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ABSTRACT

The 1982 Search for Excellence in Science Education project has identified 50 exemplary programs in physics, chemistry, biology, and earth science. Descriptions of four of these programs and the criteria used in their selection are presented. The first section reviews the direction established by Project Synthesis in searching for exemplary programs, discussing the desired and actual states in such programs as related to four goal clusters (personal needs, societal issues, fundamental knowledge, and careers), curriculum, instruction, evaluation, and teachers. The criteria used by professional organizations in selecting one exemplary program in their respective discipline are also provided. Organizations include the American Association of Physics Teachers, American Chemical Society, National Association of Biology Teachers, and National Association of Geology Teachers. The second section provides a description of each of these four programs, including school setting, program history, and program maintenance. The third section analyzes the four programs in terms of each other, and lists the generalizations arising from a study of the 50 National Science Teachers Association exemplary programs. Among the features of these programs are the utilization of laboratories, field experiences and community related projects/activities and the concern with the affective domain and all-round growth of students. (JN)

Exemplary Programs in Physics, Chemistry, Biology, & Earth Science

NATIONAL SCIENCE TEACHERS ASSOCIATION

Robert E. Yager, Editor

EXEMPLARY PROGRAMS

IN

PHYSICS, CHEMISTRY, BIOLOGY, AND EARTH SCIENCE

Edited by

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Robert E. Yager

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Focus on Excellence Series

In 1982 the NSTA Board of Directors authorized the creation of the Focus on Excellence monograph series. Volume One was made possible because of financial support from the National Science Board Commission and from the National Diffusion Network. NSTA staff and University of Iowa staff of the Science Education Center contributed much time, effort, and supplies to initiate the series. The assumption has been that income generated from sale of the monographs would be adequate to pay for the series for the next year.

Volume One consists of five issues. They are:

Focus on Excellence: Science as Inquiry
Focus on Excellence: Elementary Science
Focus on Excellence: Physical Science
Focus on Excellence: Biology
Focus on Excellence: Science/Technology/Society

Three additional monographs (non-numbered) also were included as a part of the 1983 effort. This volume represents one of these. The other two special monographs released in 1983 are:

Teachers in Exemplary Programs: How Do They Compare?
Centers of Excellence: Portrayals of Six Districts

Individual monographs on the entire series may be ordered from:

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EXEMPLARY PROGRAMS

IN

PHYSICS, CHEMISTRY, BIOLOGY, AND EARTH SCIENCE

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PREFACE

EXEMPLARY PROGRAMS

IN

PHYSICS, CHEMISTRY, BIOLOGY AND EARTH SCIENCE

In October of 1982 notification of funding for the NSTA Search for Excellence in Science Education was received. This funding permitted NSTA to proceed with analysis of results from the fifty exemplary programs that had been selected as best meeting the criteria in the five categories for the new Search for Excellence program. It also permitted the Association to proceed with a study of the more than two hundred teachers associated with the fifty programs. In addition, it provided a mechanism for in-depth visits at six centers of excellence for on site study of the factors involved with developing exellence and maintaining it. These centers were selected from eight which emerged from an analysis of the fifty; eight school districts which met criteria and were selected by two or more of the national committees as exemplary. The five committees (and five areas comprising the 1982 Search) were elementary science, biology, physical science, science as inquiry, and science/technology/society.

Before making the grant to NSTA, the NSF staff which was assigned to work with the National Science Board Commission on Precollege Education in Mathematics, Science and Technology urged that the NSTA effort be expanded to include other exemplary programs which reflected the unique philosophies of "discipline-oriented" societies which focus on science teaching. NSTA, long interested in closer collaboration with other societies concerned with science teaching, agreed to coordinate such an effort and to extend its own work to identify and study additional exemplary programs in physics, chemistry, biology, and earth science.

Presidents and Executive Directors (or persons they designated to represent them) were contacted concerning the project. Appropriate representatives of the American Chemical Society (Education Division), American Association of Physics Teachers, National Association of Biology Teachers, and National Association of Geology Teachers agreed to cooperate with NSTA and its Search for Excellence project. All agreed to select an exemplary program which could be studied and used to exemplify excellence in the particular discipline.

