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ABSTRACT

Eight examples of innovative and outstanding earth science programs are described. These programs were selected using state criteria and at least four independent reviewers. While Project Synthesis offered a desired state, these examples of excellence provided views of what is already a reality. The goals of an exemplary science program are provided along with the criteria for excellence. Programs described are: (1) "Computer Assisted Laboratory Science"; (2) "Geology Is"; (3) "Ninth Grade Earth Science"; (4) "Accelerated Earth and Space Science"; (5) "Earth Science for the Twenty-First Century"; (6) "Indoor, Outdoor Earth Science"; (7) "Middle Earth Science"; and (8) "Earth Science Program." A review and critique of earth science exemplary programs is presented. (KR)

Focus

on

Excellence

Earth Science

Volume 3 Number 3

Edited by
John E. Penick
Science Education Center
University of Iowa
Iowa City, Iowa 52242

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Chemistry
Earth Science

The "Focus on Excellence" series, Volumes 1 and 2, included separate monographs on:

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Science as Inquiry
Elementary Science
Biology
Physical Science
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Physics
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Foreword

Excellent Earth Science Programs—The Search

John Penick
Science Education Center
University of Iowa
Iowa City, Iowa 52242

Earth Science, often considered the last resort of students who cannot achieve in other sciences, are words rarely used in the same breath with "Excellence." But, as the eight exemplary descriptions indicate, Earth science can be excellent. The programs range from those designed to provide everyone with success to those that challenge accelerated learners. These Earth science courses are viewed by the developers as integral parts of the school's science program and of the quest for scientific literacy.

Worldwide interest in exemplary teaching and curriculum is strong. Information from the *Focus on Excellence* series is being used, contemplated, and enlarged upon in school districts of every size. As the search for excellence in science education and the *Focus on Excellence* series continue we are confident that they will offer teachers models of inspiration and innovation for their classrooms and schools.

The NSTA Search for Excellence in Science Education began when Robert Yager, NSTA president for 1982-83, became a member of Project Synthesis. The project analyzed more than 2,000 pages of information from three NSF reports and from the National Assessment of Education Progress. Twenty-three researchers worked in small teams. Each focused on one aspect of science education—elementary science, biology, physical science, science/technology/society, or inquiry. A critical part of the synthesis and analysis of the information was developing a description of an ideal or desired state for a focus area and then comparing the actual to the desired state.

During the 1982 Search for Excellence, goals arising from the description of the desired state for each of the five focus areas were used as criteria for defining excellence in a school science program. The examplary programs are described in the five issues of *Focus on Excellence* Volume 1. Volume 2 addresses physics, science in non-school settings, and middle/junior high school science. Volume 3 includes energy education and chemistry. We feel that this monograph series, *Focus on Excellence*, will play a vital role in shaping science education practices and research of the future.

Goals and criteria for Earth science were developed by Rodger Bybee and the Earth Science Task Force. Their report and criteria appear as Chapter One of this issue of *Focus on Excellence*.

Using these developed criteria, leading science educators (generally, state science consultants) in each state were identified as chairs of committees to identify and nominate outstanding science programs in their respective states. Nominations were submitted to the task force for consideration at the national level. Thus, the state exemplars were passed on to another set of review committees and a second selection process.

To aid in the selection process, all nominees were asked to fill out forms detailing information on their demographics, texts used, and the nature of their school. The state nominees were given the specific criteria for excellence and asked to provide narrative information about five major aspects of their programs:

- Describe the setting (community, location, size, specific features, school science organization).
- Describe the nature of the exemplary program (grade level, class sizes, curriculum outline, learning activities, evaluation techniques).

- Explain how the program exemplifies the 1983 criteria for SESE.
- Describe how the program came into existence.
- Tell what factors contribute to the success of the program and what is needed to keep it going.

The Task Force and Project Synthesis proposed a desired state, but these examples of excellence provide vivid views of the reality. We hope you can find inspiration and a source of ideas through reading these descriptions. The programs range from small to very large schools, represent urban and rural populations, and include schools from a broad geographical range. Size of the schools, the school budget, or the community do not seem to be limiting factors in achieving excellence.

Not surprisingly, teachers are the most significant factor. In all these programs, the teachers are dynamic, thoughtful, young at heart, and eager to learn with their students. If you are interested in the kind of teacher typical to exemplary programs see *Teachers in Exemplary Programs: How Do They Compare?*, NSTA, 1984.

Chapter one describes the criteria for excellence in Earth science education. Chapters two through nine offer descriptions of the eight programs selected as exemplary during the 1984 Search For Excellence. Chapter ten is a synthesis and critique of the ideas found in these programs along with a number of generalizations and recommendations relating to excellence in science education.

All of the programs are exemplary in various ways, but they certainly do not exhaust the supply of innovative and outstanding science education programs. View these programs as examples of excellence, and be prepared to find others and create and nurture your own. We encourage you to contact the people who devised the exemplary program that may be applicable in your school situation. You will find they have many materials, ideas, and aspirations to delight you. You will also find they have a rationale and a philosophy that guides them as they teach and continue to develop their programs. This rationale is a significant factor in keeping their program's evolution on track.

While you read, attempt to identify components of the rationale guiding a given chapter. You may well notice a similarity of goals, instructional strategies, desired student activity, and evaluations among the eight descriptive chapters. In doing so, perhaps you will be able to develop your own exemplary rationale and program for teaching Earth science to your students.

Chapter 1
Excellence in Earth Science Education

Rodger Bybee
Edward Maruna
Harold Pratt
John Thompson

NSTA Task Force on Defining Excellence in Earth Science

We realize an Earth science program such as we describe does not exist except in this paper and in the minds of Earth science teachers who strive to develop an exemplary Earth science program, we cannot ignore fundamental components. Therefore, our paper includes discussions on the major unifying themes of Earth science, the recognition of recent advances in Earth science disciplines, and the traditional goals of Earth science education.

Unifying Themes

While many themes underlie the study of Earth science, some play a more unifying role than others. Our intention is to suggest major areas that encompass the concepts and processes essential to any Earth science program.

- *Change* Understanding the dimensions, processes, and rates and directions of past and predicted change is basic to education in the Earth sciences.
- *Cycles* Understanding the dimensions, processes, and rates and directions of past and predicted change is basic to education in the Earth sciences.
- *Cycles* The cyclic nature of some changes is an extension of change as a major theme. Examples include the concepts and processes of the rock cycle and hydrologic cycle.
- *Equilibrium* Earth systems tend to change, use, or dissipate energy toward a state of equilibrium or balance. This theme applies to such diverse studies as temperature changes, erosion, and weather.
- *Energy* Changes and cycles occur through the redistribution of energy. The origin, use, and dissipation (entropy) of energy in Earth systems is a theme that unites diverse disciplines of Earth science.
- *Conservation* The total amount of matter and energy in Earth, solar, and universal systems remains essentially constant. Interactions among Earth and solar systems may change and redistribute matter and energy, but the total amount of each does not change.
- *Scale* Any aspect of Earth science requires students comprehend dimensions of space and time. Events, changes, and cycles in Earth systems occur along a continuum of very short (microseconds) to very long (geological eras) time spans, and of very small (atomic molecules to very large (continents) sizes. Study in Earth science should in student comprehension of the scale of events in space and time.
- *Resource Finiteness* The Earth's useful resources are finite and unevenly distributed. Recognition of these limitations means decisions relative to resource use must be made. The theme of finiteness stands as an important new unifying theme in the Earth sciences.
- *Interdisciplinary Nature* In order to understand nature and the many problems confronting humanity it is necessary to understand and analyze the Earth from an interdisciplinary perspective. Although Earth science is, by definition, already an interdisciplinary study, this theme must become more important in coming decades.
- *Process Uniformity* Fundamental physical, chemical, and biological processes operating today are the same as those

that operated in the past. This principle of uniformity enables Earth scientists to analyze past events and predict future changes.

- *Earth-Space Systems* Diverse elements can relate to each other and form whole units or systems. Conceptualizing change, cycles, and entropy requires an understanding of the Earth-space systems involved. Students should understand the Earth as a system, and recognize humanity's relationship to the Earth system and subsystems.

An ideal Earth science program should include these ten unifying themes. They provide a continuity across programs and a core of ideas that may be updated and changed with time.

Advances in the Earth Sciences

Examples of the diverse areas where advances have occurred include plate tectonics, space exploration, weather modification, energy technologies, evolutionary dynamics, and computers in research, etc. Advances in these and numerous other areas should have an effect on today's Earth science curriculum, for many topics from programs designed in the 1960's and 1970's are now outdated.

Society and Earth Science

Earth science advances have emerged along with numerous Earth science-related social issues. Most science teachers are familiar with the issues of communication, energy, environment, resources, and population, but some issues have particular relevance for Earth science. Land use, geological hazards, waste disposal, ground water use, desertification, soil depletion, conservation of resources, and wise use of the environment head the list.

Because they are future citizens who will help formulate policies relative to these and other social issues, students' science education must include, as major components, introduction to these problems and processes. Any Earth science program defined as excellent should include socially relevant Earth science problems.

Major Goals

Earth science education has been based on five fundamental goals. After studying Earth science, students should

- have gained a knowledge of facts, concepts, and principles related to the major unifying themes in the Earth sciences;
- be able to use and understand both holistic and reductive scientific methods as ways to acquire new knowledge;
- be able to process relevant information and make responsible decisions regarding science and technology issues;
- be aware of careers in the Earth sciences and how the Earth sciences affect such non-Earth science careers as law, politics, and economics; and
- have developed an interest in, and critical attitudes toward, science and technology in society.

In the last five years major reports redefining the goals of science education have been published by the American Association for the Advancement of Science, 1978; the National Science Foundation, the Department of Education, 1980; the National Academy of Science, 1981; the Center for Educational Research and Evaluation of the Biological Science Curriculum Study, 1981; the National Science Teachers Association, 1982; and by the National Science Board, 1982. Two reports not focusing directly on science education, but of tremendous import are *The Global 2000 Report to the President* (Bernay, 1980) and The Club Dome Report, *No Limits to Learning* (Botkin et al., 1980). All of these contain the traditional goals of scientific knowledge and inquiry; however, the reports also recognize new goals or an increased emphasis on traditional goals. Common to these reports are the three goals of (1) increased understanding and response to personal and social issues related to science; using scientific knowledge and methods to assist in personal and social decision making; and (3) greater technological awarreness. The ideal Earth science program should reflect these goals.

The primary aim of Earth science education is to help students use knowledge of the Earth and its system to improve their personal life and the quality of life of humans everywhere. This aim includes the goals listed in the last section. The aims and goals are substantially translated to specific student objectives. But, in the exemplary Earth science program, there is an identifiable consistency among the three.

The Exemplary Curriculum

Most Earth science programs are organized by the structure of the discipline upon which they are based. While the goals and objectives defined in the last section are usually evident to some degree, the balance among the goals has been weighted heavily toward the knowledge forming the structure of the discipline. This type of organization has been widely used and accepted. These programs were designed to meet a particular set of scientific, educational, and social circumstances. However, our current circumstances require a new perspective in the organization of Earth science programs.

Earth science educators must free themselves from traditional perceptions of what Earth science programs should be. A new balance among the goals must be established. We are asking the same question Herbert Spencer asked a century ago—"What knowledge is of most worth?" In thinking about Earth science programs we are primarily concerned with future world citizens, not future scientists.

We need to change our philosophy to one that is represented by a new arrangement and emphasis of the fundamental goals of Earth science education. The exemplary program has a balanced emphasis among all the goals—a balance that in practice means knowledge presented in a personal-social context with attention to careers.

The exemplary program includes an introduciton to real problems in which students gather information and make decision. Although definite challenges, these goals are achievable for the majority of students. The program would also be oriented toward the conceptual and perceptual levels of middle/junior high students as well as elementary school children.

Earth science teachers must ask: "What is included and what is excluded from our program?" Here we can only suggest some guidelines that teachers might use.

- Does the topic match the present interests and past experiences of the majority of students?

• Does the topic use inquiry processes to resolve a genuine problem that requires a decision?
• Does the topic show the limits and possibilities of science and technology in society?
• Does the topic address a personal need or social issue?

Any one topic with in an Earth science program will probably not rate high on all criteria; however, no topic should rate low on all criteria. These are only suggested questions that might provide guidance. Obviously, we cannot provide criteria that include all situations, topics, and restrictions that an individual teacher must consider. An example may clarify this point. Consider the topic of plate tectonics. The lesson sequence might include an introduction to the theory followed by examples of folding and faulting. The answers to the four questions suggest that this is not an appropriate design for this topic. The criteria suggest a different organization. To satisfy the criteria, one could begin with the study of earthquakes and volcanoes and their impact on humans. Then the lesson would progress to the theory of plate tectonics as an explanation of movements in the Earth's crust. Geological hazards, mineralization, and oil formation all provide other examples of appropriate topics that offer high interest, contain social issues, are career related, and present real problems which require decisions. In trying to solve the problems, students will gain knowledge of geological concepts and principles. But, approach this information from a personal and human point of view.

The Exemplary Teacher

The exemplary Earth science teacher for the program we suggest is not different from the ideal teacher that has been described elsewhere. This teacher is, of course adequately prepared in the subject and nature of Earth science. In addition, the exemplary teacher has an awareness and understanding of science related social issues at local, national, and world levels and can include career, technology, and societal issues to provide balance in the new program. And, the exemplary teacher has a thorough understanding of their typical student and how they learn. Probably the most outstanding characteristic of the exemplary teacher is a personal commitment to the goals and objectives outlined earlier as evidenced by formal and informal preparation, classroom practices, and professional activities.

The Exemplary Classroom

The physical facilities for the exemplary program require nothing that isn't already available in a good laboratory oriented program. Rather, there should be greater use of the natural environment and the outdoors. However, students should have access to microcomputers, at least one per classroom. Standard supplies include software for the computer, notes from papers concerning local problems related to Earth science, and a variety of textbooks as resources.

Exemplary Instruction Methods

What about instruction in exemplary programs? As mentioned, the immediate environment should be used to underscore concepts and principles related to Earth science. These experiences complement problem-solving activities in the classroom. Instruction geared for the unique needs, learning styles, previous experiences, and special talents of students requires flexible arrangements of individual, small, and large group work.

Instruction is organized on principles of learning, developmental levels of students and appropriate instructional strategies. Examples of this approach include the learning cycle (Karplus, 1979; Bybee and Sund, 1982), the approaches of Madeline Hunter (1982), and the teaching models discussed by Joyce and Weil (1980).

One important addition to instructional strategies is the inclusion of student decision making. After studying a particular topic, for example acid rain, students can evaluate the costs, risks, and benefits of various procedures that result in acid rain such as *low sulfur coal*, and make decisions concerning the problem. Earth science teachers may need inservice training in order toincorporate decision making into their programs.

The Exemplary Student

At the completion of an exemplary Earth science program students will possess a basic understanding of Earth science themes and related concepts; introductory skills of scientific inquiry; knowledge of Earth science-related personal and social issues; positive, but appropriately critical, attitudes toward science and technology; and some Earth science career awareness.

Evaluation should reflect the balance of goals and objectives in the Earth science program. Students must be evaluated on the facts, skills, and issues they have studied. And, on a national level, the Earth science program should contribute an overall increase in understanding as measured by higher average scores on, for example, the National Assessment of Educational Progress.

