail, see Appendix A.

Table 1. SEPUP instructional development programs

Elementary	
Chemicals, Health, Environment and Me (CHEM)	15 enrichment activities for use in grades 4-6, with links to literacy and integration
Secondary	
SEPUP Modules	Twelve titles; each requires 2-4 weeks
Revised Modules	In development
Science and Earth Issues (IAES)	Full-year, earth science, grades 6-8
Science and Life Issues (SALI), later *Issues and Life Science* (IALS)	Full-year, life science, grades 7-8
Issues, Evidence and You (IEY), later *Issues and Physical Science* (IAPS)	Full-year, physical science, grades 8-9
Science and Sustainability (S&S)	Full-year, environmental science, grades 9-10
Issues and Science, SEPUP's 3rd edition, middle level units, redesigned for NGSS	17 units in the life, earth, and physical sciences, from 2016-2019
Science and Global Issues: Biology (SGI: B)	Full-year high school biology
Science and Global Issues: Physical Science (SGI: PS)	Full year high school physical science (in progress)

Table 2. SEPUP teacher enhancement efforts

Elementary	
Issue-Oriented Elementary Science Leadership (IOESL)	Develop leadership for elementary science among teachers in participating districts
Elementary Science Teacher Leadership (ESTL)	Develop materials for use by college faculty and others working with pre- and in-service elementary and middle level science teachers
Secondary	
Teaching Issue-Oriented Science (TIOS)	Develop local leadership and expertise in teaching issue-oriented science

EARLY HISTORY AND INFLUENCES

Public concern for the environment is not a new idea. Native American and Asian concepts of environmental stewardship have been with us for centuries. With the publication of Rachel Carson's *Silent Spring* in 1962, stories about the environment began receiving greater attention in the U.S. media. Environmental issues—which had previously been the subject of concern primarily for special interest groups—gradually became more mainstream in their appeal. Distant environmental

concerns such as the threat of oil spills, accidental release of nuclear materials, and toxic substances were made more immediate in the latter part of the 20th century, through accounts of the Exxon *Valdez*, Chernyobl, and Bhopal, respectively. In addition to its coverage of these and other environmental incidents, the media also began to increase its reporting of business and industry environmental release data. This was made possible in part by a series of public "right to know" laws passed in the 1980s, such as the Superfund Recovery and Reauthorization Amendments (RCRA) of 1987. These laws not only provided additional funds for cleanup of Superfund sites, they required industry to disclose environmental release data in a comprehensive manner.

At about this time (late 1980s), the public's role in environmental policymaking began to change. Previously, science and environmental policy was largely the domain of elected officials and their science advisors. But, apparently no longer content with a passive role, and possibly motivated partly by the increasing media coverage of environmental stories, the public gradually became more involved in the policy process. This involvement took various forms, from advocacy, fundraising, and lobbying, to direct action in some cases. This new role of the public as participants in the policy process then led to considerable discussion about their participation in the process—a debate that continues to this day. Scientists, policy makers, business leaders, educators, environmentalists and others began to express concern over the ability of the lay public to follow environmental issues and participate knowledgeably in the policy debate.

Most of these concerns were based on the perceived ability of the public to understand the science that underlies many of these controversial environmental issues. According to studies at the time, the public did not understand science very well. In one study in the United States, over one-third of the adults surveyed could not correctly identify the length of time it takes for the earth to orbit the sun (Miller, 1987). Only 5% - 7% of the United States adult population was scientifically literate, according to Miller (1987). With such low levels of public understanding of basic science, it was argued, how could the public possibly comprehend the science behind these complex environmental issues, particularly when the scientists themselves often disagreed among themselves?

A discussion of new roles for the adult public led to a discussion of new roles for its students, who are, after all, adults-in-training. "Science education is in fashion again," wrote Herb Thier (1985, personal communication), making an early case for the use of environmental issues in science programs. Miller (1987, 89), who has written widely about adult scientific literacy in the United States, agreed that schools could make an important contribution. The role of the schools in preparing students to deal effectively with societal issues as adults has long been of concern to many national school science reform projects (see for example, AAAS, 1994; Hurd, 1985; NRC, 1994). And students were apparently concerned about the environment—over 50% of American schoolchildren said that environmental harm was a problem they want to help resolve, according to a study using a stratified random sample of 2,129 school-aged children (U.S. EPA, 1994). But what constitutes effective decision-making about the environment? Where do young adolescents get most of their information? How do they make decisions about the environment? Can decision making about environmental issues be taught effectively in schools? These and other related questions guided the early development of SEPUP and its programs.

Early development and acceptance of the alternative approaches in SEPUP was supported by the existence of alternatives to mainstream science education. One of the more popular movements was the Science-Technology-Society (STS) movement, which took root in the 1960s and 1970s, and was designed to increase student awareness of interactions between science, technology, society.

The STS movement itself was composed of many different movements, each with its own goals, but all generally united in their rejection of conventional disciplinary approaches to science teaching. By 1983, over two hundred STS-type programs were available at more than one hundred colleges in the United States and abroad. Cheek (1992) has written a comprehensive history of the STS movement, suggested for interested readers. SEPUP has elements in common with some STS programs; but also some important differences as well, as we will see later.

As with many efforts that begin informally, the exact start date is difficult to set. SEPUP "began" in 1982, according to most staff accounts. By that time, efforts to establish school exit criteria for what students should know about the risk and benefits of chemical use were underway in California, with planned support from the California state legislature for what would later become the nucleus of SEPUP. This group included Herb Thier, now SEPUP Director, Joe Davis, a local high school teacher and senior author of CHEM Study, and others, and their actions led to the development of the first SEPUP modules, *Solutions and Pollution and Risk Comparison*. As planned legislative support did not materialize, early support for the Chemical Education for Public Understanding Program (CEPUP) was established from a variety of primarily private sector sources.

A broadly-based national advisory board was soon convened, with representation from colleges and universities, business and industry, labor, public schools, civic groups, and environmental groups, including the Sierra Club. CEPUP received its first NSF funding in 1988 to develop twelve supplementary modules. In 1992, when NSF support was granted for the development of full year course materials that would incorporate topics from the earth- and life-science domains, the program formally change the initial word in its name from "chemical" to "science;" thus, CEPUP became SEPUP. To date, seven NSF grants have been awarded to SEPUP, five for instructional materials development, two for teacher enhancement.

INSTRUCTIONAL DESIGN AND DEVELOPMENT

In his book *Redesigning Education*, Nobel Laureate Ken Wilson calls SEPUP "…one of the best examples of educational design…" (1994, p. 206). What are the key elements of this design? In three words, issue, materials, and teachers. Societal and environmental issues are at the core of instructional materials from SEPUP. They come first, and they define the science that is needed and how it is presented. Students learn science in SEPUP to understand the underlying issue, and learn to make decisions that are based on evidence.

The early SEPUP instructional development process continues, with some modification, to this day. A meeting of scientists, science educators, teachers and SEPUP staff is held to discuss and select issues that seem to hold developmental promise. Questions asked at this early stage include:

- Does the issue use and apply science content?
- Are the concepts age-appropriate and standards-based?
- Is the issue motivating to students?
- Is the issue complex, i.e., does the decision making involve trade-offs?
- What approaches will best communicate this concept?
- How will the learning be assessed?

If the response to these and other questions is positive, working outlines are prepared. Then, during the academic year, staff members then develop these outlines into more complete form. Staff use local class trials with cooperating schools to obtain initial feedback, then revise drafts for national trials. Questions at this stage include:

- Are the activities working as intended? If not, why not?
- Are the key concepts and process skills achieved?
- What material needs revision?
- Is the material scientifically accurate and free from bias?
- Can the materials, as written, be taught by other teachers?

