NSTA'S NEW CURRICULUM INTEGRATES SCIENCE IN SECONDARY SCHOOLS

When seventh graders walk into Grace Beam's science classroom this fall, they will be stepping into an interesting experiment in science education. Beam and her colleagues at Pershing Middle School in Houston, Texas, are among the first in the United States to teach science using a new and somewhat controversial curriculum developed by the National Science Teachers Association.

NSTA, which represents some 50 000 US science teachers, wants to replace the typical two or three years of science that high school students now take with a coordinated six-year curriculum. Starting in the seventh grade, students would study biology, chemistry, physics and Earth sciences, so that they would have a basic understanding of all the sciences by the time they graduated from high school.

NSTA's executive director, Bill G. Aldridge, has spearheaded the project. In 1987 he was part of an NSF-funded research team that looked at the Soviet education system. Aldridge, who has a physics background, learned that Soviet schools teach physics over four or five years, instead of just one, and that Soviet students take three times as many hours of physics as their US peers and twice as many hours of chemistry and biology. Aldridge found that similar practices exist in Great Britain, Japan, the People's Republic of China and other countries and that the United States is one of the few countries where individual subjects are concentrated into one-year courses—the so-called layer-cake method. Aldridge was also impressed that all Soviet students, even those who don't intend to go to college, take science. (For background on other countries, see the Opinion column by Chiara Nappi in PHYSICS TODAY, May, page 77.)

Soviet children begin learning science at a much earlier age than their American peers. NSTA's curriculum reform program was inspired in part by the Soviet approach.

Getting started

American educators have been talking about science education reform for quite some time, and the idea of teaching science over several years is not exactly new. In 1981 a curriculum model was proposed by Marjorie H. Gardner, then director of the Lawrence Hall of Science in Berkeley, California, that called for students to take a few hours per week of biology, chemistry and physics in each year of high school. Aldridge expanded Gardner's model to encompass grades 7 through 12 and added Earth sciences (see table on page 88). This "grid" model became the basis for the new approach, which Aldridge first suggested in an article in the January–February 1989 issue of the NSTA newsletter. The approach also stresses that the individual disciplines should be coordinated with one another and that scientific concepts should be taught from the more descriptive to the more theoretical.

"Response to that article was phenomenal," Aldridge recalls. From that point on, things began moving pretty quickly: Within a few months NSTA had secured $86 000 from the National Science Foundation and assigned a task force to develop the new model, which Aldridge named "Scope, Sequence and Coordination," or SS&C for short. Last fall the Department of Education awarded $500 000 to NSTA and $1.1 million to test sites in California and Houston.

This fall NSF is giving a total of $8.6 million to programs in San Juan, Puerto Rico; North Carolina; and Iowa, as well as to NSTA and the Houston and California sites funded previously. The project recently got a further nod from NSF when Russell Aiuto, who had been head of NSF's teacher preparation and enhancement division, took a leave to serve as NSTA's R&D director. According to Aldridge's estimates, the SS&C project will cost $50 to $100 million over

the next six years, including Federal, state and local funds.

So far, NSTA has not concluded what should be taught within the SS&C model. But that will soon change. During the past year committees representing each of the four disciplines have been outlining the actual content of a generic curriculum, and NSTA now hopes to publish these recommendations within the year. The association had previously agreed to structure its curriculum along the scientific themes defined in the American Association for the Advancement of Science's 1989 report "Science for All Americans." (The report came out of an on-going AAAS education reform project, called Project 2061, which aims to reform all disciplines in all grades.)

One underlying assumption of the SS&C approach is that the science being taught should fit the student's age, says Gerald Wheeler, a physics professor at Montana State University who has been involved in developing the physics content of the curriculum. For example, one would introduce the concept of change in motion to seventh graders by "letting them experience fast and slow as they walk in front of a flashing light—without going heavily into the algebra," Wheeler says. Only in the later grades would concepts like acceleration and circular motion be introduced.

"I think of Scope, Sequence and Coordination as restructuring science education more than actually changing the science content," says Penny Moore, a high school physics teacher in Piedmont, California, who has been working with Wheeler on the physics content. "We're using many of the same scientific concepts that are taught now, but they're being presented differently."