Summary

Defining excellence in Earth science education is a complex task. The concept of an ideal program influences the many decisions teachers make while teaching a course. The foundation of an ideal program is the unifying themes of the Earth science disciplines. To implement the desired program, a strong and balanced set of goals is needed. As a result of an exemplary program, student achievement is high and congruent with Earth science education goals.

References

Barney, G. (Study Director). (1980). *The Global 2000 Report to the President. Entering the Twenty-First Century.* Washington, D.C.: U.S. Government Printing Office.

Botkin, J., Mahdi, Elmandjra, Mirzea, and Maltiza. (1980). *No Limits to Learning.* New York: Pergammon Press.

Bybee, R., and Sund, R. (1982). *Piaget for Educators.* Columbus: Charles E. Merrill.

Center for Educational Research and Evaluation. (1981). *The Status of Middle School and Junior High School Science.* Louisville: Biological Sciences Curriculum Study.

Hunter, M. (1982). *Mastery Teaching.* El Segundo, CA: Tip Publications.

Joyce, B., Weil, M. (1980). *Models of Teaching*. Englewood Cliffs, NJ: Prentice Hall.

Karplus, R., Lawson, A., Wollmen, W., Apel, M., Bernoff, R., Howe, A., Rusch, J., and Sullivan, F. (1978). *Development of Reasoning*. Berkeley, CA: The University of California Press.

National Science Board. (October, 1980). *Today's Problems Tomorrow's Crises.* A Report of the National Science Board Commission on Pre-College Education in Mathematics, Science and Technology. Washington, D.C.: National Science Foundation, U.S. Government Printing Office.

National Science Foundation and the Department of Education. (1980). *Science and Engineering Education for the 1980's and Beyond*. Washington, D.C.: Government Printing Office.

National Science Teachers Association. (1982). *Science-Technology-Society: Science Education for the 1980's.* Washington, D.C.: NSTA.

Chapter 2
Computer Assisted Laboratory Science

James Sproull
McLean High School
1633 Davidson Road
McLean, VA 22101

McLean High School is one of 23 high schools in the Northern Virginia county of Fairfax, the nation's tenth largest school system. This suburban system of 122,500 students serves the Washington, D.C. metropolitan area.

McLean's 36,000 people can be described as well-educated, prosperous, and suburban. Most parents are employed in either business, professional, U.S. Government, or military occupations and are somewhat transient.

With its proximity to our nation's capital, McLean has a mixture of students; for many, English is a second language. Adding to this diversity, McLean serves as a magnet school for learning disabled and mildly mentally retarded students. While maintaining an excellent academic record in all of the sciences, both in numbers of students served and awards received, the size of the Earth science classes classes has been kept low to allow for individualized teaching. Three-fourths of McLean's students go on to post-secondary schools. Our teachers have an average of 14 years teaching experience, and out of 100 over 80 percent have Master's Degrees.

The guiding philosophy of our three-level Earth science program assumes most students will never be exposed to the disciplines of Earth science unless they are enrolled in a course; and, for most students, Earth science can be extremely important. We want students not only to experience as much Earth science and its social applicability as possible, but also to learn and practice inquiry skills.

Our Program

All of our courses have similar objectives and emphases that are geared for students of different ability levels. General educational objectives include the following:

- *Laboratory Skills.* Students learn to exercise proper scientific method, record data and develop their own conclusions based on accurate data. They also learn to write up labs in a neat, clear, and complete format.
- *Communication Skills.* Students learn to organize data into well-structured thoughts, and communicate facts, knowledge, and data through written assignments.
- *Transfer of Knowledge.* Students learn to express an appreciation for the environment and are able to apply course knowledge to personal situations.

Our courses meet these objectives while emphasizing the following subjects:

- *Meteorology.* In the study of the atmosphere we cover the water cycle, exchange of water in various forms, heat transfer and phase change, the physics of heat, and weather patterns, energy exchange throughout the world.
- *Oceanography.* here we study the relationships between Earth and ocean, the storage system of energy and matter, and humanity's use of the sea.
- *Geology.* Our study of the solid portion of the Earth includes identification of minerals and rocks; the nitrogen cycle; plate tectonics, development of continents, and landforms, geologic features and their development.
- *Astronomy.* In the study of our universe we look at the Earth in the solar system, galaxy, and universe, and life on earth and our dependence on ourselves.

Our program is made up of three separate courses at different levels. *Earth Science Curriculum Project* (ESCP) is designed for the college bound student with good math skills. It is more than a survey course of the four applied sciences—meteorology, oceanography, geology, and astronomy because it deals with the intra- and inter-relationships of Earth science and presents the Earth as a closed system.

Students enrolled in ESCP are an ethnic mixture of college bound students. Most have excellent experiences on which to draw and are well-traveled in both this country and abroad. The average class size for ESCP is 22 students per class.

Meteorology, oceanography, geology, and astronomy are taught along with other areas, not as individual units but as ideas that support and augment the four major disciplines. Math skills, environmental impact, societal concerns, and future problems are discussed as focal points of each unit. We do not teach, for example, ecology, as a separate entity, but rather interrelate it to science and society.

Each student is expected to learn, use, and be proficient in the scientific method of inquiry. Laboratory investigations, presented in many forms, are the major focus of the course. The basic program of *Investigating the Earth* is followed, but numerous other lab activities are introduced to supplement this excellent American Geological Institute program. Through careful and accurate laboratory procedure and measurement, student conclusions not only reflect the subject being studied, but incorporate previously learned concepts.

Clear, concise, and creative thinking is an attribute that is not often found in the average high school student or, for that matter, in many adults. Earth science offers an excellent medium by which students are exposed to many hypotheses, which they can test against their knowledge and values. Memorized facts are not good enough if they are never applied in attempt to change society. Students at McLean challenge values, and create an atmosphere of free exchange of accurate, relevant, and timely data and ideas.

The ESCP classes have numerous extracurricular activities. Through the use of bulletin boards and outside speakers, career possibilities are explored on a continuing basis. Local field trips offer a varied range of experiences from the Smithsonian Institution to canoe trips through the auspices of the Chesapeake Bay Foundation. The physical setting of the school allows classes to investigate stream erosion, sedimentation, and contour mapping without leaving the confines of the school area or class period.

Honors Earth Science Curriculum Project (ESCP Honors) is a challenging course geared to students with an aptitude for science. It covers the same areas as ESCP in more depth, requires a better understanding of scientific concepts, and uses a problem-solving approach.

The small honors class allows for free intellectual exchange among the students and between teacher and students. All of the students possess a keen interest in exploring new ideas and concepts. The instructor draws upon student experiences on a daily basis.

The honors students participate in many extracurricular events not included in the ESCP class. At the Smithsonian Institution's Museum of Mineral Sciences section, the class is able to view meteorite and mineral specimens seldom seen by the public. The class is also able to see what different Earth scientists actually do.

A final project for the school year is a one-day field trip, which serves as the final exam. Activities planned for this are: locating sites through the use of topographic maps; analyzing a site for geological history; assessing the environmental impact humans have had on a site; assessing the site's use for commercial, residential, or recreational designations; and analyzing the interactions of all aspects of the sciences on the site's characteristics.

The Earth science honors program is diversified in its approach to presentation of material. *Investigating the Earth* (Matthews et al., 1978), the primary text, is supplemented with *Earth Science: A Study of a Changing Planet* (Daley et al., 1978); and *Brief Review in Earth Science* (Abel and Callister, 1978). In addition, each student subscribes to *Science 85*, a magazine which presents current science topics in an understandable format. An added benefit of this publication is the constant exposure to scientists—their work, their lives, and their involvement in society.

Each student in the honors class designs, researches, conducts, and presents a topic of special interest to them. This project may be a science fair project but must adhere to science fair guidelines. The students have at their disposal a well-equipped lab workroom, research areas within the classroom, and access to all of the science faculty, who provide both qualitative and quantitative guidance. Some of the areas that have been investigated are: Hazardous Waste Movement Through Aquifers, Acid Rain Impact Upon Algae, Carbon Dioxide Effect on Heating in a Closed Vessel, and the Planetary Distribution of Earth Accumulated Meteorites.

Earth and Space Science (E&SS) is also a survey of the four major areas of study. The course uses some math in a non-technical approach, and the major emphasis is understanding the Earth's environment and humanity's role in it.

The students in E&SS are those with less ambitious academic goals, or those with language problems. At the present time, 50 percent of these students speak English as a second language. Because these students are not academically inclined or have language difficulties, class size is kept between 15 and 20 students.

The Earth and Space Science curriculum gives students as many hands-on experiences as possible. The teacher who developed this McLean program has been actively involved in creating an activity-based county-wide curriculum. Laboratory activities focus on learning-by-doing experiences relevant to the topic. Students relate classroom and laboratory knowledge to personal experiences and insights. Critical reasoning skills are very important to this group of students because they may never again be exposed to the scientific inquiry method and its associated skills.

The E&SS program uses many school resources. At times a resource teacher for learning disabled students assists during labs, group work, or class discussions. The Project READ teacher works with these classes in developing reading, writing, and studying skills specifically for the science classroom. The science department also provides the Project READ teacher a set of applicable Earth science texts. While using the basal Scott Foresman text *Earth Science* (Pasachoff, Pasachoff, and Cooney, 1983), numerous other resources are enlisted.

This past school year, the E&SS classes were used in a developmental study of the county Earth and Space Science Curriculum guide and laboratory manual. The goal of this project is to develop a library of workable, relevant, and challenging lab activities that correlate with the Scott Foresman text and introduce reading, writing, and critical thinking activities into the classroom.

Because laboratory investigations are an integral part of the curriculum, McLean High School plans to implement computer assisted instruction in the laboratory and in the classroom. For all Earth science students, Computer Assisted Laboratory Science (CALS) provides remediation of necessary skills (drill and practice programs); introduction of new concepts (tutorial programs); laboratory and environmental simulations (computer modeling); actual laboratory investigations (interfacing laboratory equipment with Earth science investigations); and further investigative labs with microcomputers (student engineered and built software and hardware from individual and group projects).

The Earth science department received two grants to implement the CALS program. A mini-grant purchased two Apple IIe systems with an assortment of drill and practice, tutorial, and laboratory and field simulation software. Another grant gave the department two more Apple IIe's with software and lab interfacing equipment. The purpose of the second grant is to develop and execute a course of study that implements microcomputers in a laboratory classroom setting.

Because of these two grants, McLean is being used as a model school to demonstrate the use of microcomputers in the Earth science curriculum. During the first year of CALS a number of different techniques were tried and evaluated. Presently the CALS project manager is attempting to improve the quality and quantity of software available from publishing houses. In addition, a program is being planned to use the CALS computer to store and disseminate data gathered during field trips. A Chesapeake Bay Data Base will provide a water and wildlife quality index to Virginia high schools that participate in the canoe field trip program offered by the Chesapeake Bay Foundation.

During the course of the year, each CALS student completes at least one library research paper. Students are taught how to conduct research in the library setting, how to footnote, and other related topics. At least one class period during the first weeks of school is dedicated to acquainting students with resources available for science research.

The first week of classes is devoted to study skills. Each student is presented with methods to assist in organizing and completing study related tasks. McLean's Project READ Teacher, Gloria Thrall, uses this time to give the ninth grade science students the necessary high school survival skills. This program has had a marked impact on the students' readiness and ability to adapt to the learning environment in a high school.

During the geology unit, Earth science classes include many slide lectures. Approximately 2,000 slides were collected by the Earth science department during a summer geology course funded by the National Science Foundation.

A slide program is used during the water unit in conjunction with the film *Where Did the Colorado River Go?* Some other slide presentation titles are: "Stratigraphy in the Grand Canyon," "Erosional Features of Bryce, Zion, Canyonlands, and Arches National Parks," and "Geological Effects Upon the Bristlecone Pine National Forest." These programs have a profound effect on the lessons presented in each chapter. Students not only see the geologic features discussed in the text, but they see the relationships between geology, biology, ecology, and other fields of study.

Field trips are an exciting facet of our Earth science programs. Recently we used the Smithsonian's Museum of Natural History for a number of activities. On two separate occasions students visited the mineral section and interviewed scientists who study and care for the world's largest collection of minerals. Future field trip plans include visiting the Hall of Rocks, Fossils, and Geologic Time; the Naturalist Center; and the Hall of Minerals. Many extra credit and science fair projects take advantage of the Smithsonian's proximity and wealth of information.

The McLean High School Earth science program sees that students are deeply involved in studying and understanding the problems associated with the quality of life, and use of the Chesapeake Bay and its watershed. Classes have taken field trips to learn of the bay's problems. Through the Chesapeake Bay Foundation students have seen how farming methods contribute to both chemical and sediment pollution. Classes have taken canoe trips to experience and see first hand the result of human intervention on bay life. At the present time a number of students are using the bay and its associated water quality problems as vehicles for science research study projects.

A nearby park offers the opportunity for Earth science classes to take field trips without going over the 50 minute class period or leaving the school grounds. Students use the grounds for topographic map making, stream profiles and cross-sections, stream sediment analysis, and for studies in erosional and depositional features. This year will be the second that the honors class will take a final exam in the field. The field trip final exam allows students to apply many geologic, oceanographic, and meteorologic concepts to actual field studies. A description of this activity appeared in the May, 1985 issue of *The Science Teacher*.

Earth science is a difficult course to teach and learn because of the broad nature of the subject. Although this aspect presents a problem, it can be overcome by using wide-ranging activities that integrate concepts and values learned in the classroom. Both students and teachers appreciate the opportunities presented in our Earth science program. Our many activities are what makes the McLean High School Earth science program an exciting learning experience.

In all three courses, we give each student exposure to the many fields of study representing Earth science. The underlying theme of these courses, however, is not total knowledge of meteorology, oceanography, geology, and astronomy, but knowledge of the interrelationship between the Earth sciences and society. The goal is to produce a rational, clear-thinking person who can make decisions that reflect an understanding of the laws of nature.

Equipment and Materials

The maintenance system needed to administer and run this program is little more than what is considered normal school system support. It is assumed that programs have access to balances, stereoscopes, and other supplies used in most Earth science classrooms. In addition to these, the McLean High School Earth science program has been fortunate enough to receive assistance in hardware acquisition, material supplements, inservice training, and school support.

Hardware Acquisition Our hardware is primarily of two types, astronomy equipment and microcomputers and accessories. These are really the only major purchases above what is considered normal for Earth science equipment.

The astronomy materials were donated by student and community hobbyists and our observatory was built from funds managed through the county school system. It has been relatively easy to become recipients of these telescopes and accessories because of the interest generated by the former Earth science teacher at McLean. The observatory is maintained by the Astronomy Club, which has been active for many years. Money needed for repair and purchase of equipment is generated by club dues and money-making projects.

Our microcomputers were obtained through the two grants mentioned earlier. One grant came directly from the Fairfax County School Board to increase the use of microcomputers in education and the second from a federally funded project that focuses on learning through the use of technology. The maintenance for these microcomputers is through the county maintenance contract system. Any school contemplating microcomputers should investigate a maintenance service contract system or, if the system is large enough, a school system maintenance plan. School officials should also plan for proper security and a comprehensive low-deductible insurance plan.