Feedback from hundreds of teachers in a variety of urban, suburban, and rural school settings is gathered and analyzed to determine the suitability of the materials. From time to time a dead end is reached. Happily these are rare exceptions, as feedback from local trials is sufficient to determine the "readiness" of a draft set of materials.

The following diagram illustrates the major steps in the process. *Societal and environmental issues* are used to provide focus and motivation. Student activities involving materials and equipment are used to introduce *content through inquiry*. The SEPUP 4-2-1 model (groups of four students share common equipment while pairs work together; each keeps his own record) is one of many SEPUP *instructional design* elements. And the comments of hundreds of field test teachers and their students, are collected by the SEPUP staff (all of whom are former school science teachers) and analyzed in the context of what we know about best practices in teaching and learning.

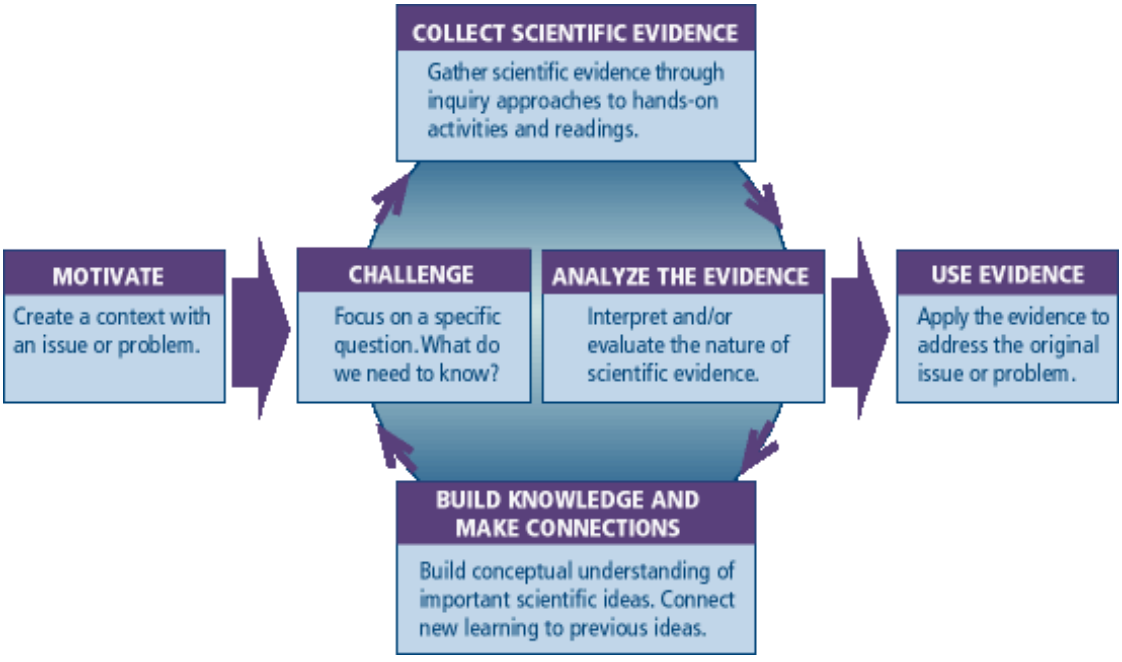

Figure 2. The SEPUP learning cycle.

For example, in the SEPUP module, *Investigating Groundwater, the Fruitvale Story*, students learn about earth science concepts—such as the movement of water through earth materials—in the context of an imaginary town that has discovered the groundwater used for drinking water has been contaminated with a pesticide. Students plot the concentration of a simulated pesticide in the groundwater by testing solutions from numbered bottles that represent local wells. By plotting their test results on an overview map of the town, students can determine the source of the pesticide and measure the extent of its spread. Finally, students role play a town meeting, where different options for cleanup up the spill are presented and debated—by other students using information they have learned in the module. Thus, students learn the difference between science and public policy.

SEPUP is not an add-on to a traditional fact-centered course that explores societal concerns only on alternating Fridays, nor does it attempt to foster student activism for a particular environmental cause. The goal of issue-oriented science is to develop student understanding of the science and problem solving processes without taking an advocacy position. The focal issues might be personal, such as deciding whether to use a paper or plastic bag; community-based, such as deciding where—or whether—to locate a new landfill; or international, such as evaluating an international policy on CFC use or evaluating the impact of GM technologies in food production or the impact of human activities on global climate change. SEPUP materials provide a model for science education reform that is flexible and responsive to local needs and appropriate for students of all ethnic, cultural, and socioeconomic backgrounds (see for example, http://www.sepuplhs.org/human_endeavor.html).

Development of full year course materials takes time. Most SEPUP full-year courses require two to four years, as many issues related to format, content, assessment, integration, and others must be sorted out and tested in the field before commercial copy is prepared for publication.

INQUIRY AND THE CLASSROOM LABORATORY

If the SEPUP instructional design model were a heart, issues would be atria and material-centered activities would be the ventricles. But seriously, it is through the manipulation of materials and equipment that students directly explore the issues and science in SEPUP. The print materials can have very little impact without the classroom kit. Forty years ago, only a small handful of school science programs were available with an equipment or materials kit; now it is hard to find one that does not offer some kind of kit option (Thier, 2000). And in an age of crowded classrooms and dwindling school budgets, science is increasingly taught in math and language arts classrooms—rooms not equipped to teach traditional laboratory science. So the nature of the student interaction of materials must be carefully planned.

What should teachers and students do in a laboratory? From a constructivist perspective, laboratory activities provide an opportunity for learners to interact with materials and ideas on an independent basis. Tamir and Lunetta (1978) noted that the main purpose of the laboratory curriculum of the 1960s was to promote student inquiry, independent thinking, and to develop observational and manipulative skills, not simply to verify or demonstrate science concepts or laws. Over time, however, they have tended to take the form of verification-type activities. These are sometimes called "cookbook" labs, because students complete the procedure step-by-step much as a cook would use a recipe (Stake and Easly, 1978; Tobin and Gallagher, 1987). As a result, lab activities

become far less powerful, and the potential for promoting intellectual development, problem-solving, and inquiry skills is reduced. Novak (1990) asserted that "…most students in laboratories gained little insight either regarding the key science concepts involved or toward the process of knowledge construction…" Most studies of classrooms have shown that current use of laboratory activities is routine, so that students do not have many opportunities for direct experience with phenomena.

The decision to involve students in a laboratory-type activity leads to many other decisions. Gallagher and Tobin (1987) have suggested several problems facing teachers, including coping with disruptive students; large class sizes; making sure students understand the task and their roles; teaching students to communicate effectively with their peers; teaching the necessary data acquisition and analysis skills; deciding how to group students; and others. They concluded that collaboration in the classroom is a skill most students must learn. And these findings directly influenced the role of laboratory-type activities in the program's design.

The SEPUP approach to laboratory-type activities has evolved over time. Our initial plan was to use a kit-based approach as our experience in schools suggested that very few schools had the necessary materials and equipment to support a lab-based program. Even the schools that did have materials available did not necessarily have a standard set of supplies we could take for granted. Also, the issue of time can be a significant one. Cleaning up from the previous class while setting up the lab activity for the next in a four-minute passing time can also be a problem. Finally, we wanted an approach that was safe and would produce minimal lab waste, as schools began to monitor disposal of these wastes more closely.

