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ABSTRACT

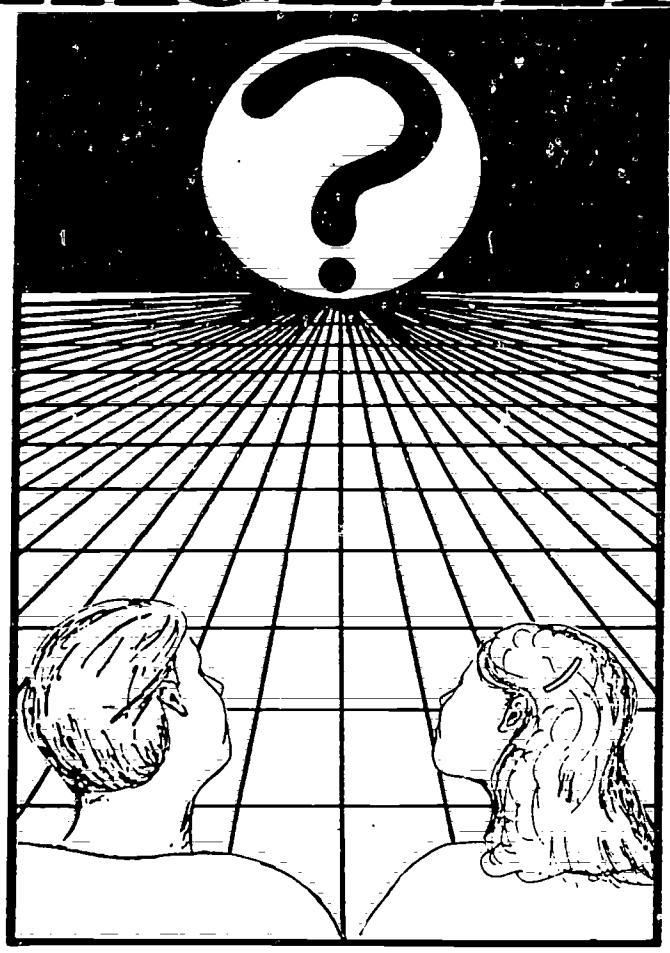
The Search for Excellence in Science Teaching and Career Awareness was undertaken to recognize programs that have proven to be innovative in leading students to greater career awareness. This document lists and explains the criteria for excellence in this search and provides descriptions of the five exemplary programs that were selected. Program titles and awarded schools include: (1) "A Nationally Validated Middle School Science Career Awareness Program" (Jones Middle School, near Columbus, Ohio); (2) "Marine Science Career Awareness" (Marine Science Center, Poulsbo, Washington); (3) "The Primary Integrated Curriculum" (Jefferson County Public Schools, Lakewood, Colorado); (4) "ESCES: Exposing Students to Careers in Earth Science" (McLean High School, McLean, Virginia); and (5) "Science Mentor Program" (Indianapolis Public Schools, Indianapolis, Indiana). A summary is also provided of the highlights of the exemplary programs. (ML)

NATIONAL SCIENCE TEACHERS ASSOCIATION

# FOCUS ON EXCELLENCE

Volume 4 Number 1





## Science Teaching and Career Awareness



John E. Penick, Editor

# Focus on Excellence

# Science Teaching and Career Awareness

Volume 4 Number 1

Edited by
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# Table of Contents

# Preface
# Careers and Science Education: Where Are We?

Teaching specifically about careers has often been relegated to a special brief unit or a single day when students are "exposed" to a variety of options. They may research a career, make reports, or even read a book or two. Sometimes they take preference tests, and perhaps receive job counseling. But in most of the schools and classes I hear about, career education, served up with little or no direction or guidance by the teacher, is for those students who plan to enter the labor market after high school, while those going on to college are merely encouraged to study more. Science teachers have science careers in mind for some of their students, but they define them very narrowly.

I once traveled nearly 2,000 miles visiting high schools in one state. At each of the 30 high schools I visited I spoke with science teachers about career education. Without fail, the teachers mentioned careers: careers in medicine, engineering, and science. Most teachers had stories about students returning as successful physicians; about the fine engineers students had become; about the research they were conducting. These teachers were very enthusiastic about their students going on to become scientists.

Unfortunately, most of their students didn't become scientists. And as far as I could tell, the careers employing 95 percent of these schools' graduates, where science might be useful, were almost never mentioned. Most glaring of all, not a single teacher I interviewed suggested science teaching as a career option for students. Each time I would suggest science teaching, teachers would add it to the list, although sometimes reluctantly. I was severely disappointed.

So, with that introduction to careers education in science, I truly looked forward to The Search for Excellence in Science Teaching and Career Awareness, one of a series of continuing searches by the National Science Teachers Association with the National Science Supervisors Association and the Council of State Science Supervisors.

The NSTA Search for Excellence in Science Education began with a Project Synthesis effort which analyzed more than 2,000 pages of information from three National Science Foundation reports and the National Assessment of Educational Progress. After careful analysis of all this data, the 23 Project Synthesis researchers developed a synthesis of a desired state for each of the various areas within science. These desired state criteria ultimately led to the first Search for Excellence, in 1982, reported in Volume I of the *Focus On Excellence* series.

Volume 2 and later volumes have arisen from criteria developed by NSTA committees especially appointed for these tasks. Goals and criteria for this search were developed by Walter Smith and the NSTA Task Force on Defining Excellence in Science Teaching and Career Awareness. They present their criteria in chapter 1 of this *Focus On Excellence* volume.

Using the criteria developed by the task force, leading science educators in each state identified outstanding career programs in that state. State nominations were submitted to the task force for consideration at the national level. To aid in the selection process, nominees provided detailed information on the nature and demographics of their schools and the outcomes of their programs. These descriptions form the basis for the chapters of the present volume.

While only five exemplary programs have been named, I am confident that this Search for Excellence will cause other teachers, administrators, and schools to look at the career education component of their own systems, and find avenues of change leading to greater career awareness on the part of their students. These five programs approach career education in different ways, but all have considerable success with their students.

We hope these descriptions of actual programs will bring the task force's desired state to life for your school and your students. These program descriptions make it clear that size of school or type of student or budgeted dollars neither make nor break a career education program. Other elements matter a great deal, but the teacher is the key factor in every program. These teachers are willing to try something new; they're confident about their abilities; and they look first of all to their clients, the students.

While all of these programs are innovative and exemplary in some way, they are only a few of the many excellent programs that must exist. We hope that through this search and report other excellent programs will be stimulated to identify themselves, while good programs will become even better. We look forward to reading about your program in the next volume of *Focus On Excellence*.

**—John E. Penick**

# Foreword
# The Search for Excellence in Science Teaching and Career Awareness

Project Synthesis, reported in Volume 3 of NSTA's *What Research Says to the Science Teacher* (Harms and Yager, 1981), affirmed four goal areas for science instruction: science for academic success, science for meeting personal (daily) needs, science for resolving societal problems, and science for career awareness.

NSTA's Search for Excellence in Science Education (SESE), an outgrowth of Project Synthesis, has attempted, first, to describe excellence in various areas of science education and, second, to identify school programs that exemplify many or all of the characteristics of excellence.

After having identified excellent programs in areas such as elementary science and high school chemistry, in 1983 NSTA turned its attention to a SESE search in the area of science and career awareness by appointing a task force composed of LeRoy Lee of Madison, Wisconsin, Walter Purdy of Washington, D. C., Douglas Seager of Fairport, New York, and Iris Weiss of Chapel Hill, North Carolina, and chaired by Walter Smith of Lawrence, Kansas. The task force, working entirely by phone and mail, started by generating criteria of excellence in the areas of program goals, curriculum, instruction, evaluation, and teachers.

A one-page list of criteria (see Figure 1) which went through several revisions by the task force during 1983-'84 and a brief synopsis of these criteria (see Figure 2) were circulated by various media in fall 1984 as part of a call for nominations of exemplary programs. The task force elaborated on the criteria in a third document, which appears here as chapter 1, for use by people considering nominations and in the selection process. Eleven programs were nominated in mid-1985 by state SESE committees; and five exemplary programs—which are described here in chapters 2 through 6—were selected by the task force, announced as the exemplars in fall 1985, and given official recognition at the NSTA National Convention in San Francisco in spring 1986.

—**Walter S. Smith**

**Reference**

Harms, N. & Yager, R. (1981). *What research says to the science teacher* (Vol. 3). Washington, DC: National Science Teachers Association

**Figure 1. Excellence in Science Teaching and Career Awareness**

The **Goals** of exemplary science teaching/career awareness programs are to produce students who

- Understand that science is applied on the job not just by scientists, technologists, and related workers, but by *all* paid and unpaid workers in every field, and that today's citizens must master at least basic life and physical science principles in order to function successfully in an increasingly technical world
- Understand that the interests and abilities needed for success in all careers exist within all groups, regardless of gender, race, creed, nationality, or handicapping conditions which formerly limited career entry
- Can make appropriate personal, societal, and on-the-job decisions which apply scientific concepts and processes
- Exhibit such essential personal attributes and interpersonal skills as the ability to reach consensus
- Can find information about various science-related careers, evaluate that information in terms of their own interests and aptitudes, and act on the conclusions they reach.

The **Curriculum** of an exemplary science teaching/career awareness program

- Includes in its regular science courses examples of the way scientific principles are applied on the job, in the home, and in the community
- Provides interactions between students and role models, including people from a range of jobs and educational backgrounds, representing both genders and all races, to demonstrate how science is used by all
- Informs students about the education and experience needed for careers which build on science skills, and teaches them how to acquire further career information
- Integrates science instruction with other subjects so students can see how science skills are used

The **Instruction** in exemplary science teaching/career awareness programs

- Engages students individually and cooperatively in hands-on science activities related to careers
- Uses individual and community resources for technological updates and career information
- Includes a range of learning strategies, levels of difficulty, and types of rewards appropriate for the diversity of students

The **Evaluation** in exemplary science teaching/career awareness programs

- Reflects the significance of career awareness in science instruction and is an ongoing, integral part of the program.
- Includes a variety of evaluation procedures so that affective and cognitive gains may be assessed; students are helped to make career decisions; and data may be used to make program changes
- Is reported to and used by students, parents, colleagues, administrators, and the community

The **Teachers** in exemplary science teaching/career awareness programs

- Achieve success in meeting the above criteria, and know that their performance will be taken into account in their job evaluation
- Know about science career applications, draw from their own hobbies or work experience to teach about them, and share their enthusiasm with students
- Participate in ongoing inservice training which updates and broadens their science career awareness and ability to impart information to students

**Figure 2. Synopsis of Criteria for Identifying Exemplars of Excellence in Science Teaching and Career Awareness**

- Career awareness is infused into the teaching of science throughout the school years so that students learn about practical applications of the scientific principles they are studying and about entry and progression requirements in the many careers which apply science.
- Students learn that science is applied in virtually all careers, not just by scientists, engineers, physicians, and others traditionally associated with science.
- Students learn that science-related careers are not limited by gender, race, creed, nationality, physical disability, or any other characteristics which formerly have limited pursuit of science careers.
- Instruction draws on community resources for technical updates and career information, and frequently provides for and engages students in hands-on activities related to science careers.
- Evaluation of students, teachers, and the school's science program reflects the importance of science career awareness.
- Teachers continually improve their knowledge of applications of science in careers and enthusiastically share this information with students.

# Chapter 1 Excellence in Science Teaching and Career Awareness

**LeRoy Lee**
**Walter Purdy**
**Douglas Seager**
**Walter Smith**
**Iris Weiss**

"What's the use of learning science?" students ask. Parents are concerned, and sometimes confused, about the science courses their children take. Policymakers debate which courses ought to be required for graduation. All these concerns demonstrate the need to define science's place in the school curriculum.

One rationale for teaching and learning science, as Benjamin Franklin told the colonists and John Dewey reminded our grandparents, is that science is practical. Aspects of science figure in virtually all careers, as well as in the home and community. Science must be given a central place in our universal education, in a manner which highlights its applications and informs students about those careers—virtually all careers—where science plays a role.

Project Synthesis, which has guided the Search for Excellence in Science Education, recognized the crucial importance of career awareness. This particular SESE search focused on finding those exemplary science programs in which career awareness is thoroughly infused into science education.