Material Supplements Many of the programs being conducted are the direct result of the science chairperson's involvement in curriculum development workshops and committees. These provide the teacher with many innovative ideas and approaches to learning and allow access to materials in the development stage. Because McLean High School uses these materials, the school has input into curriculum decisions within the county system.

Practically all of these materials are obtained through the county system. Support is provided by staff of the science curriculum coordinator. In addition to their support of three different classes of Earth science, this office has been instrumental in developing the Earth and Space Laboratory Activities, ESCP Honors curriculum, and the computer and technology programs. Their leadership role is an important aspect of the school's successful Earth science program.

The county school system office of instructional technology has been helpful in implementing the microcomputer programs. They are in the process of arranging lab-interfacing hardware and software, preview software, and building a comprehensive lending software library.

Inservice Training Fairfax County Public Schools has pushed for curriculum development and implementation, and provided inservice sessions to give teachers opportunities for input and questions. The Earth science program is a direct reflection of their continuing involvement in quality education. Workshops are available on a regular basis for any of the three courses. Additionally, inservice opportunities are available on microcomputer in the science classroom.

School Support Without leadership and support from the school administration, many Earth science programs may have failed or at least slowed down. Administrative leave has always been available for school visitations and curriculum meetings. Field trips have been an area where school support is always greatly needed, and at McLean High School there has been a renewed interest in seeing that science is learned outside of the classroom as well as inside.

Evaluation

At McLean High School we use several locally developed instruments of evaluation: The Science Survey form, program audits, and measure of adherence to the Program of Study (POS). Each facet of the program is evaluated on a regular basis to ascertain whether that particular part of the program is effective and relevant.

Science Survey Form This survey determines whether taking Earth science as an introductory laboratory science better prepares students for subsequent science courses. Each student is rated on laboratory performance, laboratory reports, and quizzes and tests. Although not a fine-tuned tool, this survey seems to indicate that students benefit from having Earth science as a foundation course. The average scores indicate that students with previous Earth science experience do better by an average of one letter grade.

Program Audit High Schools in Fairfax County undergo an educational audit every five years. These audits are instrumental in assessing whether schools, departments, and individual courses follow strict and objective educational guidelines. During our last audit the science department was commended for its "strong, diverse instructional program utilizing the strengths of individual teachers," and "appropriate use of community and library resources." Before the five-year audit, we were visited by an accreditation team which commended the school on "motivation of science students to . . . compete successfully in science related activities . . . " and "use of area and community resources."

Program of Studies For an overall school program to develop into a logical sequence of experiences, a curriculum outline needs to be published and followed. In Fairfax County a detailed program of studies (POS) for Earth science courses is available. The POS has been followed closely because its guidelines creae a standard for excellence within a framework that allows teachers to respond to student needs.

Plans for Improvement

Our major concern at this time is the phenomenon known as "too much success." Because McLean's Earth science is so well liked, more and more students sign up each year. This year, enrollment in the Earth sciences increased by about 125 percent! Teachers and administrators must avoid overcrowding the program.

Regardless of the impending overextension of the facilities, McLean will continue with its exemplary program. To expand the course offerings, the science department is considering new programs. Teachers are kept current in their areas of expertise by the county's inservice program. Additionally, our school is experiencing a renaissance of academic priorities through its instructional leader and principal, Murriel Price. At McLean High School, teachers are excited about teaching and students are excited about learning, a healthy and positive attitude.

References

Abel, V. G., and Callister, J. C. (1977). *Earth Science* (2nd ed.). Fairfield, NJ: CEBCO.

Daley, R. B., Higham, W. J., and Matthais, G. F. (1978). Fairfield, NJ: CEBCO.

Matthews, W. H., Roy, C. J., Stevenson, R. E., Harris, M. F., Hesser, D. T., and Dexter, W. A. (1978). *Investigating the Earth* (3rd ed.). Boston: Houghton Mifflin.

Pasachoff, J. M., Pasachoff, N., and Cooney, T. M. (1983). *Earth Science*. Glenview, IL: Scott Foresman.

Chapter 3 Geology Is

Rion D. Turley
O'Fallon Township High School
600 S. Smiley
O'Fallon, Illinois 62269

The community of O'Fallon, Illinois, population 12,000, is located in St. Clair County, 20 miles from St. Louis. The proximity of Scott Air Force Base contributes to O'Fallon's population characteristics. The population is transient; in 1975, nearly 25 percent of the residents had lived out of state. One fifth of the employed civilian population is classed as professional or technical, and the largest group of the civilian work force is in wholesale and retail trade. The city of O'Fallon grew by 140 percent between 1950 and 1980.

O'Fallon Township High School has 1250 students from both rural (30 percent) and urban settings. Various ethnic groups are represented. At the high school, we make Geology Is available to all students in grades 10-12. There are no prerequisites, and no special attempts are made by school counselors to recruit stud s. Students enrolled in Geology Is represent a wide .ge of student interest and ability.

History of the Program

Geology Is was created through a desire to strengthen and expand the science subjects traditionally taught in secondary schools in O'Fallon and throughout the nation.

We feel strongly that the study of the physical Earth links the traditional science offerings to the entire natural environment. For example, biology involves the study of plants and animals on Earth; chemistry investigates the composition of substances that occur on or in the Earth; and physics studies the states and properties of matter and energy that are basic to processes on and in the Earth. In these scientific disciplines, the Earth is treated only as a container. Geology, therefore, fills this gap by relating the study of the Earth and its processes to the whole physical and biological environment.

Geology in its basic format involves observation, testing, and logic, and can be taught at almost any ability level in the secondary school. A program such as Geology Is is a valuable addition to any physical science curriculum because most traditional chemistry and physics courses are not open to many average and below-average students because of mathematics prerequisites and a college-bound orientation.

We found that without a course emphasizing geology, many of our graduates enrolling in first year, college-level geoscience courses encountered major problems because they had no secondary school background. Additionally, without a secondary-level high school geology program, few college-bound students receive any career information on the geoscience fields of study.

The Geology Is staff feels that the carry-over value of a program that develops an understanding of the geologic processes is of utmost importance to all citizens. Because the Earth is finite, the kinds of decisions made by society regarding such matters as mineral and water resources, energy, land-use planning, and natural disasters have a great bearing on the future of this planet.

While trying to institute a course of study in geology suitable for the secondary student, we discovered that no secondary-level curriculum materials were available from either commercial or public educational sources. As a result, in 1976, members of the O'Fallon High School science staff, with assistance from the Earth science department at Southern Illinois University at Edwardsville, wrote a Title IV-C grant proposal requesting funding to develop an innovative secondary geology curriculum.

During the developmental years the Geology Is staff wrote and evaluated our program that, as an end product, included a textbook, accompanying activities, and a teacher's guide. In 1979, the Illinois State Board of Education validated Geology Is as an innovative and educationally significant project, and made it available to other secondary schools in Illinois. In 1982, after three years of use by 30 other secondary schools in Illinois and further refining and testing, Geology Is was granted national validation by the Joint Dissemination Review Panel of the United States Department of Education. In 1984, Geology Is was approved for placement on the National Diffusion Network, which made the program available to schools throughout the United States.

Our Program

Our course of study is designed around the unit concept. The two-semester program consists of distinct but related units divided into two volumes. These units are further subdivided into chapters.

Each chapter begins with an outline of its content. From this outline, students can see what the chapter will include and how various topics are related.

The main text of the chapter is written following an outline form. In this manner, each topic is discussed within a specific context. However, if students want to spend more time on a topic, the teacher is free to do so. We feel that this approach allows flexibility in a teacher's approach to the subject matter.

Related Activities is a list of required activities for the chapter with accompanying activity worksheets. The list gives students an idea of what activities are going to be done to help reinforce the chapter content. Within the chapter, reference is made to each activity where it corresponds to the text content.

The activities are performed by students alone or in small groups, but generally students work in pairs. Activities vary in style from controlled to open-ended. Early activities are designed for students to practice learning skills such as reading and comprehension, summarizing, and outlining. Some activities are quite basic for the purpose of simplifying or clarifying concepts discussed in class. Some teach laboratory techniques and develop student problem-solving skills. Teachers are free to add their own activities that may aid students' learning.

Geo Facts follow Related Activities, and are factual statements about the subject matter of the chapter. Designed to stimulate students' interest, they may be used as an introduction to discussion topics.

A glossary following Geo Facts is divided into geological and straight terms. Straight terms are those that some students may not know, but that appear in the chapter because they could not be simplified. Students should know these definitions before reading the chapter. Students should know the term meanings in general, but we do not require strict, rote memorization.

Problems and Questions end the chapters. Many are of a "compare and contrast" variety to encourage students to describe similarities and differences between concepts. Occasionally, questions are also asked within the chapter. They are food for thought and may be used for the purpose of discussion.

Field activities are strongly encouraged because the geosciences are best taught in a hands-on, realistic setting. If field trips are not possible, teachers show slides of and bring in samples from the study site. In a "field trip" such as this, we also use role playing. In this manner students can apply their geoscience knowledge in a realistic manner. Topics for field and group activities include local descriptive geology, environmental geology, mineral resource development, and careers in geology.

In addition to the student text, a Teacher's Guide for each chapter has been developed and includes the following:

- *Concepts* a brief introduction to the teacher explaining the general content and material in the chapter. A suggested time frame for the chapter is also included.
- *Topics* objectives of and suggestions for the teaching of the topics within each section of the chapter.
- *Activities* comments and suggestions about the activities included in each chapter.
- *Optional Activities* additional activity suggestions that have been successfully used from time to time, but were not included in the activities list.
- *Films* a list of films available on chapter topics.
- *Bibliography* a list of exceptional sources of information about the subject matter. This list usually contains pertinent articles or U.S. Geological Survey publications on specific matters of a geological or environmental nature.

The overall goals of Geology Is include:

- Providing students with geoscience learning opportunities not available in current national science curriculums.
- Developing multidisciplinary classroom materials that will lead to acquisition of general and specific skills required of or beneficial to students interested in geoscience-related careers.
- Giving students research, investigational, and field experiences in geoscience problems that are relevant to society, thereby enhancing and improving the students' knowledge of geoscience processes.

Being aware of and understanding geoscience processes help students to deal effectively with their surroundings. Through a course of study such as ours students become protectors of their environment and more responsible Earth resource consumers.

Geology Is crosses disciplines to explore the planet Earth as a finite body where decisions must be made regarding social issues such as mineral resources, energy, land use, and geologic hazards. All these processes and products have a great bearing on humanity's future, therefore, knowledge of these topics cannot be minimized.

Unit I begins with "What Is Geology?," an introduction to the scope, history, and importance of geology in today's world. The major emphasis of this chapter is on society's dependence on the Earth and the processes that shape it.

Unit II opens with a general overview of the Earth and its environment in space. From there, the focus becomes specific as the students are introduced to the Earth's possible origin, age, and general characteristics. Next comes the "stuff" Earth is made of. Rocks and minerals are studied as to their origin, composition, and characteristics. Our study of Earth materials is not only from a geologic standpoint, but from an economic, political, and social standpoint as well, and concludes with a chapter on mineral resources.

In Unit III students study the use and interpretation of maps and aerial photographs in geology. Activities include making basic maps, visualizing landscapes from topographic maps, using map location systems, interpreting geologic maps, and identifying geologic features on aerial photographs.

Unit IV involves the internal forces of the Earth. Topics in this unit relate the theory of plate tectonics to the Earth's structure, quakes, volcanos, and mountain building. In addition to studying the physical aspects of these forces, the effects and consequences of the Earth's dynamic movements on people are discussed.

In External Processes, Unit V, subject matter includes those external forces that affect the surface of the planet Earth. Specific chapters are devoted to weathering, groundwater, running water, glaciation, wind action, and ocean and wave action. Again, as with the earlier units, the geologic processes are stressed, but the effect of each process or combination of processes on people in their physical and biological environments is also covered.

In order to implement Geology Is, the following requirements and suggestions should be considered. An elaborate laboratory setup is not necessary; access to water is the only classroom requirement.

- The teacher should have at least 12 hours in geology, Earth science, or physical geography.
- The teacher should attend a one-day workshop to become familiar with the text, activities, and teaching techniques.
- The teacher should administer a pre- and post-test to students. All necessary records of the test results should be kept to allow student and program evaluation.

Many teachers use additional activities and materials, such as slide sets, video cassettes on geoscience topics, role-playing activities, and field trips. Although these activities and materials are not required, they enhance the geology program and give students a wider range of educational experiences.

Evaluation

The success of Geology Is can be measured in three specific areas: increased student understanding, course popularity, and program adoption by other school districts. Student understanding of basic geological processes has improved. Geology Is students score higher on the Geoscience Cognitive Tests, developed for the project, than students from more traditional programs. These tests also provide proof that the course has been statistically replicated.

A subjective measure of the value of the program can be found in its popularity. For example, the O'Fallon district has no science requirement for students. Yet, since Geology Is has been added to the curriculum, not only has the course grown from one to five sections, but the overall science enrollment has increased. The interest in geoscience has been such that the school now offers an advanced geology course designed for students who have taken Geology Is and want to study geology in depth, or who are interested in pursuing a geoscience career. Several of the Illinois adopters have had similar enrollment increases after the initial pilot year. It seems that students are not only learning, but are finding the course interesting and valuable. Also, since the addition of Geology Is, an increasing number of students are taking both biology and geology even though they are not college bound, or are college bound but planning a non-science major.

In the three years (1980-82) that Geology Is was validated and funded as a developer/demonstrator program on the Illinois Diffusion Network, 30 schools adopted Geology Is as an integral part of their curriculum. In addition to the 30 funded schools, 67 other Illinois high schools have expressed an interest in the program. Since the demise of the Illinois Diffusion Network, six of these schools have purchased Geology Is materials with local monies and grants. Interest by educators extends well beyond the borders of Illinois. This, in itself, is an indication that the need for such a geoscience program is national. Several districts from other states have purchased materials. This year, Geology Is was selected by the National Diffusion Network of the U.S. Department of Education as a developer/demonstrator project and was funded for distribution to schools throughout the United States.

Plans for Improvement

In our own minds, the major weakness of the program is the fact that we have not had the time or the funds to get evaluation and input from a cross section of Earth scientists and educators. This type of input could add to the quality of Geology Is. We feel we have developed a good product, but realize that the wider the view of the program, the better it can become. We hope that as more and more schools use Geology Is, a system of updating and improvement will be developed to overcome this problem.

Another area of weakness is that our activities do not have as much computer simulation as we would like. This is due to the lack of time and funds that are necessary to develop such activities. Help in this area from other geoscience teachers who have developed materials for computer use would benefit the project greatly.

Chapter 4 Ninth Grade Earth Science

Rand Hogarth
Thomson Valley High School
Loveland, Colorado 80537

We live in a continually changing and sometimes turbulent world. To survive these conditions society must be aware of its surroundings and flexible to these changes. Our business and medical industries have proven their ability to recognize and adapt to our evolving societal needs. Now it's time for the educational system to rise to the occasion and meet the same challenge.

Our educational system is encountering competition from the entertainment media and other distractions. Teenagers are growing up faster mentally and physically. As educators, we have succumbed to the competition because we have not changed our methods. This is an important concern in the future of education.