Fortunately, as the Lab-Aids company was our manufacturer, we were able to tap into their experience in these matters. Gradually, an approach developed with the following important features:

- Kits that supplied up to 160 students before consumable replacements were needed;
- Kits that featured no glassware (plastic only) or open flame for safety;
- Kit boxes with a molded plastic inner liner for storage and ease of use;
- Plastic dropping bottles for all solutions, for safety and to reduce waste

Instead of mixing hundreds of milliliters of solution in an Erlenmeyer flask or beaker, a few drops of solution could be mixed in a specially designed SEPUP tray. The tray is the "reaction vessel for many SEPUP labs, being the plastic equivalent of 5small beakers and 9 small test tubes, which could be quickly rinsed and dried for repeated use. Over time, specialty items such as filter funnel inserts to fit over the SEPUP tray's large cups meant that special lab equipment was not needed—almost any room with a sink would do. Eventually, Lab-Aids has worked with us to develop "signature items," such as a condenser unit for fractional distillation, for which a source of running water is not needed. The jacket is filled with crushed ice and water, and mixtures whose individual boiling points are 5-7 degrees apart can be separated easily.

Also early on, the SEPUP 4-2-1 model began to take shape. Students work in groups of four and share common items. Each pair of students shares a SEPUP tray, which promotes informal peer to peer conversation, thus providing a social context for school learning. Finally, each student keeps a

record of what takes place, which helps solve the problem of individual accountability in group learning situations.

Over time, SEPUP has tended to favor a "guided inquiry" approach. This approach mixes activities that are very "open-ended," with those featuring more direction for the student. In doing so, we attempt to walk a balanced path between the need to present content, as evidenced by the increasing use of "high stakes" testing programs in districts across the country, and our desire to foster authentic student learning and the development of higher level cognitive skills. This approach is consistent with the position articulated in the *National Science Education Standards*, which says "…Guided inquiry can best focus learning on the development of particular science concepts. More open inquiry will afford the best opportunities for cognitive development and scientific reasoning. Students should have opportunities to participate in all types of inquiries." (NRC, 2001, p.30).

With the development of the Next Generation Science Standards (NGSS Lead States, 2013), the role of science and engineering practices (SEP) has gathered even more attention. In developing performance expectations, the NGSS content and crosscutting concept statements are "in service" to the practices, as the performance statements all typically lead with the practice component, thus placing emphasis on what students are able to do, in order to show what they know.

ALTERNATIVE FRAMEWORKS

SEPUP design is based ultimately on an acceptance of the basic tenets of a constructivist approach, namely that students construct their own meaning from experience. In this view, what students already think is as important as what is presented to them in science class. At one time or another, researchers have described work in this area in terms of student misconceptions, alternative conceptions, erroneous ideas, naïve beliefs, preconceptions, multiple private versions, underlying sources of error, spontaneous beliefs, and others (Wandersee, 1994, p. 178). Regardless of name, one finding clearly emerges: that students' constructions about the world around them are remarkably resistant to change. That students do not generally modify their working hypotheses in light of new data—as a scientist would, for example—is to the author, one of the most significant challenges of teaching science to adolescents.

Wandersee (1994) has summarized the main findings of research in alternative frameworks:

- Students come to formal science instruction with a diverse set of alternative conceptions concerning natural objects and events.
- The alternative conceptions that learners bring to formal science instruction cut across age, ability, gender and cultural boundaries.
- Alternative conceptions are tenacious and resistant to extinction by conventional teaching strategies.
- Alternative conceptions often parallel explanations of natural phenomena offered by previous generations of scientists and philosophers.
- Teachers often subscribe to the same alternative conceptions as their students.
- Learners' prior knowledge interacts with knowledge presented informal instruction, resulting in a diverse set of unintended outcomes.
- Instructional approaches that facilitate conceptual change can be effective classroom tools.

SEPUP has responded to the challenge of alternative frameworks in several ways. We have a development staff consisting of experienced teachers, who not only are well-grounded in science content areas, they have many years of service in middle and high schools. Thus, they have the advantage of pedagogical content knowledge—the knowledge of what kinds of difficulty students are likely to have with particular topics—from density to groundwater movement—and can therefore design instructional experiences for students with this advance information in mind. Additionally, as the SEPUP development cycle is a long one, staff have the opportunity to debrief at length after local trials of the materials, and can redesign lesson sequences based on the reactions of local students. Finally, the national field trial stage involves feedback from hundreds of teachers, and the final commercial editions of SEPUP materials are only produced with direct participation of experienced teachers who have worked on the materials. For example, the initial field test of the *Fruitvale* module did not involve testing of well "water," as this was added later in response to teacher comments that it would strengthen the module, conceptually speaking.

PROBLEM SOLVING AND DECISION-MAKING

Decision-making based on evidence is a hallmark of the SEPUP approach. The link between decision-making and problem solving appears to be a strong one; some researchers have suggested that these are nearly overlapping domains and that it is merely a question of semantics. In the more recent literature, particularly, problem solving and decision-making have been generally described related, if not very similar, operations. Thus for SEPUP, the literature on problem solving is clearly relevant.

Research on problem solving has long been of interest to science educators. In the first issue of *Science Education* (then named the *General Science Quarterly*) John Dewey wrote "…the method of science—problem solving through reflective thinking—should be both the method and valued outcome of science instruction in American schools…" (as quoted in Champagne and Klopfer, 1977, p. 438). Other researchers (e.g., Simon, 1981) have noted a clear link between science and problem solving. Since about 50% of American students take no science beyond grade 10, what happens in the middle grades is arguably of critical importance.

Problem solving has been defined differently by researchers, a problem that leads to difficulty in looking for common ground. Often, researchers have described and categorized the process using terms such as scientific method, scientific thinking, inquiry skills and science processes. More specifically, Gagne (1970, pp. 260-66) noted the processes underlying the *Science—A Process Approach* (SAPA) program are equivalent to intellectual skills and can be categorized under the general terms of observing, classifying, measuring, using numbers, inferring, communicating, and others. Integrated processes include formulating hypotheses, defining operationally, manipulating variables, interpreting data, drawing conclusions, and experimenting. Gagne (1977, p. 155) notes that problem solving is not simply a matter of applying previously learned rules—it leads to new learning. Assessment of problem solving generally has evolved from evaluation of defined problem solving behaviors, to measurement of science process skills, to evaluation of integrated science processes.

It is generally well-accepted that experts tend to be better problem solvers than novices. Over the years, researchers have investigated the effect of different variables on problem solving. These include specific learner strategies, cognitive styles, reasoning abilities and cognitive development, and

instructional variables. Bowyer, Chen and Thier (1976) studied effects of a free choice environment on students' abilities to control variables, in a comparison study of the Science Curriculum Improvement Study (SCIS) materials, finding significant differences that favored the SCIS group. Quinn and George (1975) found that treatment groups did better than control groups in hypothesis formation, an important element of t he problem solving process. In a comparison study of earth science curriculum materials, Chiapetta and Russell (1982) found that experimental groups using a problem solving approach significantly outperformed the comparison group using a traditional textbook approach, and that the experimental teachers tended to ask higher-level questions as a general rule. And Butts and Jones (1966) found that inquiry training improves problem solving behaviors of sixth grade students, relative to a traditional textbook-using comparison group.