Some glimpses of science instruction may illuminate what we looked for in an exemplary program.

> In a seventh grade classroom where students are studying chemistry, a woman from the soil conservation agency helps them use the decanted liquid from chopped, boiled red cabbage to measure the pH of common household materials and soil. The soil conservationist—who is only one of several career people to have taken part in this science course—tells students about how she uses pH in her job, and adds other interesting details about her own career.

> A chemistry/physics teacher attends a nuclear energy workshop planned jointly by the regional electric power company, his state science teachers society, and the state department of education. Subsequently he works one summer for the electric company. Then, in his teaching unit on atomic particles, he informs students about how those ideas are applied in the electric power industry and about the science-related jobs he observed.

> After third graders have studied about weather and operated their own simple weather station, the unit test asks them to describe how a farmer might apply what they now know about predicting weather. They are prepared to answer.

> Using the Labor Department's *Exploring Careers* and other resources, students in an eighth grade general science class collect information about science skills needed in various careers and about the science offerings of the local high school. In an atmosphere encouraging continued science study for all, students decide on courses they want to take in their high school years.

The key concepts in our criteria, which we found actualized to various degrees in the various exemplary programs, are: infusion, life applications, inclusion of all careers, equity, K-12 integration, meaningful evaluation, community involvement, and continuing education for teachers.

## Infusion

"Science teaching and career awareness" must be understood to mean that career awareness is integrated throughout science instruction rather than added to it. While there is a proper place in the school's program for career days, career counselors, interest tests, and the like, a school having an excellent program in science and career awareness must also have a coordinated career program built into each course. In excellent programs in science and career awareness, science teachers consistently relate the ideas they present to their applications on the job and in the home and community. Students learn about these applications as they master science objectives in the cognitive domain. By seeing that science is personally practical whatever their intended career, they achieve equally important science objectives in the affective domain.

When career awareness permeates science instruction, students are motivated to learn the science being presented because they see its uses in the real world; learn about science applications (as opposed to or in addition to science theory); and are informed about career options.

## Applications

Students enrolled in exemplary programs of science teaching and career awareness feel they are mastering skills which have potential usefulness in their life and work. For example, when studying about atomic structure, students should come to understand that this information is used by professional scientists and technologists, but also by people in quite different walks of life. An English professor, for example, should know enough to use an organic solvent, rather than water, to remove a grease spot from her coat.

These exemplary programs do not exclude any theory just because it does not currently have clear applications. Some ideas are elegant simply because they help us frame an understanding of the natural world. For example, the search for fundamental particles of matter—earth, air, fire, water, atoms, protons, quarks, or whatever is emphasized at a given time—provides students a conceptual framework for thinking about diverse, complex objects as all deriving from some common denominator. One nineteenth century physicist, when asked for examples of practical uses of electricity, was correct in responding, "Of what use is a newborn baby?"

An exemplary program may teach theory—even emphasize theory more than application in some instances—because that theory opens students' thinking to new ways of looking at the world. However, in all cases, exemplary programs richly intersperse application with theory, and students master objectives dealing with both.

## All Careers

The phrase, "science-related careers," may severely restrict our view of the careers for which science study seems appropriate. Children as young as preschoolers can describe scientists. They wear white coats, work in labs with complex apparatus and smelly chemicals, and act "weird." This mental image serves to stereotype science instruction as something for the minority planning "science-related careers" such as researcher, engineer, or physician. Some science may be prescribed for all those who plan on college, but huge numbers of students are still left out. If a student plans to be a lawyer, salesperson, mechanic, hairdresser, or police officer, or does not have specific career plans, but has ruled out the so-called "science-related careers," then she or he may assume that science instruction is not necessary.

The true scope of science is broader than that dated image. Indeed, all—yes, all—careers apply science in some way. And even if mastery of science skills is not a major requirement for success in a particular field, having gained that mastery will enhance a person's career pursuit. A furnace repairer, for example, can be ignorant of density and still do the job in a rote fashion; but he or she could do a better job of problem solving a faulty heating system—and perhaps even hold a distinct edge over the competitors—by knowing that the density of water is affected by temperature, so that warm water tends to float on cold.

Exemplary programs in science teaching and career awareness give students the message that science is applicable in some way and to some degree in all careers. Students express this understanding by enrolling in elective science courses. The available science courses may or may not be differentiated into "tracks"; but however the program is structured, it emphasizes science's applications across all careers, for paid and unpaid workers, as well as in the home and the community.

## Equity

Although the situation is gradually changing, certain careers—including those identified as "science-related"—have been pursued only in small numbers by women, certain minorities, and people with handicapping conditions. The reasons for this underrepresentation are diverse, but the situation *is* correctible. Exemplary programs in science teaching and career awareness make special efforts to ensure that these heretofore underrepresented groups are not excluded and, ideally, actively recruit these students to science study. Their success is reflected in enrollment patterns which show young women, minorities, and the handicapped in elective science courses in the same or nearly the same proportions as in the school's population.

## K-12 Integration

Career awareness is appropriate throughout the K–12 grade range, although particular activities will vary depending on grade level. Exemplary programs in science teaching and career awareness plan and carry out science instruction from kindergarten through high school, with career awareness infused into science instruction throughout the grades. A first grader may visit a bakery and see that little gas bubbles expand to make bread rise. Then the same youngster might return as a senior physics student to measure this volumetric change and relate it to temperature. Whatever the activity, the exemplary program consciously plans science instruction for grades K–12 to include science applications and career awareness.

## Evaluation

The pervasive integration of career awareness into science instruction is demonstrated not only by its inclusion across the grades, but also by its appearance in all aspects of instruction, including evaluation. Exemplary programs go beyond merely exposing students to career applications. They also demonstrate the importance of these applications

by evaluating students to be sure they have understood them. Moreover, these test results, along with interest tests and other measures, are used throughout the grades to help students in their career decision making process. Finally, exemplary programs use these test results, along with other information, in evaluating the overall science program and in making improvements.

## Community

Where science teaching emphasizes science applications, and mastering science in order to do well in careers, the community plays two important roles. First, community members, through some mechanism such as an advisory council, help the school plan science programs. This planning may take place at a system-wide level or between a single teacher and key community members. The point is that community members are involved in planning the science program.

Second, community members take part in science instruction. For example, they may serve as classroom visitors who demonstrate applications of what the students are studying. They may also serve as hosts for individual or group visits to the workplace, again to demonstrate science's applications and to inform students about careers. One of the many possible mechanisms for enabling this cooperation is the "adopt-a-school" model, in which a business establishment or industry agrees to work with a particular school's science program.

In the worst case, science instruction can wear an aura of unreality, and appear distant from any future that students can imagine. But an exemplary program's involvement of the community brings the adult world into the science program, helping to shape what is taught and exposing students to real people who use science.

## Continuing Education

As has been pointed out consistently, most recently by the various reports which have proliferated in the 80s, teachers are the key to the success of science instruction. Among other characteristics, successful teachers have a firm grasp of their subject and the ability to convey information to students.

Such knowledge can be initiated in college courses prior to entering teaching, but it must be updated through continued education and—probably more important—through the teacher's firsthand experience at one or more worksites where science principles are being applied. Information may be obtained through field trips, professional meetings, or journals and other media. However, beyond this introduction, teachers need extended paid or voluntary experience—probably of at least one summer's duration—observing and taking part in work activities where the science principles they teach are being applied. The faculty of exemplary programs have had such experience, and apply the results of this experience in their instruction.

# Chapter 2
# A Nationally Validated Middle School Science Career Awareness Program

**Susan Leach**
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**Upper Arlington City School District**
**1950 N. Mallway**
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Upper Arlington, a city of more than 35,000 residents, is located in central Ohio, next to metropolitan Columbus. The great majority of its 10,850 households do not currently have children enrolled in school. The community is economically stable and ethnically homogeneous, with an average family income of $34,000 per year and an average per capita income of $14,500.

According to the 1980 census, the occupations of Upper Arlington residents 16 years and older were 54 percent managerial and professional; 33 percent technical, sales, and administrative support; 8 percent manual labor; and 5 percent service. Ninety-five percent of the population were high school graduates, and 52 percent had completed four or more years of college.

Serving this community, the Upper Arlington City School District has four elementary schools (K–5), two middle schools (Hastings and Jones, 6–8), and one high school, (9–12) totalling about 5,100 students. In 1984 the district's budget allowed for expenditures of $3,356 per student, of which 74.23 percent came from local taxation, 22.01 percent from the state, and 3.76 percent from other sources.

## Students

The majority of students in Upper Arlington plan to continue on to college or university after graduation, and 85–90 percent of most graduating classes do in fact enroll in some form of higher education. As the educational intentions of the students indicate, most plan to prepare for employment in professional areas. Especially significant interest areas include business and commerce (22%); health professions (15%); social sciences (12%); engineering (7%); fine and applied arts (7%); communications (5%); and education (5%). Computer and information sciences have recently attracted growing student interest, both as a distinct occupational area and as one with potential applications for other areas.

## Program Goals

The reasons for developing a career infusion program in the science classes of the Upper Arlington Middle Schools are well explained by the schools' philosophy statement:

We believe our overriding purpose as a middle school is to create and sustain a learning environment that meets the needs of pre- and early-adolescents of Upper Arlington. Specifically, the school should

- speak meaningfully to the unique needs of each student
- ensure success for each student
- evolve from the elementary self-contained classroom to the departmentalized program of the high school
- be staffed by persons chosen for their ability to be flexible and creative in their teaching methods, and who enthusiastically wish to teach this group of students over all other groups
- be marked by organizational diversity that accomodates, rather than dictates, particular styles of teaching and learning
- provide a diverse curriculum with active involvement by students in subjects perceived to be useful and related to personal interests
- provide co-curricular opportunities which support the curricular program and which encourage creativity and exploration

- teach basic skills and understandings in order for the student to become a self-reliant and productive member of society
- sustain a climate of vitality and compassion where students feel secure and supported when they encounter difficulties
- work actively with parents and the community at large in a coordinated and concerned effort to develop the whole child—physically, intellectually, socially, emotionally, and morally
- foster those skills and attitudes toward living and citizenship that will permit a life of personal satisfaction and civic and social responsibility

The Board of Education, administration, faculty, parents, and community place significant emphasis on providing youth with the skills, attitudes, and knowledge young people need to become successful adults. As a result of this concern, career education infusion has become an important focus for the district's science curriculum.

## Resources

The conceptual framework for the career education program in Upper Arlington has been the Ohio Model for Career Education. The Upper Arlington Career Education Director and her staff develop many career education activities. A teacher-developed curriculum guide provides career resource information. Many of the activities that are used by the Upper Arlington middle schools are teacher-developed. The district has a close affiliation with Ohio State University and uses other nearby institutions as educational resources. Parents, community businesses, agencies, and civic organizations are also our partners in education.

## Subjects Covered

The seventh grade life science course focuses on plant and animal life and their interdependence. In eighth grade earth science students study astronomy, geology, meteorology, and oceanography. Science objectives are based upon processes and concepts related to the various science topics being taught: the processes of observing, classifying, measuring, communicating, inferring, predicting, questioning, hypothesizing, experimenting, processing and interpreting data, and formulating models; and the concepts of cause-effect, change, cycle, energy, matter, equilibrium, evolution, force, model, pattern, organism, and probability.

Science textbook selection occurs on a five-year cycle, consistent with curriculum revision. In recent years increased attention has been given to selecting texts which enhance awareness of science-related career opportunities; demonstrate application of science in varied facets of daily life; contribute to the elimination of bias; address changes and trends which are likely to impact students' future pursuits; and encourage students to assume an active role in their own learning.

## Teachers' Roles and Program Strategies

Teachers use a variety of instructional techniques, including modular, informal, and structured laboratory activities, to promote a hands-on approach to learning. They facilitate student learning through many other strategies, including lectures, discussions, audio-visual programs, visiting speakers, field trips, homework assignments, independent projects, computer lab assignments, and the use of the Learning Center/Career Center.

Science teachers at all levels have been actively involved in career education planning and implementation since the inception of the Upper Arlington Program. Every school has a "building team," a committee of teachers who work together to coordinate career education across the curriculum. District-wide meetings link building teams from school to school.

