

Summary of SEPUP-related Research

Introduction to SEPUP

SEPUP began in 1983 as a not-for-profit project to develop hands-on materials about chemicals and their use for schools and community groups. It was initially called CEPUP (Chemical Understanding for Public Understanding Program). In 1987 CEPUP received its first funding from the National Science Foundation (NSF) to develop twelve issue-oriented modules on topics such as water pollution, household chemicals, and food additives.

As the mission of the project expanded to include other scientific disciplines and the development of year-long courses for the secondary grades, the name of the project changed to SEPUP (Science Education for Public Understanding Program). The NSF is currently the primary funding source for SEPUP curriculum materials development. SEPUP is located at The Lawrence Hall of Science at the University of California at Berkeley.

SEPUP programs have been revised and expanded over the years and this has sometimes involved a name change. The following table summarizes how the names of SEPUP's full year programs have evolved.

| Name of program | Acronym | Publication date | Grades | Note |
|-----------------------------|---------|------------------|--------|---------------|
| Issues, Evidence, and You | IEY | 1996 | 6 – 8 | Revised 2003 |
| Science and Life Issues | SALI | 2001 | 6 – 8 | |
| Science and Sustainability | S&S | 2005 | 9 – 12 | |
| Issues and Earth Science | IAES | 2006 | 6 – 8 | |
| Issues and Physical Science | IAPS | 2007 | 6 – 8 | Replaced IEY |
| Issues and Life Science | IALS | 2009 | 6 – 8 | Replaced SALI |
| Science and Global Issues | SGI | 2010 | 9 – 12 | Expands S&S |

In this summary, reference is made to both recent and early versions of various programs and occasionally to individual SEPUP modules.

All SEPUP materials are developed using an iterative process, which involves development, piloting, and field-testing phases. Data and feedback are collected during piloting and field-testing. These data are used to inform the revisions to the program. The core components of SEPUP curriculum materials have remained the same since the inception of the program. These include:

- An instructional model
- Inquiry-based instructional strategies
- Issue-oriented science
- Strategies geared to students' learning styles
- Balance of individual and cooperative learning
- Spiraling of important concepts and skills
- Assessment system

Research findings on SEPUP

The results of 20 years of research on the SEPUP program indicates the following:

- Positive effects on student learning in the following areas:
 - Content knowledge
 - Problem-solving
 - Decision-making
 - Investigation skills
- Increased interest in science, and increased perception of the relevance of science to students' lives

In addition, research indicates that SEPUP materials can be used as a powerful professional development tool.

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).

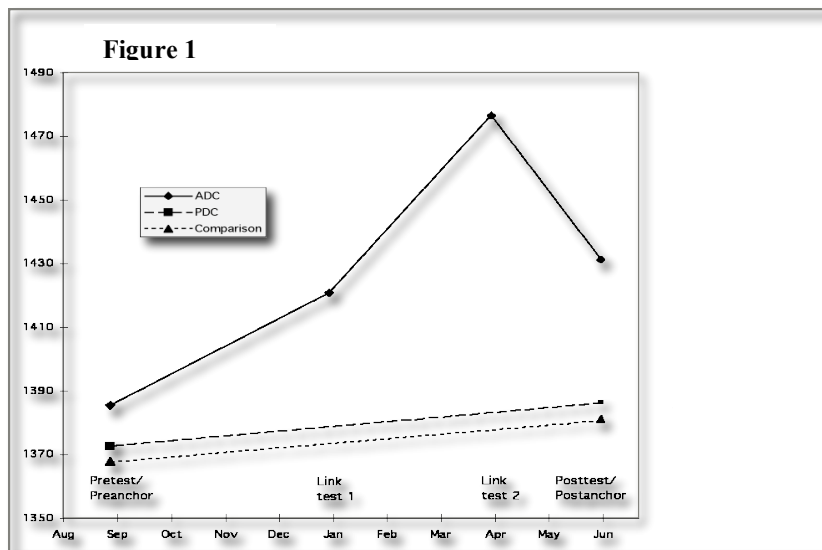
SEPUP instructional materials utilize a research-based assessment system that was developed in cooperation with the University of California Graduate School of Education. This system is recognized as "an excellent assessment component" of SEPUP materials in the NSF study cited above (NSF, 1997). In *Classroom 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.

Positive effects on student learning

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.