I wrote this curriculum to challenge the new distractions and to motivate students to learn. Our students are from diverse occupational areas, from rural agricultural to modern technological.

Loveland, Colorado, situated about 50 miles north of Denver, has a population of 55,000. While we have few minority students, 22 percent of the student body at Bill Reed Junior High is eligible for free or reduced price lunches.

Program Philosophy

The purpose of my curriculum is to express the need for change in the Earth science program at a junior high level. Like any business, a successful science curriculum must adapt and prepare for future expected conditions by the student and teacher. If not, we will find ourselves falling behind and content with mediocrity. I see this change not only as a professional challenge, but a moral obligation. A successful Earth science curriculum can meet this challenge. Below are the factors that make Earth science curriculum successful.

A primary function of the educational system is to create an environment where a student will encounter success at a consistant rate. One variable that must be considered is constantly challenging the student to eliminate a state of boredom while achieving success. This presents a problem. How can you challenge all students grouped together as one while injecting a feeling of self-achievement in each student? At best, the traditional curriculum can accomplish this with only 70-80 percent of the student body. This leaves 10-15 percent unchallenged. The future of our advancing technical society is based on the young achiever. Mainstreaming the lower 10-15 percent of the student body into a traditional science curriculum will lower their self-esteem when there is little or no chance of success. It has been argued that grouping the lower 10-15 percent together will label the student. I believe that allowing students to encounter success builds confidence and increases their self-esteem. What would you do, sentence students to possible failure in a curriculum that they have little or no chance of mastering or allow students to meet success in a curriculum designed around their ability levels? Our Earth science curriculum is organized to attack this problem.

There must be congruency within a good Earth science curriculum. All sections must follow a uniform curriculum and be accountable for what is being taught, which must be documented with terminal performance objectives, enabling objectives, and daily objectives. If these objectives are met, a system will appear throughout a science department and in each class. It is advantageous for a teacher to see a detailed overview of the curriculum. The teacher will then know exactly where the curriculum is heading and be able to pinpoint changes that need to be made as warranted.

A teaching process must be incorporated within the content. Earth science textbooks do not recognize this factor. Concepts and terminology are packed not only into the pages of many Earth science textbooks and students' cognitive thinking processes are not considered. Our Earth science curriculum incorporates a teaching process called mastery learning. Mastery is a teaching system that has one basic objective—to learn the content.

Our Program

Motivation is the key to successful education. A motivated student is a student who wants to learn no matter what the ability level. Unmotivated students not only limit their learning capacity, but could play a key role in injecting a negative learning environment into the classroom. To motivate students we need resources as varied as the students. In the construction of the Earth science curriculum drawn from textbooks, periodicals, newspapers, journals, and scientists, we always thought of our students. Simply stated, my goal was to motivate them. Achieving that eventually grew into a complex and abstract task. Motivation was dependent on our ability to reason why the content was applicable to each student and how each student could use this content in and out of the classroom.

To teach content we daily reinforce transference of one concept to another, from one unit to another, and from all the units to real-life application. The ability to use transferred material motivates retention and accelerates the learning process by providing a reason to learn concepts. My whole curriculum is based on sequencing units, concepts, and objectives to fulfill this means of motivation.

The completion of a chapter should not be considered an end. Each unit should be transfered to the preceding unit. I start my curriculum with an astronomy unit, and transfer its concepts to meteorology through an explanation of the process of differentiation, by which the Earth's interior layering formed. The formation of the atmosphere can also be explained using the term differentiation. After a lesson on the Earth's angle of inclination, this concept is transferred directly to the concept of angle of inclination and how the Earth's atmosphere is heated.

I transfer meteorological concepts to a unit on Solar Energy. Conduction, convection, the greenhouse effect, angle of insolation, and heat absorption are all directly transferable to Solar Energy processes. In my Solar Energy Unit, students transfer learned concepts to real-life applications. The students learn about active and passive solar units and discuss the feasibility of solar energy for a residence in the town of Loveland and other areas of the country where solar energy is considered an alternative source.

Another example of transference to a real-life situation is my Home Energy Unit, which uses concepts on conduction and factors that affect heat transference to show students how heat passes through exterior walls of a dwelling and how to impede this transference. As the final project of this unit, students conduct an energy inventory of their home and predict a monthly heating bill.

For transference to be accomplished, students must learn the required material first. So that each step of the learning process is motivational, I make sure students know what I expect; I teach objectives one at a time, and have students state and label each objective. Specific objectives make me and my students accountable for the material, and they let me and others see where we are going and where we have been with the curriculum. Evaluation is provided instantly through oral and written checks during and after the teaching process is completed. I use frequent subjective tests and application projects over completed units serve as evaluating and motivating tools.

Our curriculum is not expensive to maintain because our lab equipment is reusable and there are many activities where students use worksheets or design their own projects. These projects are developed for the student to apply mastered units or concepts to a real-life situation. Examples are designing a flat plate liquid or air solar panel, designing a passive solar energy house, performing an energy inventory of a house, predicting a heating bill, designing and interpreting weather maps, or proving competency through an energy debate.

Because this curriculum is multi-disciplinary, I incorporate mathematics and English skills. Necessary skills for our high tech job force will be applied mathematics and also the ability to communicate with others. The utilization of English and math skills in science reinforces the mastery of these skills and points out how all subjects are related in the overall education process. Students want to segregate subject matter; I want to integrate. One way I integrate English skills is through my evaluations. Most science programs evaluate objectively. This requires students to express their knowledge based on a one word or letter answer, and this is not communication. I use subjective evaluations and upper level testing questions which require an explanation of why the observed is happening. I try to integrate math or show mathematical relationships whenever possible. I use Metric conversions frequently. Math is used extensively in the home energy unit in calculating R values, cost to heat a surface, and payback periods. In the solar unit calculating orientation of solar panels and solar mass are performed.

The real-life problems I deal with are a curriculum within themselves. Performance expectancies of many units relate to ideas from previously learned units. My curriculum investigates wind, solar, hydroelectric, geothermal, nuclear energy, and coal, petroleum, natural gas, and oil shale fossil fuels. After completion of each unit students recognize many abstract implications of the energy source. Through a two-week energy simulation game, students learn how that type of energy production could affect them, their community, and the environment. In the game, students choose what kind of energy should be Loveland's major source of power. The students are divided into power groups and are presented with an outline of the debate that will follow. The object of the debate is to convince the Loveland city council that their source of energy is most suitable for Loveland. The city council is composed of three or four students who are role playing assumed personalities. Preparation for the debate is limited by an allocation of money to each energy corporation. Points are accumulated for facts, quotes, arguments won, and convincing a council person. This two-week simulation game covers virtually all aspects identified for criteria for excellence in the Earth sciences.

The Energy Simulation game also introduces students to the decision-making process that will help them in their role as responsible citizens. The advantages and disadvantages of the energy production in question are weighed, selected, and justified by each student. These students understand and can use their ideas.

In all activities, students have many opportunities to discuss. During discussions, I ask open-ended questions, accept a broad variety of answers, and encourage speculation about additional answers. Issues relating science and society arise often.

I believe in bell to bell teaching. This requires efficient planning of the class period. The learning process takes place in the classroom, not through homework outside of school. My class is based on a systematic approach. When the student learns this system then teaching efficiency is accomplished. I start the learning process with a focus task; this is usually some type of review of the preceding day's material. Then I initiate a need to know that day's objective—this provides motivation. An explanation of why this objective is important and how this objective fits into the terminal performance objective is based on inquiry, transference, and active teaching between the teacher and students.

Strengths and Weaknesses

I have put together an accountable system that touches many areas and applications of Earth science, is for all levels of academic ability, emphasizes a teaching process, and stresses mastery of the content. When the students know what is expected of them, the purpose of the content, and are checked for understanding, mastery will be achieved. I have set up a framework that incorporates this basic system, yet gives the teacher the flexibility to use their own personality and diversity. My students are subjected to transfer and application of mastered content. This process enables students to visualize how science affects their personal lives. The ability to use concepts outside school, often beyond school years, with mastered content is an important motivational incentive.

Another strength of our program is that it requires a low budget once the initial lab equipment is purchased, and little money is needed for maintenance.

Though the transference of content has been excellent, more emphasis on career preparation, careers, and job skills is needed. Also, I would like to incorporate more biology and math skills into our current program.

Another weakness of our program ironically stems from one of its strengths. For this Earth science curriculum to be successful, it has to be open to change and flexibility. This curriculum counts on active participation and investigation by the teacher. Teachers who are not willing to become actively involved will find this a difficult program to adopt.

Program Transferance

Working with other teachers has made me aware that few teachers can obtain the results that I have without preparation. Because this is not a traditional program, they need a workshop on the teaching philosophy and techniques behind this program. At the beginning of the year, teachers have trouble with the content, sequencing, and mastery of the curriculum for motivation. After learning how and why I presented the material, those teachers gain confidence to use this program, and they quickly experience positive results. For this program to remain healthy, individuals who understand the teaching philosophy and technique must be at the helm. This is a very flexible program designed to change where there is a need.

Chapter 5 Accelerated Earth and Space Science

Kathryn Gregory
Lake-Lehman Junior High
Lehman, PA 18627

The community served by the Lake-Lehman School District is in rural northeastern Pennsylvania. With 2500 students, the school district has one seventh and eighth grade junior high school. The Accelerated Earth and Space Science class is an elective for eighth grade students who excel in math and science and wish to expedite their education in these areas. The 28 students in this course are taking Earth and Space Science and Algebra I a year in advance of most other students.

Due to the volume of material in most Earth and space science courses, many topics can only be treated superficially. But a course designed to study a microcosm of the total science in depth allows students to experience and investigate first-hand and in detail Earth and space phenomena. With this in mind, our course is designed to allow students to study their local environment, rather than other areas of the country. Skills learned from investigating local phenomena can be applied to any region regardless of geologic differences.

Our Program

As the first specialized science course our students take, the major goal is to excite students about discovering science through their physical world. Some specific student objectives are to develop basic science skills in data collecting (with use of the students' own photography); to identify minerals and rocks; to learn to read a map; to interpret weather phenomena and night-sky cyclic change.

This course is also the first that sensitizes students to potentially life-threatening problems that occur because of our philosophy of, and interaction with, the environment. Students get involved with concepts ranging from the policies of the United States in dealing with oil-producing nations to the advisability of knowing their immediate environment. (Local information, for example, can help them to avoid certain risks, such as living in a flood plain.)

The course is divided into four units: astronomy, geology, energy, and meteorology.

Our astronomy section is constructed around volunteer "star parties" conducted in the evenings. Other astronomy activities are completed in a double laboratory period held once a week, or done over an extended period of time including on-going nighttime activities.

Astronomy begins with photography. This first activity, presented in September, interests students because most are fascinated with photography and because there is almost immediate application and positive reinforcement for their work. The photographic equipment documents and helps us share experiences. Students develop and print their own photos in the class darkroom.

Our star parties are also popular. One of the first things we accomplish is to prove the rotation of the Earth. Long-exposure photography of 15 minutes or more, at night, with the camera on a tripod, allows students to make valid conclusions about the motion of the Earth. Throughout the year reference points and positions of constellations are recorded and kept for comparison purposes to prove the revolution of the Earth.

Students graph the ascension and declination of stars in the major constellations on polargraph paper. The chart is then used during our star parties.

"Rotation of the Sun," an activity carried out over several days, uses telescopes set up in the classroom. The sun is observed and data on the position and shape of sunspots are collected on a daily basis. This leads to observations and conclusions on sunspot activity, cycles, and the rotation of the sun. Then students use similar triangles and a proportion equation to find the diameter of the Sun and sunspots. A pinhole in a cardboard box projects an image of the sun. The distance of the hole from the image and the distance of the sun from the card are proportional, and so is the diameter of the image to the diameter of the Sun. Students then use their calculated diameter in another proportion equation to find the size of sunspots shown in a photo of the sun in their book.

Students also plot the position of Mars on the celestial sphere for several months to see the looping orbit it goes through. This helps them understand why, when we observe the planet in the night sky, it seems to move backwards. The concept of orbital movement is also made clearer. Although we have not yet done this as a group, this activity can be done using the students' data collected during star parties.

Geology emphasizes our regional environment, covers topics ranging from glaciation to rock formation, and begins with five teacher-made filmstrips of the local area. Learning activities in the geology section use a double lab period once a week.

In "Identification of Igneous Rocks" students learn the basic characteristics of minerals and simple tests to identify them. Then, in a laboratory situation, they identify about 12 common minerals. In another activity, "Identification of Second Generation Rocks," students identify the rocks common to their region, both sedimentary and metamorphic.

Regional maps and maps of the Bright Angel Quadrangle of the Grand Canyon, and Stone Mountain, Georgia, are compared to help students recognize the differences between rejuvenated, mature, and old landscapes.

Data collected from three seismic stations during the formation of Surtsey, near the coast of Iceland, are analyzed and the epicenter located. This laboratory is an excellent introduction to the concept of ocean-floor spreading and plate tectonics.

Energy, with its associated economic, political, social, and environmental questions, is studied in depth, and with emphasis on local impacts. Coal mining and the resultant acid drainage and acid rain pollution are addressed, as is the future of nuclear energy. Three-Mile Island and the Berwick Installation are studied closely and offer examples of the effects of energy issues on this region.

Students plot the changes in the use of coal, oil, gas, nuclear, solar, wind and geothermal power over the last 50 years and make predictions about energy use in the future. This activity takes several days, and exhibits the local economic and environmental importance of coal and nuclear energy.

The meteorology unit emphasizes the observation and analysis of local weather elements and how they can affect us—as Hurricane Agnes did during the flood of 1972.

"Local Weather," an on-going exercise, finds students assigned, on a daily basis, to observe and record the weather elements of temperature, pressure, wind direction and speed, humidity, and precipitation. Students plot their data on a base U.S. map. Then they draw in isobars and predict the weather in our area for the next day. Because this is real data, they can check their prediction for accuracy.

Our weather predictions lead to a discussion of why the 1972 flood was such a disaster when the hurricane did not do as predicted. Many students' families were affected by this flood. It is usually an interesting series of sessions.

Equipment and Materials

Our classroom design is ordinary, but adequate. It has long tables, which seat three students each, and a few sinks along the wall. We also have a well-equipped darkroom which includes an enlarger.

Our other major pieces of equipment are the telescope and camera. The type of telescope is not critical, but one with a clock drive makes work easier and faster.

Most of our rocks and some minerals were collected locally, while maps were purchased from the U.S. Geological Survey. Our major resource for the geology section is the Pennsylvania Geological Survey. Several times a year they put out the booklet "Pennsylvania Geology," listing programs, maps, and current research being done in all fields of geology in Pennsylvania. This information opens up to teachers and students the tremendously diverse and interesting geology of the region. Because every state has its own survey, these publications would be an easy addition to any school curriculum. The Pennsylvania Geological Survey offers educational booklets and outdated topographic maps, in quantity, free of charge to teachers. The environmental science program at a local college has established good research laboratories for weather and air quality testing and an observatory for night-sky activities.

Because this course is not sequential, it could fit anywhere in a science program; yet, we feel it's in the right place. It lets those students with an interest in science discover early the importance of math as a tool, and stimulates their interest by getting away from memorization of definitions as a substitute for scientific inquiry. Because many of the laboratory write-ups and tests are essay in nature, one of the first things these students realize is that to succeed they must communicate well through the written word. The English department of our school works with us to teach students basic writing and communication skills.