Numerous examples can be cited of infusion of career education in lesson and unit planning; use of community resources to enhance career awareness; use of career education resources and materials; and involvement of teaching staff in career education leadership roles.

*Infusion of Career Education in Lesson and Unit Planning*

Teachers are encouraged to base infusion efforts on the seven developmental areas of the Ohio Model for Career Education: Self, Individual and Environment, World of Work, Economics, Education and Training, Employability and Work Adjustment, and Decision Making. The author has conducted workshops and developed materials to demonstrate how the developmental areas can be integrated in middle school science instruction. The unit and lesson plans of Hastings and Jones Middle School science teachers attest that it is being done.

Middle school students are given many opportunities to study and simulate the work of scientists, investigate science-related career opportunities, and understand the use of science in other occupational areas. Many units in the seventh and eighth grade program, for example the oceanography unit, have an overriding career exploration theme. Beyond this, individual laboratory activities and workbook selections reflect a career focus. Several teachers use career reports to further encourage students' investigation of future options.

*Use of Community Resources to Enhance Career Awareness*

Guest Speakers—Teachers indicated in a survey that they have used career-related speakers frequently. Both scientists and non-scientists have been well represented. Some teachers have used parents as visiting speakers, identifying names from their own surveys or from the career education resource file.

Field Trips—Teachers have planned and implemented a wide range of field trips for their students, with many of these funded by career education grants. An effort has been made to relate these trips to career education concepts. For example, students on one trip used an observation form entitled "Why Work?" This required them to identify at least five different kinds of workers and to write in depth on at least one of them. Students also had to reflect on the work setting featured in the trip and explain ways in which the setting did or did not fit their own preferences.

Another field trip, this one to a park called Blendon Woods, helped students focus on the following: jobs related to caring for the outdoor environment; interests and values a person should have to consider such jobs; education,

training, and skills required; and earning potential and employment outlook. Similar career factors were considered by students visiting other sites, such as Battelle Memorial Institute, Perkins Observatory, and Wright Patterson Air Force Base.

Service-Learning Projects—As part of the middle school career education program, science teachers are expected to work with their "house team" colleagues (language arts, mathematics, and social studies teachers who work with a common group of students) in planning and implementing service-learning projects. These projects involve students as active helpers in the school and community and may take the form of direct service, research, and subsequent education of others, and/or advocacy in areas of perceived need. A career education program specialist assists house teams in carrying out their service-learning objectives.

Several exemplary service-learning projects have a strong science focus and have been coordinated primarily by science teachers. Some of these have promoted environmental education, such as the ecology trash collection project and a Columbus Zoo clean-up campaign.

One particularly intensive project involved a campaign to save the Ohio State University Radio Telescope, "Big Ear," from falling victim to a proposed land sale. One hundred and fifty students participated in writing letters to newspaper editors, public officials including Senator John Glenn and President Ronald Reagan, and prominent scientists such as Carl Sagan. Students designed and sold "Save Big Ear" T-shirts and used the proceeds to finance other expenses of their campaign. Local, regional, and national media covered the project, culminating in a three-minute story on CBS News. As a result of the campaign, the radio telescope (since renamed the North American AstroPhysical Observatory, or NAAPO) received a five-year reprieve. Jones Middle School has continued to support Big Ear and has established an official School-Community Partnership (via career education) with NAAPO.

Mentorships—Recent efforts have been made to link science students with community mentors working in areas of special interest to the students. Most often these mentorships have been connected with science fair projects and have involved students with high interest and ability. The author has piloted the mentorship project and has been extremely pleased with the results. One student worked with a local TV meteorologist in investigating why snowflakes have different shapes, while another was able to expose his paramecium culture to X-rays at the Battelle Memorial Institute. One community mentor, feeling the need to develop engineering skills among middle school students, offered to organize a ham radio club for several interested amateurs.

In all these efforts, students accepted the responsibilities of selecting research topics, working cooperatively with mentors, and logging research progress. The teacher evaluated student learning by grading oral and written reports submitted during and at the conclusion of research.

This pilot effort represents only the beginning of what could be a most meaningful program for many more students and their mentors. The Columbus community is one of the largest scientific information centers in the world and offers a wealth of expertise that too often goes untapped. Both the middle school science faculty and the district's career education staff are pursuing possibilities for expansion of mentorships.

Career Shadowing Experiences—As part of the middle school career education program, each seventh and eighth grader experiences a community work setting and explores an occupation by spending a day "on the job" shadowing a designated adult. Seventh graders shadow a parent or close family associate to gain a greater awareness and appreciation of that person's work. Eighth graders shadow community adults whose work matches their own occupational interests.

Many eighth graders can identify fields of interest but need help in identifying individuals to contact as sponsors. Science teachers have been most helpful in supporting students' shadowing efforts by suggesting specific resource persons for students to contact, advising students about what to look for in science-related work settings, and helping students process their reactions to the shadowing experiences when they return to school. Such teacher support is crucial to the success of grade level career guidance activities.

*Career Education Resources*

Career Centers—Each middle school has a career center adjacent to its learning center, which houses career-related items. Each center is staffed by a half-time career education intern, a graduate student from OSU who is training to be a counselor or teacher educator. The intern also supervises the use of career education software in each middle school's computer lab.

Science teachers most commonly use the career center and its intern as resources to provide students with appropriate occupational information, secure information and assistance for arranging guest speakers, and encourage students to update and expand their career folders.

Career Education Grants—Career education funds are allocated annually to each building team and also to each house team for service-learning and field trip implementation. Building team grants are designed to help teachers fund innovative career education projects. Middle school science teachers have actively sought and used such grants in recent years. For example, they have been able to purchase aquarium equipment and materials, computer software, ham radio books and cassettes, audiovisual learning aids, and other classroom materials. In addition, career education grants have supported teachers' requests to attend selected conferences and to engage in other professional growth activities.

*Looking Ahead*—Teachers throughout the district are offered the opportunity to receive a monthly newsletter about future career trends and forecasts. Science teachers at both Hastings and Jones find the newsletter, *Looking Ahead*, informative and useful to them both personally and in their work with students.

*Teachers as Career Education Leaders*

Several middle school science teachers have assumed important leadership roles in career education. Most significantly, the building teams at both Hastings and Jones are currently co-chaired by seventh and eighth grade science teachers. One of these individuals also serves on the career education advisory council. Several other science teachers

have served on building teams in recent years.

Several science teachers from Hastings and Jones were nominated for the 1985 district-wide Career Leadership Awards. Each nominee must have demonstrated a commitment to career education by

- infusing the goals and objectives of career education in his/her work with students
- communicating effectively about career education to parents, teachers, administrators, counselors, and/or community members
- serving as a role model to other educators in the district
- making effective use of community resources
- demonstrating a commitment to his/her own professional growth and development
- working cooperatively with the career education staff and building team
- involving students in innovative projects or using innovative methods in meeting career education goals and objectives

Each nominee was nominated by a colleague and then asked to submit a written response addressing the criteria above.

The teacher survey conducted for this paper gave many other indications of career education leadership by middle school science teachers. Seventh and eighth grade faculty members have participated in and conducted workshops, written and published articles, and received an impressive variety and number of regional and national awards.

## The Student's Role

Students are encouraged to assume responsibility in planning, carrying out, and evaluating their own learning. In many instances students simulate the work of specific kinds of scientists, engage in problem-solving situations which parallel real life challenges, and learn skills which may be applied in other settings. Further, as the philosophy statement in the district's curriculum guide indicates:

A study of science can provide experiences wherein learners play an active role in the development of their attitudes and critical thinking. Science is a flexible, ever-changing method of inquiry that lends itself to the formation of highly individualized learning and reasoning strategies that have application far beyond the confines of the discipline.

## Classroom Design and Equipment

At Hastings Middle School five teachers are responsible for seventh and eighth grade science instruction. They work with 195 seventh graders (average class size, 24) and 228 eighth graders (average class size, 20). At Jones Middle School six science teachers work with 198 seventh and eighth graders (average class size, 23 for both levels). Classes are held in laboratory rooms that are equipped with storage facilities, sinks, and outlets.

Learning aids include computers, microscopes, microslide viewers, and saltwater and freshwater aquariums. Special equipment is sometimes loaned or donated by science-related institutions in the greater Columbus community. Laboratory facilities, materials, and activities provide numerous opportunities for students to function as active investigators and to apply scientific principles and methodology.

## Our Program as Part of the District Program

Career education has been a major focus for instruction and guidance in the Upper Arlington City School District for the past ten years. The district has built a comprehensive K-12 career education program which is recognized as a national model. Also within the district, special education services, including programs for learning disabled students and gifted students, federally funded Title I projects, K-12 guidance services, and vocational education options are provided.

Since all students are mainstreamed for middle school science, the science program must meet the needs of a diverse population. It is through the cooperative efforts of the Upper Arlington Special Education Services, the Career Education Department, and the science teaching staff that this is possible.

## Evaluation

In the district's most recent self-study document for North Central Middle School evaluation, the following strengths of the science program were especially noted.

- The science teachers have appropriate academic backgrounds and training in various fields of science and in the psychology of the middle school child. Most are involved in professional science organizations and continually update their science background by enrolling in university courses, attending workshops, and participating in regional and national conventions.
- Each teacher attempts to show the relevance of science topics by using community resources, addressing career opportunities involving science, and emphasizing the practical applications of science topics and activities.
- The study and developmental skills emphasized in science classes are transferable to other academic areas and represent many of the skills required for life-long learning.
- Although some retention of facts is essential, teachers emphasize skill development, decision-making, and value judgement.
- Community resources, career education, and other appropriate outside resources are integrated into the science curriculum.

*How Students and Teachers View the Program*

Student interviews indicate that they enjoy the program and appreciate its relevance. They see the importance of acquiring the knowledge, attitudes, and skills that career education infusion provides, and they relish their involvement in service learning and community partnership projects.

Our staff members have come to value their role as career educators very highly, and perceive their involvement in students' career development as essential. A survey conducted among seventh and eighth grade science teachers in conjunction with this award strongly affirms that participation in and commitment to career education are well established.

*How Students Are Evaluated*

Teachers use both subjective and objective techniques to evaluate student progress, the choice depending on the nature of the activity and desired student outcomes. Because career education content is such an integral part of the

science program, it is reasonable to conclude that as students progress successfully through the curriculum, they are experiencing significant gains in career awareness.

*Continuing Program Evaluation*

From 1981–83 Upper Arlington participated in a major federally-funded research project designed to validate the impact of comprehensive K–12 career education. Our district was one of three selected nationally to serve as demonstration sites. Upper Arlington students were compared with students of equal caliber from a similar setting who had not been exposed to comprehensive career education. Not only did our students perform favorably in basic academic skills; they significantly outdistanced the control group in career planning skills, job seeking skills, self-awareness, occupational awareness, economic understanding, ability to relate school subjects to the world of work, and sense of community involvement. Research results in these career awareness/skill areas were obtained from the Ohio Career Education Inventory and the Career Skills Assessment program developed by the College Entrance Examination Board.

From such large-scale research we know that our K–12 career education program makes a positive difference for Upper Arlington students. We also evaluate smaller segments of our program on a regular basis so that individual activities may be added, deleted, or revised to continue to meet the career development needs of our students. A review of our seventh and eighth grade activities is conducted annually with building teams, house teams, counselors, and administrators to assess program needs and progress.

**Plans for Improvement**

Career education aspects of the seventh and eighth grade science program that can be productively enhanced include

- expanded learning options for students who are gifted or have other special needs.
- increased staff time and/or incentives for coordination of enrichment opportunities such as science fairs, mentorships, and special interest clubs
- additional equipment and learning materials to facilitate individualization of instruction
- increased sharing of materials and ideas among staff

As always, we have a fundamental commitment to enhancing the career development of Upper Arlington students. We know that the district's seventh and eighth grade science teachers—if they have sufficient support and resources—will continue to make a significant contribution to this development.

# Chapter 3
# Marine Science Career Awareness

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More than two million Americans make their living in marine careers. Building on the inherent attraction of the world of water, the Marine Science Career Awareness program uses an effective three-tiered approach to provide both exemplary science teaching and career awareness.

