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ABSTRACT

In this report, the search is continued for exemplary elementary science programs. Included is a chapter explaining the excellence in elementary science concept which touches upon: (1) goals; (2) characteristics of an ideal curriculum; (3) resources and materials; (4) administrative leadership; (5) classroom environment; and (6) program evaluations. Thirteen programs are described relating individual program history, goals, instructional methods, and method of evaluation. The report concludes with a discussion of what makes an exemplary program. This, the second search for exemplary programs, was begun in 1985 by the National Science Teachers Association and is its first repeat of a search in a specific area. (ML)

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Focus on Excellence

Elementary Science Revisited

Volume 4 Number 3

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ERIC

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Foreword

In 1982, the National Science Teachers Association conducted its first search for outstanding elementary school science programs. Reports of that search, *Focus on Excellence* Volume 1 Number 2, while demonstrating that some school programs were excellent, indicated that most elementary science programs were average or worse.

But, immediately after the 1982 search, we heard from many who saw their unnominated programs as better than those selected. From all over the country indignant teachers, who did not submit their program because they "weren't good enough," now wanted recognition as they saw that theirs were exemplary. Because of this response from numerous schools, in 1985 NSTA conducted its first repeat of a search in a specific area. The NSTA task force on defining excellence in K-6 science teaching redefined the criteria and set out to see what new programs had arisen and to see if publicity would cause more to apply. And apply they did.

Once more, the task force was faced with selecting the best of a group of quite good nominations. Their selections, from all elementary science programs nominated, make up this monograph, the last in Volume 4.

John E. Penick
February, 1987

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Chapter 1 Excellence in Elementary Science

Phyllis Huff, Betty Burchart, David Butts, Gilbert Tweist, Jean Krause, Leon Ukens, Melvin Fuller, Mary McCurdy

Excellent teaching requires more than focusing on a single aspect. The following characteristics reflect a positive approach to science in the elementary school: well-defined goals and objectives; a carefully prepared curriculum; resources and materials needed for goal and objective completion, administrative and community leadership and support; a classroom environment that fosters teaching and learning for teachers and students; and regular and effective evaluation that improves and ensures the success of the program.

Fundamental to all teaching and learning are the overall goals of the school, the society, and the teacher. These goals must be built on a solid philosophy of education with meaning and purpose for the students. The goals act as a blueprint for classroom experiences and a basis for evaluation.

Excellent science programs are also based upon model instruction. This includes what happens in the classroom and what materials and resources are used. Typically, the elementary teacher uses a textbook and the students read and "discuss" or answer questions asked by the teacher. Excellent instruction requires much more. Science is exploring, grouping, investigating, being involved with the learning process. Therefore, programs require reasonable expenditures of money and support. Science materials, equipment, supplies, and books are needed to start and to maintain a good program. Hands-on investigations require equipment and materials for every child, not just the teacher. Funds are needed for effective inservice programs and for traveling to and attending conventions and meetings. For successful science, teachers must feel comfortable and enthusiastic about teaching it. Staff development enhances these attitudes.

Any program must have the support of the administration in order to be successful and to be defined as excellent. Teachers repeatedly say that the principal is the key to a good science program. Teachers and students take their cues from the principal. The excitement, the interest, and the feeling that science is important passes from the administrator to the teachers, parents, and students. Without this support even the best teachers and most interested students cannot have time, materials, and enthusiasm for science.

For any program to enjoy continuing success, every aspect of the program—teaching, materials, goals, learning—must be evaluated. This will determine if the program is fulfilling its goals. Evaluation shows competency and the depth of quality. If some changes are needed, that is also shown. The validity and reliability of the evaluation are very important to the success of the program.

Goals of Exemplary Elementary Science

Goals can make a difference between a "program of science" and an "exemplary program of science." An exemplary program must present goals that reflect the overall purposes and expectations of the program. Goals are broad statements of what we want the science program to achieve. Clear, well-defined statements of goals and objectives should give answers to these questions.

- What do you want your school's children to accomplish after studying science?
- What knowledge, skills, and attitudes should they have?
- What value is science to their lives?
- What is science good for?
- Why use science?

Today's scientific and technological society demands children be scientifically literate, an aim that should be reflected in the goals of exemplary elementary science programs. Listed below are standards that determine scientific literacy for 7th grade students. Students in an exemplary elementary school science program will

1. Exhibit effective consumer behavior by evaluating the quality of products, the accuracy of advertising, and the personal needs for the product.
2. Use effective personal health practices.
3. Use new data and ideas in learning situations.
4. Recognize the effect of people on the environment and vice versa.
5. Recognize and accept ways in which each individual is unique.
6. Recognize that a solution to one problem often creates new problems.
7. Observe variations of individual interpretations of different data.
8. Recognize that science will neither provide magic solutions nor easy answers. Hard work and processes of science are required to resolve rather than solve many problems.
9. Develop an understanding of information and concepts from a wide variety of topics selected from the life, Earth, and physical sciences.
10. Recognize the roles of people involved in scientific pursuits and the careers available in science and technology.

In selecting programs of excellence in elementary science teaching, goals can be evaluated by specific criteria. One school will not meet all the criteria, but should meet most.

Characteristics of an Ideal Curriculum

The core of a school's science program is the curriculum, which consists of plans to carry out the scope, sequence, content, and procedure. This plan, developed by the school community for the school, should be useful to the teachers and anyone else needing to know the science program's destination and route. The plan should have the following characteristics:

1. When planning a curriculum, teachers, administrators, parents, students, community leaders, and others responsible for implementing and sustaining it should be involved.
2. Curriculum goals should not only reflect those of society, the culture, and the local community, but should also be consistent with the state's education goals.
3. The plan should be developed with the intent of making science learning valuable to the lives of children now and into the 21st century.
4. The plan should provide for a thorough periodic review (i.e. 5–7 years) of the goals, teaching strategies, and other aspects of the curriculum.

A school's curriculum has the beginnings of an excellent science program when it contains the following eight characteristics:

1. Sequential, coordinated science experiences for all grade levels K–6. These experiences are just that: they involve students in the learning process and expose them to the environment, not just to textbooks. The experiences should
   - Show a distinction between grade levels, with minimum overlap between classes and grades.
   - Be many and varied, including hands-on investigations and laboratory exploration so children will develop concepts and find information.
   - Apply content and processes to make science meaningful.
   - Extend beyond the classroom to the neighborhood, nature centers, museums, zoos, airports, factories, etc.
2. Varied topics including all classifications of sciences: life, Earth, physical. environmental.
3. A study of problems relative to the students now and in the future: for example, the curriculum could cover acid rain, air and water pollution, effects of chemicals and humans upon the environment, energy production and resource availability, medical and bio-technical research, world population and hunger, military technology, etc. Students should apply major concepts to everyday life situations and formulate hypotheses to test and solve the problems.
4. Scientific processes that are an integral and prominent part of the children's reading materials. These include observing, measuring, predicting, inferring, classifying, recording and analyzing data, formulating and testing hypotheses, and designing and conducting experiments.
5. Written materials that
   - Encourage children to explore, discover, and find answers for themselves.
   - Require students to apply science processes to problem-solving situations and to solve the problems.
   - Are readable, up-to-date, and understandable, and can be easily followed by the teacher and student.
   - Proceed from simple to complex and from concrete to abstract.
   - Provide information regarding science related careers and how to pursue such careers. They also project what new science careers may be.
6. Valid evaluation materials and techniques; i.e. tests, record sheets, performance demonstrations, and reports.
7. Functional teacher's guide for each level taught. The guide contains objectives, activities, and any information to aid the teacher in directing student activities. It also has room for personal notes.
8. Time for teaching science, scheduled on a daily or weekly basis, with minimums of 100 minutes per week for K–3 and 150 minutes per week for 4–6.

Resources and Materials

The school budget should include an annual allocation of funds for financing the science program. This includes adequate funding of sufficient materials and training for hands-on experiences. Teachers should be involved in the selection and purchase of materials, books, supplies, and equipment used in science instruction and for science references. Procedures for requesting and ordering supplies and equipment should be reasonable, simple, and efficient.

The school budget should provide

1. Money for science materials, supplies equipment and/or books. Science materials (i e., thermometers, dry cells, seeds, aquaria) should be available in sufficient quantities to enable all students to have hands-on experience with them.

2. Ready and easy access petty cash funds for teachers to buy consumable and perishable science materials that can be purchased locally.

3. Funds for staff development in science; i.e., consultants for local science inservice programs, staff travel to science conferences, and teacher attendance at science conventions.

4. Transportation funds and other costs related to field trips to nature centers, zoos, planetariums, museums, or factories.

5. Allocations for a reasonable collection of science-related children's books in the school library.

6. Resources for refurbishing or replacing science supplies on a regular basis.

7. Adequate storage space for science supplies, equipment, and materials. Teachers should participate in inventorying, ordering, storing, and the safe use of science supplies.

8. Running water, sinks, and electrical outlets in the classrooms.

Administrative Leadership

The administration expresses interest and leadership in science teaching by letting teachers know they are interested. Effective administrators demonstrate a positive attitude toward science, visit classrooms when science is being taught, and support science teaching. An effective administration displays the following nine characteristics:

1. Informs teachers that they are expected to teach science for the times indicated in the curriculum plan. Follow-up to be sure that this is being done.

2. Evaluates teachers during their science teaching.

3. Questions prospective teachers about their preparation, interest and competence for teaching science.

4. Takes the lead in providing inservice programs that are in accordance with school and teacher needs. The administration should actively participate in science inservice programs by being a member and doing the group activities. Teachers should also assist in providing these programs that offer teachers specific skills, techniques, and materials useful to them and their science lessons. When needed, these programs also include management strategies for student groups, and materials for science activity learning.

5. Provides release time so teachers can participate in science education programs designed to improve skills. A number of teachers have participated in science education courses, workshops, and meetings that are provided by school or regional agencies, colleges, universities, and professional science education associations.

6. Encourages teachers to regularly use the professional library in the school, which includes journals, newsletters, and other science education reference materials.

7. Participates on committees or groups formed to select new science curriculum.

8. Makes parents aware of the school science program through parent-teacher meetings, and helps teachers involve parents in science activities and fairs. The administration should publicize such programs in school and community media.

9. Gives teachers opportunities to share ideas and activities with their peers.

Classroom Environment

The classroom is where the goals of the program are realized The classroom contains the materials and resources listed above, but the main components of every classroom are the teacher and the students. For this reason it is very important that the following 16 characteristics be clearly defined and carefully evaluated.

Exemplary science teachers should

1. Understand the goals, the curriculum plans, and the time allowed for science instruction and, thus, follow the guidelines.

2. Display positive attitudes toward science.

3. Take opportunities to learn new science techniques and try out newly-adopted science curriculum materials. They should also complete the activities before using them in the classroom.

4 Regularly use a variety of teaching methods such as group investigations, discussions, multi-media instruction, reading, role playing, game playing writing, small group projects, lecturing, and individualized or specialized work in science (e.g., self-paced study, independent study, individual projects, and peer-group tutoring).

5 Provide learning experiences that explain science content and science processes, and many opportunities for participation in science activities. This includes having hands-on sessions with real objects. These help children apply what they learn to everyday problem situations and science-based societal issues.

6. Function as guides by assisting individual students, asking questions, suggesting alternate ways of thinking, and providing additional materials. Teachers should give children opportunities and encouragement to explore science materials and find answers to questions they have formulated about science.

7 Ask open-ended questions and allow a wait-time of at least three to five seconds for students to respond.

8. Listen to what students have to say.

9. Encourage, through non-evaluation response, scientific attitudes such as wonderment, open-mindedness, critical thinking, persistence, and responsibility.

10. Help handicapped children become actively involved in science experiences.

11. Regularly combine science with other curricular areas such as reading, writing, mathematics, social sciences, health, art, music, and physical education.

12. Regularly evaluate children to determine if they are acquiring competence in the science processes, knowledge, and attitudes specified in the statement of goals and objectives.

13. Provide opportunities for students to learn to distinguish between opinion, fact, and evidence.

14. Make science-related library books readily available in the classroom to help students extend learned concepts.

15. Give evidence of continuing science experiences in classrooms such as science displays on tables, cages of live animals such as gerbils or hamsters, shelves of science-related books, plants planted and/or cared for by children,

science question boxes, mobiles, and science bulletin boards.

16. Display children's written essays, graphs, reports, poetry, or art projects that incorporate science-related content and processes.

If the science program and science instruction is good. teachers will see the results in their students. They will see that their students like science and talk about it positively. The class will be eager to explore science and able to ask scientific questions Class discussions of science topics and science activities will be long and enjoyable, as students express their observations and ideas

Evaluation

Evaluation should be conducted on a regular basis. Although evaluation continues throughout the program, there should be a regular, periodic review of the entire program.

The evaluation procedures, such as standardized tests, or the school system for giving grades, reports, or student evaluations should be consistent with the science program's goals, objectives, and instructional practices.

Students should perform as well as or better than the national average on standardized science exams, and, over time, perform consistently or improve

Searching for excellence in elementary science is a tremendous task and an important one. Children must be exposed to and involved in science to survive this and the next century. Science and technology are playing a major role in the everyday lives of all people. For this reason alone, our citizens must be informed on scientific issues To do this they must have a minimum of scientific literacy. Hopefully, this effort on behalf of excellence in elementary science will open the door to more and better science in the elementary schools of our nation.

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School District: Renton School District (13 elementary schools; 350 staff; 6,190 students K-6)
Location: Renton, Washington (pop. 75,000)

Eleven miles from Seattle on the southern end of beautiful Lake Washington, Renton is the 11th largest city in the state. The community is primarily white, suburban, and middle class

Chapter 2 The Gourmet Approach to Science Education

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History

Prior to the 1970s, elementary science was taught here with varying degrees of emphasis. In 1971, the superintendent invited four teachers to form a committee, evaluate the science curriculum, and identify its needs. To get a clear picture of what programs were taught, the committee sent a survey to all elementary schools. Results of the survey showed that most Renton teachers used a textbook approach to science education, and the textbook was out of date.

The survey also showed that teachers were frustrated due to lack of materials and supplies. The most frequent responses to the survey question: "What would you like to see in a science program?" included

- A process-oriented science program.
- Science materials.
- Science kits for individualized investigations (not just textbooks).
- Experiments based on discovery.
- Experiments for each grade level.
- Multimedia materials including supplemental books.
- A science resource teacher to help us with activities.
- Inservice training.

Altering the curriculum to be consistent with what and how children learn is a problem. So, the superintendent instituted the Science Articulation Committee. For three months, a subcommittee met with publishing representatives to learn about available commercial programs. The committee wanted a process-oriented program to eliminate their fragmented curriculum and find a sequence appropriate to children's maturity levels.

In the fall of 1972, we selected three science programs for a one-year study. While testing these pilot programs, we also surveyed teachers and parents in the community. We used the results of these surveys to revise the science program. Final evaluations of the programs were made, and a proposal for a kit program was made to the districts' directors. Unfortunately, our new proposal was rejected for being too costly.

We explored alternatives for the commercially produced kit programs. The Highline Public School District had an innovative program, *Project Ecology, ESEA III*. Funded by the Elementary and Secondary Title III Act of 1965, Highline had developed a demonstration project during 1971-1976 based on activity kits. Sent to Highline to review their program, a committee returned with glowing reports. The savings of producing in-house developed materials made this program cost-effective. Our proposal to the administration was accepted.

Philosophy

Today, our K-6 science curriculum is based on a hands-on activity approach to science. Our lessons emphasize small group work so that all students have a chance to participate. Along with the activity-based design, we implement a "kitchen science" philosophy. We want science to be a positive, practical, everyday experience. In order to implement this philosophy, we stock our kits with everyday items like food coloring, tongue depressors, styrofoam cups, etc. We want our program to be fun and exciting, not intimidating.

To formalize our goals, the Renton science program

- Provides students with opportunities to master, retain, and apply the basic facts, concepts, skills, and processes associated with science.
- Develops positive student self-concepts through their relationships with science.
- Fosters curiosity, initiative, creativity, and objectivity.
- Encourages student understanding and respect for the environment.
- Develops rational thinking processes that underlie the scientific approach to problem solving.
- Develops fundamental skills in using laboratory materials and equipment, and in gathering, organizing, and communicating scientific information.
- Develops a knowledge of and a respect for the past contributions, the future possibilities, and the existing limitations of science in solving problems that face society.
- Reinforces study and academic skills taught in other areas of the curriculum such as mathematics and language arts.
- Increases student awareness of historical developments in science.
- Provides curriculum opportunities for both college-bound and vocationally-oriented students.
- Establishes, maintains, and develops safety awareness in students.

Curriculum Guidelines

Several guidelines, established at the onset of the program, have directed the development of our science curriculum. It was important that the curriculum

- Be consistent with science program goals.
- Provide a balance between content and process.
- Reflect data regarding teacher and community preference.
- Provide a balance between life, physical, and natural science.
- Use the metric system.
- Be implemented in the instructional time allotted for science.
- Include an outdoor ecology experience for grade six.
- Be financially realistic in implementation and costs.
- Be developed around the assumption that a centralized system for replenishing and distributing science supplies would be available.

Program Menu

Teachers within our district wrote, built, tested, and revised science activity kits for each grade level: three for each primary level and five for each intermediate level. We compare our program to a gourmet meal. We have hors d'oeuvres, entrees, and desserts:

Hors d'oeuvres: Short, quick-to-do optional activities or supplemental materials such as growing crystals, sponge gardens, green sea turtles, plants, and animals.

Entrees: These kits are our required core curriculum:
Kindergarten: Your World-My World, Sink or Float, Air-Water-Weather
First: Home Sweet Earth, Animals, Light-Shadow-Sound
Second: Water, Dinosaurs and Modern Reptiles, Electricity and Magnetism
Third: Cycles, Insects, Energy, Heat and Temperature
Fourth. Water, Astronomy, Weather, Force, Motion and Machines, Endangered Species, One Day Field Trip
Fifth: Green Plants, Seashore, Light and Sound, Geology, Energy and Electricity, One Day Field Trip
Sixth: Life Science, Matter and Change, Metrics, Energy, Heat and Temperature, Mystery Powders, Biotic Communities, One Day Field Trip

(All entrees come with a teacher's guide, hands-on materials, worksheets, transparencies, filmstrips, books, and study prints.)

Desserts: These are optional extensions of the kits, focusing on a particular area and the science process skills.

Science Kits

The science kits are the core of our program; they are the required science curriculum. In addition to the life and natural science units, we have tried to provide at least one unit on Earth or physical sciences at each grade level. All of the supplies for one lesson are packaged in paper bags, which are then placed in a large plastic tub and secured with a lid. In addition to the supplies, each tub holds the teacher's guide, all the worksheets for the students, and any books, transparencies, and/or filmstrips needed to complete the unit. Films are ordered separately from the district's film library.

The teachers' guide for all of the units were developed in the same format. Each guide contains background information for the teacher, a list of kit materials and supplies, the goals and objectives for the unit, a vocabulary list, and an average of 10 lessons. Each teacher's guide is written around a single theme. Within each theme is a progression of concepts. For example, the 5th grade "Energy and Electricity" unit begins with an overview of the nature of energy. It narrows to look at electrical energy in particular and, finally, broadens again to look at the resources that provide electrical energy.

The unit lesson activities are planned so that students encounter concepts of process science: observation, classification, measurement, data collection and organization, prediction and inferences of specified events, and making and testing hypotheses. All students become actively involved in the investigations individually or in small groups. They record data from their investigations and follow-up by making generalizations and drawing conclusions. We use science beyond the traditional sense. We use an interdisciplinary approach—mathematics, language arts, social studies, fine arts, etc.

Each lesson plan is a unit in itself. Each exercise identifies the approximate time to complete each lesson. The primary lessons average 30 minutes; the intermediate average 45 minutes. Films and film-strips require additional time. The lesson plan is divided into three parts: discussion, student activity, and review and evaluation.

The discussion section reviews previous concepts and activities and introduces that day's activity. The guide provides questions and information for the teachers, and some anticipated student answers. For the activity section, the guide has suggestions for group size and step-by-step instructions for the activity. After the activity, students review orally and complete a worksheet. Approximately 35 percent of the lessons within each unit have worksheets.

Field Trips

Another feature of this program is the district sponsored field trips. Each grade, four through six, receives one field trip that is directly tied to the curriculum. In order to present the concrete instead of the abstract, each trip allows an experiential approach to real-life problems. Skills learned in the classroom are transported outdoors and into reality. The field trip occurs three-fourths of the way through the unit: typically, lessons 1 through 7 provide background information, and give students familiarity with tools, materials, and data gathering techniques; then the field trip utilizes the community to relate reality to the abstract concepts the students learn; lessons 8 through 10 serve as follow-up activities.

A specially trained resource person from the district accompanies each group on the field trip. This individual possesses a broad knowledge base and provides all instruction and coordination for the day. This has allowed us consistency on the trips and has been a key factor to success.

Time for each trip is short, so a microphone turns bus travel time into instruction time. Teachers and some parents accompany students on the trip. Classrooms are divided into working groups of six or seven students per adult. Each student (and parent), before boarding the bus, is given a field trip "handbook," listing student responsibilities and expectations for the day, a map showing the travel route, activity sheets, and resource information. Students are responsible for completing the activity sheets during the day. Each handbook has the answers for the activities.

The 6th grade field trip was initiated in 1977 and reinforced the Biotic Communities unit. This field trip emphasizes ecological relationships. After visiting a large state park that has 400-year-old virgin timber, students learn about the significance of the wood product industry in Washington State. They learn how trees grow and are harvested. They study two biotic communities and compare differences in the soil, pH, temperature, and plant and animal life. Students then explain these differences as the result of different ecological variables.

The 5th grade field trip began in 1978. For more information on this program see *Focus on Excellence: Energy Education* (NSTA, 1984).

In 1979, the Endangered Species field trip program was implemented for 4th graders. Students ask, "What is an endangered species and why is it endangered?" Students visit five forested acres owned by the district, complete with trails and covered shelters. They evaluate a habitat to see if it can support a wide variety of animal species. Students look at habitat destruction and determine how the habitat can be improved. For several years, the students have planted a variety of coniferous trees and small shrubs to rebuild the habitat, and they have become actively involved in clean-up measures.

Optional Activities

Four years ago we started a program to enhance the core kit program. For example, as an additional option to the first grade Animals unit, teachers can request that the elementary science program assistant give a 45-minute classroom presentation that uses a variety of live animals (rabbit, parakeet, chameleon, etc.) to enhance the concepts of animal classification.