SEPUP curriculum developers have included problem solving/decision-making as an important element in their work. For example, in the IEY *Silver Oaks* scenario, the town of Silver Oaks has learned that mercury has been found in its drinking water, and must determine the source of contamination of its underground aquifer. Students test samples of simulated groundwater and plot their results on an overview map of the town. After the contaminated area has been identified, students role-play a town meeting where different clean up options are discussed and debated. In another example from SALI (*Maracondo Fever)* students use a board game scenario to investigate the spread of a deadly, infectious disease in a simulated Latin American town. Students work in teams to keep track of clues and observations, and must use their math skills to determine the most likely source of the problem.

So far, SEPUP has generally not put forth a normative decision-making model with prescribed steps, as other programs (e.g, Aikenhead, 1991). In the *Plastics* module, students do brainstorm characteristics of an ideal bag, and make decisions about their preferences and uses accordingly. However, most research on adolescent decision-making (see Koker 1996, pp. 99-125 for a summary) have concluded that adolescents rarely use normative approaches. Instead of listing options and outcomes, and attaching values and probabilities to each, a behavioral model is more often used, with emphasis on simplifying, transforming (and ignoring!) data, and heuristics. Students work through the problem solving/decision-making scenario as they go, using the tools they need and when they need them.

GOALS FOR THE SCIENCE CURRICULUM

As long as there are science teachers and students to fill their classrooms, the debate over appropriate goals for the science program will continue. These goals, in turn, affect science curricula and instructional techniques. The goals for the SEPUP program, developed in 1987, align strongly to those of the National Science Education Standards, developed some years later (SEPUP, 1995), a clear example of shared vision and values.

The goals of SEPUP are:

- To provide educational experiences focusing on science and technology and their interaction with people and the environment;

- To promote the use of scientific principles, processes, and evidence in public decision making
- To contribute to improving the quality of science education in America; and,
- To enhance the role of science teachers as educational leaders in the schools and in the community. (SEPUP, 1995).

Fair enough. But what science should be learned? And how should it be learned? These and related questions guided the SEPUP staff in their early deliberation over the program goals. Bybee and DeBoer (1994, pp. 358-359) have summarized research in this area. In their priority order, they are:

- Personal and social development;
- Knowledge of scientific facts and principles; and,
- Scientific methods and their application.

Emphasis is placed on the first goal, as they argue the most compelling reason for the study of science is the "effect it has on the development of individuals and influence it has on the well-being and improvement of society." In some programs, learning science facts is assumed as a basic element needing no justification, as it prepares future scientists, or is thought to lead to further intellectual development (a badly outdated concept!). Still, others emphasize the acquisition of fact-based knowledge in order to prepare students for external, high-stakes testing, for domestic or international competition. And scientific method has, as Bybee points out, unfortunately taken the form of teaching *a* method.

Bybee provides an excellent historical summary, including a discussion of European influences and detail of the seminal events of the past century, including the publication of the report of the Committee of Ten (National Education Association, 1893). This document gave institutional sanction to what were previously statements of educational goals made by individuals. By this time, science was being taught in schools, but did not have the secure standing of more traditional subjects. However, the more relevant history for SEPUP is the curriculum reform of the late 1960s, in which the goals of personal development/societal relevance assume a greater relative importance than in the 1950s/early 1960s. At this time, in what has come to be viewed as a reaction to the *Sputnik* launch, American school science programs focused on the teaching of science as needed to support the future development of a generation of scientists and engineers. The goals of contemporary reform centered on problems relating to the individual, the cities, and the environment (Bybee & DeBoer, 1994, p. 375). Since only 5% of students in a given classroom are likely to take a four year degree in science or mathematics, why teach the other 95% the same way?

Paul Hurd (1958) was one of the first to phrase goal statements in terms of "scientific literacy." Since science had gradually assumed a powerful force in our society, it was argued, it was hard to understand environmental policy and political and economic issues without some discussion of the relevant science. The STS movement developed in the 1970s, asking science educators to consider that "…for future citizens in a democracy, understanding the interrelationships of science, technology , and society may be as important as understanding the concepts and processes of science. An awareness of the interrelationships between science, technology, and society, and society may be a prerequisite to intelligent action on the part of a future electorate and their chosen leaders." (Gallagher, 1971, p. 337). And Hofstein and Yager (1982) argued that science curriculum

should be organized around social issues instead of the disciplines, paving the way for programs like SEPUP.

These days, however, it seems that the concern and debate over science program goals and outcomes has dissolved into a shouting match over high stakes testing. Indeed, it seems that President Bush's education program titled "No Child Left Behind" might be more accurately called "No Child Left Untested." And so, for SEPUP, the challenge is to continue developing issue-based materials as well as to gather evidence that its materials lead to measurable improvement on these high stakes tests.

TECHNOLOGY AND LITERACY

The role of technology in SEPUP has changed over the years. Initially, the program did not incorporate much technology into its programs; more recent efforts clearly indicate the desire to use technology more effectively in its materials. The first applications of technology to SEPUP materials were field-based. In 1990, teachers in the Winston-Salem, NC, area used illustration software to record student results to the *Fruitvale* module. The use of light probeware to read particulate matter trapped on filters was explored in 1991 in an early module on air pollution (the module was not released).

With the development of the *SALI* and *Science and Sustainability* (*S&S*) programs, beginning in 1995 and continuing to the present, SEPUP materials began to feature technology tools and applications. For example, efforts were made to link content from existing web sites to specific SEPUP activities. SEPUP maintains the links to these websites, which are accessed through the SEPUP home page. Students can also post data on a number of SALI and S&S activities directly to the SEPUP web sites and can therefore share data with students across the country. Software simulations, such as Genscope®, STELLA, Oh Deer!, and videotape materials are integrated into the student lessons. By arrangement with Northwestern University, an interactive software portfolio program, Progress Portfolio, was adapted for use with the S&S program. Currently available for the Macintosh platform only, the program combines screen capture utilities with word processing and layout functions to allow students to produce a comprehensive, electronic portfolio of their choosing. Teachers and students can post comments via electronic notes.

From modest beginnings in the early programs, current SEPUP core programs have developed more robust support for technology. The 3rd edition (NGSS) middle level and 2nd edition high school program materials (like SGI Biology) use a variety of online simulations for students to investigate such diverse science concepts like cell division, movement of tectonic plates, and motion and forces. In addition, links to third party web content have been integrated into middle and high school programs (e.g., http://sepuplhs.org/middle/third-edition/index.html).

Efforts to integrate literacy and communication skills into SEPUP materials began in earnest in the early 2000s. *SALI. S&S*, and the revised modules incorporate strategies for literacy at some level, largely through the efforts of Marlene Their. "Literacy," as used by educators, can have many meanings. Sometimes it refers to English language literacy-the ability to comprehend written material, express one's ideas in writing, and understand and respond to oral communication. Another common use of the word literacy is as part of a phrase (e.g., "scientific literacy") which refers to knowledge or competence in a particular field such as science. Without language literacy,

there cannot be scientific literacy because language is the tool by which students articulate and explain science facts and ideas to each other, to teachers, to parents and to themselves.

Literacy skills strengthen science learning by giving students the lens of language through which to clarify their ideas, conclusions, inferences, and procedures. By integrating those groups of skills, teachers can improve students' abilities and raise achievement levels in both areas, and do so more effectively and efficiently than if the two skill areas are taught separately. Just as language clarifies and communicates the meaning of science, science can strengthen the meanings that students find in language studies. Good science and effective teaching and learning in science are dependent upon strong language skills. "In an age fueled by information and driven by technology, understanding the concepts and processes of science is as indispensable as knowing how to read, write, speak, and listen. As citizens and as workers, tomorrow's adults will need to effectively apply a range of scientific skills and knowledge to understand their world and communicate about it" (Thier and Daviss, 2002).