The first tier begins with the locally developed and nationally validated Marine Science Project: FOR SEA curriculum materials. These use the marine environment to provide a conceptual framework and content for comprehensive elementary and secondary school site programs. The second tier, the instruction provided by classroom teachers, ties together skills and scientific content. Finally, the school site programs are coordinated by the Marine Science Center, which provides in-lab and on-the-water science experiences to demonstrate firsthand that science is applied on the job by everyone. Teacher and student enthusiasm is high, and test results verify that the program is an effective learning tool.

## Historical Background: The FOR SEA Materials

The Marine Science Career Awareness program originated with local teachers in the North Kitsap School District. Recognizing a local and national need for improved science and marine science instruction, these teachers secured support at all levels of government and from the private sector to establish a center for aquatic education, the Marine Science Center. Today, the Marine Science Center, managed by Educational Service District 114, serves students from three school districts, North Kitsap, Central Kitsap, and Bainbridge Island. The districts are located in Kitsap County, Washington, across Puget Sound from Seattle.

Marine career awareness tempers the romance of the sea and gives students a true image of marine careers. The materials balance human and environmental needs, informing students about how people make a living from the seas, while emphasizing that the vast ocean resource must and may be properly managed.

Beginning a decade and a half ago, a series of comprehensive marine education curriculum guides for grades 2, 4, 6, 7–8, and 9–12 was developed at the Marine Science Center. Each activity-oriented curriculum guide contains

- a conceptual framework
- complete student texts and activity sheets
- complete teacher background for each activity
- a bibliography of children's literature of the sea
- a bibliography of elementary students' information books on the sea
- a bibliography about the marine environment for secondary students
- answer keys and a list of key words for each student activity
- a guide to marine aquaria

Recognizing the merit of this material, the Office of the Washington State Superintendent of Public Instruction awarded an Elementary and Secondary Education Act, Title IV-C grant to Educational Service District 114 to refine the program and test its educational significance.

The materials were tested in elementary and secondary classrooms in more than a dozen school districts. Participa-

ting teachers from these school districts taught the project materials in lieu of their regular science programs. The districts were selected to provide participants from both rural and urban settings, from varying socio-economic backgrounds, and from the coastal, Puget Sound, and inland areas of Washington. School districts ranged from Cape Flattery in the northwest corner of Washington's coast, serving a student population of 549, of whom more than half are American Indian, to Edmonds School District, 10 miles north of Seattle, with 17,700 students of predominantly European descent.

Test results indicated the effectiveness of the curriculum materials. On the basis of these results the program was afforded statewide validation, so that school districts throughout Washington State could use the materials. The next step was submission of the Marine Science Project: FOR SEA curriculum program to the Joint Dissemination Review Panel of the United States Department of Education. The Department of Education agreed with the test results and awarded national validation to the materials. The project materials have since been successfully used nationwide in a great variety of situations and locations.

The curriculum guides are the basis for the classroom component of the Marine Science Career Awareness program. During the course of study, typically 60 contact hours, 4500 students each year receive classroom instruction before and after they visit the Marine Science Center. There they experience in-lab and on-water science/career awareness activities impossible to duplicate in a conventional classroom setting.

## The Setting

Kitsap County is a primarily semi-rural area with an expanding population and a developing industrial base. The following is a brief description of each of the districts.

Bainbridge Island School District, ten miles west of Seattle, is surrounded by the waters of Puget Sound. The district serves 2716 students of predominantly European descent. A large segment of the adult population commutes to Seattle to work in professional and skilled trade occupations.

Central Kitsap School District, 30 miles across Puget Sound from Seattle, serves 8900 students, including an Asian minority of over 8 percent. The Puget Sound Naval Shipyard in Bremerton and the Keyport/Bangor naval facilities to the north provide the primary employment opportunities.

North Kitsap School District borders the Bainbridge Island District to the south and the Central Kitsap District to the southwest. The district serves 4365 students of predominantly European descent, drawn from a large geographic area. Native Americans and Asians are the second largest minorities. As in Central Kitsap, the navy bases are major employers.

## Our Current Program

Four sets of goals shape the philosophy of the Marine Science Career Awareness program. Goals regarding individuals' ability to use science to improve their own lives and to cope in an increasingly technological world we term *personal goals*. Goals pertaining to preparing citizens to deal responsibly with science-related social issues are *social goals*. Goals pertaining to academic knowledge of science, for those individuals likely to pursue science in higher education, are *academic goals*. Finally, goals regarding information on the nature and scope of scientific and technological careers make up the fourth category, *career education goals*.

Research indicates the critical role of elementary schools in a sound science education program. The process of developing a student's understanding of science must begin early. Further, unless children and young adolescents are exposed to science and science-related career choices early, often, and favorably, they will not develop the motivation to become scientifically literate. The Marine Science Center promotes effective science learning through a comprehensive program for elementary, middle school/junior high and senior high students.

Current research also indicates that learning science by direct experience both increases content knowledge and improves students' attitudes toward science. Direct, hands-on exposure is the heart of Marine Science Center programs.

Students in the Marine Science Career Awareness program apply basic scientific principles to a variety of topics in their classroom activities and during their visits to the Marine Science Center. Our focus on the marine environment permits instructors to present a coherent body of information from what otherwise might strike the students as a large number of disassociated facts. The application of the scientific principles in the different settings begins the process of transference which is necessary for students to apply the basic principles, now at home, later on the job, and in the community at large.

At the elementary grade levels career information comes from visits and experiences in actual work environments, from reading and non-print media, and from occasional guest speakers. For example, the grade four curriculum focuses on commercial uses of the marine environment. Students become aware of diverse career opportunities in their own familial surroundings. In their classrooms they study commercial crabbing, shrimping, fishing, and harvesting of other marine resources. They also become familiar with the broadening career opportunities in aquaculture and mariculture. Community resource people involved in these commercial endeavors are often invited into the classroom as guest speakers. People from Domsea Enterprises on Bainbridge Island share their vision of the future of aquaculture, while in other sessions local fishermen describe the present realities of commercial fishing in Puget Sound at this time of resource depletion.

After students have learned about the natural history of the oyster, they may visit a local oyster plant, Coast Oyster, to witness this business in operation. The fourth graders' visits to the Marine Science Center include activities to augment their grasp of navigation, tide chart interpretation, and marine skills they have been learning in class. The students also take a boat trip with a seasoned skipper, Jack Walsh, who brings a wealth of career experience to the task. On this trip they identify boats and shoreline features related to commercial uses of the marine environment, as well as related career opportunities around the waterfront.

Sixth graders compare the role of the marine biologist

and the oceanographer in investigating the marine environment. They have an opportunity to use some of the tools of oceanography as they identify properties of salt water. Their visit to the Marine Science Center includes a microscopic examination of living plankton.

Students in junior high explore marine geology and the related career opportunities as they follow the life of a California gray whale for a year. Activities that develop skills related to boat handling and navigation are included.

Senior high students studying marine biology and oceanography get an in-depth look at the physical and biological factors that influence life in the sea, as well as current issues in ocean use and management. These issues deepen awareness of marine careers related to resource use and management. Senior high students also have the option of becoming teacher aides, another opportunity to examine career options. Field trips to National Oceanic and Atmospheric Administration facilities, Suquamish Tribal Grounds, state and federal hatcheries, and parks, as well as trawls taken with Marine Science Center staff provide students with first-hand information about the role of science in a wide variety of careers.

Secondary students become increasingly involved with people who use science to make a living in the marine realm. Because it is difficult for most working adults to come to school on a regular basis, the interactions usually occur in a Career Day format.

As noted earlier, the emphasis of the Marine Science Career Awareness program is hands-on science, engaging students in the process and content of science while exposing them to how people use scientific knowledge and skills to gain their livelihood. The materials and lessons were developed with input from reading specialists, who included activities to strengthen communication skills as they build observation skills. The materials, especially at the elementary level, are interdisciplinary, and work to teach science/career awareness in the context of language arts, mathematics, and art.

## Program Evaluation

Students participating in the Marine Science Career Awareness program are evaluated both formally and informally.

A thorough review of existing test instruments failed to reveal any appropriate to the project's objectives. A new test instrument was developed at each grade level in consultation with an evaluation specialist and refined through a rigorous procedure of statistical evaluation. Every effort was made to assure that these measurement instruments were valid and reliable in assessing the knowledge and skills taught by the project. The steps in our evaluation process included the following:

- The major curriculum strands were identified by the Project Developer.
- A scope and sequence were developed which specified the major concepts taught.
- Multiple choice test items were developed, also reflecting the major concepts.
- All items were reviewed to eliminate ambivalence and insure clarity of content and grade level appropriateness. Instruments were revised as necessary at this point.
- The instruments were checked for reliability by administering the tests to a sample of students (N=30) at the grade level for which the test was developed.
- The instruments were checked for validity by administering them to an astute population (advanced students, grades 11–12) who were known to have had course work in marine science.
- At each stage of field administration the tests were checked for adverse floor and/or ceiling effects. The reliability and validity figures fell within an acceptable range.
- Evaluation of the Marine Science Career Awareness program establishes its worth in several areas. Of primary importance are student gains. The test instruments we developed at each grade level show significant gains from pre- to post-testing in our students' marine science career awareness, especially when compared to a control group.

The tests provide empirical evidence of student knowledge gains. We also assess student attitude toward the activities, suggestions for improvement, and the like. Written instruments are coupled with informal assessments made by the instructors, 11 of whom have received training in evaluation techniques. Evaluation results are reported directly to students and, through conferences, to parents and administrators.

In the post-treatment comparisons, the experimental groups outperformed the control groups by a substantial margin at each grade level. The gains were greater than the control group means plus standard deviations.

Participating teachers also evaluate the Marine Science Project: FOR SEA curriculum component and the Marine Science Center instruction component using separate printed evaluation forms. The forms cover a wide range of topics and present a graded scale on which teachers indicate the effectiveness of the materials with their students. Space is also provided for additional comments. Teacher evaluations indicate widespread enthusiasm for the program.

Important program evaluation is also obtained informally through conversations with instructors involved in the program. The conversations provide insight which leads to improvements in teaching strategies and program content. For example, Marine Science Center staff are now assessing the potential of a mentor program which would match students with a particular marine interest with people working in that area to produce a final project or product.

## Plans for Improvement

In a time of continued fiscal austerity, all programs are scrutinized for cost effectiveness. The districts cooperating in the Marine Science Career Awareness program commit staff resources and teaching time, and spend $25 per class for the FOR SEA curriculum guides. The Marine Science Center component is funded by the cooperating districts at a cost of about $4 per student visit. The Center employs three certified persons and one support person to operate these programs. The Marine Science Career Awareness program works constantly to improve the educational value received for district expenditures.

Each of the three tiers which comprise the Marine Science Career Awareness program is capable of standing alone. The Marine Science Project: FOR SEA curriculum is used successfully in hundreds of school districts nationwide.

Many areas use marine materials in classroom instruction, and there are other centers like our Marine Science Center. But the key to our exemplary program is the coordination of these three components into an effective and powerful curriculum package. A vision of the whole and a leader to articulate that vision are critical for the success of the program. An administrator with support from a district's central offices could fill this role and create such a coordinated program anywhere in the United States.

The success of a program such as Marine Science Career Awareness depends primarily on the enthusiasm of the participants. Teachers and staff involved have to see the program as uniquely beneficial for their students. Good public relations is essential to keep participants apprised of program developments and opportunities and ensure community support. Our program staff produce and distribute a bimonthly newsletter highlighting matters of interest to teachers and administrators impacted by the program. Public awareness presentations to local service groups and others also promote the community support necessary to operate the program.

## Conclusion

The Marine Science Career Awareness program presents an effective, three-tiered approach to exemplary science teaching and career awareness. The locally developed and nationally validated Marine Science Project: FOR SEA curriculum materials use the marine environment as a conceptual framework for a comprehensive elementary and secondary school site program. The school site programs are coordinated by the Marine Science Center, which also provides in-lab and on-water science experiences demonstrating firsthand that science is applied on the job by everyone.

Evaluations of the program indicate its acceptance and worth. Implementation of the printed curriculum materials in varied settings nationwide indicates the widespread applicability of the program. The Marine Science Career Awareness program plays an important role in making students aware that every career has a scientific component.