Presidents and Executive Directors of each of the four "discipline" societies met with the NSTA President and Executive Director in December of 1982. The group formed a special council with the NSTA Executive Director selected as the convener, secretary, and temporary chair. The group selected the name Council of Science Teaching Associations (COSTA). The group decided to cooperate on surveys of the status of science education in the U.S., Congressional Testimony, convention sessions and dates, publications, and other areas of mutual concern.

The COSTA representatives also agreed to cooperate with the NSTA Search for Excellence. Each society selected an exemplary program to represent the particular discipline. The criteria used were compatible with those accepted by NSTA; the format for a discipline-oriented monograph of exemplars was also an area of agreement.

This volume represents the results of the Search for Excellence from a discipline perspective. It includes an elaboration of the criteria used by each society and descriptive information concerning the four exemplary programs selected by the four science discipline societies. The last section is an analysis of the four programs in terms of each other, the criteria established by the four societies, and the generalizations arising from a study of the fifty NSTA exemplary programs, especially the six centers of excellence which met the desired criteria in multiple categories used in the search.

Robert E. Yager
National Science Teachers Association
June, 1983

A. THE CRITERIA FOR EXCELLENCE

1. THE DIRECTION ESTABLISHED BY THE PROJECT SYNTHESIS REPORT

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Serious challenges to science education were advanced early in the 1970's--presumably in response to the challenges directed to most other institutions and professions. For many, however, the challenges were more severe as science and technology were cast as causes for our problems--not solutions to them. The challenges reached a peak in 1976 when all NSF funds for science teacher education were suspended and all active curriculum developments questionned, scaled down, and/or phased out.

It was the following year that resulted in the funding of three gigantic status studies designed to determine the impact of the two decades of federal support which had occurred following the 1957 launching of the Soviet Sputnik. The three NSF studies included a review of all the relevant science education research that had been reported, a large demographic study designed to determine what professionals reported the status to be,and a large ethnographic study designed to determine what trained observers could see by direct on-site observations. As the NSF studies were undertaken, the Third Assessment of Science conducted by the National Assessment of Educational Progress was underway as well. This added data provided information about the status in terms of student achievement and student attitude.

As 1978 emerged, the results from the three NSF studies and the NAEP data were available--more than 3,000 pages of information. This was the setting as Norris Harms, himself the architect for the innovative affective battery that was incorporated into the Third Assessment of Science by NAEP, conceptualized Project Synthesis.

The first facet of Synthesis was a proactive synthesis of futuristic reports, reviews of social indicators, information from scientific societies, critical analyses of schools, reviews conducted by public and private foundations as new problems were identified and possible solutions proposed, analyses prepared by educational and scientific commissions, and research concerning school successes and failures. The analysis of such information provided the ingredients for the formulation of an idealized science program for schools. The synthesis that resulted provided a validated Desired State condition for school science in five focus areas.

A total of twenty-three researchers were involved with the synthesis of information. Five "teams" were involved--one each for the five focal areas of synthesis, i.e., elementary science, biology, physical science, science as inquiry, and science/ technology/society. After each team defined a Desired State, each reviewed the NSF Status Studies and the NAEP results to determine the Actual State conditions--a retrospective synthesis. A comparison of the two states resulted in recommended actions for achieving the Desired conditions.

One of the organizers for determining the Desired and Actual State conditions was the identification of major goals for science teaching. Four goal clusters were identified by a panel of experts prior to the preparation of the synthesis proposal. The major goal clusters represent the major justification for school science. An elaboration of the four areas include:

1. Personal Needs of Students

   Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world. Goals that fall into this category focus on the needs of the individual. For example, there are facts and abilities one needs to be a successful consumer or to maintain a healthy body. One should have some idea of the many ways science and technology should affect one's life. Knowing that is still not enough. Science education should foster attitudes in individuals which are manifested in a propensity to use science in making everyday decisions and solving everyday problems.