We encourage teachers to pursue additional areas of study, and we try to provide supporting materials for them. We have available for checkout such materials as microscopes, incubators, magneto hand generators, aquariums, etc. Of course, we also give out any of the regular kit stock items such as soil, magnets, corn starch, etc. as needed. We also supplement our kits with live plants and animals. Gerbils, hamsters, guppies, and curly-tailed lizards are all available for checkout at any time for any grade level.

One mini-unit that is particularly successful is the unit on Owl Pellets. This optional activity follows the fourth grade Endangered Species field trip unit. Students examine owl pellets, slowly dismantling and reassembling the bones to reconstruct the skeleton found inside. This science activity reinforces many of the science process skills, and involves language arts, math, and social studies. We will develop these optional short units for every grade level.

Inservice Workshops

From the beginning of the program we provided inservice workshops for our teachers. Teachers who had written, trial-taught, and revised each unit provided instruction for the workshops. Each inservice gave background information opportunities for hands-on experience. As time progressed and as we neared completion of our core program, teacher turnout decreased. We attributed this mainly to teacher familiarity with the design of the program. We continue providing one-on-one inservice for teachers new to our district and this program. We also receive requests from teachers who have changed grade levels. On a district-wide scale we continue to provide inservice workshops for specific concerns.

Science Newsletter

In 1981, we started publishing "Serendipity," a science newsletter. The newsletter was published about three times a year and circulated to all the K-6 teaching staff. We expanded our scope and objectives to include pertinent district happenings and state and national information. Teachers were informed of local and regional workshops and classes. Available materials and activities, along with addresses and information regarding any free materials (posters, kits, etc.), were also published.

Evaluation

Our program revolves around students. Observed student behavior indicates the program is well received. "We should do it again" and "It's even better than recess" are common statements. The design of the activity-based program makes it difficult *not* to succeed. Hands-on activities lead students to comment, "Wish we could learn like this all the time (where) we're doing something." The designated student objectives are the minimal standards for that grade level. Hopefully, students' achievement will exceed these minimums.

Objectives in the K-6 science curriculum are evaluated by several methods. Until 1984, science was graded on report cards merely as pass/fail. Evaluative tools consisted mainly of teacher observation of student cooperation, attitude, and skills with materials. Evaluation was also based on teacher-made tests and teacher assessment of student projects. When science grading began, we developed standard objective referenced tests. In 1983, a standardized pre/post test was given at the 3rd grade level. Standardized pre/post tests were designed and distributed for the 4th, 5th and 6th grades between 1984 and 1986. Through multiple choice questions, these tests show a concrete reflection of learned facts and concepts.

We have yet to develop a tool to measure student's process thinking. Although process thinking is difficult to evaluate, we are considering alternative approaches to accomplish this. Hopefully, this will not be a pencil-paper test, but an actual activity where students discern the nature of a problem, design an investigation, and ultimately arrive at a solution. Material and data manipulation will be an integral part of the evaluation. This area of study will provide a basis for more scientific study and developing advanced skills.

The program evaluation process is extremely important to us. Teachers must feel comfortable with materials and processes, and students must be able to perform the activities and understand the concepts. Administrative staff are always available to help teachers. When a teacher has been unable to perform a lesson, we offer assistance.

Our teachers continue to play a key role in the program. The Renton School District's science program is the result of in-house, teacher-developed materials. When each new unit is published or an older unit is revised, we send out a short survey form to solicit teacher responses to new materials. We monitor teacher opinions attitudes, and successes with the units. Teachers are solicited for comments on kit materials, lesson plans, concepts, films, and support materials. We try to eliminate any feelings of doubt and inadequacy. If the teachers are comfortable and enthusiastic about the program, the students will be. One of our teachers wrote to us: ". . . with the kit and the field trip, I'm sure my students think I can teach science. Keep up the good work. You making us look like scientists."

As we completed the writing phase of our core program, we spent an entire spring with teachers in a major evaluation process. Teams of teachers at every grade level were selected to review the kits. The kits were evaluated by several criteria.

- Were the kit concepts appropriate for the grade level?
- Were the lesson plans easy to set up and perform according to expectations, and were they easy to understand?
- Did the kit materials arrive in good working order? Were there enough? Did they fill the needs in the lesson plan?
- Did the films and support materials enhance the lessons? Were they up to date?
- Are there any special needs or requirements?

This major program evaluation coincided with the beginning development of our standard referenced tests. The objective for our tests was two-fold. For the teacher: Did the students learn the material and perform the objectives in each unit? For us: Did the program accomplish what it was designed to do? With the results compiled by the evaluation teams and the tests, we began a kit revision process.

Plans for Improvement

Though we have come a long way in 15 years, there are still some areas that could be enhanced. Some are readily attainable, others are not. These changes could be grouped into four areas: physical classrooms, teachers, the Science Resource Center (us), and the administration.

The physical classrooms could be enhanced by increasing space and reducing classroom enrollment to 20–25 students. Running water, portable partitions, and carpeted areas would give each classroom greater opportunities. An available "science" room in each elementary school would enhance learning in science.

Our teachers need a stronger background in the science process skills and the art of questioning—both skills not limited to science but inherent in producing "critical thinking skills." Teachers feel hampered by the lack of a science background. Increasing college requirements in science is one way of handling this. Teachers must also realize it is not bad to say "I do not know." They need more flexibility and the ability to say "Let us find out."

At the Science Resource Center, we need to finish developing our objective reference test and a tool for evaluating process skills. The logistics of our own system of inventory and kit sign-ups would be enhanced by a computer, which would allow us to be more productive. Teacher inservicing is also an area where we could expend more energy.

At the administration level we have had considerable support and are thankful for it. However, our program could be enhanced by eliminating split grade level classes, giving us more space in our materials service center, mandating more time per week for science and, of course, more money.

School District: Winchester Public Schools (5 elementary schools; 65 staff; 1,462 students K-6)
Location: Winchester, Massachusetts (pop. 21,000)

Predominately upper middle-class, this is a proud, stable, somewhat conservative community. A large proportion of the population is employed in business and professions; the average income is among the highest in the state.

Chapter 3 Great Opportunities in Science

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History of the Program

Until 1968, the elementary science program in the Winchester Schools was based on a textbook by Navarra and Zaffaroni. Students read about science with no particular conceptual scheme. There was no continuity between grade levels.

In 1968 we introduced *Experiences in Science* (EIS) by Tannanbaum and Stillman, a process- and inquiry-oriented program. It was not an outstanding program but it provided continuity and gave us a foundation upon which to build.

Gradually we replaced EIS with both *Elementary Science Study* (ESS) and *Science Curriculum Improvement Study* (SCIS) materials, and in 1976 we adopted SCIS as our basic program. SCIS is an organized, well-integrated, highly structured program employing all the skills of inquiry science for concept development.

We established a central distribution system where kits were refilled and refurbished. Members of our staff went to university summer sessions where they studied SCIS and learned to lead process science workshops for teachers. Each year the curriculum was explained and demonstrated to new teachers. In our first year, we organized a five-week nature workshop for teachers conducted by Ivy LeMon, a regionally acclaimed naturalist. The following year, Montine Smith of the Audubon Society gave an inservice course on our town's natural resources. We also developed a nature program which blossomed into Nature Trails, a volunteer group whose members take our students on field trips to local ponds as part of the SCIS units titled Environments and Communities.

Because of our success in developing the science program, we were asked to conduct the school drug program for grades five and six, presenting drug workshops for teachers, and securing and updating materials for drug kits.

We further expanded our teachers' skills in process science with a series of inservice courses. Ken Taylor, a nationally known expert on the preparation of SCIS teachers, conducted a five-week course; 31 members of the staff and five Nature Trails people took part.

We also designed an inservice course "Sciencing, Adding the Do to Science." Not only did we have outside experts, but our local Winchester talent made it special.

We then prepared a human growth program in which

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we made up six kits dealing with one of the body systems—one for each grade. As part of that program, we conduct the sex education program at grades five and six.

From 1976 through 1979, the school's director of science, Francis X. Finigan, was the part-time associate director of the Massachusetts Elementary Science Curriculum Implementation Project (MESIP). This project was funded through the National Science Foundation (NSF) and conducted at Boston College. Through MESIP, Finigan further committed Winchester to process-oriented science.

For six summers from 1979 through 1984, we committed funds to curriculum writing in elementary science, developing a core team of three outstanding elementary teachers, Susan Doubler, Robert Lynch, and Joanne Martignette, working in conjunction with the director of science. We noted an increased interest in elementary science as a result of that team's efforts.

Our current program is an integrated K-12 curriculum designed to promote scientific literacy. The program features a combined system based upon the Winchester Guide to SCIS II, the Winchester Elementary Science Reading Program, and an Applications component. The Winchester Guide describes each of the chapters in the SCIS II modules, the value of each activity, the problems that arise during the activities, and recommendations for use. Our reading program includes 35 science tradebooks for grades K-6, teacher's guides, and study questions/worksheet ideas. The teacher's guides suggest how the tradebooks can extend the SCIS program and develop students' listening, reading, and analytic skills.

Winchester Elementary Science is taught by the classroom teacher. Staff is available to advise and assist the classroom teacher with information and management techniques. We also have developed instruments to assess our program and to evaluate student achievement.

Our Program

We believe in the attitude stated by John Gardner, "Why give students cut flowers, when they can grow their own plants?"

The Winchester Elementary School Science Program focuses on phenomena in the natural environment, stressing the collection and processing of data and a balance between the physical and biological programs. Our elementary curriculum is organized around problem-solving skills, real-life issues, and decision making.

At the 5th grade level, for example, the physical science unit is Energy Sources. During a semester-long study, students explore various energy systems to develop an understanding of energy concepts. Students work with a slider-sphere system to develop their concepts of energy source and energy receiver. The best way to transfer energy, called the stopper-popper system, is also explored. By keeping a record of temperature change, students, in a very dramatic way, learn that energy is transferred from water to ice in a glass of ice water. All the unit activities help develop the concept of an energy chain. Along with hands-on experience, students are expected to record data and draw conclusions. Based on their understanding, pupils are encouraged to explore on their own. Students also plan and design their own energy chains.

In the biological unit for the 5th grade, Communities, students observe the interaction of terrarium and aquarium populations to develop their concepts of food source and food cycle. Children find life study fascinating. Both the physical and life sections of the SCIS program give students the opportunity to use their own experiences as a basis for understanding and analyzing. They then share and discuss their findings.

The Applications component of our program, developed in the summer of 1984, includes what many hands-on programs do not: materials for all students to explore applicable problem-solving activities both in and out of school. The balance between physical, Earth, and biological sciences focuses on the student's total environment. While instruction concentrates on hands-on activities, children work in groups to develop group process skills and learn to build ideas from the ideas of others. Applications accompany each unit to emphasize the relationship of SCIS concepts with science, and the relationship of science to other areas of study. In Farm Animals, an application used in the first grade with Material Objects, 1st graders expand their understanding of classification by building a model farm. To extend the 2nd grade physical science unit, students build simple machines and further their understanding of the evidence of interaction.

At the 5th and 6th grade levels, students' biological study is reinforced by a week in a camp setting, where they focus on environments and the life in those environments. At camp, students get their first glimpse of a caddis fly and become aware of the fragile salt marsh ecosystem. They take what they find back to the lab for a closer look. One of the benefits of this experience is building group and individual awareness. Fifth graders end their camp experience with a problem-solving activity based upon their week's learning. In a land assimilation game, for example, a problem is presented to the students: the town of Centerville must decide how to use the gift of five acres of land. Each student group develops a plan and then presents their case to the town officers, trying to convince them that the plan makes the best use of the land.

Closer to home, children are involved in the Winchester Trails program, run by town volunteers with the guidance of the director of science to give young children an opportunity to explore various environments in our own community. We have incorporated this program into both the populations and environments units.

We also encourage community volunteers, resource people, and parents to take part in the science program. Parents are also involved through home activities. After studying rectangular coordinates, parents of 4th grade students are asked to help their child map a room. As children share their excitement with parents, parents in turn become active participants in the program.

All of our elementary schools are equipped with Apple computers and our students use LOGO. While we are not pleased with our present simulation software, we hope that microcomputers will help our classes simulate situations we cannot easily observe through demonstrations or laboratory experiments. We are trying to maintain real world experiences in direct laboratory and demonstration experiences, and use our computers as a tool for computation, for processing information, and for creating and testing models for describing processes, procedures, and algorithms.

The Teacher's Role

With a process-centered program the teacher's role changes to that of observer, listening and watching children's progress. The teacher must also guide children to see the relationship of their findings to the key concepts of science. The teacher must also be an expert manager. Obviously, to meet these challenges, the teacher needs support. In our system, this support began with a simple sheet called SCIS Survival which gives basic teaching recommendations such as: "Remember Murphy's Law—Try the experiment before doing it with your students" or "If your crickets croak, call the organism bank!"

After surveying all teachers to find out which parts of the program were successful and which were creating problems, the SCIS II Guide was developed to inform teachers of the value of each activity, problems to avoid, and recommendations for use.

After completing the guides to each SCIS unit, we saw that there were problems common to every unit. Therefore, we compiled *The Key Is Inter-Action*, a list of general recommendations for the entire program.

Finally, a brief list of *Logical Strategies for Teachers* helps teachers with management. Management is only one problem the elementary science teacher faces. Others include how to find set-up time, where to find storage space, and how to maintain live organisms. To help with such problems, all elementary science teachers attended a live organism workshop where Marion Harris of Boston University showed teachers how to take care of classroom creatures.

Another workshop, conducted by Gerald Abegg of Boston University, focused on process activities for the classroom and trends in science education.

Evaluation

It is an established procedure in our school system that an assessment component must be part of the program design. We constantly ask for input from our teachers on the status and quality of our program. "The Implementation Update On Elementary Science Program," "Database for Split Grades Curriculum Planning," "Science Reading Program," "Assessment," and an annual "SCIS Evaluation Sheet" are typical titles for data on the science program submitted by our teachers. These data are analyzed and reports are prepared for faculty and administration. These then become the basis for changes in our program. For example, the Summer 1983 Curriculum Workshop was a direct result of a call for everyday applications of process science.

It is interesting that even though we are using a process-oriented program, the results of the Stanford Achievement Test, which uses a fact-oriented approach, indicate that we continue to score extremely well and in fact improve as the years go on. Even though we do not use a textbook, our students do not lack in content knowledge. For many years we administered a test at the 4th grade level made up of items that were released for publication by the National Assessment of Education Progress (NAEP). The results revealed that Winchester is significantly above the national norm on correct answers in all but three of the 40 questions that make up the exam. And our students score significantly higher than national groups in the process area.

We stress formative evaluations in analyzing our progress. We developed evaluation instruments for grades two and four that cross-referenced each question with two objectives, one dealing with the science process, the other with the concept developed. For example, a question in the grade four evaluation dealt with the predicting process and fell under the environmental factor concept. This cross referencing helps identify possible weak spots in our curriculum. Moreover, the 4th grade evaluation is keyed to a micro-computer software program, Mastery Management, where student answers are analyzed in terms of our predetermined objectives. This allows us to provide teachers and students with immediate feedback.

Plans for Improvement

Since the beginning of our process science program there have been concerns, most of which have been successfully addressed and others which continue to some degree. We expected this. The change in approach to science education was traumatic as the textbook prop was pulled away. There was anxiety over whether the process learning represented the best science experience for our children. The introduction of a laboratory approach was likely to lead to a messy classroom and the new materials and approach required increased investments of time, energy, and commitment on the part of the teacher. Our teachers have responded by nurturing a science curriculum that continues to grow and to reach out to affect all students. It is our job to see that not only do children become acquainted with their world, but that their needs are met so that they may become knowledgeable individuals capable of functioning successfully in a science-oriented world. Elementary school is where it begins. A child's self-image, relationship to others, and orientation to a larger world is formulated here. The foundation for later attitudes and indeed, success itself, can often be traced back to elementary school. Our responsibility is great.

At this point in the history of the program, we have made the transition from a text-centered to an experience-centered elementary science program. The staff overwhelmingly accepts the views that hands-on science ought to be at the heart of what we do with elementary school children. We feel that our elementary science program provides the foundations for a scientifically literate society.

Recognizing this, our new superintendent of schools, Charles L. Mitsakos, gives elementary science priority status within the system. Our assistant superintendent, David Ackerman, has urged increased time allotments to each grade level, and encourages teachers to take advantage of our consultant services and in-service opportunities.

We have been effectively funded. In 1968, we requested a budget of $4,000 to introduce a pilot program in process science. How that has grown! We now have an established per pupil allotment of $4.20 for consumable supplies, we purchase 15 aquariums at a time, we place weather stations in schools at a cost of $500 apiece, we pay for animal workshops conducted by outside experts, we maintain an organism bank at the high school, we have a person whose main job is to replenish our kits in a central distribution center, we have computers in each school, and we have the money to fund summer curriculum workshops to fill in the missing pieces in our program.

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Chapter 4
From Reading to Doing

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School: Douglas Elementary School East (18 staff; 375 students)
Location: Douglas, Wyoming (pop. 9,000)
District: Douglas Public Schools (2 elementary schools; 54 staff; 846 students 1–5)

Originally a ranching community, Douglas grew with the energy boom of the 1970s and now serves ranches, uranium mines, coal mines, and oil and gas fields. Located on I-25, the area is accessible to Casper and Cheyenne.

History of the Program

The staff of Douglas Elementary School East spent two years developing school goals and communications skills before we began to write curriculum. This process began in 1977 when a new principal came on board, hired with the assigned task of creating an alternative school environment.

Working with assistance from parents, by the 1979-80 school year we had developed a direction for our curriculum and programs.

Before designing a curriculum, we had to establish a philosophical foundation. We decided our program would be consistent with Piaget's theories on cognitive growth and development, and that all curriculum development teams would use these theories as a basis for their work. An outline of our curriculum guide included statements about the following areas as they related to children, the school, and teachers: student outcomes desired, critical teaching behaviors, skills, attitudes and concepts, student evaluation, record keeping, and reporting. The new curriculum would reflect these priorities.

We decided to avoid writing specific objectives for each grade level and considered our curriculum a total school program encompassing all grades. The activities would be based on the guide, the teacher's knowledge of students and their developmental levels, and the appropriateness of activities for those students. Flexibility was to be allowed in scheduling, content areas, selection of materials used, and in methods employed. We became a school that derived its resources from a variety of materials and people, not from a textbook.

Staff development paralleled curriculum development. Inservice training focused on understanding Piaget's work and its application to our program, and used various print and non-print resources as well as personnel from three colleges and universities and the Wyoming State Department of Education. Staff development continues today.

We had trouble orienting new teachers to the changes. Our solution was to develop a support team structure among the teachers. Each teacher was assigned to one of three teams. Each team consisted of teachers from each grade level and from the support areas of art, music, physical education, and special services. This grouping of teachers from all grade levels and areas helped to develop the concept of a total school program. These groups also instilled individual feelings of "ownership" among teachers, as they found themselves involved in both the design and then practice of the new curriculum.

Our curriculum development progressed in the following way:

1978–79

- Staff survey identifies science as the curriculum needing the most development.

1979–80

- Science curriculum team is selected and begins planning.
- Staff adopts belief statements.
- Critical teaching behaviors are identified and adopted.
- Work begins with Wyoming State Department of Education.

1980–81

- Student outcomes finalized and adopted.
- Science processes identified and adopted.
- Summer college course on Piagetian theory presented at East.
- Program implementation plans developed utilizing support teams.
- Work begins with Universities of Wyoming and Colorado personnel.
- Superintendent of schools and curriculum director accept program.
- Webbing workshops begin (see "*Instruction Methods,*" p. 19).
- Teachers visit University of Colorado Mountain View Center.

1981–82

- Work continues on understanding and applying Piagetian theory.
- Support teams begin to design and practice curriculum.
- East staff demonstrates *Elementary Science Study* (ESS) materials.
- Webbing workshops continue.
- Program evaluated in April.
- Science team identifies program needs.
- Work continues with university personnel.

1982–83

- Piagetian work continues.
- College course on Piaget offered again, attracting teachers from other districts.
- Work begins on questioning techniques.
- ESS kit resource persons selected.
- Creative problem-solving inservice begins.
- Work continues with university personnel.
- Available library media resources are addressed.
- Student problem-solving group initiated.

1983–84

- Staff increases use of community resources.
- Work continues on questioning and creative problem solving.
- Statements adopted regarding student evaluation and record keeping.
- Work continues on organization and management of materials.
- Principal attends summer thinking-skills workshop.
- School science center opens.

1984–85

- Teachers attend thinking-skills workshop.
- Student cumulative record science form adopted.
- Development of more Piagetian-related classroom activities.
- School science center continues.
- Minimum requirement of four science units per year adopted.
- Additional print resources obtained.

In addition to these activities, teachers developed classroom units, collected materials, expanded their knowledge of science, read professional literature, attended workshops, and met in informal sharing sessions.

Our Program

Our science program emphasizes hands-on, exploratory activities. Content areas vary with the interests of students and teachers, current events, and the availability of resources, and all teaching focuses on process skills.

With our emphasis on Piagetian training, learning activities are based on their suitability to the developmental levels of the students. Experiences vary from guided instruction to playing with materials and ideas. This includes student research to develop a knowledge base, experimentation, small-group projects, brainstorming, individual research projects, and whole-class discussions.

Each teacher in our school is considered a teacher of every subject. Thus, art and music teachers incorporate science into their classes, and science teachers integrate other subjects into their own classes. Through webbing and a thematic approach, we attempt to integrate all subjects into an area of study.

Our staff philosophy of sharing and communication enables us to make optimum use of supplies and materials and lets us exchange ideas and activities. Students benefit, as the strengths of each teacher are used by other staff members in their planning and classroom activities.

Though our teaching methods and classroom activities are customized to meet our students' needs, we are bound together through common school goals, pupil outcomes, and specific areas of emphasis. This provides continuity while allowing room for creativity and flexibility.

Thus, we have succeeded in making science one of the major curricular areas in our school by having total staff "ownership" and involvement in the design and implementation of our program.

Program Goals

Our program is designed so that students will

- Be curious learners.
- Willingly involve themselves in problem solving situations.
- Show curiosity and explore materials
- Experience each of the processes of science.
- Understand that some problems have more than one solution.
- Make efficient use of time and materials.
- Show care for their own materials and those of others.
- Demonstrate respect and care for other people and all life.