Houston and California tests

Starting this school year the SS&C model will be tested in four Houston area schools and in about 50 schools in California. The course content and the teaching materials are being developed by the schools themselves, with assistance from NSTA. In Houston the project is being run through Baylor College of Medicine and headed by Linda Crow, a science educator who has a background in geology. Baylor is part of the Texas Medical Center, which employs 50 000 people, making it the area's biggest source of jobs. According to Crow, the center has had difficulty in recent years recruiting qualified workers. It has sponsored a number of education projects in the region, in part to cultivate a more literate crop of potential employees.

A major thrust of the SS&C approach is to relate scientific ideas to each other and to their applications and social context. Crow has structured the Houston seventh-grade materials along several themes, with such catchy titles as "Floating and Sinking" and "Hot Stuff." In Floating and Sinking, for example, students will discuss density (that's the physics) and solutions (the chemistry) and oceans (the Earth sciences) and fish (the biology).

In California, the reform movement has taken a slightly different shape. There are 110 high schools and 104 middle schools now planning to reform their science curriculums, with each school district tailoring the NSTA model to meet its own needs. In some schools, for example, the curriculum will span grades 7 through 12, while in others it will only be taught in grades 9 through 12 or grades 7 through 10. Each school is free to decide how and when science is taught, although the content must adhere to the California Framework, a 300-page document that specifies what must be covered in the state's public schools.

Since February the US Department of Education and the state have given the participating high schools about $8000 each to plan SS&C-style curriculums; about 50 schools will begin testing their curriculums this fall. The state has also sponsored several conferences to allow teachers and administrators to exchange ideas. At a 20–21 August meeting at Fullerton State University, discussions included teaching credentials, how to make sure that college admissions offices understand the SS&C approach when considering students' applications, and how to get more funding.

One can hardly talk about education without mentioning books. At present there are few textbooks published in the US that complement an SS&C-style curriculum. That's why the selection of test sites in California and Texas is considered to be strategically important: The two states are the largest purchasers of textbooks in the country and set trends for the other 48 states.

NSTA recommendations for revising US science curriculum

	Grade level						Total time spent (hours)
	7	8	9	10	11	12	
	(hours per week)						
Biology	1	2	2	3	1	1	360
Chemistry	1	1	2	2	3	2	396
Physics	2	2	1	1	2	3	396
Earth science	3	2	2	1	1	1	360
Emphasis	descriptive		empirical		theoretical		

Reservations and pitfalls

Because the SS&C program is new and as yet untested, it has drawn little open criticism. Most people's reservations tend to fall into the "what if" category: What if teachers can't or won't handle that much science? What if college admissions offices won't treat the new science courses as equivalents of existing science courses? What if the brightest students are not sufficiently challenged by the curriculum?

As originally conceived, the SS&C model all but does away with the practice of tracking—placing students into separate courses based on their abilities and career plans. But not everyone is willing to give up on tracking altogether. In many of the schools where the SS&C model is being adopted, some form of tracking will remain. In several California schools, students will be able to take elective science courses—or not take science at all—during the last two years of high school, as they do now.

Responsibility for the new curriculum's success will fall heavily on the science teachers, who will have to adjust their teaching styles and their schedules. Especially at the junior high school level, teachers may need to upgrade their own understanding of the science they will be expected to teach. "In most schools, it will require a strengthening of the science teaching staff," says John Rigden, director of physics programs at the American Institute of Physics. "But such a move should be made regardless of the curriculum being used."

At present, teachers in many states need not major in science to be certified to teach science, according to Donald Kirwan, director of AIP's

education division. In South Carolina, for example, an individual who has taken just one science course in college—whether that be introductory geology, chemistry or astronomy—can be certified to teach any science subject at any grade level.

NSTA is now considering SS&C for kindergarten through sixth grade, grades in which science education has typically been weak. According to Aldridge, development of an elementary school program may start as soon as next year. But here, too, finding qualified teachers may present a problem.

