Every Science, Every Year

Recognizing that in the real world the traditional science disciplines are no longer isolated from each other or from other intellectual fields, 16 teachers at South Gate worked together to restructure their science courses.

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Rosa Nagaishi teaches science at South Gate High School in Los Angeles, a year-round high school of about 4,000 students, 97 percent Hispanic. Two years ago, Nagaishi and about 15 of her colleagues at South Gate decided to restructure their science courses based on the Scope, Sequence, and Coordination (SS&C) initiative of the National Science Teachers Association (NSTA).

They wanted science to be more responsive to the needs and experiences of their Los Angeles students, and they wanted to find ways to help students succeed in science. South Gate High School is now one of more than 214 schools in California where science teachers are voluntarily restructuring their curriculums to realize the vision of SS&C: Every student gets every science in a systematic, coordinated way every year.

At South Gate, science had been scheduled as a 10th, 11th, or 12th grade elective, with no earth science and no regular physics courses available. Ninth graders took science only if they were planning to take one of the 10th–12th grade courses. To broaden opportunities for science study, the South Gate science teachers planned Integrated Science I, a yearlong course that would be followed by Integrated Science II for the second year of science. The two-year sequence would meet California's high school graduation requirement.

Principal Raul Moreno scheduled the new science course for all 9th graders for 1990–91. A good number of 10th, 11th, and 12th graders also elected to take the course. Twenty-one new science classes were added.

A National Effort

The NSTA's Scope, Sequence, and Coordination project is a national reform effort. It is being carried out with funding from the National Science Foundation and the U.S. Department of Education. California's SS&C project is one of five SS&C implementation sites in the country (the others are in Iowa, North Carolina, Puerto Rico, and Texas). NSTA coordinates the state sites, providing communication and eventually a core of recommended content.

SS&C seeks to put an end to the traditional "layer-cake" approach, created in 1893 by the NEA Committee of Ten. That committee decided that high school science study should take the form of discrete discipline courses starting with "physical geography," followed by biology, physics, and chemistry, in that order. The physicists managed to overtake chemistry and claim the top-dog position, to become the science that only our best and brightest students would take by surviving the filtration system provided by the three previous disciplines.

As a result of this system, most American high school graduates do not study physics (only 6–19 percent took physics, according to 1982 data), many never study chemistry, and, in most states, the majority of students never study earth sciences in any consistent way. Obviously, connections among the sciences cannot be understood if all the sciences are not available to all students.

To replace the layer-cake curriculum, the SS&C project promotes teaching a "slice" of each science every year in a well-coordinated way for all students in middle and high school. SS&C emphasizes learning through direct experiences first, with terminology, symbols, and equations coming as a consequence of prior understanding. It recommends teaching fewer topics to allow greater depth (less is more) and the elimination of tracking in science.

Getting rid of tracking, which has traditionally tagged students as "science-capable" or "not science-capable," is a basic for SS&C. A redefinition of success in science will emerge as we operate on the assumption that all students can succeed—perhaps in different ways, but they can succeed. Mixing students contributes a multitude of students' needs and talents to the classroom environment, and signals to each student, "You can succeed."

However, we need to take care not to equate "mixing" abilities with "averaging" everyone's ability. Mixing does not require that our brightest students become average achievers. Mixing provides opportunities for interaction, leadership, and success in science for all students at the level that

matches their capabilities.

Exploring the Interfaces

Out in the real world, the traditional science disciplines are no longer isolated from each other or from other intellectual fields. A recent editorial by Daniel Koshland, Jr., in the AAAS magazine *Science* described the new practice in scientific work:

> The flow among disciplines also occurs: physicists have become biologists, chemists work with ecologists. . . . The rapid pace of modern science means that few people today are doing exactly what they were trained to do (Koshland 1991).

Because so much of modern scientific research occurs at the interface of science disciplines (geophysics, biochemistry, human ecology), science must now be taught in a way that makes connections among the sciences and with the real world of the student.

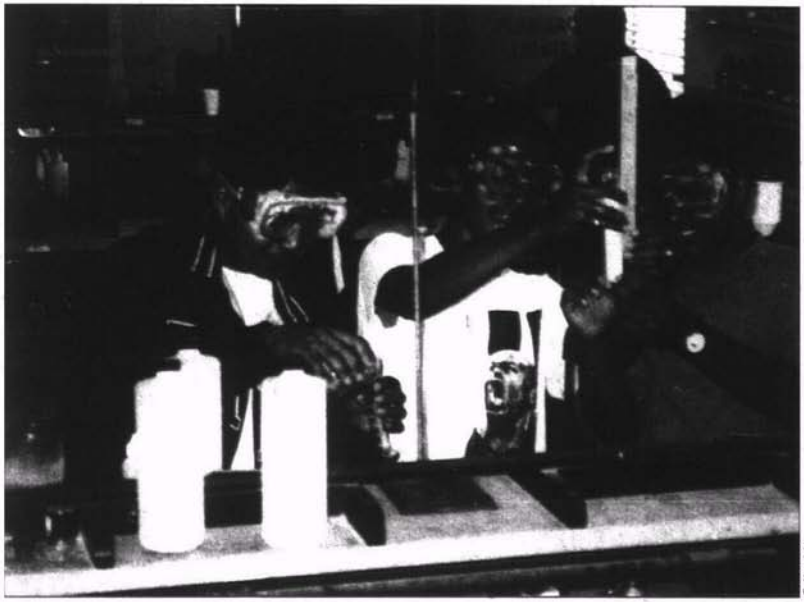
Coordination of the sciences is a first step toward science curriculums that explore interconnections. As teachers become more experienced at developing methods for integrating disciplines, this coordination of the science disciplines may eventually lead to integrated science. But during this initial experience with restructuring, only coordination is encouraged—unless faculties feel ready for higher levels of integration.