2. Current Societal Issues

   Science education should produce informed citizens prepared to deal responsibly with science-related societal issues. The goals in this category relate to the needs of society. They pertain, for example, to the facts and skills a person needs to deal with the environmental and energy issues which affect society at large. In order to vote intelligently on science-related societal issues or participate in responsible community action, not only are specific facts and skills important, but also an understanding of the role of science in society, a knowledge of issues and how science relates to them, and a recognition that in providing the solution to one problem science can create new ones. Of course, to develop informed, concerned citizens and wise voters, science education also must be concerned with attitudes. It must instill in students a sense of responsibility, an appreciation of the potential of science to solve or alleviate societal problems and a sense of custodianship to protect and preserve that natural world with which science concerns itself.

   A common element of personal and societal goals is the importance of the applications of science to problems of personal and societal relevance. In order for students to be able to apply science to such problems, it is necessary that they have an understanding of the problems, of the aspects of science which apply to the problems, and of the relationship between science and these problems. Students should also have experience in the processes of applying science to the solutions of such problems.

3. Career Awareness in a Society Governed by Science/Technology

Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests. Science classes in all disciplines and at all levels which prepare students to make informed career decisions regarding jobs related to science and technology would logically place emphasis on topics and learning such as: awareness of the many possible roles and jobs available in science and technology including such careers as scientists, technicians, equipment designers, computer programmers, laboratory assistants, as well as in jobs which apply scientific knowledge in such areas as agriculture, nutrition, medicine, sanitation, and conservation; awareness that persons of both sexes, all ethnic backgrounds, wide ranging educational and ability levels and various handicaps can and do obtain such jobs; awareness of the contributions persons in such jobs can make to society as a whole; knowledge of the specific abilities, interests, attitudes and educational preparation usually associated with particular jobs in which individual students are interested; a view of scientists as real people; a clear understanding of how to plan educational programs which open doors to particular jobs; a recognition of the need for science, mathematics and language arts coursework as well as a broad base in the social sciences to understand better the relationship between science and society; a knowledge of human and written sources for further information in all areas listed above.

4. Concepts Needed as Preparation for Further Study of Science/Technology

Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs. Goals in this category pertain to scientific ideas and processes which form a part of the structure of scientific disciplines, which may not be related easily to specific decisions about one's own life or about societal issues, yet which are necessary for any further study of science.

These four "clusters" of goals provided one essential parameter and a reference point for the synthesis efforts.

Another plane for the synthesis analysis was envisioned as certain critical incidents. The five primary incidents were goals, curriculum, instruction, evaluation, and teachers. The desired direction and the actual state existing in most schools can be summarized as follows:

1. Goals

An effective science program for the 80's should utilize the human being and human adaptation as organizers. Alternative futures is a desirable focus. Too often there is little or no emphasis upon the human and his/her environment in current programs. A second goal for an effective program is the utilization of current problems and issues as organizers; currently there is only marginal emphasis upon such goals. A third goal is concerned with processes. Effective science programs should emphasize those processes that can be used. In the past, inquiry skills that have been included have emphasized processes that scientists use. A fourth goal for desired science programs suggests the importance of practice with decision-making skills involved with using scientific knowledge in a social context. Too often the current emphasis in science classrooms provides skill and practice with uncovering correct answers to discipline-bound problems. A fifth goal for the desired science program is in the area of career awareness. Such considerations should be an integral part of learning, not incidental. In current programs such attention to careers is usually limited to highlights of historical personages only. A sixth goal for a desired science program deals with value, ethical, and moral considerations. In the desired program these are important areas when dealing with problems and issues. Currently, science is too often taught as value-free and discipline-bound concepts and activities.