Evaluation

There are always more students who sign up for this course than are academically ready to take it. But there is great motivation for the students to do well and it is unusual for "C" work to be done. The course has a reputation for being difficult, but interesting. Student success stems from the opportunities to explore the immediate natural environment and from enthusiasm.

Perhaps the best evidence of the program's popularity is the high attendance, averaging about 40 percent, at the voluntary star parties. After-school sessions are also well attended and, students sign up to use the darkroom during their free time.

Students are graded on the laboratory exercises they do as part of the course and also on tests for each new topic.

Twice a year inclusive semester tests are given. The success rate is high.

It is difficult to compare this course to others because of its specific limited content and the fact that the students opting to take it have already proven themselves capable of handling an accelerated course. Therefore, the only continuing evaluation process for the program, outside of what has already been mentioned, comes from our opinion that the course is progressing positively.

Plans for Improvement

Our major problem comes from the specific design of the course. Because the field of Earth science is so vast, this course presents only those parts of the discipline that manifest themselves in the local environment. Therefore major branches, such as oceanography, and specific topics, such as wind erosion, are not covered because of their lesser importance in the geology of our region. There is no immediate solution to this problem. Ideally, in the future, another course could be designed to deal with important topics that are omitted in this first course.

Perhaps the key to the high activity level and excitement about the course is the teacher's enthusiasm toward the subject and the students. If a teacher lost enthusiasm, the extra-curricular activities, a vital part of this course, would stop.

To help combat this and keep the course fresh, new student activities are constantly being developed. This year, color slides by students became part of the course and a new laboratory was developed that has students work out the orbit of the moon (Earth-moon-sun placements) by using at least eight different photographs of the moon in one month with the accompanying pertinent data. During the appearance of Halley's Comet, the astronomy section will change dramatically to emphasize this once-or twice-in-a-lifetime phenomenon. I stay fresh by thinking about our course, seeking new ideas, and trying to implement units and activities that will excite students and lead them to learning.

Chapter 6 Earth Science for the Twenty-First Century

Robert Groover and Robert Lewis
Hanby Junior High School
2523 Berwyn Road
Wilmington, Delaware 19810

The Brandywine School District is located in the smallest and most populated of Delaware's three counties. It has 400,000 residents with a wide variety of ethnic, cultural, and racial backgrounds. In New Castle County, high-to middle-income families typically live in the suburbs and low-to-middle-income families live in the city of Wilmington.

Wilmington is the corporate headquarters for chemical industry giants Du Pont, Hercules Powder, and ICI America, Inc.; New Castle County also hosts the National Guard of Delaware and General Motors and Chrysler assembly plants.

In 1978, a dramatic change occured in the organization and structure of our public schools: eleven school districts, including the Wilmington public schools, were merged to form one system—the New Castle County School District. The order called for busing students from the predominantly black Wilmington schools to the predominantly white suburban schools. Under this plan, all schools would consist of 75 percent white and 25 percent black students.

The New Castle County School District was divided into four area school districts. This organization remained in effect until 1981 when the four area school districts separated. Area I schools became the newly named Brandywine School District, which now consists of four high schools, three junior highs, ten elementary schools, and two special schools.

As a result of the desegregation policy, many white students were withdrawn from the public schools. The declining enrollment and the consequent reduction in financial resources to public schools changed the mood and climate of northern New Castle County, particularly for parents with school age children. However, the initial, strong emotional concern about student safety is now changing to a growing interest and concern about the quality of education in all the schools.

History of the Program

Since the early 1960s our science department has been involved with curriculum innovation. At that time, Earth science became a specific course in its own right, and, in its infancy, was taught mostly using teacher-demonstration techniques. Through the years, with programs such as the Earth Science Curriculum Project and Time-Space-Matter, more student involvement has occurred. This continues to be the major direction for program improvement.

During the fall of 1982 and spring of 1983, under the charge of the district school superintendent, the assistant superintendent, and the director of secondary education, meetings were conducted with science department chairs to upgrade our science curriculum. Present at each of the meetings, serving as a consultant and advisor, was the state supervisor of science and environmental education During this time, a number of parents and scientists from the industrial and technological sector met with us to discuss our curriculum and its relationship to the community; later, they helped write curriculum guides. Teachers involved in the meetings came away refreshed and charged with the responsibility of providing a quality Earth science program for our students. All teachers were paid for their time during the course of the meetings.

We have received enormous praise from students and parents for maintaining and expanding the laboratory-oriented Earth science program in our school. While rewriting the curriculum has greatly improved the Hanby program, consistent support from the administration, community, and teachers has always been critical to the program's success. The administration approved and supported the curriculum design, the in-service teacher training, and the development programs; their financial commitment was crucial as well.

Teachers involved in the establishment of the program showed knowledge of proposed instructional content, experience in teaching many of the components, and a personal commitment to developing the program.

Our Program

Hanby Junior High School's Earth science program, at the eighth-grade level, averages 24 students per class. It is taught within a rotating seven-period schedule and meets at a different hour each day for 45 minutes. Homogeneously grouped classes at three levels provide ample opportunity for student success and motivation.

We have developed a program in Earth science education that includes a new approach to the arrangement and emphasis of Earth science education goals. Although concerned primarily with providing a high-interest science content, our program also tries to instill in students curiosity and awe toward their world and the confidence (through knowledge) needed to deal with it.

Much of the success of the program at Hanby can be attributed to the students. They are lower-middle to lower-upper income families and 70 percent are motivated enough to select three years of science after completing the eighth-grade Earth science course. Our students are meeting the following goals we have set for them:

- Developing an appreciation for the advantages of scientific knowledge and literacy.
- Understanding the history of scientific discovery in relation to the career efforts of living persons.
- Recognizing the value of scientific research in making our lives more productive.
- Discovering that the study of science can be fun, profitable, and mind-expanding.
- Learning that scientific knowledge belongs in the mind, not just in the laboratory.

The program offers core continuity through ten major themes. These themes, though traditional in nature, reflect an awareness that old themes must have a new emphasis on, and be presented in, a personal-social context; topics must match the interest, experiences, and career aspirations of the middle/junior high school student.

The Hanby Earth science program covers geology, meteorology, oceanography, paleontology, astronomy, and space science. Specific topics from the curriculum are presented through discussions in which students' ideas are sought. Teachers accept many ideas and ask many questions. We often introduce curriculum areas with an appropriate film. Following a film presentation, there may be a discussion on the content and meaning of the presentation, and how it relates to class ideas. Teacher-led field trips to local areas of scientific interest often round out a given topic. Throughout the program, teachers interact with administrators and colleagues and review curriculum and instruction-related materials.

Specific Activities

Field trips play an important role in our curriculum. Students spend 15 days each year on field trips that range from a three-day overnight field study to one-day museum visits. These trips use the natural environment and community resources to provide students the opportunity to apply what they are learning to real life. In addition to the three-day field study trip to Camp Arrowhead, other field trips include visits to: the National Aquarium, Baltimore, MD; Maryland Science Center, Baltimore, MD; Franklin Institute, Philadelphia, PA; Hagley Museum, Wilmington, DE; Mt. Cuba Observatory, Wilmington, DE; and Smithsonian Institution, Washington, D.C. We also make a fossil collecting trip to the Chesapeake and Delaware Canal, conduct a study of Delaware's coastal environment, through a program written by two members of Hanby's science department, and study a local stream.

In addition to field trips, students spend a lot of time performing hands-on activities. Most of our study topics have accompanying student laboratories.

- *Evolution* Students observe and describe variations within a species, explaining why species variations are necessary for an organism to evolve.
- *Hydrologic Cycle* Students observe in the hydrologic cycle different processes and percentages involved in the transformation of the states of water. They predict what effect a change in the size of soil particles will have on the amount of water the soil can hold and the rate at which water can move through it. Students also use Wilmington water budget graphs and Brandywine River flow charts to identify periods of water shortages and forecast floods.
- *Equilibrium* Students describe the relationship between heat energy and temperature change as water changes state in the water cycle.
- *Weather* Using data collected during their weather watch, students determine the altitude at which clouds form.
- *Distribution* Students describe and test relationships between heat, energy, and temperature as water changes state by using the data collected in their energy laboratories.
- *Transformation* Students investigate changes in energy forms.
- *Quantity* Students investigate some physical properties of the Earth, sun, and moon, such as density layers, to show the similarity of materials between these solar bodies.
- *Conservation* Students devise solutions for resources problems, and describe the roles of government, industry, schools, and private citizens.
- *Water Usage* Students explain the effect of organic wastes on fresh water bodies.
- *Interaction of Technology* Students use the computer in weather analysis, hurricane tracking, star constellation locating, space travel, and rock and mineral identification.

• *Population Growth* Students investigate population growth and the dangers of overpopulation.
• *Volume* Students describe the nature of the Milky Way galaxy and its position in the enormity of space, and compare it to other galaxies.

Hanby's science facilities have been cited by the state of Delaware as exemplary. Three rooms, designed by Earth science teachers specifically for Earth science, have, besides the usual lab equipment, special features such as built-in stream tables, mineral exhibit cases, and a special weather instrumentation area.

Parent support at Hanby runs high; they aid the staff by raising money for field trips, assisting in curriculum development, and promoting public relations when we have our Brandywine-On-Review Program. Often, parents give guest lectures and chaperone field trips. Local businesses provide equipment and guest speakers. The Du Pont Company has shown tremendous support by sponsoring one teacher from each of the 3? schools in New Castle County to attend the 1984 and 1985 NSTA National Conventions.

Many members of the department are involved in professional organizations. Our chairman was the first middle/junior high school director of NSTA and we are all members of the Delaware Teachers of Science; four of us have served as officers in that organization. In addition, two department members have chaired NSTA committees. Through professional organizations, the department stays abreast of current trends in science teaching.

The Brandywine inservice program is also a great help to Hanby. Teachers, with the approval of the principal, attend professional meetings, conventions, and special field trips sponsored by the school district.

One of the biggest factors contributing to the success of the Hanby Junior High School Earth science program is the freedom teachers have concerning what to teach and how to teach it. Our staff has a large and well-organized curriculum guide. Teachers organize their classes and select activities and strategies that will best meet the needs of their students.

Evaluation

Each year our students are tested as part of a statewide program. Hanby students as a group have placed either first or second in the state of Delaware each year. In 1983 and 1984, eighth-grade science students participated in the Science Olympiad at Delaware State College and received top honors.

As part of the district-wide evaluation program, our teachers are formally observed every year. Through observation results and our own ideas we constantly change our program.

Our model is being used throughout the district, and the program is transportable because of the way the curriculum guide and investigation activities were prepared. A good teacher with a well-developed rationale could easily use our materials.

Plans for Improvement

One of our concerns is the lack of articulation between the elementary and secondary schools. We have little information concerning the background of incoming students. This information would enable us to adjust our teaching to better assist our students. Despite this, our data indicate that students are achieving the objectives of the Earth science program.

Improvement steps currently underway in the district include an upgrading of elementary science education, a more sensitive in-service program geared to the needs of teachers, funding of science aides for the secondary system, and increased funding for laboratory materials. These activities must continue in order to keep this exemplary program healthy and growing.

We hope an ongoing refinement will occur through continued outside interest from other school districts. For, while the Search for Excellence in Science Education was initiated at the national level, improvement in Earth science education must occur at the local level.

Chapter 7 Indoor, Outdoor Earth Science

Bob Frank
Jefferson Junior High School
Caldwell, Idaho 83605

Caldwell, Idaho, a small agricultural community in the Snake River Plain of southwestern Idaho, has a population of less than 20 000.

The community and the school board are supportive of student and teacher activities in education, music, and athletics. With enrollment a little over 4200, most of our students are from the surrounding rural areas.

I have designed an Earth science program in which a young person can enjoy and learn about the wonders of nature through color slides and films and actual field trip experiences. I advocate activities that promote a hands-on and inquiry approach to learning. Two outstanding science teachers made an impression on me in my science education. Don Haynes of Meridian High School and Terry Armstrong of the University of Idaho not only taught me the facts and methods of science but also taught me that learning can be fun and that laughter is permitted in the classroom. I want to teach my science classes in the same way that these two did for me.

Our Program

Earth science is a required course at the ninth grade level. Along with the other secondary science courses, it is part of a strong science curriculum.

My main concern is that students gain an understanding and awareness of the environment around them. They need to know they live in a finite world with limited resources, and that as individuals they can have a positive or negative influence on the well being of "spaceship earth." A population literate in science should be the primary goal of all science educators. Students must understand the nature and usefulness of science.

Our Earth science year begins with a study of the scientific method and the processes of science. I attempt to get my students to view the Earth from space, and discuss the concept of spaceship earth and the need to see shapes, sizes, and patterns on the Earth's surface. This leads them to a study of mapping, map reading skills, and mapping techniques.

The next lessons present Earth chemistry, minerals, rock types and the rock cycle, mining, diastrophism, plate tectonics, earthquakes, and volcanoes. Earthquakes is one of my favorite Earth science topics to study and teach. I begin the discussion of earthquakes and then ask for student input. Students give me their first impressions of what the word means to them. I ask if there are any students who have had the personal experience of "surviving" an earthquake. They share with their classmates what went through their minds during the quake. This is a little easier now since the October 28, 1983 Challis earthquake in Idaho (7.3 on the Richter Scale).

I develop the topic by presenting data on transparencies about severe earthquakes during the past 1100 years. This is followed by a short discussion of the historic earthquakes, including the 1906 San Francisco earthquake, the 1959 West Yellowstone/Hebgen earthquake, the 1964 Alaska earthquake, and the 1755 Lisbon, Portugal earthquake.

I compare the loss of life from other natural and man-made disasters and have students interpret the data in a variety of ways. We discuss what to do during an earthquake so students and their families can survive such a disaster. Students plot the epicenters of 100 earthquakes on a world map; this gives them an overview of earthquake occurences and an opportunity to see what patterns exist. Once patterns are recognized it is an easy step into the study of plate tectonics and active volcanic areas.

After focusing on the world earthquake picture we move to the U.S. From data provided, my students color maps according to guidelines that will make the patterns evident. This is a fairly good activity; but to take it a step further, they copy a map of the United States from an overlay transparency that shows the most active seismic zones. This is a more accurate map that enables the students to get a better idea of the location of earthquake zones in the USA. My students also do a seismic map of the state of Idaho. Notes are given about earthquakes and diagrams of major folds and faults. We also learn how to read and understand the Richter and Mercalli scales.

A slide presentation is given covering historic earthquakes. The film *San Francisco—A City That Waits To Die* is an excellent introductory film for the study of earthquakes and plate tectonics. I use several of the Crustal Evolution Education Project (CEEP) modules on the spreading of the ocean floor and plate boundaries to enhance the study of earthquakes and plate tectonics.

In the second quarter of the school year we cover the hydrologic cycle, mass wasting, weathering and erosion, and weather. The hydrologic cycle includes the study of rivers, lakes, oceans, groundwater, and glaciers.

In the third quarter of the year students study deserts, ecology and the environment, and fossils, geological history, and time.