At East, we believe that teachers should nurture the curiosity of children by

- Being aware of what children bring to the classroom and using that as a starting point for study.
- Knowing that children already have interests and curiosity when they come to school.
- Providing a variety of experiences that allow students to

become involved in their own education.

- Giving students the opportunity to communicate their ideas, formally and informally.

Teachers should also encourage understanding, respect, and concern for the physical and social environment by teaching that

- All people are a part of the environment.
- All parts of the environment are related.
- People's actions affect the environment.
- The classroom is part of a student's environment.

We believe that teachers should actively involve students in learning experiences by

- Providing time and materials for students to explore both on their own and through teacher-initiated opportunities.
- Guiding students in the proper use of equipment and materials as tools for exploring.

Our teachers should encourage students to develop and engage in critical-thinking activities. Because our emphasis is on processes, attitudes, and concepts, we have no specified content areas of study. Teachers choose conceptual areas such as matter, energy, form, time, change, scale, and living things. Students may study a particular content area several times during elementary school.

Instruction Methods

Our budget allows each teacher to select and purchase science equipment and materials for classroom use and demonstration. Resource units, equipment, and materials are available in the media center and many teachers have their own units. Equipment and materials available at East include microscopes, lab equipment, ESS kits, science reference books, a microprojector, a computer, a telescope, student photography material and a darkroom. The quality, quantity, and variety of our instructional materials are excellent.

Process-oriented science is apparent throughout the school day as we integrate science into the total curriculum. Many instructors connect lessons and activities to a central topic as they plan and prepare their units—a procedure called webbing. This integration lends itself to applying science skills (such as observing, classifying, and measuring) to other areas of the curriculum. Many teachers use thematic units and include all curricular areas in the chosen theme.

We try to make study immediately useful and accessible for students. Materials that children bring to the classroom are often used as a starting point for study. Everyday items are often used to involve students in exploring and sharing In the small engine class, a core group of fifth graders learned how to dissemble and reassemble a lawn mower engine, and then became instructors for other students. Our students have visited the mountains for overnight outdoor education camping trips, local taxidermists, the hospital, the North Platte River, the Casper planetarium, various local businesses, and the natural area adjacent to the school. Current events discussions have led to activities dealing with pollution, drug abuse, energy conservation, world-wide food production, child abuse, space travel, and energy.

Teachers

The administration and fellow staff members encourage teachers to try new methods and ideas in science. Opportunities for new ideas and techniques are provided through inservice trips outside the district, resource personnel, informal sharing sessions, and staff meetings devoted to the teaching of science

In working with the science teachers at the middle school, we have been able to coordinate our efforts to assure a continuity of programs and compatibility of goals. Because of our proximity to the high school, we often use its teachers as resources for ideas and materials.

For a science program with our focus, almost any type of material will work. Library books, reference books, magazines, textbooks, letters, and interviews serve as excellent print resources. Manipulative materials can be brought from home, donated by businesses, or purchased with the ESS kits. Natural areas near our school provide an environment for study which complements that of the classroom. Resource persons in the community are also valuable to the program and are usually happy to visit free of charge.

Evaluation

Our students' success is ultimately measured by what they do after leaving our school. Communication with middle school science teachers tells us that our students are interested in exploring their world and are ready for more complex tasks.

Within our school, student progress is evaluated by classroom teachers using a variety of methods. Questioning techniques and teacher observation are important in keeping anecdotal records of student interest, effort, thinking strategies, behavior, and progress. Oral and written tests, activity sheets, lab journals, folders, projects, pupil self-evaluations, and student reports are also used. Teachers fill out a yearly student record sheet for science and Piagetian Task Cards, and pass them on to the next grade level in the cumulative folder. These include student levels of progress in using the process skills and the units of study.

We have used three major evaluation techniques to maintain and improve our program. First, yearly assessments by our building science team are on-going. These involve input from the total staff concerning areas of need and ideas for future implementation. Second, in the spring of 1982 a comprehensive evaluation of our science curriculum covered the way teachers were meeting critical teaching behaviors and students were reaching identified student outcomes. This process included a self-evaluation by our staff, an evaluation by one teacher from each of the other schools in the district, and an evaluation by personnel from the Wyoming State Department of Education, Universities of Wyoming and Northern Colorado, and the Mountain View Center in Boulder, Colorado. The building science team used the results of this evaluation to determine needs for future work. Third, during the 1983-84 school year, East Elementary was part of a district-wide NCA evaluation. This evaluation included a comprehensive self-study of our K-12 science program and an on-site evaluation by educators from throughout Wyoming. During 1984-85 we reacted to the recommendations with implementation plans for the 1985-86 school year.

Plans for Improvement

Our teachers are committed and willing to become active participants in all of the curricular areas. Their enthusiasm and desire to grow professionally enable us to improve our program every year. Total sharing and cooperation facilitates the learning process for the staff and students. When it becomes necessary to h re new teachers, the applicant's backgrounds in child growth and development and in math and science are examined. Considerable effort is expanded through the support team structure to make new teachers aware of our program, its goals, and its expectations.

The personnel currently employed in the program effectively use the available resources. Should the funding for these resources decrease, it is expected that our program would be maintained due to the creativity, resourcefulness, and commitment of our staff.

We continue to foster parental knowledge of our purposes and willingness to encourage, assist, and provide materials for their children. Through individual conferences and newsletters, our teachers keep parents knowledgeable and involved. Because of family support, children are enthusiastic learners who find exploring and sharing with their peers an exciting experience.

There are no major parts of the program which we anticipate changing dramatically. Rather, we will grow and expand with what we have begun. We will continue to increase our knowledge of child development and how it applies in the classroom, improve our classroom studies, and improve our student evaluation. We have established an excellent base for our science curriculum. We now plan to increase our skills and knowledge to make it even better.

We have a strong, exciting program because of the continued commitment of a supportive school committee, administration, teaching staff, support staff, parents, and most importantly, students who act responsibly toward themselves and their environment.

In summary, John Gardner wrote, "A new series of great opportunities will always come along, brilliantly disguised, of course, as insoluble problems." We have established the beginning of a top-flight K-12 science program. We must continue our effort. We accept the insoluble problems of Gardner for what they truly are: great opportunities.

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Chapter 5 Learning by Doing

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School District: Hillsborough County (93 elementary schools; 3,562 staff; 59,000 students K-6)
Location: Tampa, Florida (County pop. 647,000)

This rapidly growing area, consisting of Tampa and many smaller, culturally diverse municipalities, has the 14th largest public school system in the nation. Florida, however, ranks 50th in per capita spending for education.

Background

In 1975, our schools converted from *Science: A Process Approach* (SAPA) to SAPA II. While schools received equipment, most kits were left unopened and staff attitudes were largely negative or indifferent. Some of this could be attributed to the emphasis on reading and mathematics (the "back to basics" movement). Teachers felt overwhelmed and did not think they could manage a laboratory program.

In 1977, the leadership in science changed at the district level. With this change, the science program took a new direction. The district identified problems in the science program, including negative attitudes, lack of time for teaching science, lack of teacher confidence with laboratory materials, and lack of teacher creativity and enthusiasm. The district then developed the following strategies to address the problems:

- Use existing materials and resources as much as possible.
- Use teachers, administrators, curriculum specialists, and university personnel in curriculum development to create "ownership."
- Design training programs to give teachers help in their specific content areas.
- Build flexibility into the program and provide a variety of experiences.
- Establish a district steering committee.
- Design a long-range plan.

The Science Steering Committee, established in 1978 and composed of curriculum specialists from eight groups of schools in the county, gave guidance and advice through 1982. They helped develop an effective communication network in the schools and advised in the development of strategies and programs to create enthusiasm for science. Most notably, their input was instrumental in the development of Systems-Balance-Change (SBC), Science Connections, summer camps and specialization.

Curriculum revision began in the summer of 1979. The expertise of H. Edwin Steiner and John Bullock, from the University of South Florida, was helpful in guiding this process. Major support came from L. H. Worden, general director of elementary education, the district staff, and the Science Steering Committee.

Over three years the curriculum revision effort established the SBC curriculum. Some features of SBC are

- Three nine-week units per grade level.
- One nine-week unit for teacher-developed curriculum (to promote creativity, enthusiasm, and involvement).
- Eight objectives and 17 lessons per unit.
- Correlations to science texts and other subject areas.
- Materials organized into a kit for each grade level by life,

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physical, and Earth science units.

- Line item ordering of consumables to prevent warehousing of unused supplies.
- Student tracking cards.
- Criterion-referenced tests for each unit.

In 1980-81 we conducted a pilot study of SBC in five schools with 43 teachers to evaluate effectiveness of lessons, teacher attitude, confidence of teachers with lessons, effectiveness of training, and quality and suitability of materials.

The district Department of Testing and Evaluation designed an evaluation model for the pilot with three phases of evaluation. After each unit of instruction, all teachers were interviewed. During 1980-82, the Department of Testing and Evaluation helped develop SBC test specifications, unit tests, and test validation.

A critical aspect of implementing SBC was the design of an effective training program for teachers, giving them the confidence to instruct the SBC units. The model that was developed identified teachers to be trained by grade level, required three full days of training with one day spent on each unit of life, physical, and Earth science, required presentation of each topic and set of lessons, and required teachers to work through each activity with the workshop leader, who modeled ways to deliver the lesson in the classroom.

The district staff gave impetus to the implementation of SBC by supporting the funding request for teacher training. This support has permitted a large number of teachers to be trained.

Science Connections

Concurrent with the development of SBC, Science Connections was initiated to promote, encourage, and create student and teacher enthusiasm for science. A K-12 District Committee began setting guidelines in the fall of 1979. In May 1980, the first Science Connections Day combined student projects, science olympics, exhibits, demonstrations, and skits in three days of activities to bring schools and the community together. In 1984, Science Connections involved the county in two major events: the Hillsborough Regional Science Fair in March, and Science Olympics in May. Both events have grown remarkably over five years in both the number of schools participating and in the quality of student work.

Summer Activities

In 1982, the Science Steering Committee endorsed the concept of Summer Camps in Science. Tampa Electric initially funded the camps, which give students and teachers an immersion experience in hands-on science. Evaluations of this program have been consistently excellent. A state grant increased the number of camps from 10 in 1982 to 60 in 1984. Camp instructors have become leaders in local science education, called upon to lead workshops and serve on district curriculum committees.

A marine science summer program for gifted students in grades 3-6 began in 1984. Each of the 14 teachers taught two sessions, each three weeks long, for four hours each day. The number of student registrations in the 1985 camps demonstrated a high level of student interest in this voluntary program.

Academic Gifted Program

In January 1982, Frank Farmer, assistant superintendent for instruction, formed a committee to review the district's gifted program. The existing program, referred to as the Learning Center, emphasized enrichment. For one-half semester, students were bused to a centralized site one day per week. After a year-long study, the district implemented a school-based program in grades 3-12 in mathematics and science. Programs in each subject were designed to include sequential offerings in grades 3-12, accelerated study, expanded of topics, in-depth research, independent study, and a consistent system of access and evaluation for all students. The program has resulted in teachers of gifted students serving as science resource people, the expansion of specialization to more schools, and an increase in time allocated to science in the basic program.

Management and Organization

Time and specialization are significant factors in the improvement of science in Hillsborough County. The concept of specialization was presented to the district staff with the implementation plan for SBC in 1980-81. This concept involves teaming teachers with either reading/language instructors or other math/science instructors. It targets specialization for the intermediate grades 4-6 as part of a long-range plan to assist teachers dealing with increasingly sophisticated curriculum in all subjects. The district staff approved the concept, but few schools altered their self-contained organization pattern until the implementation of the gifted program in 1983-84.

In the 41 schools currently following the specialization model, the following strengths for specialization have been identified:

- Improved inservice training efficiency.
- Fewer subjects a teacher prepares daily.
- Improved cost efficiency (materials can be concentrated with teacher specialists).
- Increased time in science. In September 1983, schools implementing the gifted program increased their science time to one hour per day. Under the direction of Dr. Worden, a committee was established in the 1983-84 school year to review the district's redefined day schedule. The committee implemented new guidelines for academic time allocations for all elementary schools for the 1984-85 school year. The revised time schedule requires science daily, 30 minutes in grades K-3 and 50 to 60 minutes in grades 4-6

Hillsborough's Program

SBC, the core curriculum of the Hillsborough science program K-6, is a locally-developed laboratory curriculum adapted from SAPA II. The curriculum balances content with process, giving equal representation to life, physical, and Earth/space sciences. SBC emphasizes activities that build problem-solving and critical-thinking skills while being consistent with research on teaching, learning, and childhood development. The program gives students practice in the science process skills: observing, classifying, measuring, predicting, communicating, identifying variables, interpreting data, hypothesizing, experimenting.

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The series of three nine-week units, developed by the district and taught at each grade level, gives students a balanced presentation of topics each year. All 93 elementary schools in Hillsborough County are required to teach SBC as the 27-week core program for science, K-6.

The basic program has been expanded by textbooks, field trips, science fair projects, Science Olympics, the Academically Gifted Program (AGP), and summer camps. Science fairs and science olympics permit schools to focus on the application of science to the students' daily lives. Textbooks, media resources and field trips provide opportunities for students to learn the relationship between science and technology and to develop awareness of careers in science. The AGP is a school-based program beginning in grade three with daily instruction in science and mathematics. Impressively successful in grades 3-6, this program is positively affecting the district's basic program. There are presently 81 teacher units in the AGP in 59 schools serving approximately 1,900 students.

The goals of the Hillsborough elementary science program are to

- Develop and apply critical-thinking skills.
- Develop and apply problem-solving skills.
- Acquire knowledge in the biological, physical, and Earth/space sciences and an understanding of the impact of science on their personal lives.

The objectives for the SBC units address these goals. Each unit has approximately eight objectives, making 24 for each grade level with unit lessons written to the objective. Each lesson in SBC gives maximum user success. Because of the time required to implement SBC (5 years), we selected experiences that would endure and relate to students now and in the future. The durability of a hands-on program was a cost-effective reason for electing a laboratory program over a textbook program.

Throughout the lessons in SBC, students use equipment and identify procedures to investigate a topic. For example, first graders develop procedures for comparing volumes. Second graders discover how to use a spring scale. Third graders develop tests for plant transpiration. Fourth graders infer circuit board patterns. Fifth graders investigate levers and 6th graders develop tests for unknown gases.

The Science Olympics provide excellent opportunities for creative problem solving. These competitions require students to design, engineer, construct, invent, estimate, and apply content and process knowledge. All events are judged on a quantifiable measure to determine winners. Kindergarten students discover ways to construct the highest tower using milk cartons, 1st grade students estimate lengths of masking tape in paper clip units, 2nd graders design planes to fly the farthest, 3rd graders engineer clay boats that will hold the most marbles without sinking, 4th graders design and engineer solar heaters to raise water to the highest temperature, 4th graders design and build the longest bridge they can out of a soda straws and masking tape, and 6th graders see who can make the longest cantilever using soda straws and masking tape.

The life science unit of the curriculum is sequenced so students learn about organisms, populations, communities, and ecosystems. For example, the 5th grade life science unit devotes attention to the impact man has on his surroundings. Endangered species are a topic of special interest and study with the fifth grade unit.

Many environmental curriculum materials have been locally developed for teacher and student use. These materials, very popular with teachers, enrich and extend the SBC curriculum. These materials help students gain greater knowledge of food chains, food webs, and the concept of interdependence. Also, field trips to district parks and environmental centers give students a unique instructional experience to investigate organisms, communities, populations, and ecosystems. Three representative trips are to the Busch Gardens educational program (a national SESE exemplar in 1983), the Museum of Science and Industry, and Nature's Classroom, which all 6th grade students attend.

First-hand investigation is the foundation of the program. Whether determining the most effective fertilizer, the most economical battery or discovering the fat content in beef (topics Hillsborough students studied this past year), students learn to draw conclusions and make decisions from their own collected data. The emphasis on conducting investigations and collecting data begins in kindergarten. Participation in science fairs, Science Olympics, and SBC focuses student attention on learning answers to questions about the phenomena that surround them. As students explore and seek greater depth in their investigations a variety of equipment is used, school and public libraries are visited and agencies and labs are contacted. Further, engineers and psychologists are interviewed and consulted to give information and suggestions on topics and procedures for students in their investigations.

One day per week of the science time is designed for project instruction and research study, where students conduct extensive, in-depth longitudinal investigations. The standard for these projects has progressed over the past five years to a high level of quality. Students realize, through the investigation process, that science is hard work and that one solution to a problem only leads to many other questions to be investigated. One of the outcomes of student investigation is the pride and satisfaction that students take in their work. They enjoy telling about what they have studied.

Weekly Schedule

- SBC two or three days per week: teachers are furnished with Teacher Editions and are given three full-day workshops by grade level to train them in the lessons and materials.
- Textbooks one or two days per week. teachers are given ways of using adopted texts to augment SBC topics. Workshops on professional study days broaden teacher background knowledge and give them additional classroom ideas.
- Projects and research one day per week: an instructional booklet "Great Investigations" gives guidance on how to do a science project.

Materials

The district recommends a ratio of one SBC kit to every three teachers. Some schools purchase additional kits to provide a ratio of one kit for every two teachers. The organization of the kit allows a teacher to have exclusive use of all materials required for a nine-week unit. There-

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fore, three teachers can use the same kit and have adequate materials for their students. During the 1984-85 school year, we surveyed all schools to determine equipment needs. Based on the assessment, the district allocated $90,000 to purchase new equipment such as aquariums, microprojectors, microscopes, and models to support science instruction. A variety of materials also reach the classroom as a result of summer science camps. Each of 40 camps received $1,300 worth of materials this past summer.

Evaluation

During the 1980-81 academic year, teachers in five elementary schools throughout the county piloted SBC in order to determine its strengths and weaknesses prior to countywide dissemination. The Department of Testing and Evaluation also developed a three-phase evaluation procedure.

A trained consultant conducted interviews with pilot teachers following the instruction of each unit. More than 75 percent of teachers responded favorably to the units and reported that their students were enthusiastic about the curriculum. Only 6 percent of teachers responded negatively.

Teacher training has been a significant component of program implementation. Workshops are evaluated on a scale of 1 to 5 and teacher ratings range between 4.7 and 5.0. Evaluations by the Department of Testing and Evaluation indicate that training has been a major factor in the success of SBC.

Teacher training sessions emphasize the importance of helping students understand how science affects them in their daily lives. Instructors model strategies that will help teachers discuss and demonstrate the importance of science in and out of the classroom.

To evaluate our students, the Department of Testing and Evaluation assisted in a test development project from 1980 to 1982. The department provided technical assistance and support in clarifying objectives, writing item specifications, editing and revising items, illustrating and assembling the tests, pilot testing each exam, checking results, revising inappropriate items, and field testing on a pre-test and post-test basis. Our tests are based on objectives stated in each unit of SBC and measure mastery of facts and concepts within a particular unit. After an extensive development process, 18 tests were evaluated by administering the tests to a sample of students before and after instruction. Mean scores for overall tests, along with difficulty values for each item, were derived.

Pretest scores indicated that 1st and 2nd grade unit tests were relatively easy, particularly in the area of physical science. Based on this finding, these tests were extensively revised. Unit tests at other grade levels underwent minor revisions. •

Academically Gifted Program

In 1983-84, the Department of Testing and Evaluation appraised the degree of implementation of the AGP. Evaluation of the program was based on three things: examining input and process variables, producing a data base, and a feedback mechanism for program decision makers.

The evaluation information was shared with program developers so they could make well-informed decisions about what the program needed and where it should go.

The annual evaluation report of AGP presents a project history and description, explains the evaluation methodology, summarizes results of the program evaluation, and offers conclusions and recommendations for program improvement.

Three evaluation cycles were planned for the elementary AGP during the 1984-85 school year. A formative Cycle II gathered observations, interviews, and other background and implementation data. A preliminary summative Cycle (III) gathered program effect data, and a summer Cycle (IV) gathered descriptive information about summer offerings.

Classroom observation data from Cycle II evaluation reported that almost one-half of science activities involved knowledge or comprehension, and about 30 percent required students to apply acquired skills. Analytic thinking was required in 10 percent of all science activities. Synthetic or evaluative thinking was required in 14 percent of all observed science activities.

In the 1985 AGP Cycle III Evaluation, the Ross Tests of Higher Cognitive Processes (1976) were used to measure higher level thinking skills of AGP students. The Ross Test was administered to the students in April 1985 and showed first and second year AGP students scored at or above the 50th percentile rank.

The science sub-test of the Sequential Test of Student Progress (STEP) was used to assess AGP students' knowledge of science content. The tests for grades 3-6 cover basic concepts in biological, physical and Earth/space sciences.

Evaluation is an integral on-going process in the development of the Hillsborough elementary science program. It has proven to be invaluable in guiding needed program improvements.

Plans for Improvement

One of the most difficult elements in the program is maintaining the quality of materials supplied with the kits. Even with a per student cost of $1.65 annually, each year brings new and old problems. Materials arrive late, substitute materials are sent, or the materials are defective. To combat this problem, training sessions suggest ways teachers can use readily available classroom materials to teach curriculum concepts. Patience and perseverance are the key to success with this problem.

Classroom design is another area for improvement. Slant-top desks, for example, inhibit hands-on laboratory science. Incorporating elementary science labs into new construction is one way to address the deficiencies in classroom design. Future plans include greater specifications for developing elementary science labs. Currently, new schools are installing science labs for the gifted classroom, and classroom design is improving.

To sustain the program's vitality, we find several elements to be successful. First, teachers should be involved in science through training opportunities such as SBC training, (we trained 1,887 through 1985), professional study days in science (we offer 15 or 20 each year on activities, investigation, etc.), state conferences, institutes, and summer instruction.

We also review our curriculum regularly and systematically to ensure that materials are current and responsive to research. The district is in the process of completing a second edition of SBC, reflecting considerable growth since the beginning of SBC in 1979-80. The second edition will include support for meeting the state objectives and standards of excellence in science, more emphasis on interactions of science, technology, and society, and more emphasis on how science affects students' lives.

A third element to ensure a successful program is the involvement of teachers in curriculum decisions. Giving teachers the feeling of "ownership" in the program through participation in writing teams and review committees maintains their enthusiasm and advocacy for science instruction.