Many of the literacy strategies in SEPUP units and modules help teachers explore students' thinking and give students multiple opportunities to confront their preconceptions. Anticipation Guides, KWLs, Talking Drawings, and Teacher Edition questions elicit students' ideas about a topic before a reading or series of activities and then allow students to look at those ideas later and analyze how their thinking has changed. Another strategy that is built into SEPUP programs is keeping a science notebook. When using a science notebook, students are often asked to record their initial thinking about a topic, their observations and data collected during an activity, and their reflections after an activity.

IMPACT RESEARCH

Over the years, a variety of external and internal studies have attempted to determine the impact of SEPUP on teachers and students. For space reasons, only a few recent impact studies will be cited here; for more information, please see *http://sepuplhs.org/research.html* and https://lab-aids.com/evidence-impact.

SEPUP began developing science instructional materials with funding from the National Science Foundation (NSF) in 1987. Twenty years of research and evaluation show that the use of SEPUP programs:

- increased students' interest in science and perception of its relevance to their lives; lead to meaningful gains in student performance; and,
- improved students' content knowledge and ability to engage in scientific practices.

SEPUP has also been highlighted in several influential publications. In his book Redesigning Education, Kenneth G. Wilson (1994) calls SEPUP "…one of the best American examples of educational design" (p.205). Wilson, a Nobel-prize winner in physics and the former director of Project Discovery (a 5-year federally funded project to restructure K-12 mathematics and science in Ohio), has written extensively on school reform, noting that "…the [SEPUP] program develops its [materials] through a small scale version of the redesign process, from tracking basic research in education and testing prototypes in real classrooms to integrating innovations and mentoring teachers…" (p. 205).

As part of a 3-year research project at the University of Arizona, Stanley Pogrow (1993) reviewed and ranked middle school materials to identify those that were the most "creative, relevant, and rigorous." SEPUP materials were cited as exemplary and fulfilled his criteria that curriculum: 1) relate science content to issues of concern to students; 2) support a reflective, Socratic approach; 3) develop thinking skills; and 4) present content in a rigorous fashion.

The National Science Foundation Division of Elementary, Secondary, and Informal Education used more than 40 specific criteria to review NSF-funded middle level materials. In addition to questions relating to content, the reviewers asked whether the materials "push teachers to teach differently" and "provide students the opportunity to make conjectures, gather evidence, and develop arguments to support, reject, and revise their explanations for natural phenomena" (Lewis, 1996).

The examining committee recommended both SEPUP modular and full-year comprehensive programs as materials that meet these criteria, noting that "the materials are engaging, provide good activities for student decision-making and opportunities for student-designed inquiry." (NSF, 1997). SEPUP instructional materials utilize a research-based assessment system that was developed in cooperation with the University of California, Graduate School of Education. This system is recognized as "an excellent assessment component" of SEPUP materials in the NSF study cited above (NSF, 1997). In *Classroom Assessment and the National Science Education Standards* (National Research Council, 2001), the SEPUP assessment system is presented as a strong example of a system that can be used for both formative and summative assessment. Materials included in a SEPUP Teacher's Guide, such as scoring guides (or rubrics), are reproduced in the book for general use.

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In addition to showing greater gains in content knowledge, several studies suggest that SEPUP students also improve more than comparable non-SEPUP students in a variety of specific skills. For example, Koker (1996) examined students' decision-making skills and found differences in student responses that generally favored SEPUP students over non-SEPUP students. He also found that SEPUP students were more likely to approach problems with empirical methods (e.g., doing tests, gathering evidence) rather than non-empirical ones (e.g., using "conventional wisdom" or rhetoric). Furthermore, Samson and Wilson (1996) found that compared to non-SEPUP students, SEPUP students not only performed better in problem-solving situations that called for scientific evidence but they also believed that science was more relevant to their lives. Use of SEPUP materials benefits all students, not just those who plan to major in science or pursue science-related careers.

What follows are short summaries of impact studies or empirical data to support the efficacy of SEPUP materials. Some of these are foundational studies, others are much more recent. They are listed in rough chronological order of publication date.

In 1995, the Los Angeles Unified School District (LAUSD) started implementing a two year high school sequence of Integrated/Coordinated Science (ICS) classes that were substantially based on Science and Sustainability. The ICS students showed significant gains on the SAT9 (Stanford Achievement Test) science test (Scott, 2000). The SAT9 is a norm-referenced assessment that includes a science subtest designed to assess knowledge from life, physical, and earth and space sciences.

The results of the LAUSD study of ICS also showed higher numbers of students, and in particular underrepresented minority students, enrolling in advanced science courses after taking ICS (which contained the Science and Sustainability program from SEPUP). The table below shows the percentage of students who chose to take an additional (third) year of science beyond the two required by LAUSD. For each of the ethnic groups that are in shown in the table, the percentage of students enrolling in an additional science course is much higher in the ICS group that used Science and Sustainability than those who took the traditional first two years of science (Advanced Physical Science and chemistry).

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A study by Wilson and Sloane (2000) measured the progress of three different groups of middle school science students over the course of a year. The comparison group of students did not use SEPUP while the other two groups used Issues, Evidence and You (IEY). The PDC group used IEY without the assessment system whereas the ADC group used the assessment system. Group comparisons were made using a pretest/posttest comparison. The ADC group was evaluated at the end of each unit. The other two groups were evaluated at the beginning and end of the course. In total 63 teachers were involved in the study (26 ADC teachers, 25 PDC teachers, and 12 comparison teachers). The researchers concluded that the results for the comparison group were equivalent to a student moving from the 50th to the 59th percentile over the course of a year. The gain for the ADC group is equivalent to the mean student moving from the 50th percentile to the 77th percentile over the same time period. This is a gain of 3.46 times greater than the comparison group. The researchers concluded that this was "an educationally significant change, marking the difference between a student who typically achieves partial success, and one who achieves satisfactory completion about half the time." (Wilson & Sloane, 2000).

Reliability estimates for the pre/post –test measures ranged from 0.73 to 0.82. Effect size was calculated using Cohen's d where a small effect size is .20 to .50; a medium effect size is .50 to .80, and a large effect size is greater than 0.80. As shown in the table above the effect sizes varied from .48 to .80 indicating moderate effect sizes for most units. The conclusion of the evaluator was that the results showed consistent evidence of the effectiveness of the curriculum.

Comprehensive, longitudinal data in CPS is very difficult to come by, but there is some historical evidence from the field that this approach works. The main measure of student academic improvement is related to the annual Illinois State Achievement Test for Science (ISAT), which has not been used for some time as the state moves to full adoption of NGSS reforms According to Jeanette Bartley (jeanettebartley@utepchicago.org), former CPS K-8 Science Manager, district-wide performance (% students scoring proficient or better) on the Illinois State Achievement Test (ISAT) increased from 47.6 in 2003 to 60.6 in 2006 (Source: Chicago Public Schools).

Building on this work, according to Wendy Jackson (wendy.jackson@berkeley.edu), former CPS 6-8 Science Coordinator and currently Director of School Science Programs for DePaul (Chicago) University, in 2009, CPS increased support for middle level science access to high quality instructional materials, and sustained, coherent professional development on those materials. A cadre of professional development leaders was created by the district and supported by Lab-Aids, resulting in a jump in state test scores for middle grade science by 5.6 points in 2009, the largest gain for any grade and subject that year.