2. Curriculum

The curriculum should be problem-centered, flexible, culturally as well as scientifically valid. Currently, the science curriculum is textbook-centered, inflexible, and only valid in a scientific sense. Secondly, the science curriculum should include the human as a central ingredient. Currently, humankind is only incidental in the curriculum. There almost seems to be a conscientious effort to make science inhuman, antiseptic and void of humans. A third feature of a desired curriculum is that it is multifaceted with local and community relevance. Currently, the curriculum is textbook-controlled and local relevance is fortuitous. Fourth, use of the natural environment, community resources, and current concerns should be foci for study. Currently, contrived materials, classroom-bound resoures, and commercially prepared manuals are used almost exclusively. A fifth feature of the desired science curriculum is the view of scientific information that can be used and applied by students in a cultural/social environment. Currently, the science information is presented in a context which only considers the logic and structure of the discipline.

3. Instruction

First of all, instruction should be individualized and personalized, recognizing student diversity in a desired program. Currently group instruction is the mode and it is geared to the average student and directed by the organization of the textbook. A second feature of desirable instruction is emphasis upon cooperative work on problems and issues. In most science classrooms there is little group work and it is often in the laboratory which deals mostly with verification-type activities. A third feature of a desired instructional mode is that it be based upon current information and research in the area of developmental psychology. Most current procedures arise from weak psychological bases; most that do exist are from a behaviouristic orientation.

4. Evaluation

Testing and evaluation should stress the use of knowledge to interpret personal and social problems and issues. Currently, testing and evaluation are based upon replication of assigned information. Another feature of a desired evaluation program is its concern for growth in rational decision-making strategies. In too many current classrooms students are merely expected to state "correct" solutions to preplanned problems. Many examinations stress vocabulary mastery.

5. Teachers

Teachers need to have some specific characteristics for the kind of desired science education which has been synthesized. Teachers will need to develop a commitment to human welfare and progress. Such philosophical perceptions are not evident in current practices. The only observable commitment on the part of science teachers is one of commitment to science as a discipline. The desired science program will require teachers with new philosophical positions, since such positions affect goals, curriculum and teaching practices.

Currently teachers perform without a theory base--one like they themselves experienced.

This general description of an ideal K-12 science program was accepted by the NSTA Search for Excellence in Science Education Committee. The desired goals, curriculum, instructional practices, evaluation techniques, and teacher characteristics were accepted as criteria for the NSTA 1982 Search for Excellence. The specific descriptions of the Desired States for elementary science, biology, physical science, science as inquiry, and science/technology/society were criteria for the NSTA Searches in the same five areas. An elaboration of such criteria in the five areas is included in each of NSTA's five Focus on Excellence monographs released in 1983 as Volume 1 of the new series.

The members of COSTA (i.e., the leadership of AAPT, ACS, NABT, and NAGT) accepted the general descriptions of the Desired State conditions advanced by the Project Synthesis researchers. The specific criteria for excellence in physics, chemistry, biology, and earth science arise from this setting. These criteria are compatible with the generalized Desired State for science teaching advanced by the Project Synthesis researchers and accepted by the NSTA Board of Directors.

2. THE AAPT CRITERIA

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Oak Park and River Forest High School's selection by the American Association of Physics Teachers (AAPT) as the 1983 Exemplary High School Physics Program occurred after a careful review of potential selection criteria. As a formal description of the factors that produce such a program did not exist at the time, the Association turned to its recent publication, "AAPT Guidelines for High School Physics Programs." This document was prepared recently by a group of high school and college physics teachers and carries the formal endorsement of the AAPT Executive Board. In the preamble to the document, a quality high school physics program is defined as one containing the following essential components:

1. A broadly appealing course in physics which is not totally dependent on advanced mathematics;

2. Laboratory activities in which each student gets "hands-on" experience;

3. Appropriate opportunities for especially gifted students to develop their scientific abilities through special projects and activities;

4. Working conditions and support of professional growth which enable teachers to remain alive as professional science teachers.