# Chapter 4
# The Primary Integrated Curriculum

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The Primary Integrated Curriculum (PIC) in the Jefferson County, Colorado Public Schools is an action-centered program for first and second graders that blends science, social studies, health, environmental education, and career education into one unified, comprehensive curriculum. Students are introduced to the primary-level concepts traditionally presented in compartmentalized instruction without being confined by the traditional boundaries of these individual disciplines. This program, fully implemented at both grade levels for three years, has been welcomed as a significant and successful change by teachers, students, parents, and administrators for two primary reasons: it has achieved a balance in the instruction of all subjects, and it has alleviated the time pressures placed on teachers to crowd more and more subjects into the school day.

Activity, problem solving, and cooperative learning permeate the PIC program. First and second graders are presented with concrete, holistic learning experiences while receiving direct instruction in and then practicing the skills necessary to work together. The program has proved its versatility. It has served as a curriculum basis for gifted and talented students; it is in place in the district's school for children with multiple handicaps; and it is in use in the two alternative elementary schools, the Open Living School and the Fundamental School.

## The Setting

The Jefferson County School District was formed in 1951 when 39 small, independent school districts were unified as the first reorganized school district in Colorado. The county is large (783 square miles), running north-south, beginning at the western boundary of Denver and moving into the mountains on the west. The total population of the county is 387,000, with a school population of 76,529 students (down from 81,000 four years ago), most of whom are of European descent.

The PIC program is taught to approximately 12,000 first and second graders by about 375 teachers in the district's 77 elementary schools.

## The Impetus for the Program

The PIC program was developed after a district task force conducted a needs assessment in 1978 and discovered a discrepancy between what *was* taking place in the first and second grades and what *should* have been taking place according to the program guidelines. Teachers in Jefferson County, as elsewhere, were being increasingly pressured by the public to intensify classroom emphasis on the basic skills. At the same time, they were also expected to give children balanced instruction in social studies, health, science, environmental education, and career education, as well as encourage creativity and aesthetic appreciation. Teachers could not find enough hours in the school day for this intricate balancing act. The district's needs assessment study found that 15 percent of the first grade teachers were spending 15 minutes or less per day on subjects other than the three R basics; 48 percent were spending 16 to 30 minutes; and only 5 percent were spending from 46 minutes to one hour on non-basics. The study showed that

when teachers were pressed for time they usually chose to teach whichever pieces of the optional subjects interested them the most or they felt most comfortable in teaching.

Before 1978, the district's program for elementary students in science consisted of units from Elementary Science Studies (ESS) and the Science Curriculum Improvement Study (SCIS), plus some Mini-MAST ideas. It was a hands-on program with no text books. In social studies, a nationally recognized text was the basis of a traditional program of family, neighborhood, transportation, patriotism, and related concepts. Complete district programs also existed for career education, environmental education, and health and safety. Each subject had its own complete and sizable teacher's guide.

When accountability and the back-to-basics movement began to have an impact on schools, the inevitable question was asked: how can we say our programs are teaching students when we are not sure that they are being taught?

An integrated approach to all the subjects other than reading and math seemed ideal for our primary children. Students would learn more, and teachers would have a more efficient delivery system. Area superintendents, elementary principals, the Elementary Curriculum Council, and the School Improvement Process Council (the district's accountability committee) all concurred in this judgment.

## Designing the Program

The board of education supported the recommendation for a unified curriculum integrating the objectives and content of science, social studies, health, environmental education, and career education, plus some of the literature and verbal skills aspects of language arts. After a fruitless search for an already existing program, we set out in the fall of 1978 to develop our own, with a team composed of representatives from eight departments working under the director of elementary education.

Development of the Primary Integrated Curriculum followed the district's prescribed curriculum development process. This well-defined system included the needs assessment study, curriculum objective statements, curriculum writing, pilot testing and evaluation, field testing and evaluation, and, finally, district-wide implementation. Pilot testing evaluated the quality of the resulting materials and field testing checked for potential problems with implementation. During each stage of development the revised program was reviewed by the Elementary Curriculum Council, elementary principals, and the School Improvement Process Council.

The major resource invested in the PIC program was time. The coordinators of the subjects covered in PIC—science, social studies, environmental education, health, language arts, and career education—spent a year devising the process, then began the development of the curriculum, working together under the leadership of the Coordinator of the Primary Integrated Curriculum. The present coordinator of PIC, Marge Melle, a member of the original team, assumed leadership two years into the development of the curriculum. Together, the coordinators planned, developed, coordinated, evaluated, revised, and implemented PIC with assistance from teacher writing teams, special education consultants, citizen experts, and a professional editor/writer. Professor of Science Education, Roger Johnson, at the University of Minnesota and co-author of *Learning Together and Alone* (1975)*, acted as writer/consultant on the cooperative learning strategies.

The PIC team developed the grade one program first. After the evaluation of the first grade pilot assured PIC's success, the grade two program was begun. In all, complete development of the program, from inception to total implementation, required six years.

The writing team created original materials and activities, while the departmental coordinators made sure that the objectives of each discipline were addressed. The writers also adapted and extended some materials from ESS, SCIS, Mini-MAST, and the Educational Resource Center (USMES). Parts of the Denver Children's Museum's Disabilities Awareness Curriculum were also included.

## The PIC Program General Philosophy

The original goals of the Primary Integrated Curriculum were relief for teachers and balanced learning for students, but the program developers had other educational ends in mind as well. They set as their developmental aim a curriculum that would

- Respect the priority of basic skills and not undermine the district's successful pattern of progress in each basic skill area
- Deliver the content of science, social studies, health, environmental education, and career education in a holistic fashion
- Include experiential units based on activities of interest to, and appropriate for children aged six through eight, who are entering the concrete stage of cognitive development
- Include detailed strategies to introduce and systematically reinforce the cooperative learning skills advocated in *Learning Together and Alone*
- Use the special events, parties, and holiday handicrafts emphasized in primary grades to transmit an appreciation of our natural and cultural heritages and to introduce the skills of cooperative group interaction, to be reinforced in subsequent units
- Introduce and have students practice the skills of problem solving and critical thinking
- Vary instruction with three basic teaching techniques: information (presented facts), discovery (students discover the predetermined solutions of problems or results of experiments), and experience (students directly experience problems or experiments whose solutions or results are unknown at the outset)

Like our elementary science program for grades three through six, this program aims to be concrete, interactive, exploratory, applicable, relevant, and success-oriented.

* Roger Johnson and David Johnson, *Learning Together and Alone: Cooperation, Competition, and Individualization* (Englewood Cliffs, NJ: Prentice Hall, 1975).

## Goals of the Two-Year PIC

The following goals for PIC students were adopted at the outset. Students should

- Explore and manipulate materials and objects in the real world
- Develop the skills of observing, describing, identifying, ordering, classifying, and determining differences and similarities
- Ask questions, find answers in a variety of ways, and develop the ability to solve problems that are a part of their immediate world of home, school, and neighborhood
- Be aware of how their immediate actions affect their environment, themselves, and other people, and how the environment affects them
- Act with a sense of responsibility toward themselves, their peers, family, friends, neighbors, and natural environment
- Begin developing the skills and attitudes needed to interact constructively with other individuals and groups
- Begin developing their unique talents and sense of worth through a variety of experiences from their immediate world
- Begin developing and understanding the ability to maintain good physical health and safety
- Be able to express their feelings and tell how their feelings and the feelings of others affect behavior
- Recognize that there are recurring social and natural events in their immediate environment
- Understand and use societal conventions and practices appropriate for primary students

## Program Design: A Series of Interdisciplinary Units

The Primary Integrated Curriculum combines all first and second grade academic subjects except reading, math, and some portions of language arts in a program taught for approximately 40 minutes (or 13 percent) of each instructional day.

A common set of learning outcomes and activities satisfies the content and process requirements for science, social studies, health, environmental education, and career education, and at the same time reinforces the listening and speaking skills of language arts. The activity-based units require students to blend concepts and skills from all the disciplines to solve realistic problems and challenges, which do not come neatly labeled "science," "social studies," or "language arts."

At both grade levels, the curriculum consists of a series of nine or ten units developed around the interests of primary students. Each unit emphasizes three or four of the student goals and three or four disciplines; however, most units include activities that involve some aspects of all disciplines and goals. Students are expected to meet specific content and process objectives within each unit in a planned, sequential manner. The learning strategies employ information interviewing, brainstorming, coming to consensus, hypothesizing and testing hypotheses, conducting experiments in controlled situations, recording data, comparing data of repetitious experimentation, and sharing information and discoveries with peers. In most activities the teacher acts as the facilitator rather than the giver of information, and all of the activities are student-centered rather than teacher-centered. A list of the units and a description of each follow:

*First Grade*

- First Things First. Students become acquainted with classmates and school. After sorting classmates by physical characteristics, they describe and classify material objects. They visit members of the school staff and learn about the jobs that must be done to make their school an excellent place for learning. (Particularly relevant to careers)
- Special Times Together, I. Students celebrate holidays and special events on 15 occasions throughout the year. Each time, they learn and practice a specific cooperative skill which they continue to practice in subsequent units.
- Dragons, Dinosaurs, and Tiny Creatures. Students read famous legends and create fanciful puppets; they identify and compare happy, secure, and fearful feelings; they observe and describe prehistoric creatures found in pictures and in the Museum of Natural History; they use their observing, data-collecting, and care-taking skills on the dinosaur's tiny living relatives: chameleons and salamanders.
- Sidewalk Safaris. Students take five sidewalk excursions to become acquainted with the school neighborhood. They meet the school neighbors by chance and appointment and interview them on the job. On their trips, students observe and study the neighborhood environment. (Particularly relevant to careers)
- Radishes and Rutabagas. Students grow bean sprouts and salad gardens—planning, working, and practicing their observation and recording skills. They are introduced to good nutritional habits and consume their crop at a harvest celebration. An expert gardener, either hobbyist or professional, explains the fine points of growing green things. (Particularly relevant to careers)
- Family Ties. Students observe and compare many different kinds of families: their own, classmates', families in books and films, gerbil families in the classroom, and animal families at the zoo. They explore the privileges and responsibilities of family members. On the trip to the zoo and at the zoo they observe and discuss the workers they see. (Particularly relevant to careers)
- Walking Out to Wonder. Students experience five nonconsecutive days of outdoor activities, seeking out wonder spots and hunting for objects and happenings in nature which arouse their curiosity. They develop "seeing eyes" and "listening ears."
- Rolling the Distance. Students roll and race different kinds of balls down ramps as they develop the skills of observing, comparing, recording, and predicting. While competing in the races, students develop an understanding of the need for and function of rules. After investigating wheels and machinery, students roll on the wheels of the RTD, Denver's Regional Transportation District buses, and learn about public transportation and distribution systems and the people who make them run. (Particularly relevant to careers)
- Classroom Construction. Student groups are given pieces of a 1.8 m × 1.2 m structure and actual carpenters' tools to put it together. Cooperative group effort is required to assemble the structure. Problem-solving and decision-making skills are required to choose a use for the struc-

ture, and to design and carry out creative modifications. In the unit, students are exposed to the real-life jobs of making things with tools. (Particularly relevant to careers)

- Manufacturing/Soft Drink Design. Students complete a problem-solving, decision-making unit as they meet one of two challenges: find the best way to produce a needed item in quantity, or invent a new, healthy, soft drink that can be produced and served at low cost. In this unit, students compare the efficiency and the results of assembly-line production with one-of-a-kind production. These challenge are based on USMES. (Particularly relevant to careers)

*Second Grade*

- Person to Person. Second graders get acquainted as they identify and celebrate their likenesses and their differences in appearance, tastes, and feelings. In a set of *Like Me, Like You* activities from the Denver Children's Museum, students consider individuals who are different because of disabilities. Students' attention is drawn to what the disabled can do, and to their similarities to everyone else rather than their differences. (Particularly relevant to careers)
- Special Times Together, II. Students celebrate holidays and special events throughout the year while learning and practicing a higher level of cooperative skills.
- Good Humor. Students laugh a lot, explore different sources of humor, and on a simple level, compare types of humor. They are asked to distinguish between laughing with and laughing at, and to suggest positive ways to react to others' misfortunes.
- Approach to Patterns. Students search for patterns in the human-made and natural environments and identify three of the most common pattern types: repeating, mirror, and round. They create and experience each kind in movement, sound, and visual arts.
- Minibeasts and Butterflies. Students watch and wait as the butterfly life cycle unfolds in their "butterfly gardens." While waiting, they create homes for minibeasts, small insects found on the playground. They move their minibeasts into temporary homes in the classroom for close observation and data collection.
- Kids and Computers. Students gain an early entry into their technological world with hands-on experience at the computer. They sequence simple tasks, draw the sequences on flowcharts, and role-play how the computer works, They query parents or neighbors on how computers are used at their workplaces. (Particularly relevant to careers)
- Pools, Pipes, and Puddles. The tub of water is the laboratory as students conduct sink and float and waterflow investigations. They investigate and compare home, school, and personal water use and conservation. They play water games and delve into the school's water system. They learn to use the pipes and tools of the plumber. At the conclusion they explore and enjoy the aesthetics of water. (Particularly relevant to careers)
- Delicious! Nutritious! Students experience preparing and tasting a variety of foods while gaining the basic concept that they need many different kinds of food for growth, for health, and for energy. They develop and follow their own recipes, measure ingredients, and observe property changes. A food service or food production worker visits the classroom and describes his or her job. (Particularly relevant to careers)
- Nature Trails/Using Free Time/Classroom Zoo. Students develop problem-solving, decision-making skills as they meet one of three challenges: develop a temporary outdoor trail and help others appreciate nature; design, create, and use something that is fun and worthwhile to do during free time; or develop a classroom zoo. These challenges also are based on USMES.