Hillsborough County has a history of commitment to quality science education. Many individuals (students, teachers, staff, administrators, university consultants) share pride in the impressive gains achieved thus far in science excellence. However, a goal that has not yet been attained is to have effective science instruction every day for every student. Striving to attain this goal and to provide students with a high quality science program is a continuing effort in Hillsborough County.

Chapter 6 Teaching Basics for the 21st Century

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School: Berwick Math/Science/Environmental Studies Alternative School (18 staff; 360 students)
Location: Columbus, Ohio (pop. 565,000)
District: Columbus Public Schools (86 elementary schools; 1,065 staff; 32,920 students K–5)

Berwick is located in a residential neighborhood on the east side of Columbus. Approximately half of the district's students are members of minority groups.

History

Locally, the movement toward alternative schools began in 1972, when we adopted the Columbus Plan to address the problems of segregation. As part of the plan, five alternative schools were established. In 1979, Columbus Public Schools faced court-ordered desegregation. In 1982, in response to a school levy campaign, three new alternative schools were proposed. Each new school would have a specific and different curriculum focus. Parents would submit applications for particular schools through a city-wide lottery process, ensuring a racially-balanced student body. The levy campaign was successful, making Columbus Public Schools the first urban public school system in the country to pass a school tax issue while under court-ordered busing.

The dream of an elementary school in Columbus that emphasized math, science, and environmental studies became a reality in the fall of 1982. The concept was consistent with and supportive of our growing technological society. Research indicates that we must return to the basics, but the "basics" of the 21st century are not only reading, writing, and arithmetic. The new "basics" must include communication and higher problem-solving skills, as well as scientific and technological literacy—thinking tools that will allow our children to understand the technological world.

During the spring of 1982, a principal and a resource teacher (who would assist with program planning and curriculum development) were chosen for the new school, and 42 teachers were interviewed for the 14 positions.

Columbus Public Schools devoted considerable time to planning and inservice training, bringing in consultants from the school system and local universities, and forming a steering committee to develop plans for building changes, staff inservice and selection of educational materials and equipment.

Berwick Math/Science/Alternative Studies Elementary School opened in September 1982 with 415 K–5 students. There were two to three self-contained classes at each grade level.

Our Program

Berwick emphasizes science process skills. Students learn to understand the natural and man-made environment in the classroom and on the playground. They do this with resident camping programs in grades 1–5, visits to Spruce

Run (Columbus Public Schools' environmental center), and other varied programs and trips. Each classroom has a wide variety of plants and animals which provide opportunities to learn observation and proper care.

Our philosophy is dynamic. It fits the needs of boys and girls in our multi-ethnic society while adhering to the curriculum prescribed by the Columbus Board of Education. We want our school to provide opportunities in a wholesome surrounding for each child to fully develop skills and talents. We emphasize math/science/environmental studies to help each child grow academically, morally, socially, and to become a contributing member of society.

We view science and environmental studies as the investigation of our natural environment. The body of knowledge in science results from studying the physical world and the interactions of all things. We feel that science plays an important role in all human activity.

We believe our curriculum needs to be integrated to help children live more richly and effectively while preparing them for the role they are to play in our society. It must be based on the needs, interests, and creative abilities of our children, providing enrichment opportunities for group living and the development of human relationships. It should help children to think, to solve problems on their own, and then to apply their solutions to everyday life.

Our Teachers

Berwick teachers believe in inquiry-based science education. We use hands-on experiences, demonstrations, discovery learning, and field studies. Students should have knowledge of the major concepts of science and be able to apply them; they should use the processes of science in solving problems and making decisions; they should understand the partnership of science and technology; they should develop skills that will enable them to function effectively in career and leisure activities; they should develop attitudes compatible with conservation. Most important, we want our students to develop interests that will lead to a richer, more satisfying life. Science and the study of our environment can be a life-long quest.

Within the limits of time, each teacher at Berwick attempts to provide a daily hands-on science experience for each student. We use *Science Curriculum Improvement Study* (SCIS), *Elementary Science Study* (ESS), *Outdoor Biology Instructional Study* (OBIS), *Educational Resources Information Center* (ERIC), textbooks, publications such as *Science and Children*, and tradebooks as resources when planning for instruction. We integrate math, reading, language arts, art, and physical education into the science program.

Berwick's teachers are facilitators of learning. They stimulate and encourage children to look at things in new and unusual ways. Each teacher plans a science program, but grade levels also work as teams in planning and implementing programs. The staff makes curriculum decisions together.

Berwick teachers are creative and innovative. Dedicated and hard-working, they spend many hours at workshops preparing themselves for implementation of Berwick's goals. Teachers received Ohio State University credit for a course designed to help prepare for residence camping. They participated in workshops on learning styles, problem solving, nutrition, campfire programs, etc.

The School Environment

We have created an environment conducive to inquiry. In any given classroom there may be a rabbit, a guinea pig family, tropical fish, hissing cockroaches, a newt, and parakeets. Students nurture and care for these animals. We provide a stress-free environment for each pet. Animal behavior, genetics, nutrition, and reproduction are obvious topics for discovery and research. Students also raise mice, mealworms, crickets, and goldfish as food for other animals. Birth, illness, care, and death are realities at school. Children discuss these topics naturally, without embarrassment. Animal studies are extended by visits to the zoo, animal shelters, environmental centers, and veterinarians' offices.

Each classroom has plants. In addition to decorating the room, they provide a basis for the study of propagation, disease, environments, and horticulture. Some classes raise herbs while others grow vegetables or tree seedlings. Our playground is a much-used location for environmental experiences. Teachers may plan a square-foot study, an insect walk, or an unnatural hike. Classes observe birds and make leaf collections. They study simple machines used in playground equipment. They plot temperatures and examine their adopted tree. The playground becomes a classroom for population studies of dandelions; leaf and bark studies; erosion and reclamation studies. These inquiries lead to trips to a conservatory, city parks, and our environmental education center.

Classrooms have learning centers where children can investigate and wonder. A pendulum, bulbs, batteries, or measuring sticks may stimulate much creative thinking, problem solving, and inquiry. Children are encouraged to write about their observations; many keep logs. A variety of reading material is available both for casual reading and research.

Each child at Berwick does a project for our annual science show. Younger children often do demonstrations and display collections. Older children learn to develop a hypothesis and test it. They write up their research, make a display, and share their findings with others.

Our environmental program is one of the most exciting components of our science curriculum. Each class does many activities on our playground and at various parks in Columbus. One of these is Spruce Run. Spruce Run, Columbus Public Schools' environmental center, is a 50-acre natural site on the outskirts of the city. Robert Patton, an Ohio State University professor, gave it to the Columbus Public Schools in 1974. He wanted the site to be kept in its natural state and to be used by children. Prior to 1982, few school groups used the site; there was no naturalist nor any inservice training for teachers. Better use of Spruce Run was one of the goals of the school administration when Berwick's environmental emphasis was chosen.

Once the site began to have more enthusiastic visitors, the school administration developed plans for a classroom module. Now, two mobile classrooms have been transformed into a rustic-looking building with two rest rooms, office, storage closet and a large classroom. Berwick teachers developed a field trip guide to assist other schools that wanted to use Spruce Run. The guide includes a history of the site, philosophy of use, rules, and a variety of field-tested activities. Berwick's resource teacher conducts training sessions several times a year at Spruce Run. Interested teachers can receive orientation at the site, participate in some typical student activities, and take the guide home for further reference.

Each Berwick class visits Spruce Run three or more times a year. Throughout their six years at our school, students observe changes that occur in the stream, woodlands, pond, and succession plot at Spruce Run. So students can be divided into small groups, parents and volunteers help with teaching. A typical day for a 1st grade group might include a hike, a rotten stump study, stream studies, an art activity, and predator-prey games. Children use all their senses in their investigations. Although it is not a primary goal, they learn some plant and animal identification. We try to foster attitudes necessary to preserve the environment.

Spruce Run is also the site of our family picnics on early fall evenings. Families from all over town meet each other and soon become friends. Other picnics are held in the spring as a way for teachers to say "thank you" to supportive families. Some classes even spend the night at Spruce Run. First graders sleep on the floor in the building; 5th graders pitch small tents.

Berwick students begin resident camp experiences in kindergarten with a day camp at Camp Mary Orton. Each class at Berwick, beginning with 1st grade, goes to a resident camp at least one night a year. First graders go to Spruce Run and Camp Akita; 2nd graders to Willson Outdoor Center; 3rd graders go to Camp Ohio. Fourth graders spend two nights at Lutheran Memorial Camp. Our 5th grade classes have a four-day fall experience which includes one night at a primitive outpost at Camp Ohio and a two-day winter experience at Camp Templed Hills. At resident camps the children have first-hand experiences in different outdoor environments. They grow and develop as they participate in real-life activities away from home. In addition to learning about the environment through a hands-on approach, our resident camp teaches community living skills and group cooperation. Children develop skills in personal and social adjustment and strengthen interpersonal relationships.

Some camps provide staff to help with programs; at other sites, Berwick teachers and volunteers do it on their own. Teachers receive no stipend for participating in this program. A recent 5th grade experience at a Nature's Classroom site included an environmental hearing, a night hike, a student variety show, and classes in geodesic-domes, wild edibles, bridge building, dissection, winter weeds and many other topics.

Resources and Support

Berwick School has 20 Apple microcomputers. Students learn to program with LOGO and BASIC, developing problem-solving skills. Older students learn the basics of word processing. Now, many students use a word processor to write their science research. Science simulation games such as *Odell Lake* and *Oregon Trail* are popular. Software is available for specific topics such as the brain and astronomy.

Speakers and field trips enrich the science program. While studying water, a class might visit a water treatment plant, probe a nearby pond, or hear a speaker on water purification. These activities would be in addition to class work and outdoor work on water testing, water scopes, sinking and floating in fresh and salt water, dissolving various mystery powders, absorption of towels, etc. To learn about water, the child needs to have many experiences with it.

Many resources are available to both students and teachers. In addition to thousands of volumes in our Library Learning Center, we have an extensive library in our resource lab. Many texts are available, including the 1980 Holt Elementary Science textbook series and the 1987 Silver Burdett Elementary Science Program. Both texts are used by teachers and students as a resource—not as a teaching guide.

Berwick's resource lab houses many materials which make it easier for teachers to initiate hands-on experiences. Bulbs and batteries, chemicals, beakers, petri dishes, compasses, magnifying glasses, materials for sink and float activities, solar-powered devices, and microscopes are just a few of the items readily available. The lab also stores food for animals along with aquariums and other animal supplies.

The Berwick staff worked cooperatively to write our science scope and sequence. We emphasize life science in the fall, physical science in the winter, Earth science in the spring. The scope and sequence is a suggested starting place for each grade level so that topics are not overlooked or repeated unnecessarily. It is much like a road map—we know where we are going and where we have been but we are free to make extra stops along the way.

Students are active participants at Berwick School. They have many opportunities to explore manipulative materials as well as their natural environment. Abundant experiences provide for growth in problem solving.

Fourth and 5th graders participate in the Young Experimental Scientist Program at the Center of Science and Industry. While there, they participate in a variety of hands-on workshops, and share the ideas they learn with other classes at Berwick. This gives students the chance to experience the role of teacher. Some children help with outreach programs in which they share classroom pets with children at other schools.

Berwick's program is supported by a staff of 14 teachers, one resource teacher, a principal, secretary, library aide, and a half-time aide. This small paid staff could never implement such an energetic program alone. We have the support of one of the largest PTA's in the city—a membership of approximately 600. Each spring at our volunteers' luncheon we honor over 200 volunteers. These volunteers make the difference between good and excellent programs. Volunteers help gather materials for centers and experiments, help supervise hands-on lessons, teach classes at our nature center and at camp, assist with computers, coordinate fund-raisers . . . the list is endless.

To supplement limited board of education funds, we have three fund-raisers each year: a coupon book sale in the fall, cheese and sausage sale in December, and a candy sale in the spring. About $8,000 helps defray student camping fees while another $6,000 provides teaching supplies, computers, and other school needs. This school year our Board recognized the major expense of our large animal population by granting $1,000 a year to help defray animal expenses. This will supply approximately 40 percent of our actual need.

Evaluation

At Berwick, we evaluate students formally every nine weeks. Grades are earned in "science" and in two subheadings of science: "uses the skills of science in investigating problems" and "understands important science concepts." Columbus alternative schools have the option of writing their own report cards, but our staff felt it prudent to work on our program before changing our reporting tools. We will consider a report card more specific to the goals and objectives of Berwick in the near future.

Students are evaluated daily in an informal manner. Teachers observe students as they work on experiments and projects, seeking evidence that they understand science concepts, perform the operations of science, and acquire desirable behavioral outcomes. Teacher-made paper and pencil tests also are administered. Throughout, students are evaluated on their ability to apply information and explore its applications. Children write about their experiences. They graph the results of their experiments.

All 4th and 5th grade students in Columbus Public Schools take California Achievement Tests in reading and mathematics each spring. Berwick students have consistently had the highest or second highest scores of any school in the district. (Remember, Berwick students are not chosen by ability but are selected through a city-wide lottery.)

Evaluation of a program is vital to teaching and learning. In addition to the evaluation that is naturally done throughout a school year, the Berwick staff has taken a day each spring to evaluate and recommend changes. Evaluation goes hand-in-hand with change. The science scope and sequence was written as a result of one session. Staff development on computers was planned after another evaluation.

The Berwick staff works in committees to plan programs. Each group works to determine their successes and failures, and then plans accordingly. We have committees for each of our special emphasis areas—math, science, and environmental studies. Other groups deal with assembly programs, fund raisers, and future events.

Plans for Improvement

Berwick School is constantly changing, developing and growing. No exemplary program can remain static. We are always looking for outstanding programs and good sources from which to draw ideas.

One of the areas we would like to strengthen is our relationship with Ohio State University. After taking courses at Ohio State and working with OSU participants and student teachers, we would like to do more long-term planning with the university.

Our school is located on a large field. We have started to develop a land lab on the site. We are now working with the Franklin County Soil and Water Conservation District to develop a master plan. We hope to add larger gardens, a rock pile, a succession plot, a swamp area, a sensory garden, and a prairie to our land lab. We are finishing raised herb and flower gardens next to the building and have enlarged our vegetable plots so that each grade has its own space.

Berwick's alternative program is successful because of the joint efforts of the Board of Education, administration, faculty, students, parents, and friends. It works and will continue to do so.

ERIC Full Text Provided by ERIC

School District: Broward County Schools (97 elementary schools; 3,096 staff; 80,000 students K–6)
Location: Davie, Florida (County pop. 1,000,000)

Beautiful weather year-round makes outdoor learning here viable and popular. The primarily high-tech business community is sound, with little unemployment. Classroom science teachers have little or no special science education.

Chapter 7 Integrating Science With Other Curriculum Areas

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We designed the Broward County Elementary Science Program with the belief that science is a vital part of children's education. Content is no more important than the processes students use to find information and solve problems or apply ideas and facts to the real world. Further, science can be used to integrate the skills of reading, writing, and mathematics. Science is also a forum for pupils to ask questions, offer ideas, and investigate topics of individual interest in a non-threatening, non right-and-wrong classroom environment.

The program goals include increasing children's awareness of the world around them and of ways to discover that world, developing cognitive skills, and instilling an appreciation of the beautiful in nature.

Curriculum

While developing our curriculum, we studied textbooks to determine the organization of content and process at particular grade levels. A review of current literature and research findings such as *Project Synthesis* and *What Research Says to the Science Teacher* (NSTA 1978-1984) sparked good discussion.

We designed elementary science curriculum guides over several years with input from teachers from a wide cross-section of schools. The guides include specific instructional units covering topics in life, physical, and Earth/space science. Units include the identification of concepts and related objectives. They suggest activities which allow teachers to incorporate the processes of science into teaching science concepts. Each grade level features an introductory unit designed to familiarize teachers and students with science process skills which can then be used throughout the year as needed.

The program objectives identified in the curriculum guides correlate with recent state initiatives mandated by the Florida legislature. These include the State Standards and Skills of Excellence in Science and the State Minimum Student Performance Standards in Science. Additionally, the science objectives correlate with the district's basal reading series to illustrate the fact that science can be taught in an interdisciplinary fashion.

Evaluating student mastery of program objectives and minimum basic skills for each unit is done through criterion-referenced examinations. Teachers trained in item writing strategies developed these exams, which have been validated over a two-year period. Teachers also assess student performance using observation and successful completion of activities and projects.

One useful development is the "Microscope Handbook" for elementary teachers. The book helps familiarize teachers with this vital tool, so they can provide an effective learning situation for their students.

Curriculum Implementation

Once we developed the curriculum, we had to train teachers to use it effectively. We began with large, district-wide workshops, followed by smaller ones at the individual schools. Because large systems have considerable teacher turnover, the implementation phase is continuous. Special summer institutes funded by the state have given us the luxury of training many elementary teachers for three full weeks at a time. During the last summer institute, elementary teachers heard lectures by a university elementary science educator in the west, a creative elementary classroom teacher, an environmental science teacher, and a computer teacher who showed the teacher participants how to integrate computers into the science program. Each teacher was also evaluated on a pre- and post-diagnostic examination, and each had to teach a full science lesson in a clinical setting for further evaluation, a first for most. For some it was also the first time that the instructional strategies used in the delivery of their lesson were objectively critiqued.

Participants in the summer institute received a salary for their attendance.

Curriculum Evaluation

The elementary science program is evaluated formally and informally. Informal observations are made on a daily basis as representatives of the area curriculum staff and the district's science staff visit schools and teachers. Many visits take the staff right into the classroom to work with students.

Formal evaluation takes place in a variety of formats. At the school level, administrators evaluate teachers in the classroom and review lesson plans. Administrators, in turn, are evaluated in terms of compliance with policy, which further helps to ensure that each school is teaching science.

Criterion and norm-referenced examinations evaluate student progress in terms of local and national parameters. The science supervisor assesses the test data to determine student achievement, school profiles, curriculum effectiveness, and district gains over the last few years. The data has helped us identify areas of strength and weakness. Science items on district-developed tests have been analyzed and revised as needed. Each school also has a scanner that not only grades tests but also provides immediate item analysis. Such instant feedback is useful to the classroom teacher.

Elementary science will soon become part of the State Assessment Testing Program that has been in place for reading, writing, and mathematics for the past eight years. Student mastery of the minimum objectives in science will affect promotion/retention at grades 3 and 5.

Resources

Four years ago, we had virtually no resources for elementary science. Today the situation is vastly improved. Elementary science textbooks are available for every student, and every school received a minimum of $8,000 worth of science equipment and supplies as part of a district wide effort. First, we developed a basic equipment list for elementary science, matched to the facilities suggested in the curriculum guides and in the textbook series. We then decided all schools should have certain basic apparatus, including 10 monocular microscopes with built-in lights, 10 stereomicroscopes, (all microscopes are of high school quality), a microprojector, an incubator, animal cages, triple beam balances, and a planetarium. Each school then used its remaining funds to select items from the basic equipment and supply list. The district Superintendent approved the purchasing first, and then the school board.

Now the equipment is being used more in some places than others. When asked, teachers tell us that because of their meager background in science and their inexperience in handling equipment, they do not feel comfortable using some material in the classroom. This has prompted the science department to organize training for teachers in handling and using basic science apparatus. Teachers who attend these workshops—paid for by inservice funding—say they use their equipment more.

Science Fair

Perhaps the most successful addition to the science program has been the Elementary Science Fair. To date, some 86 public and private elementary schools participate in the fair, which functions on the belief that children can learn to identify and solve problems using the scientific method. Rather than stress a win-lose philosophy, the district has spent hundreds of hours training teachers in the process of problem-solving in science. Teacher workshops abound. Teachers have an opportunity to see samples of individual and class projects. The net effect has been that thousands of children are learning how to identify and solve problems, and hundreds of teachers are no longer thinking that a volcano model is a good a science project.

We hold the elementary science fair in a regional shopping center where hundreds of people can see the projects, and other children who have not participated can begin to learn what the science fair is all about. The science fair culminates in an awards ceremony where parents, grandparents, and siblings can enjoy and recognize accomplishments. The community provides judges for the fair, and awards and recognition for both students and teachers.

Each year, teachers who have demonstrated extra effort and initiative are recognized for their contribution to science education. For some teachers, it is the first time they have received recognition for their efforts. Frequently, administrators are also recognized for fostering an environment that allows science to truly blossom. The letters of appreciation received from the recipients attest to the real need in education to do more of this kind of thing.

Other Features

The science program is not limited to classroom activities. Several other components have increased interest in elementary science as well.

Elementary staff members are attending grant writing workshops in an effort to obtain more environmental minigrants from the state. As a result, more schools are receiving grants and building on-campus outdoor centers. Our principals share their accomplishments at administrative conferences and some have received the state's Little Red Schoolhouse Award for their accomplishments. This is a refreshing change from administrators boasting about budgets or athletic competitions.

The Week of the Ocean School Marine Fair, held in a regional shopping center, gives students an opportunity to explore the ocean and related topics through arts and crafts, poetry, science projects, photography, and even salty satire and cartoons.

Our science staff is always looking for timely, district-wide activities that will motivate teachers and students. Examples include Halley's Comet workshops and materials, and classroom presentations by NASA, Florida Power and Light, and the Discovery Center. Students also take field trips to the Florida Keys where they spend several days exploring the flora and fauna of the oceans and surrounding land areas.

The district has a portable science classroom, where we hold teacher workshops and show models of mini-science centers, bulletin boards, and ideas for science activities for teachers to incorporate into the classroom. One need only visit a school supply store to confirm the void of commercially prepared materials in the area of elementary science, and reaffirm the importance of such creativity and resourcefulness.

Staff Development

The district receives funding from the state to provide extensive staff development for teachers and administrators. In addition to the district initiated workshops, schools have individual inservice budgets that allow them to offer workshops suited to their specific needs. The budgets can also employ elementary science consultants to work with teachers. Administrators have an opportunity to attend district, state, and national academic conferences.

Special administrative workshops help foster the development of elementary science. "The Principal Makes the Difference" was the theme of our most recent workshops. Principals worked in small groups, held lively discussions, and addressed individual concerns. The workshops focused on ways of overcoming stumbling blocks in science education, and principals identified specific strategies which could foster quality science in their own school. (After all, if he or she had never seen a quality elementary science program, how would a principal know if their individual school is doing all it could?) These efforts have had more impact on the growth of elementary science than anything else we have done.