Themes That Connect

Coordinated science sometimes makes connections among the four basic science groups (earth sciences, biology, chemistry, and physics) through themes common to all sciences (or to at least two sciences). Patterns of Change, for instance, is a theme integral to all the sciences. Chemistry, biology, earth sciences, and physics all deal with patterns of change. Some changes are steady, some cyclical, some irregular, but each discipline has change in common with the others. Steady change, for example, includes the acceleration of falling objects (physics), radioactive decay (geology and physics), and growth of new island ecologies (biology). Cyclical changes include life cycles (biology), seasonal cycles, planetary cycles, water cycles, rock cycles, and plate movement (the earth sciences of astronomy, meteorology, and geology). Irregular cycles include the unpredictability of systems caused by random changes never repeated exactly, such as population cycles.

Project 2061 of the American Association for the Advancement of Science suggests the themes of Systems, Models, Constancy, Patterns of Change, Evolution, and Scale (American Association for the Advancement of Science 1989, pp. 123–130). The 1990 California Science Framework identifies Energy, Evolution, Patterns of Change, Scale and Structure, Stability, Systems, and Interactions as themes for schools (California Department of Education 1990, pp. 26–38).

Of course, various themes can be identified. The important thing is to help students understand the connections that exist within the sciences and within the real world the sciences seek to understand. Developing science curriculums that use themes to help with coordinating connections among the sciences can give students a chance to learn science as it is understood and practiced today.



R. Nagaishi

Teacher Frank Higgins (left) and two of his students investigate the potency of soap they created in the lab.

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The South Gate Experience

To develop their interpretation of SS&C, Rosa Nagaishi and her colleagues at South Gate looked at all 7th–12th grade science topics in the Los Angeles curriculum and the California State Framework for Science. They looked for themes that would work for each grade level, then planned a spiral

approach to connect science topics from grades 7 through 12. They developed the 9th grade course first because the science vacuum at that level presented an opportunity. Units coordinated the sciences and increased student involvement and creativity—Robotics and Diseases are two units, for example.

The teachers, certified to teach one or more science disciplines or general science through 9th grade, shared materials, laboratory plans, expertise, and time as students rotated through appropriate times with the appropriately credentialed teachers. Each classroom had one set of textbooks in life science, one set in earth science, and one set in physical science. Teacher Frank Higgins tackled the Robotics unit. He recalls:

> One notable instance occurred during our attempt to develop hinges to mimic the bending, twisting, and rotational movement found in the joints and bones associated with the human wrist. After exhausting my ideas, I posed the problem to the students. One student, Jose, seemed particularly challenged and vowed to develop a workable solution. To my amazement, he returned to class the following Monday with a working prototype that exceeded our expectations. The "Jose-joint" was quickly copied and incorporated into projects by other students. This was but one example of the initiative and creativity demonstrated when I stepped back and permitted the students the widest initiative in the development of their project in Robotics.

One student told Nagaishi: "This is the first time I've passed a science test." Teachers' reactions to the coordinated science course have also been positive. Higgins has seen a big turnaround in his students because they understand what they're doing now. They bring things from home and connect science with their own world. The teachers like coordinated science because they talk and communicate with each other constantly. They ask for more meetings. "Teaching is fun now," they say.

All 9th graders at South Gate High School took science last year, and the enrollment in science electives for 10th grade has increased substantially. But because of deep budget cuts in Los Angeles, there is no 9th grade science this year. The new course will have to wait until federal, state, and local funding make it possible to resume the 9th grade science class. This year's 9th graders are the losers.

The good news is that the teachers are changed forever. As one puts it, "You can't go back to old ways once you've found new ones." From now on, the traditional science courses will be taught in a more connected, student-centered way, with extensive communication among the teachers, until funding is available to return to developing their coordinated science courses.

To Each His Own

How can SS&C be carried out in our schools with the multitude of existing constraints? That's the problem implementation sites throughout our country are starting to figure out, each in its own way.

California is supporting the grassroots, professional leadership of science teachers in its 100 Schools Project, as they forge their own local interpretations, while the State Department of Education and California State University coordinate the requisite statewide support systems for them.

The University of Iowa's approach to SS&C reform is aimed at setting science in the context of technology and society, making sure all students learn the science content and skills they need.

The University of North Carolina–Wilmington and Eastern Carolina University are guiding the SS&C interpretation in North Carolina with an emphasis on middle school curriculum development and implementation.

The University of Puerto Rico is developing a Spanish language-based approach to SS&C that will be of great interest throughout the United States—to Rosa Nagaishi in Los Angeles, for instance.

Teachers, state departments of education, the National Science Teachers Association, National Science Foundation, and other funding agencies, local to national, are all in the process of finding out how to make new ideas take the place of traditional practice. And it's working in schools from California to Puerto Rico. With enough determination we will find a way. In the case of SS&C, there will be many ways, because different teachers are making it work in their classes. Our society must find ways to help them accomplish this important task. □

References

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Author's note: For information on the SS&C core curriculum or how you can begin to use an SS&C approach to secondary science programs, call Russ Anito, NSTA, 202-328-5800.

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