## The PIC Classroom Design

If you visited PIC classrooms you might find one class drawing flowcharts on posterboard; another floating shells, erasers, and paper clips on water and salt water; another staging puppet plays of famous fairy tales; and a fourth pasting up a giant winter mural.

Diversity? Yes. But it's diversity with underlying similarities and connections. Looking closer, you will find that children everywhere are working in groups. Everywhere, everyone is *doing* something. No one is running to the teacher for help. Nowhere is the teacher taking center stage. The teacher plans, orchestrates, and facilitates; while students do the real work of learning.

What subjects are these students learning? The flowchart activity could be math, but now the groups are dramatizing how a computer works; the sink and float activity could be science, but now everyone is singing a water song; the puppet fairy tales could be primary literature, but tomorrow during this time the students will prepare homes for some tiny "dragons," the classroom salamanders. The mural-makers are not just cutting and pasting, they are looking each other in the eye, talking directly to each other, and practicing responses.

The PIC classroom changes as the activity changes. Often small groups need their own spaces for working together. At other times the whole class works together, or individuals work independently. The PIC Teacher's Guide alerts the teacher with a distinctive logo for each kind of learning structure.

## Equipment Needed for the Program

The PIC program uses unconventional instructional materials. It requires carpenters' tools and construction materials, kitchen utensils, small balls of various sizes and compositions, live organisms (gerbils, caterpillars, chameleons, and salamanders), containers for the organisms, seeds and containers for growing them, and many miscellaneous items. Letters to parents at the beginning of each unit make a one-time request for small, collectible items that can be brought from home. More traditional instructional materials, such as story books, films, and tapes are rented or purchased.

Equipment and materials are preboxed and placed in each classroom. A per pupil, school-based allotment maintains materials and live organisms. It is difficult to estimate the exact cost of the one-time use of instructional materials, as local sources were used for most of ours. However, the projected annual PIC maintenance cost per pupil is estimated to be $1.50, much less than the former

cost of maintaining materials for the separate programs of science, social studies, health, environmental education, and career education. (This cost does not include the live organisms.)

## How PIC Fits into the District Program

The PIC program for first and second graders has proven to be a solid stepping stone for their entrance into all areas of the third grade program. After two years of PIC, students have developed the requisite skills for the district's science program by practice in observing, sorting, ordering, classifying, predicting, collecting and recording data, and simple experimenting. They have practiced oral communication to an extent rarely reached in the conventional curricula. They can share ideas based on information they have personally gathered; they can accomplish tasks cooperatively and make decisions by consensus; and they are proficient beginning problem solvers. The computer unit in PIC enriches and clarifies the elementary computer curriculum that the district has put into place.

The objectives of PIC and its general philosophy are compatible with the goals of the Jefferson County Public Schools and lay a solid foundation for their attainment. The school district has set the following goals for students.

- Master the basic skills for continued learning
- Develop a sense of responsibility
- Act with understanding and respect toward others
- Develop unique talents and sense of worth
- Learn to influence change and benefit from it
- Develop the skills and attitudes needed to earn a living and contribute to society

Each PIC unit has a particular emphasis in support of the district goals.

## Evaluation of Students

Students are graded for PIC, but no specific testing is done over the PIC areas. The ten goals of the program are broad enough to warrant many years of study. The long-range results of primary children learning to observe objectively, to cooperate, and to identify and solve complex problems in a holistic manner will come much later. The results of the first two years' work in these areas are shown when students enter third grade and the disciplines are separated. Third grade teachers say newcomers to the district are behind our PIC-prepared third graders in readiness for these separate programs, in problem solving, and in group cooperation.

Within the PIC program, the teacher assesses individual and group products according to criteria written into the learning strategies. In addition, the teacher monitors individual students' ongoing growth in cooperative learning skills.

## Acceptance of Program

Principals, teachers, students, and parents have responded enthusiastically to PIC. Parents are made to feel a part of the program. Frequent communications are sent home with information and requests for help. The helpers have turned into staunch supporters. Students are eager participants in the action-based activities. They like doing things. Principals have seen that the program is highly motivating and provides a balanced curriculum; they need no longer worry about what is and is not being taught.

Teachers, however, are the program's strongest advocates. They say that PIC takes a different mode of planning and teaching, and that it is difficult for some teachers to master. However, they agree that it is relevant to the interests and needs of children, and effective in providing opportunities for movement, interaction, and problem solving. Its content establishes relationships and connections in the real world. For many teachers, though, the biggest advantage of PIC is that it provides a reasonable solution to the balancing act. No longer must they crowd six or seven subjects into one short time period.

## Student Grades

The teacher monitors each student's growth in cooperative skills, and grades are partially based on progress in these skills. Individual progress is assessed on the basis of the one or several individual worksheets or projects in each content area. Group products and the group process are also evaluated. At the end of each nine-week term, PIC is listed on the students' report cards along with mathematics, reading, and language arts. A footnote tells the parents what PIC includes. A three- or four-point scale (depending on the form chosen) is used for grades. On the attitudes and behaviors side of the report card is listed "Participates cooperatively in groups". This behavior is graded as Highly Satisfactory, Satisfactory, or Needs Improvement.

## Continuing Evaluation of the Program

The PIC program is under continuing evaluation. Specific program evaluation features include the following.

- To maintain quality instruction, three inservice days, spaced over a year's time, are provided for all new teachers entering the system. Teachers who change grade level to the first or second grade also attend PIC inservices. Trained inservice leaders, who are practicing PIC teachers, review the philosophy, units, and content; engage participants in hands-on activities from the units; share management and organizational tips; identify assessment activities; and introduce generic teaching strategies, such as wait time, and the role of the teacher in cooperative learning.
- The PIC central office staff makes comfort and caring visits to PIC classrooms regularly to answer questions, model behaviors, and support teachers.
- Principals, teachers, and central PIC personnel collaborate to monitor program quality through the program improvement process. Seven key feature indicators are the criteria used to identify a well-implemented program.
- The final type of evaluation is an external program audit. By board of education mandate, PIC, like all programs of the Jefferson County Schools, is systematically and continuously reviewed and upgraded with input from appropriate administrators, teachers, students, and community members. The model for this evaluation requires a statement of the desired state based on a literature search,

a description of what is currently in place in the schools. identification of discrepancies between the desired and the actual state, and improvement plan to eleminate the descrepancies. This audit takes place on a five-year, recurring basis. PIC is now in the process of an external audit.

## Plans for Improvement

During the rigorous process of the development of the Primary Integrated Curriculum, four major problems were identified and resolved. When implementation began, teachers were unprepared for a change as revolutionary as replacing traditional disciplines with an integrated curriculum, and were unfamiliar with the new teaching techniques required. To meet this foremost difficulty, all teachers were given extensive inservice training that outlined unit content and presented strategies to promote cooperative learning, critical thinking, and problem solving. Outside consultants were employed for additional inservice help.

Planning time created a second problem for teachers. Preparing materials and the classroom and making grouping arrangements requires forethought, and cannot wait until just minutes before the lesson. Years of experience and support from inservice leaders have alleviated this problem. Teacher concerns had lessened appreciably by PIC's second year.

The integrated curriculum units use many unconventional learning materials, from carrot graters to water tubs. Seeking out these unusual items could put an unwelcome burden on teachers. This difficulty was eased by providing unit kits containing all nonstandard supplies and sending frequent communications to teachers concerning resources and supplies.

The pilot tests made it clear that understanding and support from principals and parents would be essential for success. To give the program this necessary boost, explanatory meetings and abbreviated inservices were held for principals, and letters were sent to parents explaining the new curriculum and requesting their help and encouragement.

## Keeping the Program Healthy

The four areas mentioned above could always offer potential problems, so their solutions must be ongoing. New teachers and teachers new to PIC will always need inservice in the philosophy and content of the program. Information on sources for replenishing supplies must always be kept current. The support of principals and parents must always be encouraged.

To keep the PIC program strong and healthy, supply inventory lists are included in the teacher's guide with instructions for reordering. A newsletter, *Nit-PIC-ing*, is distributed on a needs basis to offer useful tips and update teachers concerning changes, field trip information, and supplies. Parent letters and prepared presentations share the program with the community each year.

Today, the Primary Integrated Curriculum is in its third year of full implementation at both grade levels and in its ninth year since conception by Jefferson County educators. To students, PIC means action and involvement. To teachers, it means time to get their important job done. To coordinators, administrators, and parents, it means no more discrepancy—they *know* what is taking place, and it is what they feel *should* be taking place.

# Chapter 5
# ESCES: Exposing Students to Careers in Earth Science

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With a population of 1400 ninth through twelfth graders, McLean is one of the smallest of Fairfax County's 23 high schools. McLean students come from diverse backgrounds, and English is a second language for many. Programs throughout the school have been designed to meet the needs of all the students, and the excellent faculty is committed to student success.

The ESCES program—Exposing Students to Careers in Earth Science—focuses on success, and offers many opportunities for students to experience success in science. Administrators and teachers work together to assure smooth operation of the program. Currently only one teacher uses the complete program, but many other teachers use some of its components.

Our location close to the nation's capital has added to the effectiveness of the ESCES program at McLean, since many of the components depend upon resources in Washington, D.C.

## Our Program Goals for Students

Students who participate in this program are exposed to a variety of techniques and teaching materials that introduce them to science careers and science-related careers. Goals for students are:

- Students will have many successful experiences in science which will spark their interest and motivate them to ponder and/or pursue science as a career. Students will become interested in science and actively develop this interest.
- Experience component—Students will acquire an in-depth knowledge of experimental problem-solving situations in current research and career opportunities in an area of personal scientific interest.
- Visitation component—Students will be visited by scientists who convey the importance of scientific research and dissemination of information. By their presence, scientists will serve as role models to encourage students to continue their interest in the sciences and in science-related careers.
- Site component—Students will visit various facilities of earth science interest and observe how scientists pursue research and disseminate information at each site.
- Project outreach component—Students will visit a research site that they as a class have selected. They will spend a productive day at the site touring labs and talking with scientists.
- Students will meet with scientists to discuss research the students are conducting. These meetings will help students gain confidence in themselves as future scientists.
- Rewards component—Students will be informed of various contests and competitions. Some will receive awards and recognition for their scientific work; all will be encouraged to continue their research.
- Course counseling component—Students will be informed of high school science courses available to them and be personally guided in their selection of future courses. They will learn how to prepare themselves for these science courses. Students will be encouraged to take science courses and will be more likely to continue taking them because of this encouragement. They will begin to

see that they can be successful in science and continue to nurture this talent.