How Did We Get There?

The growth of the elementary science program in Broward County Schools did not happen overnight. A combination of planning and action, on many fronts at the same time, have brought us over the years to our current status. Communication was one of the most critical aspects: keeping people informed, helping them understand the nature of elementary science, and providing them with the information and ideas necessary to implement an elementary science program in their own schools. After all, when the district person leaves and the teacher's door closes, what goes on in the classroom is what makes the difference. That is why it is essential to involve teachers and administrators from the beginning. Visibility to parents is also important. Their support is essential, and usually quite gratifying when they see the changes actually taking place in both the school and the child. District advisory committees and parent/teacher groups should be invited to participate in the elementary science program whenever possible.

Individual schools cannot do the entire job. District support in the form of a science curriculum professional is a necessary corollary to implementing a quality elementary science program. Our district effort also helps us to identify stumbling blocks to elementary science and to implement the strategies necessary to overcome them.

Plans for Improvement

While elementary science is alive and well, much remains to be done in order to provide quality instruction to all students and further enhance the learning environment of the classroom. As before, this will require further planning, expertise from within and outside the district, and general enthusiasm for elementary science at the school, district, state, and national levels. The energy, effort, and strategic planning that have gone into the development and continuance of our elementary science program cannot be slowed down. They can only be redirected as needed, into areas such as staff development, resource identification and acquisition, evaluation of student achievement, successful school programs, effective principals, and overall interest in science in the schools and in the community.

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Chapter 8 Tanglewood Kindergarten Science Program

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School: Tanglewood Elementary (28 staff; 400 students)
District: East Baton Rouge Parish (66 elementary schools; 1,500 staff; 27,522 students K–5)
Location: Central, Louisiana (pop. 23,000)

The population of this Baton Rouge suburb is predominately white, middle-class, and protestant; many are employed by the local petroleum industries. The school population, however, is 51 percent black and 49 percent white.

Philosophy and Goals

Our primary goal is to encourage children to see and explore relationships by making observations and discoveries about the environment. Our kindergarten science program encourages use of all the senses through a hands-on approach.

Our discovery center, a permanent area in the classroom, is easily accessible to all students. The center looks inviting because it capitalizes on children's interests. Materials and units of study reflect life's on-going and current happenings and are assisted by permanent discovery materials such as balances, magnifying glasses, magnets, rulers, rocks, and shells.

Our kindergarten science program begins with children as they discover themselves in their environment. Immediate interest in themselves allows us to introduce our unit on the senses. Our children recognize immediately that they can discover a wealth of information by using their own sensory skills. The students are encouraged to work in the discovery center. Teachers ask open questions, encouraging interest in the world. This is the beginning of a continuous process.

Background of Kindergarten Science Program

In 1979, two kindergarten teachers who saw the need for nurturing children's scientific questions and inquiries developed our program. Earlier kindergarten science programs were merely teacher "show and tell" with no input from students. Kindergarten children did not reach their own conclusions. Instead they were shown, step-by-step, materials, procedures, and conclusions. Our inspiration for developing a kindergarten science program based on discovery through the senses came from our observation of how four- and five-year-olds learn. A child sees that two leaves are alike because they are the same color. A child hears that two sounds are different because one is loud and one is soft. A child feels that a needle is sharp. Using the senses is fundamental to learning and should be emphasized at an early age.

Kindergarten Science Rationale

Our kindergarten science program bases its learning on discovery and well-organized teacher-student interaction. Teachers provide a wealth of pictures, charts, books, and materials, such as a pan of water to discover what sinks or floats, magnets to discover what will be picked up, bird nests to determine their structure and materials, scales for weighing items, skeletal bones for classification, and rocks, shells, leaves, and any item a student might bring to share.

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Nature of the Program

All aspects of a total kindergarten curriculum can be found in our kindergarten science program. We stress the eight basic science skills: observ[illegible] inferring, classifying, using numbers, measuring, [illegible], space/time relationships, communicating, and predict[illegible] So that no science unit is taught in isolation, all science discoveries are correlated with reading readiness, math readiness and creative art activities

While discussing the dentist, children discover the effects of sugar on teeth. We place a real tooth in a container of cola and another in a container of clear water. After several days someone discovers something has happened to the tooth in the cola. Through guided questioning, the child infers cola is not healthy for teeth. We have the children bring their own toothbrushes and toothpaste for daily dental hygiene.

Finger paints and water colors are primary art media for all kindergartners. While exploring primary colors, children discover they can make the secondary colors. Bottles of food coloring with droppers are added to the discovery center along with baby food jars of clear water. By mixing drops of food color to the water, new colors are discovered.

A study of firefighters is always fascinating to kindergartners. The benefits and dangers of fire are an integral part of our study. By allowing children to build a fire in our playground sandbox, they discover the components necessary for a fire. Again, teacher-guided questioning helps pupils to infer that by taking away any one of the components, a fire cannot exist.

Skeletons, ooh, how frightening! But are they really? We all have one. We have discovered Halloween is the ideal time to let the students discover that most familiar creatures have skeletons. Real X rays of people are added to the discovery center along with a real deer leg bone. Before we realize it, the discovery center is covered with bones brought from home. Students begin measuring and weighing bones, comparing sizes, shapes and colors, and even locating where an individual bone is in their own skeleton.

From these bones, we later move to a study of dinosaurs. Dinosaurs become realistic to the class as we look at pictures and paint murals of them. A trip to the Louisiana State University Museum of Science and Geology is an exciting educational experience that furthers students' knowledge of dinosaurs and bones.

Cooking also is an excellent opportunity to experience and discover basic scientific facts while using all of the senses. Cooking gives children concrete experiences with scientific terms and definitions. For example, what's a solution or a mixture? We make a solution by dissolving gelatin powder in water. Students examine tools and utensils to see how they work. How does an egg-beater beat? How does a juicer juice oranges or a can opener open cans? Children explore changes by watching an egg take different forms, and watching cheese melt. When cooking, they find themselves in an informal setting in which they can share opinions, speculate about what they think will happen, and ask questions. These questions, guided by the teacher, generate involvement, curiosity, and discovery. Our children become young scientists as they discover the meanings of scientific terms and internalize these concepts through cooking. And they can eat the results!

We provide an educational study trip to the Louisiana Arts and Science Planetarium. This introduces the in-depth study needed for understanding the solar system with emphasis on our planet. When we ask students to jump up and stay up, they discover they cannot. From here, we introduce gravity and experiment with its effects on various objects in their immediate environment. Through dramatization, children discover the relative location of the planets to each other and to the sun. Pupils hold models of the planets and station themselves around our model sun.

A recent musical extravaganza developed and presented by the kindergarten students related facts they had learned about the solar system. The program was lauded as the most lavish educational science program ever presented by kindergarten students in the State of Louisiana. Our exemplary kindergarten science program allows our children to become learners in the most active sense. They are doers, not just spectators.

Science Fair

Tanglewood Elementary School's faculty sponsors a dynamic science fair. We have discovered that participation in our science fair is an excellent evaluative tool for kindergarten science. We encourage each kindergartner to present a science project,and we have 100 percent participation. The science fair entry is a cooperative home/school project. We send parents a note that reviews scientific concepts the children have discovered. With help from home, each kindergartner selects a project to work on. Even though we encourage parental assistance, we stress that the display be representative of the child's work. Each project is judged not only on appearance, but also on the scientific knowledge of the child. The kindergarten participant is interviewed by the judge and asked to explain the project. The judges are often amazed by the child's clarity and understanding of scientific discoveries. Our judges are selected from the petroleum industry, middle and high school science departments, the news media, and supervisory personnel from our school board.

Evaluation

We use a variety of evaluation methods. Our evaluation techniques reflect our objectives to emphasize sensory as well as verbal skill development. Children demonstrate successful attainment of an objective by doing specific things we can observe.

Our kindergarten science program at Tanglewood Elementary fosters positive scientific attitudes. Our students have developed an appreciation of science in their everyday lives. By the end of the school session, we can see them comfortably using their skills of observing, inferring, classifying, measuring, communicating, and predicting.

Financial Needs

Our kindergarten science program is not externally funded. We have an effective Parent Teacher Organization that allocates a small amount of money to be spent on the total kindergarten program. The majority of our science materials are salvaged from such community resources as dentist offices, medical clinics, restaurants, shopping mall trash bins, garage sales, and cooperative parents.

Organization: Board of Cooperative Educational Services (BOCES)
Location: Spencerport, New York

A regional agency, BOCES allows local school districts to join together in a cooperative effort to provide for their mutual needs. The Monroe 2-Orleans BOCES serves nine suburban and rural school districts.

Chapter 9 BOCES: Districts Working Together

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Every school district faces educational needs too great or too costly to be met by local resources. In our state, the Board of Cooperative Educational Services (BOCES), a regional agency, allows local school districts to join together in a cooperative effort to provide for their mutual needs. There are 42 BOCES throughout New York state: while each offers occupational and special education, their services vary according to the needs of the local districts. The Monroe 2-Orleans BOCES, located in Spencerport, New York, serves nine suburban and rural school districts and is unique in offering a comprehensive support system for elementary science education.

The 453 people employed by the Monroe 2-Orleans BOCES, mostly in occupational and special education programs, include 43 persons (four professional and 39 technical aides) as a support system for the Elementary Science Program (ESP). The ESP represents a major cooperative effort among educators at the district, regional, and state levels to increase and improve elementary science instruction throughout New York.

In 1972, our BOCES initiated an elementary science service providing direct technical assistance to classroom teachers. This included the development of program materials, staff development, and an ongoing support system.

Throughout New York state, 183 school districts from 24 BOCES areas currently subscribe to this service. The communities involved range from rural to densely populated suburban areas. No large cities have requested ESP services. The ESP provides materials to regular classes K–6, gifted classes, special education classes, Pre-K, grade 9, special schools, such as the Convalescent Hospital for Children, and private and parochial schools. The students involved are representative of the communities served.

As a result of this service, approximately 4,166 teachers and 104,150 students are provided with a hands-on approach to science each school year. Because of the success of this approach, five other BOCES and one large city district have replicated this service.

Our Program

ESP, a hands-on program, teaches students to be problem solvers. The content, skills, attitudes, and teaching approach vary from one unit to another. ESP, a student centered program, encourages the use of library books instead of textbooks as reference books, encourages students to write and draw results of their experiments in their own style, and encourages teachers to listen to students and increase their sensitivity to individual student needs. The ESP is designed to be open-ended: as a class

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studies a give unit, what the students learn and experience will be unpredictable.

ESP also improves the instruction of elementary science by training teachers in the proper use of materials and program learning theory. The staff is sensitive to teacher needs and open to teacher ideas and suggestions. Teachers suggest changes in teacher's guides and materials on a regular basis. Periodically, the professional staff reviews teachers' ideas and considers needs, cost effectiveness, and whether or not the suggestions are educationally sound before revision of teacher's guides and kits take place. The ESP professional staff meets with the ESP Advisory Council on a regular basis to discuss and review curriculum revisions. We encourage technical staff to contribute ideas on packaging and other department procedures. Unit offerings must be flexible to meet the individual needs of the various school districts. Individual school districts decide the grade placement for each unit they select based on the district's scope and sequence. The overall philosophy of the ESP professional and technical staff is to provide a cost-effective, quality elementary science program for teachers and students.

Goals for Students

We feel ESP should help the student develop

- The ability to solve problems effectively.
- The ability to systematically apply inquiry process skills and language arts skills and processes.
- Positive attitudes toward science by participating in hands-on activities.
- Increased understanding of scientific concepts and principles.

Subjects Covered

The program contains 152 units for regular and gifted, and special education classes pre-school through grade 9. Unit offerings include a variety of life science, physical science, Earth science, and general skills. The majority of the activities in any one unit are hands-on activities. Each activity involves science concepts, inquiry skills, language arts skills, and processes and attitudes. A behavioral-type evaluation strategy, which teachers use to evaluate student performance as well as monitor their own teaching, follows each activity.

The Teacher's Role

The Elementary Science Program will be most effective in classrooms where inquiry is encouraged, and where teachers are able and willing to listen more than talk, observe more than show, and help students progress in their work without engineering its precise direction.

The role of the teacher changes from that of being a dispenser of knowledge to a director of instruction in the classroom, actively exploring questions along with the students.

To be successful in this program, teachers must be committed to it. Teachers must want to explore, speculate, and try things on their own. Teachers must be sensitive, responsive, provocative, and attentive to children.

Teachers order the kits most appropriate for their class and within the scope and sequence developed by their district. After using the kits in a safe and recommended manner, they take inventory of the supplies before returning the kit to the ESP office.

The Student's Role

- Help plan class activities.
- Interact with and assist other students.
- Use a model for problem solving.
- Keep notebooks or journals when appropriate.
- Follow safety precautions.
- Follow rules.

Materials Needed for the Program

Kits of materials are fabricated and refurbished at the ESP. Teachers request the units based on their district's curriculum design. The ESP sends kits to teachers, who then return them to the ESP where they are refurbished and sent to other teachers. Correlated with the kits are other components such as teacher's guides, student books, activity sheets, films, and living materials.

Service Dimensions

The ESP also provides inservice courses for teachers and administrators. These courses cover the proper use of materials and the educational philosophy necessary to teach hands-on science. When educators complete ESP inservice courses they have the ability and knowledge to change from the traditional textbook-lecture method to hands-on instruction. ESP coordination services and materials provide support for teachers so they can begin and sustain this change in teaching style.

The materials provided by the ESP include kits, teacher's guides, transparencies, worksheets, reference books, student activity books, a newsletter, *The Gerbil Journal*, and cultures of living materials. Materials are scheduled based on teacher requests. The Educational Communications Center prints worksheets and teachers' guides for the ESP, and all materials loaned to districts remain the property of our BOCES.

Living materials supplied include cages of gerbils, guinea pigs and rabbits, and cultures of crayfish, protozoa, mealworms, fruit flies, toad eggs, snails, isopods, butterflies, and aquarium plants and animals. Humane treatment of all animals by teachers and students is stressed.

The ESP Professional Staff regularly meets with teachers and administrators to consult, advise, and assist them in the implementation, development, and evaluation of their specific program. Coordination services include demonstration lessons, inservice courses, workshops, and curriculum development.

Evaluation

It is not the ESP's role to evaluate students. Rather, each district determines which method(s) to use.

The best evaluation of the program can be seen in the fact that an ever increasing number of districts subscribe to the ESP. Our hypothesis is that if the program materials and support system are educationally sound and successful, then school districts will continue to subscribe to the program, joined by other districts.

Since the ESP was established as a BOCES service, it has conducted periodic self-evaluations. These evaluations consist of measuring changes in teacher attitudes before and

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after inservice courses. Teachers also evaluate the quality, quantity, and appropriateness of the materials in the kits.

The subscribing districts also evaluate the ESP. These valuations measure teacher attitudes, student attitudes, student achievement, and the quality, quantity and appropriateness of the materials in kits. The ESP staff is not always privy to district evaluations because they are district property.

Plans for Improvement

The ESP has grown significantly in the past three years. The main problem areas are:

1. Curriculum Development: Development of new units and revision of old units has slowed. The ESP Director needs to delegate some supervisory, budgeting, and product research responsibilities in order to get curriculum development back on track.
2. Staff Supervision: The ESP has grown from nine to 43 people in the past five years. The amount of staff supervised directly by the director and assistant director needs to be reduced by delegating responsibilities to other people.
3. Space: The ESP Center moved to its present location in May 1980. The present center was established to provide services to about 20 districts. With 183, ESP has outgrown its present space. A second center has been be set up to refurbish selected kit titles, but the demand for space continues to increase more rapidly than additional new space can be found.

What Could Undermine the Program?

The following situations must be monitored so the program is not undermined:

- Teacher apathy.
- A breakdown in communication between the ESP and subscribing districts.
- A change in philosophy of the administration or board of education of the BOCES or subscribing districts.

Methods to Keep the Program Healthy

- Maintain sensitivity to needs of teachers and students.
- Maintain good communication with subscribing districts.
- Maintain constant curriculum development.

School District: Fairfax County Public Schools (116 elementary schools; 2,400 staff; 60,000 students K-6)
Location: Annandale, Virginia (County pop. 650,000)

This suburban county near Washington, D.C. is made up largely of professionals; primarily with the military and civilian agencies of the federal government.

Chapter 10 Promoting Scientific Literacy

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Program Overview

The Fairfax County Public Schools elementary science program consists of 114 tradebooks and 29 activity-centered units patterned after the *Elementary Science Study* (ESS). It is designed to develop critical-thinking skills and to promote scientific literacy. The program emphasizes five major developmental goals: curiosity and interest, initiative and inventiveness, observation and record-keeping, independent critical thinking, and persistence.

All teachers have a science kit for each activity-centered unit. The kits, produced at the Instructional Materials Processing (IMP) Center, contain teacher resource guides, various laboratory hardware, and student activity books. Each science kit contains resources for children to participate in a variety of activities, independently or in small groups.

To increase the amount of instructional time allotted to science, Fairfax County Public Schools developed the Elementary Science Reading Resources Program. This integrated science and content reading program contains 114 tradebooks which extend and broaden children's interest in science, as well as reinforce basic reading skills. Each classroom has its own collection, and a set of activity cards that help children focus on the concepts and information contained in each book.

Each card is divided into three sections: a language arts activity, content questions, and suggestions for individual and group activities. Teachers have found the cards to be an excellent basis for short units of study. This is especially true at the early primary level where teacher and parent volunteers often read the books aloud to children. Students often do research projects for their local school science fairs based on ideas from the cards. An unexpected positive effect of the Elementary Science Reading Resource Program has been a noticeable increase in science fair participation.

One strong aspect of the program is the continuing inservice program. Since the early 1970s, all teachers have been required to participate in science inservice training. Inservice workshops help teachers understand the program's principles, and also provide teachers with an opportunity to discuss instructional strategies necessary for implementing the program.

Activity-Centered Units

We encourage children to investigate nature through teacher-directed activities and independent experimentation.

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For all young scientists, this kind of learning experience emphasizes the essence of science—not one of learning by rote, but open inquiry combined with experimentation. The activity units help children develop their capacity and courage to think imaginatively, logically, and critically—in short, to think for themselves.

The activities draw upon the natural sciences and mathematics. Some involve working with and observing living animals. Others develop process skills. All can be related to other areas of the curriculum, such as social studies, language arts, or mathematics. The materials provided are appropriate for children at different stages of intellectual development: the same basic unit with minor modifications can be effectively used with gifted and talented students as well as with children who have learning difficulties.

So, while working with concrete materials, children learn not to be intimidated by science but to feel at ease with the concept of scientific inquiry. At the same time, each activity emphasizes positive attitudes, curiosity, initiative, self-reliance, and persistence. This gives children the opportunity to develop confidence in their ability to solve problems.

Activity-centered units used in the program and grade levels at which they are used include:

- Kindergarten: Free Exploration, Patterns, Counting and Writing Numbers (integrating science and math), Sorting and Comparing, and Number Experiments.
- Grade One: Learning Through Nature, a year-long unit organized by month. We study Senses (September), Leaves (October), After Leaves Fall (November), Evergreens (December), Growing Seeds (January), Producing Plant Growth Without Seeds (February), Budding Twigs (March), Flowers (April), Weather (May), Review (June).
- Grade Two: Animal Life, Primary Balancing, Match and Measure, Attribute Games and Problems.
- Grade Three: Attributes and Shapes, Mystery Powders, Batteries and Bulbs I, Sink or Float
- Grade Four: Rocks and Charts, Colored Solutions, Exploring Metric Measure, Butterflies, The Sun and Its Neighbors.
- Grades Five and Six: Behaviors of Mealworms, Batteries and Bulbs II, Small Things/Pond Water, Peas and Particles, Stars and Constellations, Investigating Matter (Liquids), Pendulums, Mapping, Exploring the Universe.

The science units for grades five and six often contain expensive equipment. In order to reduce manufacturing costs, these units are supplied on a two-year cycle. Although the sequencing of units within the cycle varies from school to school, by the end the children will have worked with all units in the cycle.

A unique feature of the astronomy units (grades four, five, and six) is that each includes a visit to one of Fairfax County Public Schools' nine planetariums, which allow students to observe and study the night sky during daylight hours. As part of their planetarium experience, students record observational data which they later use in the classroom.

The IMP Center delivers science kits to individual teachers according to a centrally planned schedule. The kits are delivered in double-walled reusable cartons. Some units can be contained in one carton, others require as many as three. Each semester, 4,000 kits are shipped from the IMP Center to elementary school classrooms, then back to the IMP Center for refurbishing. Teachers do not have to procure any materials themselves. This organization eliminates the need for teachers to waste valuable instructional time gathering and replacing materials.

The IMP Center is responsible for checking each science kit that is returned, replenishing expendable items, repairing broken apparatus, and sending the kit out again to another school. Using the kits more than once during the year drastically reduces the number of kits needed and makes them more cost effective.

We encourage all teachers to participate in a continuing program of quality control. They supply feedback to the IMP Center staff on equipment malfunctions, difficulties with directions, need for assistance in teaching a unit, and whether various aspects of a unit are meeting objectives.

Elementary Science Reading Resources

There are separate collections of approximately 30 titles for primary, middle, and upper grades. Teachers develop a cooperative plan in each school plan to use the books as part of their language arts program. The books excite science students, and at the same time, generate new enthusiasm toward reading. The program provides more than free time for reading; it provides opportunities for children to discuss, analyze, compare, and share activities that deepen their enjoyment of reading. Students communicate their new knowledge by showing pictures, making posters, building clay models, sharing experiments, writing stories, and giving oral reports.

The program enjoys widespread support from teachers, administrators, and the community. Our district has adopted the books as basal material and appropriated adequate funds for the replacement of worn-out books and for the addition of new titles.

Not all tradebooks are suitable for classroom use. Careful selection is important. The National Science Teachers Association and the Children's Book Council have established helpful guidelines for selections. NSTA publishes a list of "Outstanding Science Tradebooks for Children" each year. It is also important to include children's opinions in the selection process. Books that appeal to adults are sometimes boring to children.

Although an elementary science program should be built around hands-on activities, it is not always possible to investigate all science topics through hands-on activities. Tradebooks can provide an additional avenue for students investigating certain science topics. Both reading and guided activity have their place. Our program provides an effective balance between the two.