The results of the study are shown in Figure 1. 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 data represent mean scores for the three groups of students. 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)

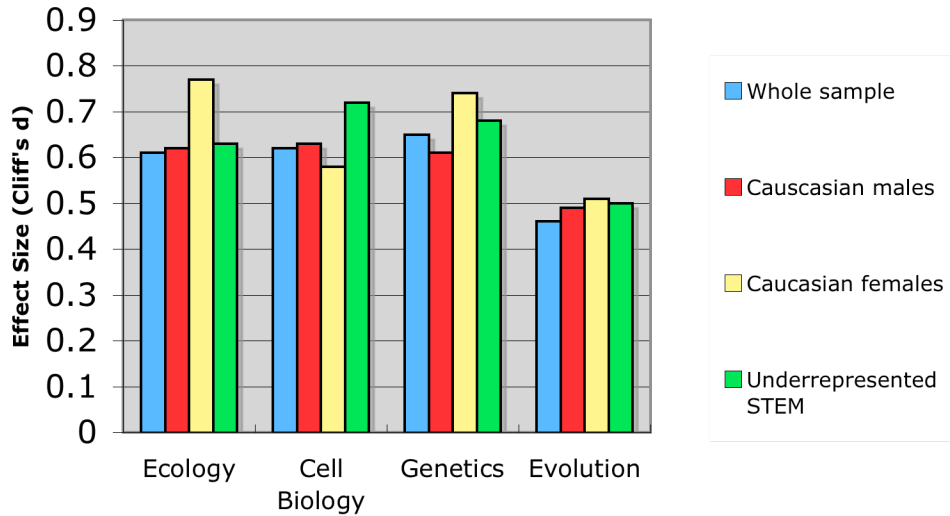


A more recent study followed the progress of students who were field-testing the biology units from *Science and Global Issues*. In this study students took a pre-test before beginning each unit and a post-test after completing the unit. The results shown are in the form of effect size expressed in terms of Cliff's d. In this system a small effect size would have a Cliff's $d \geq 0.147$. A medium effect size would have a Cliff's $d \geq 0.330$ and a large effect size Cliff's $d \geq 0.474$. The results shown in Figure 2 clearly indicate that the effect

sizes were large for each unit with the exception of Evolution, where the effect size was on the on the upper limits of medium.

Figure 2

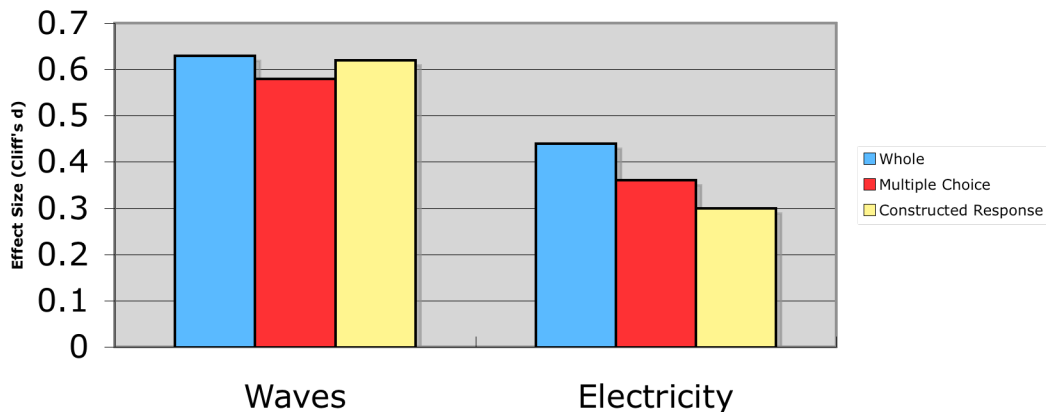
SGI Biology 2008-9 Field Test Pre/Post-Effect Sizes



The results shown in Figure 3 represent the pre-/post-effect sizes for the two SGI Physics units. The data indicates a large effect size for the Waves unit and a high moderate effect size for the Electricity unit. All of the tests used in the SGI analyses were based on content-standards and included one or two questions on the Evidence and Trade-offs assessment variable. The tests consisted of multiple choice and constructed response questions.

Figure 3

SGI Physics 2008-9 Field Test Pre/Post Effect Sizes



The Center for Research and Evaluation at the Lawrence Hall of Science had the responsibility for conducting and scoring data analyses for the *Issues and Earth Science* curriculum 2004 – 2005 national field test. They reported the following results for the seven units of the program.

| Unit | N | Mean % correct Pre-test | Mean % correct Post-test | Mean gain in % correct | Effect size (Cohen's d) |
|------------------------------|-----|-------------------------|--------------------------|------------------------|-------------------------|
| Studying Soil Scientifically | 334 | 43 | 64 | 21 | .69 |
| Shaping the Land | 207 | 32 | 53 | 21 | .67 |
| Rocks and Minerals | 196 | 46 | 67 | 21 | .48 |
| Plate Tectonics | 170 | 46 | 71 | 25 | .64 |
| Weather and Atmosphere | 76 | 52 | 70 | 18 | .62 |
| The Earth in Space | 138 | 34 | 75 | 34 | .80 |
| Space Exploration | 123 | 46 | 69 | 23 | .69 |

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.