The last quarter of the school year, when the weather is warm, is devoted to astronomy. Students make an in-depth study of the solar system, constellations, galaxies, nebulae, and other topics. Lunar samples from the Johnson Space Center in Houston, Texas are a high point in our study of the moon and the Apollo Space Program. Evening astronomy programs and field trips to local and nearby planetariums are offered. I also teach a section on space travel and the USA/USSR space programs. For those students interested in model rocketry I sponsor a model rocketry club in which we build several rocket models from the Estes Model Rocket Corporation.

Armchair field trips are enjoyed in the classroom through slide presentations about western national parks. During the past nine years, I have had the privilege of taking over 600 students and 40 teachers more than 18,000 miles to many of these parks, including Glacier, Yellowstone, Grand Teton, Grand Canyon, Bryce, Zion, Yosemite, Crater Lake, and Mt. Rainier.

Many of my lab activities come from the Earth Science Curriculum Project (ESCP) and CEEP. Filmstrips, cassettes, and overhead transparencies also enhance the course.

I use as many "inquiry" and "hands-on" labs and activities as I have time for with each topic. Students must take an active part in learning Earth science. I field test every lab, activity, or assignment that is given.

Building vocabulary is a must, and I encourage it by review and slide identification. After completing laboratory assignments, students learn new words easily.

Equipment and Materials

Jefferson Junior High was built ten years ago and our six science rooms were well planned to accomodate a full laboratory-oriented science class. The rooms have separate lecture areas with desks and completely furnished lab areas with sinks, running water, and lab tables and chairs. Each of the science rooms has plenty of cabinet space and a separate storage room. My room has eight glass wall display cases filled with specimens such as fossils, rocks, minerals, and seashells. I'm a firm believer in the use of audiovisual tools in education. Most of our Earth science textbooks had only black and white pictures, so I began suplementing my program with color slides. Now I have a personal and school collection of over 3,000 slides covering a range of geological subjects from earthquakes and volcanoes to astronomy and the national parks.

The Public Broadcasting System supplies me with a large variety of special Earth science films. My course is also supported by tapes from such programs as "Cosmos," "Nature," "Nova," "Earth Explored," "Making of a Continent," "Life on Earth," and "The Living Planet." Additional programs are NASA releases.

For effective audiovisual presentations, good equipment is needed. A 16mm film projector, a filmstrip projector, a cassette recorder and a good quality overhead projector and screen are all necessary pieces of equipment.

Evaluation

For the past three years, Jefferson Junior High has been recognized for its outstanding programs by the Secondary School Recognition Program. Our school is the only one in the state of Idaho to be so honored three years in a row. The school has also achieved national recognition. My classes are a composite of students of all abilities, and fill up quickly during pre-school registration.

The students' grades are determined by the quality of their work on quizzes, tests, homework, laboratory activities, extra points earned in class, review work, and projects. An overall average is taken to figure grades; however, an individual's abilities and weak and strong points are taken into consideration. I believe that an overall average best reflects the student's true grade. I compile the grades according to the school district's grade scale, and find most students to be very successful.

Plans for Improvement

One weak point in my course is a lack of computer-oriented Earth science materials. Our science department does not have a computer nor do we have anyone adequately trained to run and teach science programs on the computer. We are making plans to change this in the next few years.

To make sure I am meeting student needs I ask for their input. Student criticism helps me to be more aware of their needs and find out where my program's strong and weak areas are. I am not so rigid with my program that I cannot adjust to changes that are dictated by outside circumstances, and I always try to be flexible in my scheduling. My course is constantly being revised, and is kept practical, relevant, and up-to-date in the best interest of my students.

Chapter 8 Middle School Earth Science

Carolyn Farnsworth
Wellington School
1822 Fishering Road
Columbus, Ohio 43221

The Upper Arlington School District serves one of 24 suburban communities forming the greater Columbus metropolitan area. Located in central Ohio, this area has a stable economic base due to its diversification and emphasis on information-related industries rather than manufacturing.

Upper Arlington itself has 42,000 residents. Among the adults more than 95 percent are high school graduates and more than 50 percent are college graduates. Most residents work in governmental, managerial, technical, or educational capacities, earning an average family income of $34,000.

With very few businesses and industries located within the city limits, the revenue available to the schools is almost all from property taxation. Sixty percent of our teachers have a master's degree or higher and expenditure per pupil is approximately $2800.

Our district has a four-year high school, two middle schools, and six elementary schools. The total school enrollment exceeds 5500 with a pupil-teacher ratio of 18 to 1 (excluding non-teaching-certified personnel).

Approximately 300 academic and vocational courses are offered to students in grades 9–12. There are concurrent university studies for accelerated students, as well as foreign exchange and travel study programs. A full range of services and classes for gifted and handicapped students is offered. The career education program is a nationally recognized K-12 program which includes internships, exploration activities, and opportunities for a student to observe a typical working day of a chosen professional. At the elementary and middle school levels, students may enroll in either regular, contemporary classrooms or informal classrooms. The informal classrooms are arranged around learning activity centers that emphasize individual learning styles and teachers work mainly with small groups and individuals.

Students are very successful scholastically and athletically. Eighty-five percent of Upper Arlington graduates attend college and at least five to six percent more continue their education with vocational or technical training.

Program Philosophy and History

The philosophy of our K-12 science curriculum stresses that education will be successful only if each individual can develop a positive attitude toward learning. To bring this about, we offer a variety of learning modes so students can learn in the manner in which they learn best.

We believe science provides experiences where learners can actively develop their attitudes and critical thinking. Science is a flexible method of inquiry that lends itself to individualized learning and reasoning strategies that have application beyond the confines of the discipline.

This philosophy complements the components and objectives of our K-12 science curriculum. Components include the nature of science and its values, the processes and concepts of science, science and society, interest in science, and manipulative skills. Our Earth science objectives focus on the process and concepts of science and instructional units. These objectives are determined by means of a three-dimensional matrix that incorporates the processes of science, the concepts of science, and the instructional units as separate axes. For example, the objective that students should be able to describe the apparent motion of the stars at night and through the seasons was determined by the cell resulting from the intersecting of the observing process, the change concept, and the astronomy unit of instruction.

The process components of the Earth science program include expected student outcomes, which are used as guidelines and can be adapted or replaced by the individual teacher. The following is a list of processes and their expected outcomes:

- *Observing* involves one or more of the senses in a personal experience. When direct observation is inadequate or impossible, indirect methods are used. As an outcome, the student recognizes cause and effect relationships after observing related events.
- *Measuring* develops a comparative or quantitative description of such properties as length, area, volume, weight, temperature, or pressure, using standard and nonstandard units. The outcome is the ability to use direct and indirect methods to measure precisely.
- *Communicating* develops students' ability to write or speak. Students learn the use of communication skills that help them work as a group and use data to support their inferences or predictions.
- *Inferring* involves reaching conclusions on the basis of observation and/or past experiences. Realizing that inferences may need changing on the basis of additional observations is the expected outcome.
- *Predicting* involves arriving at future observations on the basis of previous information, rather than guessing. The outcome of predicting is that students base future observations on valid inferences and use interpolation and extrapolation to make predictions from trends in data.
- *Questioning* has students expressing their queries based on the perception of a discrepancy between their observations and what is known by the questioner. As the outcome students are able to state questions in such a way that they can be answered experimentally.
- *Hypothesizing* involves stating tentative generalizations used to explain a relatively large number of events that are subject to immediate or eventual testing by one or more experiments. The outcomes are learning to modify hypotheses on the basis of controlled experiments and realizing the relationship between hypothesis, theory, and law.
- *Experimenting* has students plan data gathering that will provide a basis for testing a hypothesis or answering a question. As a result, students can design and conduct a series of controlled experiments to evaluate the effect of more than one independent variable.
- *Processing and interpreting data* helps students seek patterns or other meanings inherent to a collection of data, and leads to stating a generalization. Through this, students become familiar with the uses of mean, median, and range in processing data, and identifying patterns in data organized in tables and graphs; from these, they make generalizations.
- *Formulating models* involves the building of a mental, physical, or verbal representation of an idea, object, or event as a basis for explanation and interpretation. Models may be used to communicate information, demonstrate the relationships of subjects, or express abstract ideas. The outcome is that a student can adapt or modify a model to solve a problem.

The present and continually evolving Earth science program has resulted from the philosophy that students at the eighth grade level can learn better and can be more highly motivated through hands-on instruction. The development of the Earth science program from a textbook-oriented course to an individualized hands-on approach and an exemplary program has been the result of individual teacher commitment. The developmental progress was facilitated by a number of mechanisms.

One mechanism was teacher enrollment and participation in university courses, predominantly at Ohio State University (OSU). OSU and Upper Arlington City School District have a reciprocal arrangement involving a student teacher training program. The district's teachers can attend classes tuition free and salary schedules provide pay increments for graduate work beyond the bachelor's level and through the doctoral level. Many of the university courses are designed by enrolled teachers to meet such immediate needs as unit development, classroom management strategies, and current topics within the science disciplines. The teachers can update their knowledge of Earth science and also have an immediate product to use in the classroom. In return, the extensive field-based student teacher training program at Ohio State University assigns student teachers within our district. In addition to the obvious benefits for the student teachers in such a program, the placement of student teachers and their supervisors in the classroom promotes an interchange of ideas and an atmosphere of constructive self-evaluation. This situation promotes not only the development of sound instructional practices but also the identification of successful classroom activities.

A second mechanism was the active participation by department members in both the development and field testing of such science programs as the Earth Science Curriculum Project, the Ohio Project for Unified Science Education, the Ohio Sea Grant Project, and the Crustal Evolution Education Project. Participation in these programs offered valuable experiences in the development, implementation, and testing of instructional materials.

Inservice training and staff organizational structure set up by the administration through the building principals was a third mechanism. The Earth science program is one part of an interdisciplinary team teaching approach implemented in this district. Within this approach, a team of four teachers representing mathematics, Earth science, English, and American history has responsibility for a block of approximately one hundred eighth-grade students for four school periods. This team has the flexibility to schedule students and plan student activities. The team members share a planning period and are encouraged to develop units that are exemplary for their subject area and facilitate the transfer of skills and concepts from one academic area to another. This interdisciplinary and holistic approach to teaching is an area of strength in our program.

A fourth mechanism was the development of a K-12 science curriculum guide. During the preparation of this guide, all teachers were actively involved in its evolution.

The final product not only serves as a reference for the district's teachers, but has been used as a model by other school districts. The curriculum guide states the science department's philosophy and the major components of science, and includes a K-12 scope and sequence, instructional objectives, a list of required and optional units for each course, objectives for each unit, an exemplary activity for each unit, the materials and resources available for implementation, and a suggested method of evaluation or an evaluation instrument. The process involved in producing this guide and the one that will be used in subsequent revisions employs a systems approach which defines the current status of an evolving program and focuses on the direction for continued evolution.

The Earth science program continues to evolve and change because each of the four mechanisms is in place and active.

Our Program

The Earth science program in the two Upper Arlington middle schools, part of an overall interdisciplinary program, is the eighth-grade component of a mandatory middle school science sequence. General science, with major emphasis on life, Earth, and physical sciences, is taught in the sixth grade, and life science is taught at the seventh-grade level. Each middle school science class meets five days a week for 42 minutes and includes laboratory experiences.

The Earth science faculty consists of eight teachers. Seven have taught Earth science in the Upper Arlington system from 12 to 17 years. All have a Master's degree except one who has graduate coursework beyond the bachelor's, and one who has a Ph.D. in education.

Concepts covered by one or more of the Earth science units include:

- *Cause-effect* a relationship of events that substantiates the belief that nature is not capricious. Once established, it enables predictions to be made.
- *Change* everything is in the process of becoming different The rate at which it occurs varies from fast to slow so that it may be unnoticed.
- *Cycles* the pattern in which events or conditions seem to be repeated at regular intervals.
- *Energy* that which enables something to be moved or changed.
- *Matter* any material that has mass and occupies space and exists in the form of units which can be classified at different levels of organization.
- *Equilibrium* the state in which opposite directions exist or happen at equal rates, or rates of the same magnitude.
- *Evolution* a series of changes that explains how something arrived at its current state or what it might become in the future.
- *Force* a push or pull.
- *Model* a tentative scheme or structure that corresponds to and explains a real structure, event, or class of events. A model includes theory and scale.
- *Patterns* include the idea of symmetry.
- *Organism* a dynamic system th at is characterized by the process of life.
- *Probability* the relative certainty (or lack of it) that can be assigned to certain events happening in a specified time interval or sequence of other events.

Our instructional units are the traditional units of astronomy, geology, meteorology, and oceanography. In addition, individual teachers have selected topics from these broader units or grouped certain concepts and processes to form additional units. Our teacher-developed units include using data, energy, discovering with instruments, and natural disasters.

Our adopted textbook is *Exploring Earth and Space* (Laidlaw Brothers, 1980). Other Earth science textbooks available include *Interaction of Earth and Time* (Rand McNally & Co., 1972) and *Investigating the Earth*, (Houghton Mifflin Co., 1973). Reference books and science magazines and journals are borrowed from the school and nearby public libraries and used with specific units. Some of the necessary reading materials are teacher-designed modules. All classrooms have subscriptions to *Current Science* and *Science World*, which are used for classroom assignments. Current articles from newspapers, magazines, and journals are posted and discussed. The Earth science department subscribes each year to the *Search for Solutions* film series and its accompanying activities.

A variety of teaching and learning methods is used—lecture, demonstration, class discussion, individual and group projects, laboratory activities and investigations, library research, audiovisual presentations, guest speakers, and computer drill, practice exercises, and simulations. Each teacher tries to maintain student interest and motivation by using more than one technique during a class period. Students are usually required to record data, complete questions, and maintain an organized notebook of assigned work.

We have many locally written or locally modified student activities. In Tin Can Planetarium students construct a simple device for illustrating the obvious constellations and brighter stars, in Identifying Minerals Using a Mineral Key students apply classification skills, and in Law of the Sea students simulate political problems involved in determining territorial limits. The success of activities in the Earth science program is probably the result of motivated teachers with excellent science backgrounds, interesting activities, and frequent sharing of classroom experiences.

Our curriculum helps students develop a knowledge of the major unifying themes of Earth science. The curriculum guide is oriented toward the traditional science topics which comprise the Earth science studies, i.e., astronomy, geology, oceanography, and meteorology. Yet, within these topics, the units include the major unifying themes, such as plate tectonics. Several teachers have crossed the topics with unifying themes, as in Instruments and Natural Disasters. In addition, relevant social topics such as energy and conservation of natural resources are incorporated into energy units, but do not appear currently in the curriculum course outline.

The curriculum helps the student to develop an understanding of, and an ability to use, the processes of investigation used in the Earth sciences. Most of the teachers use an inquiry approach to learning and units contain individual student projects as part of the course work.

All units of the Earth science curriculum encourage students to look at the social issues and make responsible decisions. The objectives and purposes of the Natural Disaster unit and the Law of the Sea unit raise national and global issues. Social issues are also addressed through programs such as the Women in Science Day, Project Business, career education speakers, science fair projects, and the Big Ear Campaign. The teachers are involved at the local, state, and national level with social issues as members of professional organizations.

Students develop appreciation for and critical attitudes toward science and technology as an integral part of society because this topic pervades all of the units. We try to prepare students for changes in life styles that we cannot now predict. The use of the computer and the modernization of the school's facilities have helped in this quest.