Inservice Training

Before using a unit in the classroom, teachers must gain experience using apparatus and activities. Skimping, by not providing such training, is poor economy. The success of any activity-centered unit hinges on the teacher's familiarity with the ideas and materials involved.

Our continuing inservice effort is one of the strongest aspects of our program. During inservice, teachers acquaint themselves with class materials, formulate lesson plans, and discuss instruction strategies. All workshop instructors are volunteers, usually teachers or administrators who are experts in a particular activity-centered unit. The county also has four science specialists who respond to individual calls from teachers experiencing difficulties. Each science specialist serves approximately 30 elementary schools, six intermediate schools, and six high schools.

Teacher training goes on throughout the school year. On Monday afternoons the elementary schools close early to allow time for inservice programs and team planning. Teachers also receive inservice training for the designated activity kits and the reading resources used at their grade levels. This training requires five sessions, two and one-half hours each. Such training requires large investments of teachers' time when compared with the amounts of inservice training elementary school teachers traditionally receive. The program designers have found, however, that inservice training is the most important element in the program. Without adequate training there is a high probability the materials will be either misused or never used at all.

For teachers who need additional knowledge in science, the school district offers a tuition-free science seminar. Teachers completing this 48-hour course receive three certification credits from the Virginia Department of Education and credit toward a salary increment.

To a large extent, the success of any instructional program depends on the school principal's support. Therefore, another important aspect of the science inservice program is the training of principals. Fairfax County sponsors seminars for principals to keep them aware of curriculum changes. The seminars are patterned after the *Project for Promoting Science Among Elementary School Principals* sponsored by the National Science Teachers Association.

History

The Fairfax County Public Schools Elementary Science Program had its beginning during the administration of former superintendent of schools Lawrence M. Watts. Soon after his arrival in July 1969, Watts expressed concern about the elementary science curriculum, which consisted primarily of a science textbook with practically no supporting materials. As a former science teacher, he recognized the value of learning by doing and pushed to implement a hands-on, inquiry-oriented curriculum.

In January 1970, we selected Douglas Lapp to direct the Elementary Science Project. The project integrated teacher training and materials that would introduce activity-centered units into the elementary school. Thomas A. Ferguson was designated Coordinator of Teacher Training and Leslie J. Benton was appointed Supervisor of the Instructional Materials Processing Center. The mission of the IMP Center was to: (1) produce science kits less expensively than they could be commercially purchased; (2) circulate science kits among elementary schools; (3) maintain the science kits in a ready-to-teach condition by refurbishing them between multiple uses; and (4) sponsor an inservice training program.

Kits for 12 different units were first produced during the spring of 1970 for use in a summer staff development program. The kits were then assembled in large quantities during the summer for use in the schools that fall. A total of 1,650 kits, each containing enough materials for a class of 32 students, were prepared. The number of kits increased to 2,200 by January 1971. Each teacher in the program received three or four units per year and used them for 8 to 16 weeks, depending on the units.

In addition to manufacturing kits, the staff at the IMP Center sponsored a teacher training program. Inservice workshops introduced half of the elementary school teachers to the science kits during the fall of 1970. The workshops were conducted by a team of 24 local educators including elementary supervisors, science specialists, and principals. All members of the team received extensive training and had teaching experience with the program materials. By the spring of 1971, the inservice program reached all of the elementary teachers in the county. Since the initial effort, workshops have been offered every year to train teachers new to the system and those changing grade levels, and to introduce new or revised units.

Fairfax County Public Schools introduced the Elementary Science Reading Resources Program in the fall of 1978 with implementation to take place over a three-year period. The original program provided one set of activity cards to each classroom teacher and one set of books for every two teachers. Since the response to the program was so positive, it was expanded to include one set of tradebooks for each classroom. To keep the sets current, new titles are continuously being reviewed and added to the program.

Program Maintenance

The start-up costs for the IMP Center were moderate because it was housed in a vacant elementary school building. The few pieces of needed machinery and equipment were acquired from surplus sources. The Center originally used two rooms in the building, and today occupies the equivalent of 22 classrooms.

In setting up the IMP Center, Fairfax County Public Schools solved a problem that has plagued school systems attempting to institute an activity-centered program: maintaining a steady flow of ready-to-teach science materials into classrooms. The IMP Center staff works constantly to improve the science kits and encourages teachers using the kits to suggest improvements. These services—the returning to the Center, checking, replenishing, repairing, and making modifications to fit the needs of teachers—are not available when commercially packaged kits are purchased.

The labor required to construct apparatus such as microscopes, circuit boxes, and balances and to package the materials that go into the activity-centered kits comes from a variety of sources. During the spring of 1970, eight people from the IMP Center neighborhood worked part-time pre-packaging materials to be included in the activity-centered kits. The following summer, 27 student workers continued the kit assembly work and constructed some of the specialized apparatus required in large quantities. The students constructed more than 7,000 elementary microscopes and 1,500 two-pan balances. The student summer workers included 20 Neighborhood Youth Corps workers and two Fairfax Community Action Program workers whose salaries were paid through a federal grant.

During the 1970-71 school year, the work force that refurbished the kits included 10 part-time adult workers from the local community, as well as high school and intermediate school students working after school. In addition, a pilot program at Lincolnia Elementary School successfully involved special education students in some of the

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kit assembly tasks, in a sheltered workshop-type setting.

During the summer of 1971, 25 student workers and 12 adults from the local community combined their efforts to refurbish kits for the original 12 ESS units, and to prepare apparatus and materials for 12 new units. In addition to repairing the microscopes and other apparatus contained in the original kits, the student workers manufactured 1,600 balance-board fulcrums, 3,200 micro-balance stands, 7,000 two-pan balances, and 8,000 gas analysis racks. The staff at the IMP Center now consists of 13 assemblers, three student aides, three truck drivers, a supply clerk, a materials specialist, and a coordinator.

Even when overhead and administrative costs are included, the science kits produced by the IMP Center cost substantially less than those available from commercial suppliers. The first 4,000 kits produced at the Center cost approximately $221,000 instead of the $420,000 commercial cost. The kits continue to be produced for approximately half the cost of those available from commercial sources.

Commercial science kits often require teachers to provide many of their own materials, such as chemicals or potting soil. Some require teachers to spend many hours constructing apparatus. The IMP service allows teachers more time to concentrate on the subject content of the kits and appropriate instructional strategies.

The largest program cost has been and continues to be the operation of the IMP Center. The inservice program does not incur any direct costs. Four science specialists and teacher volunteers conduct inservice on Mondays, when schools close early, or on days set aside specifically for this purpose.

Fairfax County has made a large investment of teacher time in inservice training and an even larger investment in money for materials. However, the school district believes the investment in time, effort, and money has been well worth the cost. The program has successfully introduced a spirit of inquiry into the elementary classroom and has provided children with opportunities to learn and to think independently and creatively. Although the program is in its 15th year, it still enjoys the enthusiastic support of parents, teachers, and administrators.

Evaluation

Fairfax County Public Schools constantly assesses all aspects of the K-6 science program. The Department of Instructional Services analyzes information gathered through a variety of instruments, including: (1) Science Research Associates (SRA) achievement test scores; (2) science kit evaluation questionnaires; and (3) program audits. In addition, a total review of the science program is periodically conducted by a committee of teachers, parents, and administrators in conjunction with a task force of eminent science educators.

In Fairfax County, the SRA achievement test is administered at grades four and six. The average science score at both grade levels is well above the national norm. The questions on the science portion of the test (1971 edition) can be grouped into six categories—Living Things, Matter and Energy, Earth and Space, Experimentation, Charts and Tables, and Reading Comprehension. Student performance has shown a significant increase in each of the six categories since 1974-75. Between 1978 and 1980 there was a 40 percent increase in the reading comprehension category. Since the Elementary Science Reading Resources Program was introduced in 1978, this may indicate that tradebooks in the classroom have a positive effect on the development of reading skills.

In March 1982, Fairfax County Public Schools administered the 1978 edition of the SRA Achievement Series/Educational Ability Series for the first time. This new test involves a different population of students for norming, uses new items, and has some additional tests and subtests. Since this new test format is now being used, a comparison of present test scores with scores prior to 1982 is not possible. However, an analysis of the available information shows that the average science scores for grades four and six are again well above the national norm. In 1983-84, the fourth grade average score was 19 percentile points above the national norm and the sixth grade average was 26 percentile points above the national norm.

Since 1973, a teacher evaluation questionnaire has been placed in each elementary science kit. It is designed to help the IMP Center staff gather information on the use and effectiveness of the materials. The questionnaire provides each teacher with an opportunity to comment on the student materials supplied in the kit, the period of time the kit is available, the quality of the inservice workshops, and the elementary science program in general. Teachers are also asked to describe their experiences with each science unit and to offer suggestions for improving the program. The questionnaires received from teachers are read and analyzed. Problems identified through this process are investigated, and steps are taken to make the necessary program modifications.

The program audit is another management tool the school district uses to assess the effectiveness of individual school programs. Program audits are conducted in approximately 25 schools each year. They are designed to identify strengths and weaknesses in local school program, provide help in addressing instructional problems, and monitor the implementation of policies. The audit team is composed of teachers, administrators, and subject area specialists. In evaluating science instruction, the team uses a list of instructional standards and observable behaviors to rate the observed science lessons. Based on the team's ratings, commendations and recommendations are made to the area superintendent, the school principal, and the faculty. The local school staff must formulate a plan to correct any deficiencies in the local program.

In 1983, an Elementary Science Study Committee conducted a K-6 program review. The review committee consisted of science specialists, teachers, principals, parents, and a task force of eminent science educators from outside the school district. The task force included Phyllis Marcuccio, National Science Teachers Association; Howard Hausman, National Science Foundation (retired); Raymond Hannapel, National Science Foundation; and Teresa Audridge, Commonwealth of Virginia. The 30-member committee reviewed all aspects of the program including the unit objectives, the basal and supplemental materials, the planetarium program, the Elementary Science Reading Resource Program, the materials support system, the inservice training program, and the SRA test score. The committee, in order to make a broad appraisal of the science program, requested the Office of Research and Evaluation to design and administer an elementary science inventory. The inventory assessed the feelings, attitudes, experiences, and expectations of teachers in an effort to determine program needs. The inventory was administered to 700 county teachers and more than 95 percent of the teachers (668) returned the survey forms. In addition, the committee compared the Fairfax County science program to a national standard (Characteristics of a Good Elementary Science Program) established by the National Science Teachers Association under a grant from the National Science Foundation. The Fairfax program met 80 percent of the listed criteria for a good elementary science program.

Chapter 11 Outdoor Science

Leonard V. Ross
Turner Elementary School
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School: Turner Elementary (21 staff; 540 students)
District: Fresno Public Schools (59 elementary schools; 1,316 staff; 33,600 students K–6)
Location: Fresno, California (pop. 220,000)

By using the warm weather and other natural resources of the San Joaquin Valley, Turner Elementary and the Ross Center for Environmental Science blend basic skills with on-going projects with plants, animals, and nature.

Picture a cool, bubbling fountain in a rustic setting filled with flowers. Then visualize 440 children eating vegetables and strawberries fresh from their own garden, viewing pond life through a microscope, and feeding a friendly nanny goat and kid. Add rabbits, pigeons, and ducks in the middle of an outdoor classroom and you have the Ross Center for Environmental Science—not just school and classroom activities, but an important part of a child's day.

When children are eager to go to school, save their milk cartons for seedlings, bring plastic bags to take their own home-grown vegetables home, talk freely about school, voluntarily make campus "sweeps" to pick up debris, and don't want to leave their environmental center, you can be sure that something unusual and good is happening!

The Ross Environmental Center is the focus for student attitude, motivation, and school spirit and pride for students at Turner Elementary School. Fund-raisers, garden contests, community meetings, and school barbecues are just some of the many activities taking place at the center, which is adjacent to the school. Our students are busy, active, and proud of their school and center, and it shows in their positive attitudes, eagerness to learn, and our minimal discipline problems.

The Center

The Ross Center, a half-acre outdoor science facility, serves the students of Turner Elementary School plus other visiting classes in the Fresno area. Each class at Turner School (K-6, Special Education, 16 classrooms in all) has weekly scheduled times in the environmental center for science lesson, or hands-on follow-up activities in one of the 18 learning stations at the center (greenhouse, pond, cactus garden, weather station, animal area, etc.). Each classroom at Turner maintains a 15-foot by 18-foot garden where students are involved in all aspects of gardening, from soil preparation to harvesting. In addition to their own classroom gardens, students work in and maintain a community garden; vegetables from the community garden are sold at local markets. Whether it is collecting and studying pond life or milking a cow, hands-on sensory learning is the key to the Ross Environmental Center.

Whatever is done in our Environmental Center, we all do it together, from getting hay to bringing in manure. Turner School no longer relies on the airport weather station for reports—we now have our own weather station. On field trips, the students take a homing pigeon with them to release when they reach their destination to let us know of a safe arrival.

Our students have built seating areas from brick and rock they have collected and cleaned. The lumber and corrugated metal used in our center was taken from old buildings we demolished in the country. Even before building could begin, students brought the materials back to school, where they cleaned, pulled out and sized nails, and cut the lumber. Older students brought gloves and volunteered to work before and after school and in their spare weekend time. Smaller children fetched and carried.

Two pole barns house the hay that students have donated and gathered. In this area, we house rabbits, guinea pigs, snakes, tortoises, mice, wild pigeons, and tame mourning doves.

Three corrals contain large animals brought in for study. Here students learn that milk does not come from the corner store, and every student has the experience of trying to milk a placid dairy cow. Various types of horses and other large animals are brought here, where safety measures are carefully taken. A squeeze chute permits the children to approach, look, and touch without fear. We have strict safety rules for our center. Areas are also set up for milking our resident nanny goat and containing her kids to keep them out of the garden.

In the class garden plots, students grow four varieties of seasonal crops. Several methods of irrigation are available for the students to use as they learn the needs of the different crops.

Philosophy

Using the resources of the San Joaquin Valley, the Turner Elementary School and Ross Center blend the school's basic skills program and on-going project work with plants, animals, and nature. Ecology and science meet reading, writing, and art in a creative atmosphere. Parents and staff work together to offer unique opportunities for channeling the enthusiasm of students from kindergarten through 6th grade.

We provide students with an opportunity to actively participate in constructive projects and experience success. This improves self-image, increases positive feelings towards school, increases motivation for learning, increases positive interaction between students and teachers, and decreases discipline problems.

History of the Program

Turner Elementary School began in 1980 as a magnet school under the Emergency School Aid Act. The magnet program, expected to reduce racial isolation by voluntarily moving students to a school offering a special curriculum, was contingent upon federal funding to our school district. Our first step was to bring our community and school population into the planning stage. We met with school staff members, parents, the student council, administration, science representatives, university professors, 4-H advisors, Women in Agriculture, the Farm Bureau, Fresno County Farm Advisors, Future Farmers of America, Peerless Pump, Fisher Industries, and people in other local businesses.

The magnet project staff believed that we must work toward a set of comprehensive educational objectives. Our task force was well represented and we were getting positive community response and support. We welcomed a constructive parent/community involvement to help carry out our program. We began a calendar of planned activities, formulated goals, and developed means of program assessment.

Our program was to be funded in the amount of $148,925. The planning was well on the way when disaster struck: The U. S. Department of Education cut over 30 percent from all federal school programs. Fresno Unified School District's magnet program application was ranked only 64th of 84 school districts that applied for funding from the Emergency School Aid Act. (Our ranking had nothing to do with the quality of our program. Those districts just starting desegregation programs were funded first.) The possibility of funding was remote, and by the end of March, 1981, the news was out: No money for the project.

Our staff, parents, and community were disappointed after working so hard and having such high hopes. We had come to a dead end—but not for long. Was money going to deter us now that our plan was in progress? With the momentum of a community behind us, we decided to put the wings on our project and fly. We soared.

Building our center was possible only through the cooperation and planning of all those involved from the beginning, including the administration. Always supportive our superintendent of schools, Dr. Stremple, helped wherever possible. We followed the original building program, adding something even more priceless—community spirit and school pride. Through necessity, we learned to share as we developed our dream. The children were involved with the parents and community, and they worked as hard as anyone else. When we needed rocks for our pond area we rented a truck, drove 48 miles to a rock quarry, and loaded them. We then stopped to swim in a lake area and had a picnic, making it a day of work, fun, and accomplishment. A local builder donated his trucks and heavy equipment, as well as valuable know-how, to help us get started. Relatives pitched in to help school staff and students in organizing, working, and cleaning up. Former students, neighbors, and businessmen came to help in any way they could.

Through the past two summers, the center has been a continual labor of love, pulling our school and community together.

The Program

Our program is simple. What children hear about in the classroom, they do in the center We have an area at the center where our resource person does demonstrations in conjunction with particular lessons. Children then work in the Environmental Center, putting into practice what they have learned in the classroom. The third area is a place where children work in their gardens or on activities their instructors designate. Because there is continuity between the classroom and the center, and a variety of activities, the children never seem to get tired. What they learn in the Environmental Center may give rise to questions referring back to the curriculum These questions are taken back to the classroom.

Science is most effectively learned when it is experienced. Therefore, the outdoor science facility has 18 participatory science areas (everything from a pond to a greenhouse).

The center provides a focal point for science education at Turner, and is the hub of all curriculum areas. At the center we teach and reinforce math, reading, language arts, and fine arts. The link between the classroom and the environmental center is the key to the quality education program at Turner School.

The center offers students an opportunity to study and explore their environment, extending the basic curriculum through indoor and outdoor learning centers. A variety of activities give students first-hand experiences in the world of physical, life, and Earth sciences.

Skillful teachers, assisted by specialists from the community, guide investigations in such areas as horticulture, botany, agri-science, animal science, zoology, air and water pollution, and ecology. Demonstrations, speakers, field trips, and research involve students in projects, experiments, and activities to develop good learning habits. Students expand their knowledge of the environment, learn how to appreciate it, and assume an active role in its improvement.

Parental involvement in the educational process is essential. The interest and encouragement that parents give at home strengthens efforts at school. The program encourages parents to volunteer as project leaders, club sponsors, and classroom assistants. Such family involvement provides greater opportunities for learning, sharing, and developing community spirit and school pride.

Curriculum

Students receive instruction in the biological and physical sciences appropriate to and challenging for the grade level. Our curriculum includes biology, botany, zoology, horticulture, gardening, animal science, geology, meteorology, ecology, and conservation. Hands-on experiences include gardening, animal care, pond life study, microscope investigations, rock and mineral investigations, weather observing and recording, and experiments with energy and conservation.

Our center increases the effectiveness of the curriculum by adding a practical aspect to all fields of a child's education. For example, a student weak in reading might ask why tomatoes turn from green to red. We give him a pamphlet at his level that explains the process, and he can see a purpose for reading. The student who does not like math, thinking multiplication is a bore, finds interest and importance when asked how many plants will be needed for her garden with 16 plants to a furrow in 12 furrows. Again, the student sees a purpose for learning.

In addition to their regularly scheduled time in the center, students tackle special research projects, seeking, for instance, to control algae in our pond, or comparing the growth rate of various vegetable plants.

Our science curriculum is a comprehensive instructional guide for our K–6 and Special Education program. It identifies the general curriculum topic each month (i.e. geology, weather, plant life, pond life, ecology) plus the specific lesson taught at each grade level. The curriculum provides a progressive science program. Each year's new concepts build upon previous concepts. Hands-on activities reinforce science concepts identified in our curriculum. The activities are many and varied, ranging from measuring heat in the compost pile, or creating the topography of California in a special topography sand box, to building a barometer with bottles and balloons to study air pressure.

Each classroom has a scheduled one-hour period each week in the center. When a class comes to the environmental center, they have already completed their science text reading and planned classroom science activities. After the short 15-to-20 minute lesson, the class is divided into groups for various activities. Activities are grouped as follows:

- Reinforcing activity. This group works with the resource teacher on a hands-on activity that reinforces the concepts just taught.
- Classroom garden. This group works with their teacher in the classroom garden (planting, maintenance, harvest).
- General science activity. This group works on a planned activity such as planting seeds in the greenhouse, working in the community garden, and petting small animals.

All students rotate through all three groups during the period. In addition to their regularly scheduled times, students have the following opportunities to be involved in the center:

- Sixth grade students are scheduled in groups of two (each week) to further investigate class activities and carry out individual science projects.
- Sixth grade students sign up to be animal caretakers and are responsible for the feeding, watering, cage cleaning, and general care of all animals.
- Fifth grade students sign up to be weather watchers. They read and record the various weather data each day, and put up a weather report and forecast in the cafeteria each day.
- Fourth grade students sign up to be the maintenance crew responsible for center maintenance tasks (emptying trash cans, sweeping).
- Fourth through 6th grade students are chosen to be on our Energy Patrol, which monitors the school's energy use and campus cleanliness.
- Older students are selected and trained to work with small groups of younger students at the various learning areas in the center.
- Older students are selected and trained to assist with visiting classes from other schools.

In addition to these activities, the center is open at recess for students to come in and work on various projects. We allow one other school from the Fresno area per week to come for a two-hour educational, hands-on learning experience.

Role of the Teacher

Our teachers and the resource teacher in the center present science in a positive and dynamic way—creating situations where students are eager to learn and discover for themselves the wonder of the world around them. Our teachers have the widest range possible of media with which to teach—from protists in our pond water to creating "insects" on a computer screen. They can use all areas of the center as teaching tools. The excitement grows when a science experience (growth of a tomato plant, data from our weather station) becomes the basis for that week's math or language arts program. The elementary science resource specialist may provide assistance by designing student worksheets to strengthen math graphing skills, and the art teacher may encourage special ar lated curriculum in the center such as murals, or blend art into our existing science lessons and plans.

Turner has successfully developed and operated the Ross Center for four years. Rick Mitchell, the full-time resource person, has been directing the program at Turner for three years. As the resource teacher for the center, he plans science for K-6 plus special education classes and directs all activities in the center. He also is directly responsible for all maintenance and new construction.

Student Evaluation

We monitor student progress in a variety of ways depending upon age and ability of the student. In the classroom, we evaluate students on weekly assignments, participation in activities and discussions, and appropriate tests for each grade level. In the center, a variety of graded tasks are assigned to grades 4-6 each week such as observation, recording, drawings, skill sheets, task demonstration, model making, and oral quizzing. Tests are given at the end of each curriculum unit. Grades are averaged and reported to the classroom teacher. The teacher then averages the center and classroom grades for the report card grade. For K-3 students, a weekly task is evaluated with oral checking and/or tests where appropriate. The best test is the result of their accomplishments.