Professor John Settlage and colleagues at the University of Connecticut have been studying science achievement in grades 5 and 8 with funding from the National Science Foundation (grant #1119349).. Stamford, Connecticut has implemented multiple SEPUP units in grades 6-8, beginning in 2008. Since this time we have worked with the district to provide ongoing professional development and are continuing to support their efforts to address the NGSS. The district reported a 10% gain in CMT 8th grade results between 2008 and 2012. The district correlates this increase with the implementation of the hands-on, inquiry based SEPUP approach. External evaluation studies done by the University of Connecticut have shown strong, positive educational outcomes associated with regular SEPUP use.

The Maine Physical Science Partnership, a NSF project led by the Research in STEM Education (RISE) Center at the University of Maine, showed that SEPUP students outperformed their non-SEPUP peers in tests measuring physical science/chemistry content knowledge. The same study documented the improvement in content knowledge and pedagogical skills in teaching chemistry (Somnath Sihna, University of Maine, Orono, 2014 somnath.sinha@maine.edu). Teachers' understandings of using evidence and reasoning to support claims increased as a result of participating in the RISE project that featured the use of SEPUP materials.

Additional student gains by SEPUP students as compared to their non-SEPUP peers have been documented by research faculty at Loyola University of Chicago (Renn, D., Shefner, R., Holmes, K., Wenzel, S., Osthoff, E. *Meeting the Evidentiary Needs of School-University Co-Researchers Implementing the Next Generation Science Standards*. Paper presented at the American Educational Research Association conference in 2018, New York, NY.)

ASSESSMENT

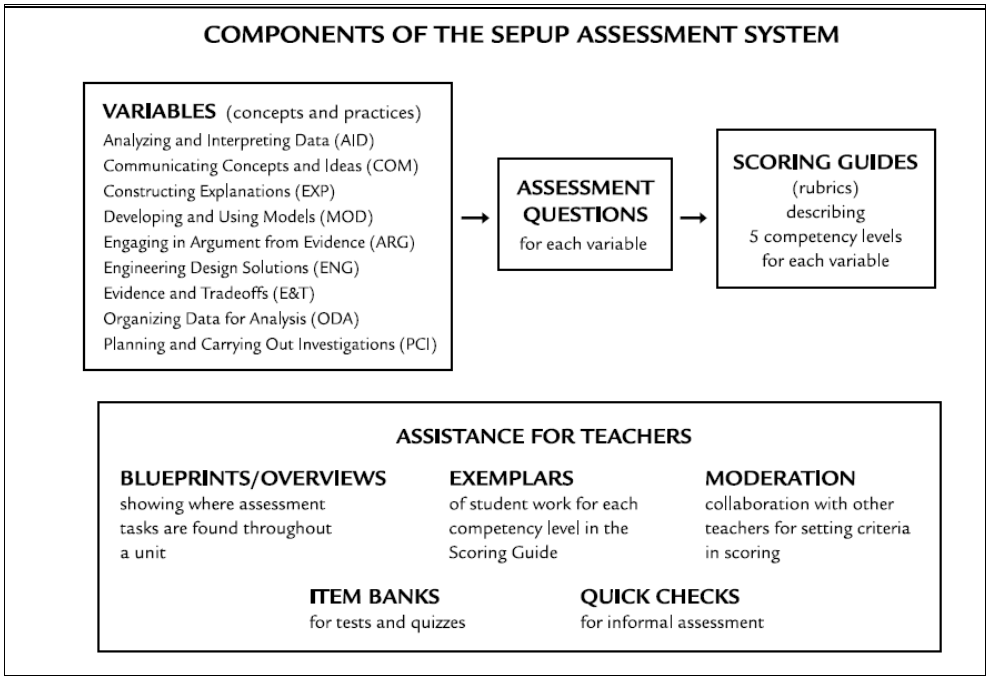
SEPUP materials include a research-based assessment system based on a system first developed by the Berkeley Evaluation and Assessment Research Group (BEAR) at the University of California, Graduate School of Education, working closely with SEPUP. Studies show that students in classrooms where the SEPUP Assessment System was used as part of a yearlong SEPUP middle school course scored better on post-assessments than did students in classrooms where this assessment system was not used (Wilson & Sloane, 2000). In *Classroom Assessment and the National*

Science Education Standards (National Research Council, 2001), the SEPUP assessment system is presented as a strong example of a system that can be used for both formative and summative assessment.

The assessment system used in the NGSS edition includes assessments that are designed to support classroom instruction and a series of indicators to monitor that the students are provided with adequate opportunity to learn science in the ways laid out in the Framework and the NGSS. As part of the process of revision to develop this third edition, additional assessment variables have been developed to capture several of the NGSS practices. These assessments provide support for the instructional shifts in practice embedded in the NGSS, and all SEPUP units feature the following:

- Support for pre-assessments, and formative and summative assessment practices
- Support for teachers to implement the system, including rubrics, blueprints, exemplars and samples of student work
- Support for students to self-monitor and assess their own performance

Using the SEPUP assessment system, students complete tasks, producing student work that can be scored using rubrics developed for each of the practices of the NGSS, including Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Arguing from Evidence, Communicating Concepts and Ideas, and more. The assessment opportunities are distributed over time, allowing teachers to monitor student progress.



Forming the core of the SEPUP Assessment System are assessment variables (concepts and practices to be assessed), assessment questions or tasks used to gather evidence, and Scoring Guides for interpreting students' responses. The diagram below shows the key components. The nine assessment variables, listed in the first box, define the NGSS concepts and practices that students

are expected to learn. Each of these variables is complemented by a Scoring Guide with which to measure students' achievements according to five competency levels.

The SEPUP Scoring Guides are formatted as holistic scoring rubrics. However, they are easily converted to analytic scoring guides by adding criteria specific to each embedded assessment question. The nine Scoring Guides are used from unit to unit of Issues and Science for teachers to closely monitor students' growth and encourage their progression from novice to expert on each variable.

The assessment system used in the NGSS edition includes assessments that are designed to support classroom instruction and a series of indicators to monitor that the students are provided with adequate opportunity to learn science in the ways laid out in the Framework and the NGSS. Using the SEPUP formative assessment system, students complete tasks, producing student work that can be scored using rubrics developed for each of the practices of the NGSS, including Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Arguing from Evidence, Communicating Concepts and Ideas, and more. The assessment opportunities are distributed over time, allowing teachers to monitor student progress.

The Quick Checks and some of the embedded assessments work best for formative purposes. This is the case whenever an embedded assessment appears before students have had sufficient opportunity to master a concept. Any analysis item and many of the literacy strategies may also be used for formative assessment. For example, when students complete a literacy strategy, such as an Anticipation Guide, Concept Map, or Talking Drawing, the teacher should review students' work to see what they already know. Students are also encouraged though various strategies to share ideas with each other. Peer review of ideas is facilitated by the teacher and student in a variety of activity types.

More specifically, most units and activities within units in SEPUP feature embedded opportunities for calling out student preconceptions and for using formative strategies for uncovering them. For example, in the *Weather and Climate* unit, which has a focus on understanding the science behind climate change, the initial activity (Activity 1, "Climate Change", Student Book pages 3-6, TE3-16) opens with a opportunities for the teacher to use formative assessment practices to better understand student ideas and beliefs about climate change. This is followed up throughout the unit as students learn more about the science behind climate change.

In Activity 1 of the SEPUP unit *Land, Water, and Human Interactions* (Student Book pages 3-7, TE3-18), students examine their preconceptions around the effects of human activities on land and water quality, using a KWL chart to collect and analyze their initial ideas, and return later in Activity 16 (Student Book pp. 245-253, TE pages) to review how these have changed over the unit. In the Energy unit, Activity 1, "Home Energy Use" (SB , TE6-13,-teachers elicit student ideas about energy and energy efficiency using an Anticipation Guide literacy sheet (Student Sheet 1, TE B15). Most units use formative assessment strategies in this way, but their use is not confined to initial activities.