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.

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. These SEPUP approaches can help students in future scientific as well as non-scientific contexts.

Increased interest in science and perception of science as being relevant

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).

| Ethnicity | Percentage of students by ethnicity enrolling in a third year of science after earning a C or better in ICS2, Advanced Physical Science (APS), and chemistry | |
|------------------|--|-------------------|
| | ICS2 | APS and chemistry |
| Hispanic | 53.5 | 35.6 |
| African American | 49.4 | 33.3 |
| Asian | 68.8 | 60.3 |
| Caucasian | 50.9 | 43.4 |

This supports the results of the study by Kelly (1991) that showed that students in classrooms using SEPUP showed significant improvements that reflected the goals and objectives of the SEPUP materials. For example, students said that SEPUP materials helped them learn about the environment, health, industry, the community, and science – all of which are investigated in SEPUP’s issue-oriented approach to science instruction.

Powerful professional development tool

Teachers who use SEPUP materials often show an increase in good teaching strategies and professional leadership (Kelly 1991, Koker 1992a, 1992b). This includes cooperating with other teachers, working with college science and science education faculty, participating in professional organizations, such as the National Science Teachers Association, and collaborating with outside groups related to industry, environmental, or community concerns. SEPUP instructional materials, assessment rubrics, and moderation activities are powerful professional development tools. Several studies have found that they improve teachers’ ability to assess learning as well as improve their own teaching practices such as clarifying learning goals and establishing fair standards (Roberts, Sloane, & Wilson, 1996; Roberts & Wilson, 1998).

Based on this type of evidence, some institutions have used SEPUP materials as the basis for professional development workshops for teachers. In 2001, the University of North Carolina, Chapel Hill used activities adapted from SEPUP to create a professional development program. Environmental Resource Program educator Michele Kloda, who developed and led the workshop, commented, “Our goal was to help teachers give students real-life, meaningful experiences to show them that there are things we can all do every day to help maintain a healthy environment. It is an opportunity to help teachers, and ultimately students, understand that the work taking place [in research labs] has a direct application to our lives.”

References

Kelly, P. J. (1991). *Perceptions and performance: An impact assessment study of CEPUP in schools*. Berkeley, CA: Science Education for Public Understanding Program.

Koker, M. (1992). *SEPUP in Cleveland: An impact study of SEPUP on teachers and students*. Berkeley, CA: Science Education for Public Understanding Program.

Koker, M. (1992). *SEPUP in Philadelphia: An impact study of SEPUP on teachers and students*. Berkeley, CA: Science Education for Public Understanding Program.

Koker, M. (1996). *Students' decisions about environmental issues and problems: An evaluation study of the SEPUP program*. Unpublished Ph.D. Dissertation. University of Southampton, England.

Lewis, A. (1996). Content standards for science: NSF panel tells districts which materials meet its standards. *Harvard Education Newsletter*. September/October, 4.

National Research Council. (2001). *Classroom Assessment and the National Science Education Standards*. Washington, D.C.: National Academy of Sciences, 65–69.

National Science Foundation. (1997) *Review of Instructional Materials for Middle School Science*. Directorate for Educational and Human Resources, Division of Elementary, Secondary, and Informal Education.

Pogrow, S. (1993). Where's the beef? Looking for exemplary materials. *Educational Leadership* 50, 8: 39–45.

Roberts, L., Sloane, K., & Wilson, M. (1996). *Local assessment moderation in SEPUP*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Roberts, L., & Wilson, M. (1998). *An integrated assessment system as a medium for teacher change and the organizational factors that mediate science teachers' professional development*. (BEAR Report Series, SA-98-2) University of California, Berkeley.

Samson, S. & Wilson, M. (1996). *The SEPUP Issues, Evidence and You curriculum: Achievement and student attitude evidence from the pilot year*. Paper presented at the Annual Conference of the American Educational Research Association, New York.

Scott, G. (2000). Integrated science study. *Science Teacher*, 67 (6), 56–59.

Wilson, M., & Sloane, K. (2000). From principles to practice: An embedded assessment system. *Applied Measurement in Education*, 13(2), 181–208.