- Club involvement component—Students will be encouraged to pursue their scientific interests in after school clubs and activities, and continue these interests outside of school. A variety of science-related after school activities will be available and invite participation.

## Teacher Responsibilities

Teachers are classroom managers, planners, activities coordinators, and faithful listeners, to suit the varying components of the ESCES program. Below is a brief explanation of major teacher responsibilities for each component of the program.

In the experience component the teacher works closely with students through the four phases of search, design, conduct, and apply. In the first phase the teacher helps students identify a project they will research. Before students begin their search the teacher needs to become familiar with the science resources in the school library and in nearby local libraries.

During this phase, frequent communication between the teacher and the student researchers is essential. The teacher needs to guide each student toward successful completion of a research project which will serve as the basis of an experimental project.

During the next phase, design, the teacher helps each student design an experiment which explores one scientific principle. After the teacher has approved the experimental design the students enter the next phase, conduct. Now the teacher listens, hearing students' concerns and the problems they encounter as they begin their experimentation. The teacher offers advice which shows credible insights into each scientific problem, along with appropriate assistance in completing experimental projects.

After the project is complete, the students visit the school's career center to research the career opportunities available in their specific areas of science. The teacher works with the career center personnel to develop a meaningful activity for the students to complete. The teacher and the career center personnel also help the students find information about the careers they are researching.

For the visitation component the teacher must seek out scientists willing to speak with students and who can effectively explain careers. The teacher can find speakers by surveying parents at back to school night, held shortly after the school year begins. The teacher can also contact local agencies to learn if representatives would be willing to talk to students.

While developing a speaker pool, the teacher begins to arrange for speakers to visit the school. It is important for the teacher to preview the text of each presentation in order to design an appropriate pre-talk assignment. Students might be asked to formulate questions about one topic the speaker will address, or otherwise develop some personal awareness of the guest's field.

The teacher asks all speakers to include a description of the college courses they took to prepare themselves for their chosen careers. The speaker should also plan to explain work conditions in the field and offer advice to students who may be considering similar careers.

After the talk the students should summarize what they have learned. A brief thank-you letter highlighting what they enjoyed most or considered the key point both provides a review and increases the chances the speaker will return.

For students to participate in opportunities made available in the site component the teacher needs to learn of facilities in the surrounding area and keep abreast of open houses, science symposiums, current museum exhibits, and special offerings. The teacher can learn of these by making phone calls, by belonging to science organizations, by subscribing to newsletters, and by following current events.

When the teacher learns of scientific happenings he or she informs the students. Usually students are given extra credit incentives for participating in events. This compensates them for the extra effort they put into these activities, which are often after school or on weekends. The students are responsible for sharing their experiences with the class.

The outreach component was a grant-funded program for which the teacher designed a plan and submitted a proposal. After receiving the grant the teacher told the students about the new opportunity and asked them to recommend sites they were interested in visiting. Once a site was agreed upon, the teacher contacted the site's public affairs office to determine if students could visit. The approved grant permitted the teacher to take a day of leave and escort students to the research site.

The site initially selected was the United States Geological Survey. Personnel hospitably arranged for the students to spend an entire day. The teacher helped the students to identify areas of interest, informed the site personnel, and arranged to pair students with scientists in these areas.

The day at the site was full. The teacher escorted her students to different laboratories in the morning. In the afternoon students met with their scientists and were taken to the research library to work on topics they had chosen in advance. The funding made it possible for students to purchase materials that would be helpful for their research.

After the trip, discussion and journal writing helped students to put the new information into perspective. The teacher also designed an evaluation form which the students were required to complete, and passed results on to the site personnel.

In the rewards component, the teacher learns of contests for students and ensures they understand the entry requirements. She helps them select and enter appropriate contests.

For the course counseling component the teacher counsels each student individually and works with him or her to plan science courses to take in high school. The teacher provides each student with a course counseling form and alerts the guidance department to look for it.

The teacher also offers students the opportunity to further their science interests by becoming active in an after school club—the club involvement component. To do this the teacher may become a sponsor of a science club, advertising club meetings and inviting students to join. During the meetings the teacher works with the students to select activities for future meetings and may also choose to meet with the club officers to plan the agenda.

## Classroom Design

Our classrooms are equipped with lab tables, shelving for textbooks, a bulletin board, blackboards, sinks, and cabinets for storage. There are 12 lab tables which each accommodate two students. The students can work individually, in pairs, or in teams of four or larger, since the tables can be rearranged to suit each day's activity.

The walls of the classrooms are covered with student work, posters, information about science activities and clubs, and other items of interest. The ceilings have posters too—if a student's mind starts to wander there are intriguing images to direct the course of imagination.

## Equipment for the ESCES Program

The ESCES program requires large amounts of commitment and community involvement, and relatively little in the way of purchased equipment or facilities. In the experience component the teacher supplies earth science textbooks and students must supply their own research journals. These are loose-leaf notebooks used solely for project information. The school library offers current reference material. The students are expected to supply the materials they need for their research projects, but the school is equipped to lend basics such as glassware and microscope slides.

For the apply phase of the experience component the teacher should be able to use the facilities of a career center. If this is not possible the teacher will need to compile career information and make it available to the students.

Club involvement component materials will vary depending upon the interests students choose to pursue. Our astronomy club uses telescopes, star maps, reference books, and computers with skywatch programs for night-time sky watches. The science club uses laboratory materials available in most high school science labs.

## The Places of the ESCES Program

The ESCES program is used in five sections of Earth science at McLean High School in Fairfax County, Virginia. Of the five sections, three are traditional Earth science courses, one is a lower level earth and space science course, and the other is a gifted and talented Earth science course. All courses follow the suggested program of study for Fairfax County Public Schools and the state of Virginia.

ESCES extends the concepts covered in Earth science by suggesting practical applications to everyday life. It also encourages students to take themselves seriously as scientists and to consider science-related careers. It is different from other Earth science courses in that the students are able to immediately apply their learning and are guided in determining their career goals.

Portions of the program have been adopted by other members of the science departments, as well as by members of the English and social studies departments. Phase four of the experience component, apply, has been modified by the career center staff for other subject disciplines.

## Student Success

To satisfy graduation requirements for the state of Virginia, students must complete two courses in science. Since the beginning of ESCES we have increased enrollments in gifted and talented biology classes, traditional biology classes, lower level biology classes, and higher summer school enrollment for science enrichment courses. Students who have participated in the ESCES program usually complete at least three courses in science during their high school career, while some finish as many as six.

Students are more involved in after school science activities such as clubs and individual experimental research. Students from McLean High School have performed well in science contests and competitions, including the Fairfax County Regional Science Fair, the Washington Junior Science and Humanities Symposium, and the Virginia Junior Academy of Science.

## Student and Teacher Satisfaction

McLean High School faculty have been encouraging in their support for the program. ESCES classes are full to capacity, and guidance counselors want to lift enrollment limits, as more and more students learn of the program.

Students who have participated in the ESCES program return to tell us how much they enjoyed the activities and how much they benefited from participation in the program. The positive reaction of student participants has been our most effective advertising. The program continues to grow.

## Grading

Students are evaluated by a variety of methods—such as objective tests, creative writing assignments, and special projects. One proven method is the use of a composition book or science "thought" book for collecting ideas, for pre-writing activities, for directed observations, and as a springboard for discussions. Many of the entries require students to relate what they have learned to practical applications in the outside world.

Another method of evaluation which has proven effective during the experience component of the program is a biweekly progress evaluation by the teacher and students. At this time students inform the teacher of the status of the project they have proposed.

## Program Evaluation

To improve the experience component of the program, student work is collected and stored in loose-leaf binders. Students can read about projects from previous years and obtain ideas for their own research.

After the third phase of the experience component, students are encouraged to enter abstracts of their work onto a disk for the science department computers. At the beginning of the year new students can refer to the disk for ideas for their own projects. They can quickly view the abstract of a project and then refer to the binder for the complete project papers.

The ESCES program is continually undergoing improvements and modifications to meet the needs of our students. Each year the program grows and expands, involving more teachers and a wider sharing of ideas. We are enthusiastic about the future of ESCES and the future of our students.

# Chapter 6
# Science Mentor Program

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The Indianapolis Public Schools (IPS) Science Mentor Program pairs interested students with exemplary professional scientists. These exemplars help students make realistic connections between school work and career work, bridging classroom science with applications in industry and research. Program goals are to improve students' scientific and technological literacy; to show real applications of science, math, and communication skills; to demonstrate the critical need for skillful problem solvers; to identify career opportunities through experiences and conversations with professional scientists; and to assist in making informed curriculum and career choices.

## Why is Mentoring Important to Students?

Other than slick advertising announcements, there is very little help available for students interested in careers in science or technology. Our formal guidance program starts in a student's junior year. If he or she first decides on a scientific career at that point, it is already too late to schedule many of the prerequisite high school courses like chemistry, physics, trigonometry, or calculus. Many guidance counselors and teachers are not well informed about the academic experiences, professional courses, postsecondary institutions, or job opportunities available, and have little grasp of the changes recent technology has introduced, such as the computer's role in applied science and mathematics.

Students encounter their first formal science and mathematics courses in seventh grade. This is the time when they begin to challenge teachers. Why must they accept the discipline and extra time required to understand science and math concepts? Without an answer to their challenge—such as satisfying experiences that friendly, informed mentors can provide—many steer away from careers in medicine, research, or engineering.

## What Kinds of Mentoring Activities are Available?

Our first approach to mentoring was worksite partnering, in which students released from school meet with a mentor in the worksite and participate in an activity exemplifying the mentor's responsibilities and work skills. The activity is planned to show the range of work responsibilities and skills as well as the people and tasks involved in accomplishing the mentor's or employer's mission. The mentor develops one of three types of activity plans. In one, the student works with one mentor in one department; in a second, the student works with different mentors and each visit is in a different department; in a third, the student works with different mentors for three to five visits, and then selects one mentor for more in-depth activity. During 1985–86, there were 25 worksite partnerships for students in junior high and 65 in high school.

The worksite partnerships have stimulated four other kinds of school-based mentoring activities.

- Project assistance—Students often do original scientific work as part of their school courses, and need specialized or technical assistance. Mentors advise and assist individuals or small groups of students with, for example, a

science fair project on interfacing computers with laboratory instruments.

- Instruction—Mentors may present seminars, lectures, or laboratory special topics to individual students or small groups; for example, by assisting a student in a formal presentation of the worksite partnering activities, or speaking as part of a career day program on chemistry concepts at work in a hospital lab. Instruction may be at the school or incorporated into a field trip to the worksite.
- Counseling—Mentors advise students about career opportunities, requisite training, and desirable out-of-school experiences.
- Sponsoring—Mentors help teachers organize events and recruit specialists for after school special interest group meetings, such as Junior Engineers and computer, photography, or astronomy clubs.

## Who Are Mentors?

Mentors are role models who, in their interactions with students, stimulate them to reach for excellence as they prepare for careers. Mentors come from all areas of the working world: parents, teachers, electricians, lawyers, detectives, contractors, programmers, nurses, physicians, and managers can all function as career role models.

## How Students Get Involved in Mentoring Activities?

Partnering is limited to top students, who must meet rigid standards for participation, including the maintenance of a B+ average in all core courses. The technical assisting, instructing, counseling, and sponsoring activities are open to all students in the science/math magnet programs at Shortridge Junior High and Arsenal Technical High. When possible, special presentations are videotaped for review by other classes. In this way, many students can have access to a single mentor.

## What Determines Student Eligibility?

To participate in science/math magnet programs: junior high students should have scored at two years above grade level in the reading and science or math tests and subtests, Iowa Test of Basic Skills (ITBS); a score of at least 50 percent on the Critical Thinking Test (SJHS), and have a recommendation from a teacher.

High school students should have scored at two years above grade level in the reading and science or math tests and subtests, ITBS; have a score of at least 60 percent on the Critical Thinking Test (CAHS), and have a recommendation from a teacher.