Plans for the Future

We started with nothing but a corner of the school grounds and have created a unique, child-oriented learning center. And we are not stopping now. Our plans for improvement are many. We never stop thinking of new ideas and new ways to approach our scientific projects. We currently use teachers on special assignments to bring in other curricula through math, art, and written language. This adds color and incentive to an already outstanding program. We are also planning to build greenhouses (without cost) that will last 20 years. Parents, children, community, and staff will do most of the work. This is a labor of love.

Each year, we send out needs assessments to parents and the community. The San Joaquin Valley is largely agricultural. Every day, we receive new ideas and new approaches from the community. In this way, the community is involved and aware of our program and proposed projects. Our goal is to continue to feed our students with knowledge and encouragement, and continue to teach using the senses and the hands to learn.

Chapter 12 Adding Writing to Science

Fred Rundle
Annistown Elementary School
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School: Annistown Elementary School (41 staff; 1010 students)
District: Gwinnett County Schools (26 elementary schools; 1,192 staff; 27,643 students K–5)
Location: Lithonia, Georgia (County pop. 226,000)

Annistown Elementary is 30 miles northeast of Atlanta. Gwinnett County is one of the fastest growing counties in the U.S., and its population is expected to double by the year 2000.

Annistown Elementary nestles in the shadow of Stone Mountain, a growing suburb of Atlanta. The K–5 school includes a special grade level called Readiness, a grade between kindergarten and 1st, and all 41 teachers teach science. An instructional lead teacher (ILT) for the county helps classroom teachers implement the district's curricular programs. Teachers work with the lead teacher to adapt programs to meet the needs of children in a particular school.

We have combined the popular *Science—A Process Approach II* (SAPA II) program with writing and classroom science projects to create our curriculum. Children at Annistown keep a science log, recording procedures, descriptions, hypotheses, data, and graphs for each science module. The log serves as a means of organizing all communications about the activities being done in class. Logs also help the children design and implement their projects for the annual science fair. (These are classroom projects, not individual ones, and the topics are usually an outgrowth of one or more of the modules in the regular curriculum.)

History of the Program

SAPA was first piloted in the Gwinnett County elementary schools in 1970. In 1971, we implemented SAPA in half of our 16 elementary schools, and adopted SAPA-II countywide in 1976. However, by 1978 only one school in Gwinnett County was consistently and systematically implementing SAPA-II.

When I opened Annistown Elementary School in 1981, I hired faculty with the understanding that teaching the county-adopted curriculum was not an option but an obligation. I emphasized SAPA-II and equated its importance to that of language arts and mathematics.

Meanwhile, our county staff supported SAPA-II. They put into place inventory procedures for replacing broken or missing kit items, and strategies for storing and distributing kit materials in each school. We placed items such as incubators, gooseneck lamps, and small animal cages on the county-level Basic Equipment List, making them easier to acquire.

The commercially-available SAPA-II program was designed to use modules 1–15 in Kindergarten, 16–30 in Grade 1, and so on. In 1978, we modified the program for Gwinnett County to implement modules 1–3 in Readiness (developmental first grade), 4–15 in grade 1, 16–30 in grade 2, 31–45 in grade 3, 46–60 in grade 4, and 61–75 in grade 5. This placement seemed to meet the needs of the students in Gwinnett County more effectively, and more

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easily accommodated children's progress with objectives that reflect Piaget's developmental theory.

The county held an intensive training session for ILTs in 1979. In the training session, ILTs participated in all 75 modules as if they were the students and the science coordinator was the teacher. The session emphasized organization, particularly student management strategies which make a hands-on science program more effective.

That same year, the county science coordinator first offered courses for teachers on the planning and teaching of SAPA-II. Approximately 15 teachers a year have completed this program, including four at Annistown.

In 1980 we wrote our *Elementary Science Curriculum Guide* and revised it in 1983. We tried to determine which objectives to teach for mastery and which for exposure, then matched activities with the objectives and suggested a plan for each module. Some activities were essential to meeting the objectives. We classified others as enrichment or remedial.

Our guide authors offered "Teacher Tips" based on their experiences with the module. The guide includes a timeline to help them pace themselves through the program, and planning procedures to help teachers think about all the variables that can arise in a hands-on situation.

In 1983-84, the science coordinator emphasized the research base for activity-based programs through principals' meetings, ILT meetings, and the Summer Leadership Conference held annually in Gwinnett County. These meetings also dealt with integrating language arts with science skills. A booklet, *Stretching Science*, which we distributed in the fall of 1984, offered suggestions on how this could be achieved. One article in this booklet, "Using the Writing Process to Design a Science Fair Project," was written by the science coordinator and Deanna Fraker, a teacher from Annistown Elementary.

Philosophy

Teachers at Annistown encourage students to explore materials, invent a concept, and then apply the concept Science is a process, a way of looking at or investigating the world. Therefore, it is imperative that the program include plenty of hands-on activities. Science also involves a set of basic skills and concepts that should be available to all students regardless of their abilities.

Other subjects can and should be integrated with science in the classroom. These tenets have led us to adopt the following goals for science instruction:

- Implement the SAPA-II program in every classroom at every level.
- Integrate other curricular areas, particularly writing, into the science program.
- Provide opportunities for children to actively experience science processes.
- Create an environment that allows children of all abilities and learning styles to succeed.
- Encourage the development of natural curiosity.
- Create an environment in which children learn to use communication skills generated by actual experience.
- Foster development of positive attitudes such as persistence, good school relationships, and self-confidence.
- Offer all children, regardless of academic talent, a chance to experience science.

Our Program

Our program, a modular approach, stresses basic skills and content in science. It offers a planned science experience for children, moving logically and sequentially from simple to complex, concrete to abstract. The modules allow students to find and generate answers for themselves. The written materials accompanying the modules are adaptable to student needs.

We teach science from a teacher-structured but student-centered perspective at least an hour per week in grades K-2, at least 90 minutes (preferably 135 minutes) per week in grades 3-4, and at least 150 minutes per week in grade 5. Science centers, instructional bulletin boards, and homework assignments given on an ongoing basis, give science an emphasis not often seen in elementary schools.

Annistown students participate in group and individual investigations, multi-media instruction, reading, role playing, games, small and large group projects, lectures, individualized instruction, and writing. As a facilitator, each teacher provides information, materials, and feedback, and encourages exploration and discovery. Children are guided by open-ended, divergent questions, and teachers provide suggestions, close observations, and a listening ear.

Student attitude is a vital part of each teacher's program. We create enthusiasm in a number of ways, such as publishing student writings on science in school newsletters and literary magazines, displaying projects at science fairs, and awarding an outstanding achievement certificate to the highest achieving 5th grader in the science program each year.

Each teacher is responsible for organizing materials, resources, and areas used for science within the classroom. Throughout the building, shelves are found containing animals, books, equipment, materials, and projects. Centers, instructional bulletin boards, media materials, computers, hall and library displays, graphs, and time-lines are also found throughout the school. While stressing the importance of science in everyday life, each of these factors contributes to developing students' positive attitudes and interests. We also relate science to other subjects to reinforce and extend learning and show the far-reaching effects of science and its related skills.

Among the many features of our science program are three that make science especially meaningful for our students· Project Write, student logs, and whole-class projects.

In 1982 we piloted Project Write, a staff development effort to infuse the writing process into the curriculum. Students write about procedures and discoveries, invented concepts, and consequential operational definitions.

Logs provide an avenue for students to express their interests, problems, and eagerness in science. They also write about procedural techniques, process descriptions, hypothesis formulations, data collections, graphs, and opinions. The log is evidence of the student's ability to analyze and synthesize science knowledge; keeping a log encourages the student to use these skills in every day life situations.

Our annual science fair strengthens both science and writing skills. The science fair is an integral part of the program, stressing *classroom* projects rather than individual ones. The projects are an extension of a regular curriculum module and teachers use them to bring current events and potential career opportunities into the classroom. In these whole-class projects, students become involved in the processes of science instead of merely turning out a finished project. The students design and implement the project as a group using the writing process. The science processes are used and labeled in each step of the project to reinforce the curriculum. The students keep individual logs describing the nature of the project, what they do, and the results.

Evaluation

Our evaluation procedures are tailored to the process being evaluated, and vary from module to module. Teacher observations and student log entries are a major source for evaluating individual student progress. Teacher-made tests also play a major role in assessing each module, and are shared within each grade level. Modules are also evaluated by the quality of activities, projects, and oral discussions they elicit.

The overall science program at Annistown is continually evaluated locally and systemwide. Each building develops a plan for improvement each year, addressing staff development and other needs. For 1984-85, and again for 1985-86, we identified science as an area needing continual inservice. This year, the county provided one-half day of inservice on the integration of other curricular areas, especially writing, into science. Such communication is vital to the success and improvement of any program.

At the system level, each curriculum area is reviewed every five to seven years. The principal at Annistown serves on the Elementary Science Curriculum Steering Committee and at least one teacher from Annistown is selected to serve on a Materials Selection Committee.

A major part of the review process is our survey of teacher attitudes. Results of the survey, based on documents published by the National Science Teachers Association (Mechling and Oliver, 1983), are being analyzed and will be available to our school's staff.

In November 1983 the county tested a sample of 4th grade students with the Comprehensive Test of Basic Skills, Level FU, because it most closely parallels the goals and objectives of the current science program. The sample of students at Annistown scored at the 84th percentile while 4th grade students in the systemwide sample scored at the 78th percentile level. Teachers at the 3rd and 5th grades at Annistown, along with their counterparts at seven other schools in Gwinnett County, have participated in a University of Georgia research study that is examining the relationship between achievement in science skills and in reading skills.

Program Maintenance

We attribute the uniqueness of our science program to five distinct components of program maintenance.

First is the commitment to science education on the part of the principal and the ILT. The main function of this team is to continuously remind teachers that science is as important in the curriculum as reading and mathematics. The administration demonstrates support for science education by discussing the science curriculum with teachers, attending and conducting science inservice programs, and visiting science classes. And each year, the administrative team helps plan and implement the school's annual science fair.

Teacher surveys, conducted each fall, indicate that teachers want continual updates in science and science curriculum. As a result, the administrative team implements a science inservice in which new teachers actively participate, and veterans of the program offer valuable insight and assistance on using SAPA-II. The focus of the science inservices for a recent school year included organizing classroom science materials, correlating media materials with science modules, evaluating students, introducing new teaching methods, and discussing methods for grouping students during science instruction.

Every six weeks, teachers attend one-half day inservice sessions. Here teachers share their knowledge, support, and ideas.

Another component, which adds to the maintenance of our program, is the professional library for teachers. The library contains reference books on science education, software, and other related science materials for teacher use.

The final component that makes us unique is our use of county and locally provided resources. Core materials (one kit per three teachers), curriculum guides, and module manuals are county funded. Local school funds provide supplemental books, materials, equipment, supplies, audiovisual aids, and computer software. Teachers are consulted prior to purchases and are reimbursed for purchases of consumable items. All materials are centrally located and readily available to each teacher. An organized check-in, check-out system with paraprofessional assistance (provided at local school expense) ensures effective management. Supplies are refurbished on a regular basis, and inventories, orders, and storage are maintained. This system assures that materials are available so all children may have hands-on experience with each module.

Plans for Improvement

We need more structured training for new teachers early in the year. We are exploring the possibility of creating a buddy system, where an experienced teacher is paired with a new teacher at the same grade level. The buddy system would create the kind of sharing and support that is already present among the staff members and that is crucial to successful implementation of the program.

We must select and purchase additional tradebooks to accompany the SAPA-II modules. Children are so enthusiastic about what they are doing that they want to read about it too. Trade books are the best mechanisms for providing up-to-date information at various reading levels.

The professional library needs to be expanded, providing teachers a richer array of resource materials in both content and methodology. A continuation of staff development in science is also needed for all teachers.

Because our program is a dynamic one, it will continue to change and improve. The gains made in Annistown Elementary's program since 1981 attest to its uniqueness.

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Chapter 13 Fitting the Program to the Community

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School District: Carroll County Public Schools (16 elementary schools, 600 staff; 20,000 students K–5)
Location: Westminster, Maryland (County pop. 96, 356)

This rural community is growing rapidly as families move into the area from surrounding metropolitan school systems. The county ranks low in per pupil spending and teacher-student ratio, but high in standardized testing results.

The planning for this project began in the summer of 1981. Results of a teacher survey indicated that our then current program, *Concepts in Science*, was not popular, and 69 percent of our teachers who responded urged that *Concepts in Science* be either revised or replaced.

Inspired by these results, we created a task force of teachers, principals, and administrators to do just that. The task force developed a "Statement of Principle" that listed desirable characteristics for an elementary science program. Some of the key points in that statement were that elementary science should use hands-on activities, use concepts appropriate to the developmental level of students, and use the processes of science.

Using the key points of this statement, we then analyzed and rated over 20 textbook programs, identifying 12 as worthy of further consideration. Using the "Checklist for Evaluating Science Textbooks" (developed at the University of Georgia), we narrowed the number of commercial programs under consideration to three. The primary author of each program met with the task force to present and discuss their series. We subsequently adopted two of these, along with a locally developed, laboratory-based approach to elementary science.

Our program development was different than that conventionally employed. Instead of having a scope and sequence of content, the task force first determined what processes to teach at each grade level. Topics which lent themselves to those processes were then sought. After making certain there was no duplication between grade levels, writers developed lessons for each topic.

Many of the ideas were patterned after other programs, especially those which placed heavy emphasis upon science processes. Teachers, however, wrote their own agendas, tailored for their own needs, instilling on their part positive, personal commitment to the curriculum. Before long, the program was perceived as one developed by teachers to meet the needs of teachers.

Basic Lessons

Our program is based on process skills. The somewhat unconventional development and sequencing of content closely parallels the Maryland Curricular Framework where, as students progress from level to level, higher order processes are introduced. Instruction emphasizes observation in 1st grade, classification in 2nd, experimentation in 3rd, analysis in 4th, and application in 5th.

Each grade level has its own curriculum guide. These provide a sequence of basic lessons, and also include much

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of the teacher support materials required to implement the curriculum, such as masters for transparencies, dittos, and other class handouts. Lessons specify the processes being taught, the content objectives and the estimated time required. They also list a series of structuring questions for the teacher to use.

While the basic lessons within each unit define the content required of all teachers, a series of extension activities provide a basis for enrichment, diversity, and specialized interests. These activities are intended to follow the initial investigation. The extension activities often carry the primary lessons into the areas of language arts, math, or art. For instance, students may write a story or draw pictures about what they have done. At the upper grade levels students also maintain a journal in which they record their activities and discoveries.

In 1st grade students work primarily on the skill of observation in three units: Seeds, Patterns, and Magnetism. Students begin the school year by collecting seeds by walking through fields of weeds and grasses with white stockings on their feet. Using the seeds they collect, as well as others brought in, students observe and classify them through a series of activities. Students learn the parts of the seed and how to identify different types of seeds. Study in the 1st grade continues with a Patterns unit. Students look at apples, oranges, and kiwis to observe seed patterns. They learn symmetry by studying geometric shapes and certain letters of the alphabet. The unit continues with patterns found in animal tracks, or tracks made by their own toys, especially small cars and trucks brought from home. Students might typically run them across a piece of carbon paper, leaving a track on the paper below. The final 1st grade unit is Magnetism. A large number of hands-on activities lead students to understanding magnetic and nonmagnetic substances, magnetic poles, and magnetic lines of force. We place particular emphasis on the idea that like poles repel and unlike poles attract.

In 2nd grade the three major units are Insects, Sink or Float, and Measurement, all of which emphasize classification skills. Students construct sweep nets to collect insects, then bring their specimens back to the classroom where they study them over a period of days. Youngsters also raise painted lady butterflies and mealworms to view stages in the life cycle. We also study fruit flies. Each day, students estimate the number of flies in a culture vial. Predictions of a continually increasing population eventually go awry, and the culture declines as the food supply is exhausted. In the Sink or Float unit, students design and construct boats from clay or aluminum foil: the goal is to build a boat which will hold the greatest amount of cargo. In the Measurement unit, students measure mass, length, and time in a series of simple activities including, among other things, a simple balance and water clock. (This is closely related to work students do in their math classes.)

In 3rd grade students experiment in the areas of Flight, Measuring, and Plants. In Flight, students make an autogyro, parachute, and paper airplanes in a series of investigations that focus on variables. Throughout this unit students manipulate the placement of weights on these objects and determine how it affects the flight of each. Often this results in a 3rd grade "fly off" in which students test their findings. Youngsters who best understand the factors studied produce the plane that flies the farthest or the parachute that lands the softest.

Third grade students continue with another unit on Measurement, building on the previous year. Some of the activities deal with measurement related to bouncing balls. Students investigate by altering variables—the height from which a ball is dropped, the surface upon which it is dropped, and the kind of ball itself—to see how high a ball will bounce. Although this unit develops skills in the various aspects of measurement, the unstated focus continues to be variables and ways students can experiment in altering them.

Youngsters also study plants at this grade level. A sequence of lessons deals with seeds and the changes they undergo in the germination process. The seedlings that result are raised for a period of time in the classroom so their growth can be measured and charted. The influence of certain environmental conditions such as soil type is investigated. At the conclusion of the unit, students study the parts of the plant, especially the flower.

In 4th grade, students begin to focus upon the skill of analysis in three basic units, Bio-communities, Electricity, and Chemistry. In Bio-communities, students study pond water. Using microscopes, they observe the organisms present, studying the role of the various organisms and the interactions between them. A board game entitled "Food Chains of the Pond Community" accompanies this unit, followed by the observation and study of an ant community.

In the Electricity unit, students undertake a sequence of investigations that begin with the study of static electricity. Pupils continue by learning about series and parallel circuits. For this, a number of battery and bulb experiments are used. Students make and investigate electromagnets, small motors, and buzzers. These activities teach science concepts and also have a direct application to students' everyday life.

Fourth grade students also study a unit on cupboard chemistry. Common household products demonstrate the properties of matter in an exciting way. Student work results in understanding the states of matter, mixture and solutions, and the dissolving process, as well as acids and bases. The highlight of the unit is a fascinating "mystery goop" which has properties of both a solid and a liquid. Analysis skills are developed as students apply observations they make about known substances to identify the composition of unknown mixtures of some of those substances.

In the 5th grade curriculum on Earth Science, Soil Analysis, and Small Animals, students undertake a number of Earth science activities which have a geology emphasis. Simple tests are applied to rocks and minerals to study weathering, erosion, and sedimentation. Study of sedimentary rock leads to student work with fossils.

Living Organisms

Many of the activities require living organisms. A system-level Live Materials Culture Center supplies teachers with organisms. While most of them are commercially available, several required sets of organisms are specific to this elementary science program. For instance, grade two uses a mealworm kit with specified proportion of larva, pupa, and adult beetles. Grade five uses fruit flies to study population dynamics and investigate the role of food supply.

For this, a special fruit fly kit is prepared which consists of ten cultures of the organisms started at specified time intervals. Providing living materials from within the system helps ensure further program implementation by eliminating the inconvenience and financial considerations which could become impediments.

Science is typically taught either concurrently or alternately with a social studies unit in the elementary classroom. Depending on the grade level, 30 to 50 minutes per day are prescribed for science instruction three to four days per week. Teachers find that the lab-based, hands-on program requires a minimum of 30 minutes for set-up, lesson development, group activities, and clean-up.

Kits

We supply teachers with materials for the program in custom-made kits developed for each grade level. An itemized list of contents accompanies each kit. We provide teachers with all the supplies they need, including toothpicks, straws, sugar, and other common items. Although teachers could obtain these at grocery or hardware stores, we try to spare them the inconvenience.

Delta Education designs and builds our kits. They took lessons from each grade level and developed a list of required materials. They then built a prototype kit for each grade level which our writing team evaluated and modified

Tradebooks

Teachers also receive a series of tradebooks to supplement the curriculum at each grade level. These provide additional reading and teacher support on the topics studied. Arrangements were made with Pulley Learning Associates in South Carolina to have a computerized match of the Carroll County lessons with published materials currently on the market. From copies of the grade level curriculum guides, Pulley Learning Associates generates a list of books for possible use with each topic and grade level. Teacher-writers identify and evaluate books for classroom use and provide anywhere from one to ten copies to each teacher. The school's Media Center purchased those judged to be more appropriate for the library.

Summer Enrichment Program

We have now extended our elementary science program to a summer enrichment program. We have a package of materials, "Summer Science Fun," for each grade level. The activities reinforce the concepts taught during the school year, and introduce new materials. Students who complete the package of activities on their own or with their parents' help during the summer are recognized with a certificate. Although this program is completely voluntary, over 44 percent of our youngsters participate.

The new program complements the rest of our school program. It correlates with two county goals in particular, developing students' critical thinking skills, and providing for active learning. The program emphasis on using scientific processes in instruction helps students learn how to learn. It also applies logical and inductive thinking to other academic areas. Requiring students to take the role of the scientist by attacking scientific problems and using science processes ensures that active learning, meaningful participation, and application of learning will flourish.

Evaluation

We assessed the effectiveness of our program in a yearlong study which compared it with *Concepts in Science* and *Addison-Wesley Science*. The former is conceptually based, while the latter strikes a balance between concepts and processes. We randomly assigned 40 teachers to teach two of the three programs for one semester each.

We then asked five basic research questions to evaluate the situation. A statistical analysis indicated the following results:

1. How much hands-on activity did the programs generate? Teachers reported that the lab-based, non-textbook approach was more conducive to hands-on science. Unlike the text-based programs, this approach required that the labs actually be performed for the students to understand the program. With the textbook programs, teachers could talk about, instead of actually do, investigations.

2. Which program best included scientific processes? Teachers reported the non-textbook approach included more scientific processes and allowed students to discover and experiment more than the textbook approach. Neither text program was as successful as our own in providing activities where students gain new information, rather than just confirming material already known.

3. Which program best motivated students? Participating teachers perceived students to be more motivated by the non-textbook approach. Students often went beyond the assigned activity and tried ideas on their own. However, teachers perceived no differences in the way programs caused students to inquire beyond what had been presented.