An item bank can also be used as a summative check for student understanding. Copies of item banks for each unit can be found in the Teacher Resource book section IV, Unit-Specific Resources. Each item bank includes a table mapping individual assessment item to specific elements of the

NGSS: DCI, SEP, and CCC. The item banks for each unit contain questions in a format similar to the state or district tests that many students take. Some teachers use the item banks for pre- and post-assessments for each unit of SEPUP as a way to measure students' growth. The questions also provide supplementary assessment opportunities. The item banks focus on key content and process skills in the unit and include multiple-choice questions, short-answer questions, and questions requiring an extended response that can be scored with a Scoring Guide.

RELATIONSHIP WITH LAB-AIDS

It is hard to imagine SEPUP without Lab-Aids. The SEPUP/Lab-Aids relationship is one of very long standing -- Herb Thier, SEPUP Founding Director, and Mort Frank, Lab-Aids Founding President (now deceased) were fraternity brothers at college, which is a long-standing relationship by anyone's definition. Lab-Aids has been the exclusive manufacturer and publisher of all SEPUP products since 1987.[4] Although from 1987-1999, SEPUP was distributed by various vendors, since 1999, the product line has been truly "under one roof," as the design, manufacturing, marketing, distribution, and customer service are all now handled directly by Lab-Aids.

From its offices and manufacturing facilities in Ronkonkoma, Long Island, Lab-Aids has provided science kits for general secondary use since 1963. The company manufactures over 200 different kits to support instruction in all STEM fields and makes these available to teachers through a national network of distributors. Privately held, the company employs more than 45 persons on a full and part-time basis, and oversees all aspects of kit production, from initial design to finished product. In addition to its regular line, the company also produces special order performance-based testing materials for a variety of outside agencies.[5] Lab-Aids publishes materials from SEPUP as well as from the Education Development Center in Waltham, MA, and the Ergopedia group in Cambridge, MA, among others. For more information, visit www.lab-aids.com.

Lab-Aids has consistently supported SEPUP development.[6] From its initial provision of field test modules beginning in 1988, and continuing with their major partnership with NSF in the module revision project (funded by NSF, see 3.2, below), , the company provides the needed in-kind fiscal, technical, and human resource support to make sure SEPUP materials meet or exceed teacher expectations for the product. This support is provided from initial design concept to final kit production, and can take many forms—from consulting help on solution formulation from the chemistry department, to the design of signature apparatus with the help of key production staff.[7] The relationship is a strong one, and is expected to continue far into the future.

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[4] While Lab-Aids has always produced the kit materials and final packaging for all SEPUP products, from 1988-1994, print materials for the secondary supplementary modules were published by Addison-Wesley. However, since 1995, all SEPUP print and kit materials have been produced by Lab-Aids.

[5] For example, the company has produced all kits for the performance-based items for the California Golden State Exam (GSE) for the past five years, over 120,000 kits/year.

[6] The company in-kind support of SEUP module revision project (ESI-9730606) is estimated at $450,000. Similar support has been provided for previous projects.

[7] Some of the unique designs for SEPUP products include the SEPUP tray itself; a condenser that does not require running water for fractional distillation; calorimeters which can be configured with a variety of insulating materials; wet cell apparatus that can be easily manipulated by students to investigate the effect of varying electrode composition, coverage, and placement; passive and active solar collectors; and a variety of specialty print pieces, including elaborate simulation board games and single use comparison charts and cards.

In addition to support for SEPUP publishing, sales, marketing, distribution, and customer service, Lab-Aids handles the bulk of all professional development for teachers who use the SEPUP materials, in single or multi-day workshops. The company retains the services of more than 50 national consultants for this purpose and also offers online training support at http://lab-aids.com/professional-development.

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Appendix A

Summary of SEPUP Instructional and Teacher Enhancement Efforts

1. Elementary instructional programs

CHEM and CHEM-2 (1988-91; 1993-96) These two programs were supported by grants from the Exxon Education Foundation. CHEM-2 is the revision of the original CHEM (Chemicals, Health, Environment and Me) program. Designed for use in grades 4 - 6, CHEM-2 contains fifteen supplementary units, each containing activity-based, material-centered experiences for students to learn about the science behind current issues related to chemical use, their personal health, and the environment. Topics include everyday chemicals, food additives, hazardous substances in the home, the health effects of smoking, solid waste disposal, pharmacology, and others. The CHEM-2 kit contains all the equipment needed for a class of 32 plus a teacher's guide containing detailed lesson plans, student sheet masters, glossary, and an additional emphasis on integrating the CHEM units with other subjects and on developing higher level critical-thinking skills.

2. Secondary instructional programs

SEPUP Modules (MDR-8751532, 1983-1995; and ESI-9730606, 7/1/98-6/30/03). This program consists of twelve individual modules, designed for general use in grades 7-12, with each title requiring two to four weeks for completion. Each module includes a spiral-bound teachers guide containing lesson plans, masters for student sheets and overhead transparencies, glossary, assessment, and solution prep pages. Complete kits are available for each title; each kit supports up to 160 students before refills are needed. Topics include groundwater pollution, chemistry of food additives, toxic waste disposal, environmental health risks, and others.

SEPUP Middle Level Programs (ESI-9553877, 4/1/96-3/31/01; ESI-9252906, 10/15-92-9/30/00; need Science and Earth Issues, and start date). The middle level comprehensive programs consist of *Science and Life Issues (SALI) and Issues, Evidence, and You (IEY)*. Each provides print materials and an equipment kit for up to 160 students (5 classes x 32 students each class). Each is available in complete form, or as "mega-modules," covering approximately nine weeks of study. The middle level programs provide complimentary, integrated coverage of the life and physical sciences. SALI units include: studying people scientifically, human body systems, cells and cell biology, genetics, ecology and evolution. IEY units include water quality and use, materials science, energy, and environmental impact. Science and Earth Issues (working title) seeks to develop issue-oriented learning experiences from the earth and physical science domains. Formal work began in 2001-02 with limited local trials in Spring and Fall, 2002. Schedule national field test is for 2002-03. All programs feature an authentic, embedded assessment, developed in tandem with the instructional sequences.

SEPUP High School Programs (ESI-9252906; 10/15/92-9/30/00 and ESI-0352453, NSF 3/1/04-2/28/09). Designed as an integrated high school environmental science course, the course, *Science and Sustainability*, can be also used to fulfill third-year graduation requirements for non-

majors. Topics from the life, earth, and physical sciences are used to develop student understanding of major issues related to sustainability. Major unit titles include: Living on Earth; Feeding the World; Using Earth's Resources; and, "Fueling the World." A Companion book, the *Material World* (Sierra Club Press) helps to develop student understanding of sustainability. Complete material kits are available; strong links to technology are embedded in the program.

Science and Global Issues (ESI - 0352453). This is for a series of two programs, the SGI: Biology and SGI: Physical Science, which use the issue-oriented approach for high school courses. The SGI Biology program was finished in 2012, and consists of five units: Sustainability, Ecology, Cell Biology, Genetics, and Evolution. The SGI Physical Science is in development and consists of four units, two each with content from chemistry and physics: Electricity, Earth's Resources, Waves, and Fueling the World.