To participate in partnering programs, junior high students should have scored in the top 5 percent on the ITBS math, science, and reading tests and subtests; be in the top 5 percent on the SJHS; and have completed a career interest survey which shows strong interest in a mentor's work area. Students must undergo an interview to verify their interest; secure parental approval; and once selected, maintain a B+ average in all magnet courses and complete a written report of their partnering activities

High school students should have scored in the top 10 percent on the ITBS math, science, and reading tests and subtests; be in the top 10 percent on the CAHS; and have completed a career interest survey which shows strong interest in mentor's work area. Students must undergo an interview to verify their interest; secure parental approval; and once selected, maintain a B+ average in all magnet courses and complete a written report of their partnering activities.

No limits are placed on student eligibility for the school-site mentoring activities. Students must provide their own transportation for the after-school activities. More opportunities are available for high school students because of the 4-year program and because many of the mentor activities require a grasp of higher mathematics and science. Over 300 students participated in the various mentor activities during the 1985–86 program.

## What Agencies Support This Program?

We would like every agency in Marion County to participate in one or more of the mentoring activities, especially those agencies whose professional and technical staff use higher level thinking skills involving science, math, and communication. Unfortunately, some have not heard of the program, have insurance or age limitations, or do not have staff time available during the school day. The following agencies supporting the program provide four different kinds of experiences for students.

**Research and Development**
Indianapolis Children's Museum
Naval Avionics Center
IUPUI School of Science
Indianapolis Center for Advanced Research
AT&T, Consumer Products Division

**Medical Applications**
St. Vincent's Hospital
Methodist Hospital
IU School of Medicine
IU School of Dentistry

**Engineering Applications**
Detroit Diesel Allison
PT Components
Department of Public Works
Indianapolis Power & Light
JFW Industries, Inc.

**Commercial Applications**
American Airlines
First Indiana Federal Savings Bank
Chrysler Corporation
Amax Coal Company

## How Are Mentoring Activities Arranged?

Mentoring agencies are identified in a unique partnership between the Indianapolis Public Schools and the Indianapolis Chamber of Commerce. The Chamber invites participation from the agencies and the IPS Science Mentor Program director meets with company officials to plan activities. Mentors must complete an activity planning worksheet before projects are confirmed.

## What Do Students Do in Partnering Activities?

In planning the venture with IPS, mentors must identify activities that exemplify the application of science, math, and communication skills. As the project develops, they must continually show students how these skills are an integral part of successful work at their site. Mentors train students in the use of special instruments and procedures, and students are expected to participate actively on each

visit. Mentors are often part of a team of professionals working on small parts of a larger problem. As a result, students are introduced to the various kinds of staffing required in teamwork problem solving, as well as the expertise and range of skills essential for maximum team productivity.

### Some 1985-86 Projects

- Calibrating air quality sampling instruments, digitizing raw data, collecting data via telemetry, examining computer models of air quality, using a computer model to examine and manipulate quality variables
- Problem solving, programming, and troubleshooting with IBM networks
- Preparing and staining specimens for use with light, phase, and electron microscopes
- Using a computer to control a machining process, making micrometric measurements, and using gauges to check machining processes
- Calculating load and balance constraints, mapping routes, interpreting weather conditions, and observing how pilots and air traffic managers communicate
- Using analytical methods to investigate the variables influencing hormones and growth
- Programming with Applesoft and other machine languages
- Using computer analysis with DNA extractions in twin studies
- Teaming with medical students for dissection in a cadaver lab
- Studying the enervation mechanism of synovial joints in arthritic animals
- Diabetes studies and scanning electron microscopy

### How Does the Science Mentor Program Work?

The Science Mentor Program (SMP) is a special projects activity of the Partners in Education Program, part of the Indianapolis Public Schools' affiliation with the Indianapolis Chamber of Commerce (CC). The sequence of activities necessary for developing a project and the contributions of the CC and IPS are outlined below.

1. The CC and SMP director prepare a letter inviting agency participation.

2. The CC routes the letter, SMP overview, and activity planning worksheet to prospective professional science agencies in Marion County.

3. The SMP director meets with agency representatives and/or the mentor to affirm the following details.

- Start-up date and visit calendar
- Team size, student age, and other preferences or requirements
- Need for insurance if working in potentially hazardous areas
- Dress code or standards, if any
- Project activities and objectives
- Arrangements for lunch and visit hours
- Student and parent orientation plans
- Location of mentoring activities, parking, and entrance
- Mentor's office telephone and mailing address.

4. The SMP director creates the visit calendar and confirms the visit dates with the mentor.

5. The SMP director begins student selection, verifies that the performance of selected students meets established criteria, and prepares a letter informing parents of the selection results and inviting them to attend an orientation meeting.

6. The SMP director telephones parents one week before orientation to confirm receipt of information, determine attendance, answer questions and arrange for student transportation. The director also calls each student 2-3 days before each visit to discuss project activities.

7. The SMP director prepares a project synopsis and student talent profile and oversees the following activities to keep interested people informed.

- A bulletin board announcement to inform parents, school staff, superintendent, and school board
- A memo informing principals of student names, visit calendars, and mentoring agencies
- Memos to the CC on working and new projects being developed
- IPS Public Relations activities and notification of the media of project activities
- Encouragement of mentor agencies to keep photographic records of project activities and to prepare a student scrapbook for the annual culminating activities

8. The SMP director prepares guidelines for student reports, including the visit diary and final report. These reports are shared with the superintendent, mentor, parents, and school staff in science, math, and English.

9. The SMP director makes periodic visits to photograph and monitor student/mentor activities, and meet with students and mentors for informal evaluation. When project activities are completed, the director meets with mentor and agency representatives to review project and make plans for the next project.

10. The SMP director prepares thank you letters to mentor agency representatives, mentors, and teachers; and prepares memento package for students and parents which contain project synopses, student reports, and school or agency photographs.

Sample documents, including an activity planning worksheet, report guidelines, student record forms, a mentor affirmation memo, a student profile, a parent letter, a bulletin board announcement, and a principal's memo, are available on disk for a Macintosh computer. Send an SASE with $3.00 or a 3.5" blank floppy disk to the SMP director for a copy of these documents.

# Chapter 7
# Science and Career Awareness: Some Thoughts

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Excellence in science and career education is hard to find. Perhaps it exists but in small numbers; perhaps it is shy and must be coaxed out of hiding. One way or another, from over 16,000 school districts around the country, only 11 programs were nominated by the state SESE committees. And, of those nominated, only five programs approached the established criteria and were chosen as exemplars.

While the apparent paucity of excellence is deplorable, it was not entirely unexpected. After all, as Yager, Aldridge, and Penick pointed out in 1983, goals of science instruction are narrowly defined, science—as taught in our schools—appears removed from the world outside the classroom, and many schools retain outdated science curricula. Amongst the echinodermata, equipotential surfaces, and extragalactic galaxies, there seems to be little time in the classroom for topics that clearly address students' frequent and legitimate questions: "Why should I study that stuff?," and "When will I ever use that?"

Hearing the usual jargon of porifera, photons, and pyrites, students assume science is for the scientists and tune themselves out, as *Educating Americans for the 21st Century* (National Science Foundation, 1983) and other repo ts have frequently noted. Students encounter as many new vocabulary words in science than in most high school class foreign language classes. Aside from their numbers, science words are daunting because most of them refer to something students have never experienced, whereas a *cajetita* (cookie) can be seen and eaten. If science were perceived as relevant, would only one in eight 1980 high school graduates have completed physics, which some call the most basic of sciences?

Shining from this sea of dullness we found five programs which may serve as beacons for others interested in making science and science career awareness relevant for their students. Exemplary programs exist in large and small school districts, in metropolitan and rural areas, and across the nation. Four of these five programs show that the development of excellence takes time, measured in years and persistent, concerted hard work. The fifth program, in contrast, seemed to grow from the energetic efforts of one teacher who had taught in her particular high school only a short time, although she was not new to teaching. While excellence cannot be achieved overnight, the efforts of one committed teacher obviously can have a profound impact.

Key ingredients of these excellent programs include the infusion of career awareness into daily science instruction, as opposed to relegating it to career days and other rare special events, and a consistent emphasis on science's career applications. In Upper Arlington, Ohio, career education has been a high priority of the district over many years. In fact, career education is probably as strong in Ohio as it is in any state, and Upper Arlington has been a leader in Ohio.

The marine theme pervades the program at Poulsbo, Washington, where students learn through frequent first-hand experience about applications of science topics in maritime careers.

Jefferson County, Colorado faced America's pervasive problem—a lack of time in the daily primary grades schedule for non-basic subjects such as science, social studies, and career education. They addressed the problem by integrating science and career education with other essential non-

basics. The result of their integrated effort was an enriched science and career education curriculum.

In Indianapolis, the Chamber of Commerce and the public schools have a longstanding, successful "adopt-a-school" program in which various businesses and industries cooperate with local schools. Within the adopt-a-school mechanism the science department has established a mentoring program where students, working with people in the community, see firsthand how the science they are studying is used on the job.

Finally, in McLean, Virginia, a geology teacher links instruction with community resources to help students learn about science applications.

In each of our exemplary programs we expected to find and did find that the community was involved in science instruction, but in most cases the community and the schools were not working cooperatively on curriculum planning and implementation. The Indianapolis adopt-a-school program is worth close scrutiny as an example of how schools and the private sector can work together throughout a program, from planning to fruition.

The task force was disappointed in the degree to which three of the criteria were unaddressed in the exemplary programs, or at least in the written descriptions of the programs. We expected exemplary programs to (1) demonstrate to students that people in all careers apply science in some manner, (2) make special efforts to encourage women, minorities, and the handicapped in science, since these groups have been significantly underrepresented in the past, and (3) integrate science and career awareness programs across all grades.

While all five of these program reports repeated the rubric that science is used by all people, that message may often be difficult for students to hear, for it was only marginally addressed in most of these programs. Perhaps the Poulsbo, Washington program provides the best example for those considering how to address this issue.

Poulsbo's marine theme leads students to interact with a cross section of people, many of them engaged in jobs that do not require a college degree, but which clearly use science. On the other end of the spectrum, the Indianapolis mentoring program is only open to a few students who are talented and interested in science, with the vast majority of mentors representing careers with easily identified and quite traditional ties to science. Our concern is not about the mentoring program itself, for it is an exemplary program; but we urge people who emulate the IPS program to broaden both its availability and the range of careers it presents to students. Plumbers and physicists, electricians and engineers, ranchers and researchers all use science. Students need to learn, understand, and appreciate this important fact.

Although none of the programs is overtly discriminatory, the issue of equity also receives scant attention in these program descriptions. But since science has for too long been seen as the province of the white male, we had expected an exemplary program, indeed, any science careers program, to encourage the rest of the student population in science. From among these five programs, perhaps McLean's offers the best mechanism for teachers to influence all students to consider science careers.

Not leaving it to chance or the school-wide guidance program, McLean science teachers counsel every student about choosing science courses. That personal, active advice and encouragement has been shown to be a powerful albeit simple technique to keep students in the science pipeline (Casserly, 1975). We all like to be made welcome. Why can't we all learn to extend a simple, direct message of encouragement to *all* our students to enroll in science? Those few, warm words could have a great effect.

With the exception of the Poulsbo, Washington program (and perhaps Upper Arlington, Ohio as well), these SESE winners focused on a narrow grade range. Jefferson County's PIC program was clearly limited to young students, and the Indianapolis and McLean programs focused on adolescents. We cannot conclude that science and career awareness is not featured at other grade levels in these schools; but we are concerned that the benefits of science and career awareness not be undercut by a lack of sustained attention.

In spite of these real concerns, we are also encouraged that *somewhere* science and career awareness is practiced successfully in every grade. Those who would build on these examples must meet the challenge of putting together a K–12 program, as has been done at Poulsbo. We do not suggest that a unifying theme, like Poulsbo's marine theme, is necessary, but we do note that Poulsbo started its marine program with the conscious purpose of integrating the theme into the curriculum across the grades.

Although some express disappointment with the SESE process when they realize that the exemplary programs are not perfect, we need to accentuate the positive. None of us and none of our school programs are perfect; there is always room for improvement. These five schools can teach us important lessons, and show us positive directions in which to move. In addition, they clearly demonstrate that if scientific literacy—broadly proclaimed as a major goal of our science curricula—is necessary for all citizens, we must modify science programs across the nation to persuade all students of the personal, social, and career relevance of science.

These five programs do more than point a way; they show us that excellence exists, and can make a difference.

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