Our students are involved in Project Business, sponsored by Junior Achievement. The program brings community business leaders to the classroom to share their expertise in the business and economic systems. Because Columbus is a high-tech area, many of these speakers broaden the students' knowledge of technology. This project and the First Community Village Project raise student awareness of the world outside the classroom.

The faculty is aware of student needs and characteristics, and uses evaluation devices to determine academic strengths and weaknesses, developmental levels, personality, and learning styles. Students receive feedback to help them develop a positive self-image. Decision-making skills are emphasized in every unit through simulations, debate, discussion, individual student projects, and science fair projects. The students often decide how and what to learn in order to solve the problems they are given. As we move further into the information retrieval era, students are taught to use the library and the computer. Each school has 10 microcomputers. The computers are constantly used by students for word processing, and for commercial and teacher-developed software programs. One Earth science room has a permanent Apple IIe and a TRS 90 PCII.

All Upper Arlington Earth science units include information about careers in science. Our textbook includes career information at the end of each unit. Guest speakers and magazine articles also make the students aware of career opportunities.

Teachers who lead workshops, write for professional journals, win national honors, and assume leadership in professional organizations serve as role models. Students are made aware of special summer programs offered by Ohio Wesleyan University, OSU, Miami University, Ohio, and the Center of Science and Industry. The key to maintaining interest in a career in science is helping students maintain positive attitudes.

Plans for Improvement

As with all programs, there are some weaknesses in the Upper Arlington middle school Earth science curriculum. There is a need for improved communication among the teachers at the two middle schools, and for greater involvement with the scientific community as a resource for materials, knowledge, and opportunities for student placement. To tap this network, one of the teachers is a member of the operating council of the 35th International Science and Engineering Fair.

Other weaknesses are the time constraints and community expectations of a discipline-oriented course. It is often impossible to go into as much depth as a teacher might wish on an issue simply because of the pressure to complete all units of the curriculum.

The location of the community makes it difficult to develop positive attitudes and empathy for social issues which are not a part of the community and which seemingly do not affect it directly. It is also difficult to adapt some Earth science topics and themes to the developmental level of the middle school student. The curriculum guide is being revised to reflect the needs of students at this level. Presently, the curriculum guide does not state career information as a specific goal. This will be addressed during the revision.

Implementation and Maintenance

There can be no doubt that the Earth science program in the Upper Arlington schools will continue to improve when one examines those factors which have contributed to the success of the program. Each building has a science department chairperson who supervises the department budget and expenditures; serves as a liaison between the secondary science coordinator, department members, and building principals; and supervises the Upper Arlington Science Fair.

The secondary coordinator has a variety of responsibilities for the science programs in grades 7-12 and works with the elementary science coordinator to maintain the K-12 science program. The secondary coordinator's duties include curriculum and staff development, budget, and communications among the staff members of the 14 different secondary courses. The science coordinator receives one-half hour per day for coordination duties and a yearly salary increment. The science coordinator and the department chairpersons are jointly responsible for the maintenance and improvement of the science program. The evolution and implementation of this exemplary program is the responsibility of and the product of the Earth science staff teachers.

The expandable budget for the science department is administered through each building. The Earth science program is budgeted at approximately $2.50 per student per year. In the summer of 1983, the board of education allotted $200,000 to renovate the Earth science classrooms in both buildings. The size of each Earth science room was doubled by joining two existing classrooms and, to better accomodate a hands-on instructional program, each classroom was designed to have peripheral student lab stations. Wall cabinets improved the storage capability and a small room was converted into a shared storage space.

The community also helps to maintain the program. Two years ago, when funds were not available to develop an oceanography laboratory, the staff sought and obtained funding from the local Kiwanis Club. Several programs have been implemented because the staff successfully applied for PRIDE and Career Education grants. The teachers lobbied the board of education to get funding for room renovations and served on the committee which designed those renovations. Community support for science programs has been encouraged by having residents work with the science fairs and with other classroom activities.

The Upper Arlington middle school Earth science program has already been transported to other communities. The K-12 science curriculum guide has been published and sent to all school systems requesting it. Also available are the sample activities developed by the Earth science faculty. Staff members hold leadership positions in many professional organizations and have disseminated materials through that network. The school, and its science program, was a visitation site for participants at the National Middle School Convention held in Columbus in 1985. In addition, the program and its activities have been disseminated by the approximately 50 science student teachers who have done their practicums at Jones and Hastings Middle Schools and then gone on to other teaching assignments.

A real strength of this program is its flexibility. Activities can be expanded, contracted, and modified to meet the needs of the student body and the resources available in any community.

Evaluation

Upper Arlington students take standardized achievement tests only at the beginning of the fourth and eighth grades, so no standardized testing information is available about the success of the Earth science program. Instead, the teachers have built pre-testing and post-testing into the program. After administering each test, teachers perform item analysis to determine what topics the students did not understand. Besides developing tests for each unit, some of the Earth science teachers use the Teacher-Image Questionnaire and the Science Evaluation Survey to evaluate their teaching skills. The teachers also evaluate subjectively with student feedback on individual units. Staff meetings and subject area meetings are also used for evaluation purposes.

There is a less than 7 percent failure rate in science among eighth grade students. Teacher satisfaction with the program is illustrated by the stability of the faculty. The excellence of the program is shown by its national recognition and the awards received by its faculty members. In 1983, the program was chosen as the middle school exemplary program by the National Association of Geology Teachers in cooperation with the National Science Teachers Association. An Upper Arlington Earth science teacher received a Presidential Award for Excellence in the Teaching of Science (one of only 50 in the nation) and a $5,000 grant from the National Science Foundation. That money is being used to develop materials for the Earth science program. She also received the 1983 Practical Application Award from the National Association for Research in Science Teaching. Two teachers have received the Outstanding Earth Science Teacher of Ohio award, and one of those received the Outstanding Regional (4-state) Earth Science Award.

Last year, the eighth grade team, in competition with high school teams across the state, placed third in the state of Ohio on the Ohio Test of Scholastic Achievement in General Science. One middle school was recently picked as one of nine outstanding middle schools in Ohio and is a finalist in the National Secondary School Recognition Program.

Chapter 9 Earth Science Program

Leroy Lee
James Madison Memorial High School
201 S. Gammon Road
Madison, Wisconsin 53717

In Madison, Wisconsin, a community of approximately 170,000 residents, more people are employed in professional and related service than in any other industrial category—approximately 38 percent. One study indicates 40 percent of the people employed work for the government. Madison has a higher proportion of people in professional service occupations than any other U.S. city with a population over 100,000.

Our school area consists of six elementary schools, two middle schools, and James Madison Memorial High School. James Madison, one of four high schools in Madison, has 1,799 students, and possesses the most homogenous student population of any of the four attendance areas. The majority of Memorial area residents are middle to upper-middle class. Only about four percent of our students are from low income families.

Program Philosophy and History

The science department of James Madison Memorial High School is dedicated to the development of the individual student, based upon interest and educational needs. Numerous assumptions are considered as functional parts of the operating department philosophy. These assumptions are listed below, but not necessarily in their order of importance.

A Student Approach Students are unique individuals, each requiring special attention to individual needs. Personal attention is a significant characteristic of our department philosophy.

Positive Attitudes Toward Science One of the major concerns of the science department staff is to develop positive attitudes toward science. We try to stimulate objective and legitimate questions about the impact of scientific technology. Critical and informed thinking and decision-making abilities are of great value to all students graduating from our school.

Scientific Literacy Students enrolled in science courses are exposed to facts and concepts relevant to the scientific world. Although the understanding of complex facts and concepts does not constitute a major emphasis in departmental courses, the understanding of at least minimal material is considered significant to the graduating high school student. These facts and concepts contribute to intelligent understanding of basic occurences in the natural world, and to the wise decision-making our society needs. Finally, a concentrated effort toward instilling a joy of learning is fundamental to the department's overall philosophy.

Course Offerings The science department course offerings are many and varied. We have courses designed to meet specific needs of high school students. Opportunities for students at all levels to experience different modes of learning within the course offerings are also available. Specialized courses and mini-courses individualize and humanize our science program. Students may take both college prep courses and courses which stand alone; this enables them to select program offerings which best suit their needs, interests, and career expectations.

Community Involvement A concentrated effort to involve the community in program development contributes to improved communication between the school and the expectations of society. Continual program evaluation and community feedback improves public relations and public support for our programs. The use of community resource people in science programs increases expertise and program opportunities in the classroom. Student opportunities to go out into the community for specialized learning experiences also contribute to the overall effectiveness of the science program.

Evaluation No instructional program is perfect. Consequently, a continual evaluation process, emphasizing both cognitive and affective aspects of the science program, is critical to the science department's operation. Evaluation keeps the staff in tune with the effectiveness of present day curricular materials and with expectations of new curricula.

Professional Activities A successful program involves continued professional involvement on the part of the instructional staff. Professional opportunities involving local, state, and national organizations and formal coursework increase staff awareness and involvement in new science ideas and programs. An important aspect of professional involvement concerns contributions made toward science education through participation in programs designed to further science education. Attendance at local, state, and national conventions, symposia, and seminars contributes to the development of our professional staff.

The Wisconsin Department of Public Instruction has identified six major themes and Earth science concepts and 60 concept variants to be used in curriculum development. The Memorial Earth science program components have been developed around these themes. The program provides a balance of themes and exposure to as many concepts as possible. We base our program on the assumption that concepts are important for general education and that teaching these concepts in a nontraditional manner increases student exposure to them. The concepts are continually reviewed and revised.

The Memorial Science Program attempts to further student scientific literacy and understanding of the nature of science in all courses. The major introduction to processes is covered in the laboratories of the Integrated Science course. Traditional Earth science-based processes are covered in all courses. Our courses, which reflect departmental philosophy and departmental objectives, stress attainment of background information and processes of investigation—not just traditional processes, but processes as they relate to social issues.

As part of the reorganization of the 9th grade curriculum, a Title IV grant provided funds for the investigation of the integrated science program in Wausau, Wisconsin. A second Title IV grant and local school district monies allowed us to adopt and adapt the Wausau curriculum for our 9th grade.

Curriculum decisions that led to our Earth science program were: (1) 9th grade science should be based on the integration of science concepts; (2) discipline balance should be provided in the introductory course; and (3) the mini-course program should be extended to all introductory science courses.

Our Program

Our high school science department developed goals for excellence in 1975 as part of a 10-year improvement plan. A five point action program was initiated to provide direction toward reaching those goals by 1985: science for all students, development of positive student attitudes toward science and technology, science literacy, and an awareness of the interaction between science and society. Data show that our goals are being met, and state assessment tests rate our students as above average. A large percentage of students, including minorities, take science beyond the required science courses.

The Earth science program at Memorial is designed to:

- involve students in science courses and outside activities at state and national levels.
- raise student consciousness about science and scientific processes to or above state levels.
- increase the number of women and minorities in science.
- increase student scientific literacy.

Our Earth science program involves more than traditional Earth science courses. In agreement with the Board of Earth Sciences of the National Research Council on the Importance of Earth Science in K-12 Education, Memorial has developed a program that will expose the largest number of students to Earth science concepts while still meeting other department objectives.

The science staff, through sustained inservice and professional activities, has developed an Earth science program instead of just Earth science courses. Our Earth science program consists of four components: (1) traditional Earth science courses; (2) mini-course opportunities featuring integrated science concepts with some stressing Earth science concepts; (3) integrated science, an introductory science course that includes Earth science concepts; and (4) out-of-class activities for grades 2-12 and the adult community.

Earth Science I This course is offered to students who have a strong interest in traditional Earth science. Topics for the first semester include: the determination and importance of geologic time; rocks, the rock cycle and rock families; earthquakes and modern seismology; and deformation and plate tectonics. Course enrollment in the last several years has averaged 50–60 students divided into two sections.

Earth Science II This course is offered to students with a strong interest in continuing study in the area of Earth science. The topics are student selected. Topics studied in detail come from the areas of geology, meteorology, oceanography, and field work. Course enrollment varies yearly from zero to as many as three sections.

Minicourses At the end of the first semester all students enrolled in Earth science, integrated science, biology I, and physical science may elect six-week minicourses. Each student may elect three. Minicourses are topical, and each integrates concepts from two or more disciplines.

One course studies development in the many life forms that have inhabited the Earth throughout geologic time. Students study seven or eight phyla of invertebrate fossils. Topics include fossil preservation, plate tectonics as related to species distribution, and identification.

Oceanography is offered as a mini-course, and topics include: how oceans evolve, how the continents arrived at their present configuration, and why the continuous flow of large rivers into the oceans doesn't cause them to overflow. We also take a speculative look at what the oceans hold for our future in terms of food, energy, and mineral resources.

Our astronomy minicourse surveys modern and historical astronomy. Major emphasis is placed on the planets, the evolution of stars, the constellations, the universe, and the history of unmanned and manned space flight. The high school planetarium is used extensively to show students seasonal changes in the night sky. Telescopes, the sun, the moon, black holes, and nebulae are also studied.

Ninth and tenth graders can take meteorology. We study how the energy from the sun is distributed over the Earth's surface, how the Earth's atmosphere helps distribute this energy, and how the interactions of air masses, humidity, fronts, and climate affect our lives.

In our development of the Integrated Science course, guidelines and parameters that deal with learning development, the relationship of science and society, the nature of science, the knowledge of geology facts, and teaching mechanics were devised. Approximately 400 students are involved each year.

All courses provide relevant career information through guest speakers. Speakers talk on Earth science topics, how they became interested in their career areas, and how they received their initial training. Field geologists and petroleum engineers have talked to students in the Field Geology/Ecology minicourse when the class visited the Good Hope Oil Field.

We are fortunate to have a large, well stocked and well staffed career resource center. The center provides information in the form of bulletins, computer searches, and books, and maintains attractive bulletin boards and other displays.

Out-of-Class Activities Our out-of-class activities programs usually involve 100 9th-12th graders, 800 2nd-8th graders, and 300-500 adults. A major objective of our science department is to involve students in non-class-related activities. This program involves traditional subjects and science-related leisure activities. While the objective relates specifically to Memorial students, in practice it includes grades K-12 and adults.

Those activities which involve Earth science include:

- *Explorations* a six-week after school course on such subjects as paleontology, taught by Memorial staff and students for elementary students in grades 2-3 and 3-4.
- *Fifth Grade Tours* are conducted by high school students. Each feeder elementary school sends four to six selected students for a half-day tour. The high school students set up and supervise activities such as rock and water density laboratories and manipulation of a planetarium projector. The fifth graders also spend time with the high school students in classes.
- *Young Scientists Conference* is held every two years for grades 4-7. Approximately 200 students attend, and presentations are given by Memorial staff and students and community members on many scientific topics. Some Earth science topics have been: forecasting the weather (with a TV weatherman), and Wisconsin geology, rocks, and minerals.
- *Elementary Teaching Program* for grades K-5 is conducted by high school students. Over the years this has been a major program involving several hundred student hours each year. Some of the Earth science topics covered are rocks, fossils, and weather.
- *Adult Lecture Series* is given every three years by Memorial staff. It is an evening lecture series which may involve field trips dealing with Wisconsin geology. As many as 100 adults have been involved.
- *Adult Planetarium Series* is presented by the planetarium each year and includes a series of afternoon and evening sessions for adults.
- *Science Club* usually has several activities a year that involve Earth science.
- *Porcupine Mountain Field Trip* takes students to this state park in Michigan on a four-day backpacking trip each year. Any Memorial student may participate, but no credit is given. Trip objectives relate to geology, geomorphology, and mining and mining issues of the Upper Peninsula. Elementary field trips are periodically conducted and developed by high school students. The one-day local field trips cover geomorphology and geology topics in addition to ecology and biology.
- *Local Career Conferences* are attended by interested high school students and supervised by staff members. The conferences are general, but most cover Earth science-related careers.
- *Science Exposition* is an annual event developed and conducted by high school students for grades 4-7. The elementary students communicate science concepts through displays. Two to three hundred students in grades 4-7 show their projects each year, and several hundred parents, friends, and community members view the exposition. Earth science is a popular area, especially with fifth graders.