An attitude survey was administered to all youngsters at the beginning and the end of the semester. Students said they were more motivated by the non-textbook approach and the concept approach than the balanced process/content approach. Parents said their children came home talking about the non-text approach more frequently than either of the other two. Teacher observations paralleled those findings: students in non-textbook classes more often came to class wanting to know "Are we going to do science today?" or "What are we going to do in science today?"

4. Which program was easiest to implement? Participating teachers indicated that the non-text approach would be more difficult to implement. This resulted from the perception that it required more preparation time than either of the other two.

5. Which program best motivated teachers? Teachers indicated that they derived more satisfaction from the non-text approach. It also enabled them to devote more time to teaching science. However, a 20-item questionnaire assessing attitudes toward teaching science found no program-related differences.

Based upon these data, the task force selected the locally developed, laboratory-based program. However, the decision involved much deliberation and turmoil. This program represented good science, and involved and motivated youngsters. At the same time, the task force recognized that it would be difficult to implement the program. After much agonizing, we determined that the strengths of the lab-based approach would characterize the program. The weaknesses of the other two programs were inherent; little could be done to make those programs more hands-on in nature or more motivating to both students and teachers.

Plans for Improvement

Problem areas related to the program consist of

- On-going staff development and new teacher training.
- Keeping lab-kits replenished and complete.
- Avoiding teacher tendencies to move away from the intent of the program and teach an "easier," less actively involved program.

A recently awarded National Science Foundation Honors Workshop grant will ensure that exemplary science teachers in each school receive additional training and expertise in order to provide direction and support to science teachers in their schools. These honors-workshop participants were selected for their interest and enthusiasm in the science program, as well as their credibility with fellow teachers. Hopefully, these in-house teachers will serve as "coaches," providing companionship, support, technical knowledge, and feedback to their peers. They would also help train teachers who are new to the program, and ensure that they have positive and productive initial experiences with the science curriculum. This is critical if the program is to continue to be successful.

Principals, the honors-workshop participants, and team leaders in each school must ensure that teachers do use the program and that replacement materials are ordered on time. If the teacher is actually using the program and involving students in lab activities and experiments, it will be evidenced by the need for replacement of materials.

Teachers who are successful with the program are motivated to teach it because their students are excited and enthusiastic. Likewise, teachers who use the program as intended are more likely to see student success. Students currently in the program frequently say science is their favorite subject, even ahead of lunch and recess.

One area requiring further refinement involves teacher attitudes about student evaluation. Teachers still tend to seek objective data with which to grade students, and are inclined to feel a need for objective, content-oriented tests rather than personal observation of the students' scientific process in the classroom.

Conclusion

The Carroll County elementary science program is an extremely successful curriculum characterized by a high degree of teacher support and student motivation. Student learning is based on hands-on experiences which emphasize the processes of science. Students undertake a planned sequence of activities in both the biological and physical sciences directed toward the development of problem solving skills. Research data give added evidence of the success of this program.

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Chapter 14 Science Curriculum Renewal: A Three-Year Cycle

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School: Ralph S. Maugham School (12 staff; 224 students)
District: Tenafly Public Schools (4 elementary schools; 49 staff; 913 students K–5)
Location: Tenafly, New Jersey (pop. 13,450)

While the town's proximity to New York (5 miles) puts its cultural and cosmopolitan atmosphere within reach, Tenafly itself is quiet and wooded, and most residents live in privately owned homes.

History of Curriculum Renewal

Tenafly Public Schools, known for curriculum innovation and receptivity to new ideas, was quick to join the energetic, almost frantic, national effort to develop elementary school science programs in the 1960s. Tenafly Elementary Schools were trial centers for one of the more ambitious national curriculum projects in science, the *Science Curriculum Improvement Study* (SCIS) program.

By 1980, however, things had changed. Professional support for teachers had decreased, as had funding and maintenance for science materials and kits. Meanwhile, there was an influx of new teachers who had little or no experience in teaching hands-on science. The result was a decrease in elementary science instruction. Science had become overshadowed by reading and math programs.

All of this changed in September 1982, when our superintendent announced that our curriculum renewal cycle, already successful in other subject areas, would be applied to science. We then set in motion a careful examination of elementary school science instructional practices.

Curriculum Renewal

The curriculum renewal cycle is a constant, systematic assessment of instructional programs and practices which ensures that change occurs as needed. The overriding philosophy of the cycle assumes that curriculum can be a dynamic process as new instructional practices are implemented. Curriculum should reflect its social context and, if conditions change, an examination of curriculum priorities and procedures is in order.

With our curriculum renewal cycle, we hope to

1. Establish a systematic program of curriculum review and assessment.
2. Analyze current programs and practices in curriculum areas.
3. Make assessments and judgments based upon study and review of instructional practices.
4. Suggest program modifications.
5. Chart a path for future development in the particular curriculum area.

The cycle itself consists of three distinct, year-long phases of study. The first year is devoted to research and development. In the second year we begin pilot projects and then evaluate their success. Finally, based upon the results of the pilot studies, in the third year, we implement a systemwide program. The cycle is then complete, and ready to begin again when necessary.

Phase I: Research and Development

Phase I of the cycle, Research and Development, took place during 1982–83. In this first year of the cycle, a study group of teachers and administrators examined current practices in elementary school science instruction and developed a working philosophy and set of goals for science education. We reviewed old and new literature in the field, distributed questionnaires to teachers, parents, and administrators, and held parent forums. We also reviewed programs currently being used by other school districts, and materials available in the marketplace. The study group found science education was a low priority in elementary schools, receiving neither the attention nor the daily time allotments of other areas of study. This situation probably stemmed from teacher anxiety about science, fear of not having the answers to children's questions, little set-up time for experiments (in an already busy day), and a general curricular eclipse caused by concerns about reading and mathematics instruction.

The group asserted that science instruction should be a priority and that the maintenance of a quality hands-on science program is absolutely essential for youngsters to know about and participate in our rapidly changing technological society. The matter is too important to be treated with indifference, ambivalence, or the step-child status with which science is often regarded in the elementary school curriculum.

Scientific experience is essential for a child's intellectual development. Children must handle, manipulate, and experiment with the materials of their physical and natural environment. By exploring science, children gain knowledge that will serve as the foundation for logical thought.

Goals

In the first year of curriculum renewal, the study group developed instructional and attitudinal goals for the framework of a stronger science curriculum. Our instruction is designed so that students will

- Build a rational view of the natural, physical world.
- Develop science process skills.
- Gain an understanding of the major concepts of science.
- Develop analytical skills.
- Become scientifically literate.
- Prepare for responsible citizenship.

The study group identified important attitudes for science students to exhibit, including curiosity, enjoyment of work in science, and a lifelong interest in science.

At the conclusion of Phase I, the group presented its findings, goals, and recommendations for pilot projects to the board of education.

Phase II: Pilot Studies

We implemented the Pilot Studies phase of the cycle in 1983–84. Among our activities were

- Assembling science kits and distributing them to all schools.
- Offering inservices and summer workshops to familiarize teachers with the pilot programs.
- Providing a science research teacher to directly assist teachers in the classroom or lab.
- Replenishing classroom and lab materials on an ongoing basis.
- Advising teachers on use of materials, technique, and teaching strategy.
- Arranging assemblies with guest speakers (scientists, engineers, physicians, dentists, etc.) to enrich and broaden students' understanding of the roles scientists play in society.
- Coordinating trips to museums, planetariums, nature centers, etc
- Providing the community with information about our science programs.

We evaluated the pilot programs in terms of student achievement, teacher opinion, parental reaction, and teacher observation of student attitudes toward, and use of, science process skills.

Description of Pilot Programs

We consider SCIS-II superior to the earlier SCIS because of the clarity of its teacher guides and its improved equipment.

We had used the original SCIS program in Tenafly for 15 years. However, with the loss of the science coordinator some 10 years ago, enthusiasm and support for the program waned and the materials (packaged as classroom kits) fell into disrepair. As the study group considered the revised version of SCIS for pilot study, it became apparent that the inventory of old SCIS materials, although disorganized, was plentiful in the schools, and could be converted to SCIS-II with considerable financial savings to the school system. The new science resource teacher spent several weeks during the summer converting our district's old SCIS kits to the newer, upgraded SCIS-II version. All of the science kits were brought to one of the schools where materials (literally thousands of small items) were sorted and repackaged into new frames and boxes along with the SCIS-II Conversion Kits. The conversion process had the additional benefit of allowing the teacher to become thoroughly familiar with every vial, card, pump, and magnet in the program.

Once we rebuilt the SCIS kits, we distributed them to the appropriate sites within the elementary schools, and established a storehouse of surplus materials at one of the schools to service and replenish the kits.

After reviewing both the text and the laboratory programs of this series, we decided the lab program *Concepts in Science*, by Harcourt Brace Jovanovich, would best suit our needs. The group feared that overdependence on textbooks might lessen the opportunity for laboratory benefits, and since the lab program also included lab manuals with background reading material, we felt it would provide a sound science program, and opted not to purchase more textbooks. We purchased one laboratory manual for each participating student.

Elementary Science Study (ESS), published by McGraw-Hill and Delta Education, Inc., is a collection of units designed to develop fundamental skills necessary for organized scientific thought. Students develop skills in an atmosphere of investigation and discovery that makes learning an enjoyable experience.

We used units from this program to supplement the SCIS-II sequence at two of the elementary schools. The ESS modular approach enabled us to choose from the 53 available units to suit individual and local needs. Units piloted in Tenafly included Rocks and Charts, Kitchen Physics, and Small Things (grades four and five); Whistles and Strings (grade four); and Attribute Games and Problems (grades two through four).

The pilot plan also called for the establishment of an elementary science resource teacher who would assist teachers on a daily basis as they developed hands-on science experiences for the students. The plan also recommended a vigorous inservice program. We felt this arrangement was effective because it provided a natural sequence from concrete experiences in the early grades to abstract concepts in the intermediate grades.

Evaluation

To assess the various pilot programs, we developed a multi-faceted evaluation design. Its four basic components are the science objective test, the teacher questionnaire, the parent questionnaire, and the science process test.

Science Objective Test—After reviewing several standardized science achievement tests, members of the study group felt we should assemble our own objective examination. Science achievement tests are most often a part of larger achievement batteries and it seemed inadvisable to have students take an additional test battery. We developed a test of 20 questions not unlike those found in standardized science sub-tests. Question content did not necessarily follow any one of our three pilot programs, so they were equally fair (or "unfair") to all test-takers. However, the questions were more general than specific and ostensibly measured children's knowledge in physical and life science as well as problem solving, critical thinking, inductive and deductive reasoning, and investigative and research skills.

Teacher Questionnaire—A questionnaire surveyed teachers' reactions to the science pilot programs in two specific areas: assessment of student growth from the new instructional practices, and teacher satisfaction with the professional support provided.

Parent Questionnaire—Distributed to all parents of students in grades one through five, this was designed to see whether or not parents noted any effect at home of our pilot programs. Free space for individual comments or remarks was incorporated into the questionnaire as well as an item asking for parents to identify their special interests, talents, or abilities in science.

Science Process Test—The processes of science are those skills, competencies, and behaviors exhibited by scientists as they inquire, such as observing, classifying, defining, measuring, predicting, communicating, inferring, controlling variables, interpreting data, formulating hypotheses, and experimenting. This science process test was designed to assess how well students use these process skills to solve problems. A test was devised which involved comparing a single drop of alcohol with a single drop of water. The alcohol was tinted blue with food coloring and the water was tinted red. The student was asked to place a single drop of each liquid on a sheet of waxed paper. The teacher demonstrated first, using an eyedropper, and then the student followed. This test was based on practice ensuring that each child would successfully use the eyedropper. Water forms a somewhat spherical bead on the waxed paper, while alcohol is more flat and amorphous in shape when dropped on the waxed paper. Once the drops were placed on the waxed paper, the student was instructed as follows: "Investigate each of the drops very carefully. You may use any of the items here on the table: ruler, eyedropper, magnifier. Make your observations and tell me about the size of each drop and any other observations you can make as you compare the two drops on the waxed paper."

After evaluating the results of the two tests and the two questionnaires, the study group reported the following findings and recommendations:

- Teachers, students, parents, and administrators all approve of the revitalization of Tenafly's elementary science program. The community accepts and supports the hands-on approach to science.
- K–3 teachers urged that we continue the hands-on approach and the extensive use of concrete materials in student investigation.
- All pilot programs were equally advantageous in terms of 4th grade pupil achievement on the science objective test.
- The science resource teacher played a vital role in the success of the science programs. In fact, the all-around increase in professional support to teachers led directly to renewed enthusiasm in elementary science. Teacher workshops, inservice courses, and the increased availability of materials were popular and effective.
- Response from the parent and teacher questionnaires indicated a problem at the 4th grade level, and to a lesser extent at the 5th grade level. The SCIS-II content at these levels was unusually abstract abstract. It seemed that a replacement for the SCIS-II program was needed for grades four and five. We also concluded that any program implemented in grades four and five ought to be consistent and compatible with the program in grade six. For instance, teachers of grades four and five, while not using textbooks as the basis of the science program, did remark that an increase in conceptual learning would be appropriate for these grade levels.

Recommendations

After reviewing these findings, the study group developed a list of recommendations for implementing an integrated science sequence in the Tenafly elementary schools and the 6th grade at the middle school:

- Implement the *Concepts in Science* laboratory program at grades four and five in the elementary schools, and a modified version at grade six in the middle school. This will increase continuity among these levels
- Maintain SCIS-II in grades one through three.
- Implement units from the ESS program at the kindergarten level. This will enrich kindergartners' school experiences while preparing them for the science work to follow in the early elementary grades. Specific units for kindergarten include Attribute Games and Problems, Pattern Blocks, Growing Seeds, and Match and Measure.
- Maintain and augment the commitment to community involvement in the science program. Newsletters, guest speakers, and parents sharing their scientific interests and backgrounds with schools all add strength to the program. Field experiences also prove enriching for the youngsters; teachers in specific grade levels throughout

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the district should coordinate field trips and share planning and follow-up activities.

- Expand the commitment to providing inservice opportunities for teachers. Provide workshops for veteran SCIS-II teachers to encourage new ideas and the exchange of teaching techniques. A summer or early fall workshop would be helpful for 4th and 5th grade teachers who will be using the *Concepts in Science* program.
- Continue the recommended standard time commitment for two 40-minute science laboratory experiences per week. (In kindergarten and grade one, 30-minute periods may be more appropriate.)

We had several reasons to support the above recommendations. One prime factor for the retention of the SCIS-II program in grades one through three, and the proposed change to the *Concepts in Science* in grades four and five, was the firm belief that young children should be provided with a wealth of first-hand experiences with materials from their physical and natural environments. Young children also need to learn how to collect and organize data to support hypotheses and form conclusions. The SCIS-II program stresses and allows for many such experiences. However, we felt that as children enter the intermediate grades, they were ready for a greater degree of concept and content orientation as is provided in the *Concepts in Science* program. This sequence of intellectual maturity (i.e. concrete experiences preceding more abstract ones) is consistent with major tenets of cognitive psychology.

The *Concepts in Science* program in grades four and five also allows for greater continuity between elementary and middle school science experiences, since this same program has been selected for grade six The implementation of the *Concepts in Science* program in grades four and five also addressed a perceived concern about the SCIS-II program at the 4th grade level and the undue repetitiveness of this program at the 5th grade level. All of these recommendations were approved by our board of education in May 1984.

Phase III: Implementation

The newly-established science sequence underwent a comprehensive evaluation, and programmatic adjustments, as necessary, were recommended for the ensuing years. The objectives for Phase III of the renewal cycle were to

- Employ the specific programs recommended by the study group.
- Assess the level of success associated with these programs in terms of student achievement, parent reaction, and teacher assessment of student growth, ease of setup, and general satisfaction with programs.
- Continue in the efforts to support teachers in their science instructional practices and techniques.
- Provide inservice opportunities for teachers.
- Practice the recommended time commitment of two 40-minute periods of hands-on science per week in each grade.
- Continue to inform and involve the local community.
- Develop a curriculum document for science in grades K 5, consistent with other such documents developed in the school district.
- Develop a descriptive brochure about our elementary school science program.

Once the adopted programs are in place, the life of these programs is about five years. The study group, however, remains active to deal with problems as they arise and to infuse new ideas into the ongoing programs.

Ongoing Needs and Plans for Improvement

The cycle ends but the work does not. We must continue to maintain and improve the existing programs. Annual budget allocations for replenishing science kits and acquiring live materials are a continuing requirement. Most important, the professional support program must also be kept alive to help teachers incorporate new ideas and approaches into their instructional practices.

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Chapter 15 Conclusion— What Makes an Exemplar?

Phyllis Huff and John E. Penick

Everyone wants an elementary science program, and we all know a good science program when we see one in action. But what makes a program truly outstanding? In order to answer this question, we examined each of the selected exemplars in light of the guidelines and criteria the selection committee developed.

Although each program described in this *Focus On Excellence* volume was selected by the NSTA Task Force On Defining Excellence in Elementary Science Education, they vary greatly in approach, extent, and impact. One general observation, not at all surprising, was that no program met all the listed criteria. However, each met a number of criteria in such a highly satisfactory manner to indicate they were different from the ordinary and that they were, indeed, providing science to their students in a meaningful, effective, and enlightened manner.

We analyzed programs using the criteria outlined in Chapter One. Each of the four sections, Students, Curriculum, Instruction, and Teacher, will be discussed with summary criteria statements preceding each discussion.

Students in an Exemplary School Science Program

- Recognize the interaction between people and their environment.
- Use many and varied scientific resources in problem solving.
- Realize that science is work and that the solution to one problem often results in other problems
- Exhibit effective consumer behavior.
- Use effective health habits.

The exemplary programs contain many hands-on opportunities for students involving a variety of techniques and materials, with students actively involved in all aspects of the program. Two programs feature consumer education as the focus of student activity; two programs involve health education with consumer education. And each of the 14 programs is activity centered, using a variety of activities to reach their goals. Probably the most significant aspect of this area is the overall involvement of the students in what they do and, from the evaluative reports, the enjoyment they experience as a result. In all cases, students actively do science and apply their knowledge to resolve problems. Students participate in science fairs and olympics, go on field trips, and use their science in all aspects of the school curriculum.

Curriculum in an Exemplary Program

- Provides planned, sequential programs for all students emphasizing hands-on, involved learning.

- Has clear, well-defined goals and objectives.
- Has periodic review and ongoing evaluation of content, instruction, and learning.
- Contains experience and knowledge applicable to students' lives now and adaptable for the future.
- Provides teacher guidelines for planning and directing science activities.

In the area of curriculum, exemplary programs make much use of activities from programs developed with National Science Foundation funds in the 1950s and 1960s: *Elementary Science Study, Science Curriculum Instructional Studies,* and *Science: A Process Approach.* Almost all use some ESS units. The main feature of each particular program is its creative use of these activities and materials to fit their particular goals and objectives. Several of the programs tested and researched a variety of materials for a period of time until they arrived at those materials that seemed to work best for their particular situation. Many of the programs combine the NSF-developed curriculums with science texts, science activities from a variety of resources, and science tradebooks. Often, locally developed or NSF project activities are correlated to texts, tradebooks, or other parts of the curriculum.

Kits created for the classroom teacher's use focus on simple, everyday materials wherever possible. In almost all instances, these kits are the responsibility of a central office person, not the classroom teacher. Teachers don't have to worry about materials. This is perhaps one of the most important features of these programs. Teachers receive support from the administration and are encouraged to try new ideas and materials They expect success, and they receive funds and materials to successfully carry out the programs.

All these programs emphasize careers, applications of science, and science as a way of knowing. Many include aspects of health and technology. Each of these programs has been carefully planned in accordance with objectives and evaluation. This is evidenced by the thoroughness of the written description of goals and materials (although little was written about *what* teachers really do in the classroom). Most programs are concerned with the students' future science preparation and knowledge as well as the present. They aim to develop a positive attitude toward science in the students and to prepare students to be scientifically literate as members of society

Instruction in an Exemplary Program

- Is supported by an adequate budget and administrative guidance.
- Includes problem-solving activities applicable to students' daily lives.
- Provides adequate materials for students to explore.
- Meets or exceeds state and national minimum time expectations.
- Integrates science into other content areas.

Most of the programs in the area of instruction integrate science with other content areas such as reading, language arts, and math. Almost all use additional resources such as field trips, science fairs, and camps. Activities are many and varied and, for the most part, problem-oriented The programs are an ongoing part of the curriculum with ample time spent over the course of the year. To keep it that way, every program involving more than one school provides focused, intensive, and continuing inservice for teachers.

Two of the programs make science the center of study interweaving other subjects as a means of gaining knowledge and completing the activities. As indicated earlier, most of the materials are common, everyday materials that students can identify with easily. All of the program rationales state that they consider science a vital and important part of the curriculum and, as such, include it in the daily requirements.

Teachers in an Exemplary Program

- Have a clear understanding of the goals of the science program.
- Have an opportunity to learn and try new ideas and methods.
- Provide varied experiences in both content and processes of science.
- Provide a variety of experiences from many sources including the life, physical, and environmental sciences and current problems.
- Encourage students to be problem solvers.

The teacher emerged as the strongest part of the program. The enthusiasm of the teachers involved is evident in the written materials and in speaking and interacting with them during presentations at the National Science Teachers Association meeting in San Francisco in May, 1986.

Most programs provide inservice and teacher guides for all parts of the programs while *all* programs provide some type of instructional support for teachers. The teachers feel they have input, know what is expected, and feel they are meeting the goals of their programs. Teachers are anxious to try the ideas they gather from the inservice and other learning techniques. Not all of the programs cover physical, life, and environmental areas, but they do present a clear scope and sequence which ensure that all areas are covered during the course of students' elementary school years

In summary, the most important characteristics of these programs seem to be that they are well planned and have clearly stated objectives and goals; they have support from the administration; and the teachers involved are enthusiastic and able Also noteworthy is the use of existing materials (they did not develop all new materials) and the definite problem-activity focus of the programs. In addition, when science kits circulate from the central office, teachers have a focused inservice. Science is expected to be taught, and it is.

A deciding factor in the final selection of a given program as exemplary was the manner in which it was presented for review. The essays were neat and easy to read and follow. Those that sent photographs, tapes, and supporting material did so with careful explanations and clear descriptions of how this material was used and produced.

All the exemplars have stated that this experience has made a tremendous difference in their schools. They have received publicity and feel that it has given the school a truly positive image. This kind of result helps keep elementary science in the foreground.

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