The NSTA models recommends a total of seven hours of science per week, which for most students means that other courses would be displaced if the new approach is adopted. Where will the extra time come from? In Houston seventh-graders would normally take only five hours of science per week. To make room for the additional two hours, the schools have reassigned time that would have been spent in reading class to science, with the stipulation that the students read about science during that time. Other solutions may be to scale back to five hours of science per week, to integrate science with math or science with social studies, or to move such nonacademic courses as driver education or home economics to after school. There has also been talk of lengthening the school day, although that means more money.

The NSTA reform may be vulnerable to the charge of giving science too large a place in the overall curriculum. After all, why should more and more time be devoted to science class when students do poorly in other areas as well?

For all that, NSTA's proposal could end up being the biggest change to come about in science education since the post-Sputnik reforms. Proponents of the SS&C approach are gambling that their way of doing things will retain the best of the old system while getting rid of the worst. They maintain SS&C will keep students in the science "pipeline," thereby funneling more into science careers while raising overall science literacy.

"What we have in the United States is a strong tradition of teaching science through open-ended, laboratory-oriented discovery, which I think in the end makes for more inventive scientists," Moore says. "But what we're missing is getting the average student to be science literate. We're hoping that Scope, Sequence and Coordination can change that."

—JEAN KUMAGAI

PARTICLE PHYSICS EDUCATORS DESIGN 'PERIODIC TABLE,' SOFTWARE PROGRAM

In an effort to infuse modern physics into the traditional introductory curriculum, a group of physics teachers and researchers, with the backing of some of the largest US particle accelerator laboratories, has put together a package of teaching material on particle physics that includes a giant color wall chart and an interactive computer program.

The package is geared toward high school and first-year college physics classes. Its designers, who are known collectively as the Contemporary Physics Education Project, hope that the wall chart will someday enjoy the same position in physics classrooms that the periodic table of elements now does in chemistry classes.

The chart, measuring 1 meter by 1.5 meters, is a colorful compilation of figures, tables and text set against a black background. At the center is a representation of the atom's structure. On either side are tables that list the properties of fermions and bosons; below is a table on the various particle interactions. Short definitions of widely used terms—spin, matter and antimatter, and so on—are interspersed throughout the chart. Across the bottom of the chart are illustrated examples of three particle reactions: neutron decay, electron–positron annihilation and decay of an unstable hadron.

The idea for a chart originated with Frederick S. Priebe, a physics teacher at Palmyra Area High School in Pennsylvania, who proposed it at a conference on teaching modern physics held in 1986 at Fermilab (see PHYSICS TODAY, March 1986, page 103). The purpose of the conference was to promote the teaching of particle physics and cosmology in high school and introductory physics courses; among the other big projects to result from the conference is a teacher's guide on modern physics topics (see box).

Following the conference, the CPEP group was formed. From the outset the committee decided to restrict the wall chart to what was

Teacher's Guide Covers Modern Physics Topics

Two major projects arose from the 1986 conference on teaching modern physics. One project has resulted in the particle physics wall chart, as described in the accompanying news story. The other, called Topics in Modern Physics, has yielded a teacher's guide and a training program for teachers.

The Topics in Modern Physics project was organized by Friends of Fermilab and Fermilab's education office and was funded by a two-year, $190 000 NSF grant. According to the project's director, Marjorie G. Bardeen, the teacher's guide is written for the high school or first-year college teacher and covers six specific areas in modern physics: accelerators and detectors, cosmology with general relativity, and elementary particles with symmetry. The idea is to allow modern physics to be "sprinkled" throughout the introductory curriculum. The guide contains background information as well as classroom activities. For example, the section on accelerators and detectors includes descriptions of Fermilab and SLAC, sample problems, lab assignments, diagrams of detector components, and a list of educational videotapes available from Fermilab. Following a pilot test in 1988, the guide was revised and a new edition was published in June 1990.

The project has also spawned a series of workshops that have been held throughout North America. Participants learn about a specific topic from a researcher in that field and then discuss how to incorporate the information into their courses. Bardeen says that about 3000 teachers have already taken part in the one-day workshops.

The *Topics in Modern Physics Teacher Resource Book* and a schedule of upcoming workshops are available from Friends of Fermilab, Fermi National Accelerator Laboratory, Batavia IL 60510. A Spanish-language edition of the teacher's guide is also available.