The major strength of our program is that it is a program—not a course. Thus, Earth science concepts, identified from Department of Public Instruction guidelines, are included in the introductory courses *all* students take, the courses of specialization that a relatively low percentage of students take, and out-of-class activities. The result is more students (and community members) exposed to the basic concepts while those with specific interests can take special courses.

Most program strengths relate to our dedicated staff. Five of the eight teachers directly involved in the program have received state, regional, or national recognition for their teaching, and, with the exception of two new staff members, program staff have experience in teaching a variety of summer field experiences. We use a variety of instructional strategies. Field work, as indicated, is important, but we also use our computer lab.

Department commitment to a public information program has created a community feeling of pride in the science program. Public support was instrumental in implementing and continuing the Earth science and other programs.

The department budget is developed by the program staff and reflects our needs. We have control over program expenditures. Approximately $7.00 per student for supplies is spent each year. District support for released staff time during the year and summer employment provide emotional and financial benefits.

Evaluation

Maintaining our program involves continuous evaluation. A departmental evaluation of the components of scientific literacy, as well as of student perception of class mechanics and staff provides the necessary information.

To assess scientific literacy and understanding of science and society relationships, the *Wisconsin Science Assessment* is administered each year to all 9th grade students and those 11th grade students in science. Our students are well above state average.

Knowledge of Earth science processes and concepts is measured by the *STEP Test* (Level I, form X), which is given to 9th grade students each year. Students score well above average on this test also. *The Environmental Education Survey*, a survey of six schools in six states, tests Earth science knowledge. Our school ranked second.

The number of students involved in courses and outside activities reflects our improved student attitude about science. A Science Department Student Evaluation form also reflects the improved attitude. The 1983-84 science enrolment was 88.4 percent.

The diversity of staff experiences and backgrounds results in a variety of student assessment techniques. Most are traditional. However, some use such nontraditional testing methods as oral tests on concepts, production of a product such as a map, written papers, and student self-evaluation in labs.

Plans for Improvement

There are some areas of our program that need improvement. Processes are considered important and are included in each course; however, course testing does not always reflect that importance. And, while specific issues are identified and included in several courses, many additional Earth science issues, especially those relating to the 9th-10th grade students, should be included. Improvement is needed in the area of Earth science career education. We are able to include many career concepts in courses, but they tend to reflect the interest and personality of staff rather than a course objective. If specific objectives were developed, it is possible that more career emphasis would result.

Implementation

Because the program is not a specific syllabus or textbook, direct transport is not possible. What can be transported is the philosophical approach, the curriculum development process, the class approach, and various laboratories, readings, and handouts. Dissemination of the program is occuring through the educators who visit and write Memorial, and the many workshops that our staff members conduct at professional meetings and schools during the year.

Chapter 10 Exemplary Programs— A Review and Critique

Rodger W. Bybee
The Colorado College
Colorado Springs, Colorado 80903

John E. Penick
Science Education Center
The University of Iowa
Iowa City, Iowa 52240

Twenty-five years ago, Earth science literally could not be found in school programs. At best, it was included in general science or geography. Earth science education has come a long way since the "golden age" of science education gave it a new identity through new curriculum materials and school programs. As enrollments increased, Earth science took its rightful place in science education.

The inclusion of Earth science as a separate volume in the *Search for Excellence* series and this review of exemplary programs are further evidence of the identification and maturation of Earth science as a notable part of school science programs. The selection of programs to be covered in *Search for Excellence* was based on areas used in Project Synthesis—physical science, biology, inquiry, science/technology/society, and elementary science (*Focus on Excellence* monographs, NSTA, 1983-1984). Earth science was to be part of the physical science review; however, based on enrollments and programs, we saw a need to recognize it as a separate course of study. The NSTA Committee for the Search for Excellence in Science Education (SESE) recognized this, and in 1983 established Earth science criteria for the *Search for Excellence* series.

The criteria were developed by a distinguished group of Earth science educators, all of whom were recognized as excellent Earth science teachers at the pre-college level. In addition, two were associated with the Earth Science Curriculum Project, and one had co-authored an Earth science textbook. Through meetings and correspondence the criteria for Earth science excellence were established and subsequently distributed through the Council of State Science Supervisors and the National Association of Science Supervisors. Selection of the eight exemplary school programs was made in the summer of 1984 by a part of the original NSTA Committee for the Search for Excellence in Science Education.

Both excitement and disappointment were part of the final review and selection process. Excitement emanated from the realization that Earth science really had achieved a prominence in science education, proven by the approximately 40 best programs in the United States. Disappointment emerged as we recgognized the gap between the ideal Earth science program and the real programs that were submitted for final selection. The committee members knew the criteria for excellence were ideal and that no (or very few) programs would be exemplary for all criteria. However, there was still initial alarm at the disparity between the criteria and the programs identified as exemplary. These concerns were tempered by placing the situation in historical perspective. We had to realize how much Earth science education had grown in 25 years and look at its potential for future growth.

Meeting the Ideal Criteria

All of the programs selected met some of the criteria described in Chapter One, and a few met several of the criteria; but no program met all of the criteria. If this critique seems unwarranted or unfair, remember that we are in a period of substantial educational reform, and the way to make Earth science an intrinsic part of this change is to assist in its evolution through constructive criticism and review.

The following discussion reviews the strengths and weaknesses of the exemplary programs' coverage of six of the general Earth science education criteria.

1. An exemplary Earth science program should develop knowledge of the facts, concepts, and principles related to the major unifying themes of Earth science.

- These programs all provide a good grounding in Earth science content and concepts. The facts, concepts, and principles of Earth science were clearly primary to all the programs reviewed. Hanby Junior High's program (Chapter 6), Middle School Earth Science (Chapter 8), and James Madison Memorial High School (Chapter 9) exemplify programs organized around unifying themes.
- Weaknesses relative to this goal are the lack of explicitness with which the unifying themes are made a part of these programs and the lack of emphasis on evaluation of unifying themes. For the most part the unifying themes do not appear to be central to the programs. In addition, the programs do not evaluate student understanding of major unifying themes like conservation, interaction, and finiteness.

2. An exemplary Earth science program should develop an understanding of and ability to use the processes of investigation used in the Earth sciences.

- Earth science educators in the exemplary programs point with pride to how they actively involve students through the methods of scientific investigation. The Accelerated Earth and Space Science Program (Chapter 5) and Indoor/Outdoor Earth Science (Chapter 7) particularly exemplify this goal.
- However, students are seldom involved in real problem solving situations in which they can use the processes of investigation. For the most part, problems are presented on handouts and activities drawn largely from existing programs such as the Earth Science Curriculum Project, The Crustal Evolution Education Program, or other commercial texts.

3. An exemplary Earth science program should provide background and analysis of Earth science-related social issues at the local, national, and global levels.

- Almost without exception the exemplary programs provide the background needed to understand most social issues with links to science and technology. Most programs include explicit instruction concerning Earth science related issues, usually energy. Other common topics include acid rain, population, and pollution. Programs that best exemplify this goal are the Ninth Grade Earth Science Program (Chapter 4) and the energy unit in the Accelerated Earth and Space Science Program (Chapter 5).
- While concepts basic to understanding societal problems are presented, in the majority of programs there is no topical connection to problems and seldom is there any analysis of them. For most programs social topics such as toxic waste, pollution, and resource use are presented as supplemental, not centr l, to the Earth science program.

4. An exemplary Earth science program should prepare students to acquire relevant information and make responsible decisions about science-related social issues.

- Most of the programs introduce students to common and useful ways of acquiring information. Simulation activities and computer software are particularly helpful in achieving this goal. The best exemplary programs in this area are the energy simulation game used in the Ninth Grade Earth Science Program (Chapter 4), the Natural Disasters unit (Chapter 8), and the computer simulations used in the Computer Assisted Laboratory Science (CALS) (Chapter 2).
- Most programs lack both distinct problem-solving orientation and a focus on social issues. The decision-making goal was the least met of all the criterion goals. Achieving this goal requires a program directed toward problem solving and decision making, neither of which were part of the programs developed in the 1960s and 1970s. Because the exemplary programs tend to use the organization and activities of earlier programs, this goal was not often realized.

5. An exemplary Earth science program should develop an appreciation for and critical attitudes toward science and technology as an integral part of society.

- This goal was recognized primarily through citing examples of personally and socially useful aspects of Earth science study and thr ugh presentation of historically significant persons or discoveries relative to Earth science. The unit on discovering with instruments from the Middle School Earth Science Program (Chapter 8) is a particularly good example of the way this goal can be realized.
- Teaching that science and technology is an integral part of society differs from teaching the concepts and processes of science and technology. For the most part Earth science teachers in these programs do not present the history, philosophy, sociology, or politics of science. Almost without exception exemplary programs include plate tectonics and related concepts such as volcanoes and earthquakes. But there is no mention of debates about the acceptance of plate tectonics or the role of science and technology in prediction of earthquakes and social consequences of inaccurate predictions. These subjects serve as examples of the major changes in paradigms of Earth science and the social aspect of science and technology, which should be included in Earth science courses.

6. An exemplary Earth science program should provide information about careers in the Earth sciences.

- All of the exemplary programs include some introduction to careers in the Earth sciences. Recent implementation of this goal has been remarkably impressive with such approaches as guest speakers, library reports, field trips, career conferences, and career explorations in the summer. The Earth Science Program (Chapter 9) and the career lab unit of the Middle School Earth Science Program (Chapter 8) are excellent examples of the realization of the career awareness goal.
- There are few weaknesses relative to this goal. Programs could have presented a wider range of careers and

used more innovative ways of presenting the information such as computer simulations and videotapes, but for the most part the approach and emphasis on this goal seemed reasonable.

Exemplary Program Strengths

Though not necessarily the reason for its exemplary status, each of the exemplary programs has one outstanding characteristic. Each program demonstrates some strength that may be important for other programs

- James Madison Memorial High School's "Earth Science" is a totally integrated program which uses out-of-class activities well.
- Bill Reed Junior High's "Ninth Grade Earth Science" uses application of the instructional methods, particularly mastery learning, to teach Earth science.
- Jones Middle School's "Middle School Earth Science" involves special students and integrates concepts, processes, and units of instruction.
- Lake Lehman Junior High's "Accelerated Earth and Space Science" uses the local environment as a basis for the Earth science program.
- Jefferson Junior High School's "Indoor/Outdoor Earth Science" uses field trips (local, regional, and national) as a central part of Earth science.
- O'Fallon Township High School's "Geology Is" is a good overall program, well organized and integrated.
- McLean High School's "Computer Assisted Laboratory Science" uses computers as an important part of Earth science.
- Hanby Junior High School's "Earth Science for the 21st Century" is a well organized and integrated program.

Reviewing and selecting exemplary Earth science programs leads to some important observations.

- Teachers of the exemplary Earth science programs show a pride in their program that comes across in their narratives. This pride is probably based on their development and ownership of the materials, which is essential and not easily exported.
- All the exemplary programs were developed locally. Many maintain that this is the way the reform of science education will occur. These examples show eight new approaches.
- Major organizing units included: astronomy, geology, and meteorology. Lessons and activities were then arranged in these categories. The selection and sequence of lessons were mostly a reflection of teacher interest and preference rather than a conceptual organization.
- Textbooks were associated and used with the programs, but by and large they were not the curriculum. The two curriculum programs that were cited consistently as a part of a program were the American Geological Institute's Earth Science Curriculum Project, *Investigating the Earth*, and the National Association of Geology Teacher's Crustal Evolution Education Program.
- Examinations (quizzes, chapter tests, unit exams) were not oriented toward achieving the Earth science education goals. They were mostly low-level recall and did not evluate the unifying themes or processes of investigation. Examinations simply did not reflect the espoused goals. Rather, they tested vocabulary, dates, names, and facts.
- Student activities figured prominently in all exemplary programs. The activities were pirated from every conceivable source. Students were actively involved in scientific investigation, probably at above average levels. Unfortunately, many of the activities were with pencil and paper—record data or fill in the blanks.
- While great attention was paid to the development of curriculum materials—conceptual organization, topic sequencing, and use of activities—there was little evidence that any attention was paid to teaching methods such as learning cycles, models of teaching, or application of principles of learning. We suspect instruction was exemplary due to the teachers' enthusiasm, pride, and background. But courses could have been organized and taught in ways that would have further enhanced student learning.
- Energy was the social issue included most often in the exemplary Earth science programs. After this topic no other appeared consistently. Teachers often reported infusing their programs with topics. The degree to which this occurs, the topics incorporated, and the approaches used are unclear.

Conclusion

In this review and critique attention has been directed toward the degree to which the exemplary programs described in this volume show how far Earth science has advanced and outline new possibilities.

How can the improvements continue? What can be done now? Based on a thorough review of exemplary programs, the recommendations listed may help educators with the next significant steps to an improved Earth science curriculum.

- *Conceptual Organization* The American Geological Institute, National Association of Geology Teachers, National Earth Science Teachers Association, or other organizations such as the National Science Teachers Asssociation could develop a new conceptual organization. The concept organization should include the major unifying themes and their linkage to Earth science-related social issues.
- *Activities* New activities should be developed for teaching about social issues, decision making, and problem solving. If activities were made available through various public or private groups, there is little doubt they would find their way into Earth science programs. Topics that seem particularly relevant to Earth science might include acid rain, soils, desertification, land use, toxic waste, mineral resources, energy resources, water resources, air pollution, weather modification, Earth systems, and the limits to growth. Also pertinent are carbon dioxide and world climate, trace elements in the environment, environmental health and disease, solid waste disposal, species extinction, use of the oceans, and war technology.
- *Teaching Models* We must develop models of effective teaching, carefully specifying in both qualitative and quantitative ways how the teacher should teach.

• *In-Service Programs* In-service programs to help teachers develop their own exemplary programs should be implemented. Avoid direct use of the exemplary programs in this volume. The teacher development and ownership of, and pride in, a program is one of the essential differences between a good program and an exemplary program. Avoiding direct application of other programs helps teachers develop their own.

• *Examinations* Earth science teachers need assistance in developing and using examinations that reflect Earth science goals. This could be a part of both pre-service and in-service programs.

The teachers and exemplary programs in this volume of the *Focus on Excellence* series have set a direction for all Earth science education. It is time for each of us to join in and take the next step toward excellent Earth science education for all students.