3. Teacher enhancement programs

Teaching Issue-Oriented Science (TPE-9055424; 4/1/91 – 5/31/95). A multiyear effort to develop leadership among teachers using the SEPUP modules, the grant supported the attendance of SEPUP teachers at week-long summer conferences in Berkeley (with mid year follow up), where they would receive instruction in topics such as enhanced use of SEPUP materials, including follow up, assessment, non-traditional settings, and local implementation. Teams were selected so as to provide outreach to neighboring districts upon their return.

Issue-Oriented Elementary Science Teacher Leadership (ESI-9554163; 4/1/96– 6/30/01). A multiyear effort to develop leadership among participating elementary, the grant supported the attendance of participating teachers at three-week summer conferences in Berkeley (with mid year follow up), where they would receive instruction in topics such as using science to address literacy-related goals, alternative assessment strategies, and local implementation of exemplary curricula, such as CHEM, which was distributed after local matching grants were obtained. Teams were selected so as to provide outreach to their own and neighboring districts upon their return.

Elementary Science Teacher Leadership (2/1/97 – 1/31/02). With support from the Exxon Education Foundation, ESTL aims to develop strategies and materials for developing elementary science teacher leadership by working with local colleges and universities involved in teacher preparation. Proposing a multi-year model that advocates a much closer relationship than now exists between master and student teachers, the program has developed a series of monographs on such topics as literacy, the nature of science, assessment, and others.

Appendix B

Current and Former SEPUP Staff

Dr.Herbert D. Thier, Founding Program Director
Dr. Barbara Nagle, SEPUP Director*
John Howarth, SEPUP Associate Director*
Lee Amoslee, Instructional Materials Developer
Janet Bellantoni, Instructional Materials Developer*
Manisha Hariani, Instructional Materials Developer*
Asher Davison, Instructional Materials Developer
Sara Dumbkowski, Instructional Materials Developer
Kate Haber, Instructional Materials Developer
Paul Hynds, Instructional Materials Developer
Laura Kretschmar, Instructional Materials Developer
Daniel Seaver, Instructional Materials Developer
Dr.Marcelle Siegel, Instructional Materials Developer
Marlene Thier, Teacher Education and CHEM Coordinator
Chris Keller, Instructional Materials Developer*
Dr. Peter Kelly, Research Associate (England)
Dr. Mark Koker, SEPUP Assistant Director
Donna Markey, Instructional Materials Developer
Linda Mead McFall, Instructional Materials Developer
Dr. Magda Medir, Research Associate (Spain)
Mike Reeske, Development Associate
Jenny Garcia de Osuna, Graduate Student Researcher
Thanh Le, Graduate Student Researcher
Miriam Shein, Publications Coordinator
Roberta Smith, Administrative Coordinator
Maia Willcox, Instructional Materials Developer*
Donna Anderson, Administrative Assistant

*Active as of January 2015

Bios for current staff (active January 2015)

Barbara Nagle, Director
Barbara has contributed to numerous NSF-funded SEPUP curriculum modules and units as an author and project coordinator. Currently, she serves as the Director of SEPUP. Her published products, developed in collaboration with the SEPUP team, include a high school course titled *Science & Sustainability* and a complete middle school science series: *Issues and Earth Science*, *Issues and Life Science*, and *Issues and Physical Science*. Barbara is currently Project Director for the NSF-funded *Science & Global Issues* project, which is developing and publishing a two-year integrated high school science program. She also directs the Hydrogen Technology and Energy Curriculum (HyTEC), a project funded by the Department of Energy that is developing a

high school curriculum titled, *Investigating Alternative Energy: Hydrogen & Fuel Cells*. Barbara has a bachelor's degree in molecular biology from Wellesley College and a Ph.D. in cell biology from the University of Pennsylvania. She conducted postdoctoral research on cell division and cell motility at UC Berkeley. Her scientific research and publications focused on the regulation of cell division and cellular motility in a variety of systems, including cultured cells and sea urchin embryos. Before joining SEPUP, Barbara taught high school chemistry in Oakland, CA and college level biology courses at the University of Pennsylvania and UC Berkeley.

John Howarth, Associate Director
Joining SEPUP in April 2008, John Howarth is currently the Associate Director. A 1995 recipient of the Presidential Award for Excellence in Science and Mathematics Teaching, John has twenty-five years experience teaching secondary science and eight years as Science Curriculum Supervisor and Executive Director for Curriculum and Instruction for the Grand Rapids Public Schools in Grand Rapids, Michigan. John successfully introduced inquiry-based science programs in grades K-12 in schools in both Michigan and Wyoming. Prior to teaching in the United States, he used an inquiry approach to teach science in secondary schools and colleges in Malaysia, Singapore, and Brunei. He also has a long history of using technology in science education and was recognized as the IBM Teacher of the Year for Wyoming in 1992 and as Technology and Learning magazine's Teacher of the Year for the Rocky Mountain and Pacific Northwest region in 1995. John received his bachelor's degree in biochemistry and postgraduate certificate in education, specializing in the teaching of physics and applied science, from the University of Liverpool in the United Kingdom and master's degree in educational leadership from Western Michigan University.

Janet Bellantoni, Curriculum and Professional Development Specialist
Since joining SEPUP in 2001, Janet has served a variety of curriculum development roles. She served as the Project Coordinator and one of the main developers of *Issues and Earth Science*, a middle school earth science course. Janet revised the "Energy" unit and developed the "Force and Motion" unit for *Issues and Physical Science*, a middle school physical science course. Along with other members of the SEPUP team, she is currently creating the physics units for *Science & Global Issues*, SEPUP's new high school course. She is also a coauthor for that course's introductory unit, "Sustainability." Janet served for seven years as a high school physics teacher and as a Dean of Students in public and private schools in Massachusetts, New York, and California. She has a bachelor's degree in mechanical engineering from the University of Rochester and a master's degree in science education from the University of Massachusetts Amherst, and graduate studies in deaf education at Gallaudet University.

Chris Keller, Curriculum and Web Specialist
In early 2008, Chris had the pleasure of joining SEPUP as a curriculum developer, working on the development and field test of *Science & Global Issues* and the *Investigating Alternative Energy: Hydrogen & Fuel Cells* curriculum (formally known as "HyTEC"). Chris holds a bachelor's degree in physics from UC Berkeley and a master's degree in physics (with an emphasis in physics education research) from the University of Colorado at Boulder. While at Boulder, Chris worked in the Physics Education Research Group at Colorado (PER@C) studying the effectiveness of physics-based computer simulations (created by the PhET project) in various introductory college environments. In addition to conducting research and being a teaching assistant for 2 years, he served as the Lead Graduate Teacher for the physics department,

mentoring new graduate teaching assistants. Chris then went on to work jointly with PER@C and i>clicker (a manufacturer of classroom response devices, commonly known as "clickers") studying the use of clickers to determine how they can be used more effectively in college lecture environments.

Maia Willcox, Curriculum and Professional Development Specialist
Maia joined the SEPUP team as a curriculum developer in 2007, focusing primarily on the development, field testing, and production of the *Science & Global Issues* curriculum. Maia holds a bachelor's degree in integrative biology from UC Berkeley, a master's degree in animal sciences from the University of Hawaii at Manoa, and a teaching credential in secondary life science from San Francisco State University with a CLAD certification from Stanford University. Maia began her career in education teaching high school in San Francisco Unified School District (SFUSD), where she taught biology, marine science, health education, reading skills for English Language Learners, and integrated science. She also served as the Science Department Chair at Balboa High School before moving on to work as the middle and high school Science Content Specialist for SFUSD. In this position, Maia was responsible for developing and executing professional development workshops for all of the district's middle and high school science teachers.