After examining the above descriptions, the selection committee prepared a set of criteria that could be employed to test for the presence of the above factors:

1. An exemplary program should draw students from at least the upper 50% of each class;

2. A significant fraction of class time should be devoted to laboratory activities;

3. Students completing the exemplary program and graduating from the high school should demonstrate an ability to succeed in a wide variety of collegiate science programs;

4. Teachers in the exemplary program should evidence continued professional growth through their activities in professional societies at the local, state, and/or national levels.

Once these definitions and selection criteria had been settled upon, nominations of candidates for the physics exemplar were solicited from individuals active in the leadership of AAPT. (Because of the short lead time provided, it was impossible to issue a general call for nominations through AAPT membership and subscription journals. Thus, this year's selection process does not truly represent a thorough, national search. However, the AAPT stands behind its selection of Oak Park and River Forest High School as representative of the very best high school physics programs.) Many nominations, representing all regions of the country, were received and screened by the selection committee. Oak Park and River Forest High School was deemed to satisfy best the criteria chosen for this process. Tim C. Ingoldsby, AAPT Associate Executive Officer, visited Oak Park in November of 1982 to meet with teachers, students, and administrators associated with the exemplary program. A report describing the program at Oak Park was then prepared and submitted to the National Science Teachers Association.

Since the time of this search, two developments related to the above process have occurred:

1. A group of high school and college physics educators, jointly appointed by the AAPT and NSTA, have developed a formal search process to be used in a nationwide search for a Physics Education Exemplar in the 1983 Search For Excellence in Science Education process. The selection criteria and nomination materials are available from the National Science Teachers Association.

2. The news and information journal of the physics community, **Physics Today**, has scheduled a special issue on the crisis in science and engineering education, with particular focus on the impact of the crisis on physics and physics education, for September of 1983. AAPT has been asked to prepare a feature article on high school programs that are countering the trend toward less effective science education. This article will feature a description of Oak Park and River Forest High School as well as several other finalists in the Exemplar selection process.

3. THE ACS CRITERIA

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The chemistry course taught by Mrs. Jan Harris at Cy-Fair High School in Houston, Texas, was selected by the American Chemical Society as one example of an exemplary chemistry program at the high school level. Many other fine chemistry courses are being taught in schools across this nation. While delighted at the opportunity to publicize the fine work of Mrs. Harris, the Society regrets the fact that it cannot recognize all the excellent programs now in place.

Mrs. Harris is the current national winner of the ACS James Bryant Conant Award in High School Chemistry Teaching. This award, sponsored by the Ethyl Corporation, is designed:

> "to recognize, encourage, and stimulate outstanding teachers of high school chemistry in the United States, its possessions or territories at both the regional and national levels."

Given the nature of this award, and the rigorous method of selecting its national winner, the ACS Society Committee on Chemical Education agreed that it was certainly appropriate to cite the exemplary chemistry teacher of the year for the excellence of the course she both designed and currently teaches. It represents excellence and is one for which the society can take pride.

Since the identification of this program as exemplary is based upon the identification of the quality of the teacher, it is very relevant to detail the Conant selection procedure. Each year, the Society selects up to nine regional awards and one national award. Nominations for the regional award are made only by the 179 local sections of ACS around the country. Each local section is limited to one candidate per year. A nominee must be actively engaged in the teaching of chemistry in a high school (grades 9 through 12) either in the territory of the local section making the nomination, or in an adjacent territory within the geographic region not assigned to any local section.

Local sections identify candidates for consideration in a number of ways. About 50% of the sections present a local award for excellence in the teaching of chemistry. Where this is the case, the section may nominate the local winner for the regional award automatically. Many local sections either have high school teachers as full or affiliate members of the section. In this case, the teachers themselves may suggest the names of other teachers known to them for consideration. Many local sections will contact all schools within their jurisdiction either directly or through the school superintendent or science advisor. In any case, peer nomination and selection is the norm for most of the local sections participating.

Each local section submitting a nomination for a regional award completes a standard nomination form distributed by the Awards Office of

ACS in Washington. The form asks for basic biographical data on the nominee plus information on the:

1. Quality of the candidate's teaching (Unusually effective methods of presentation should be emphasized);

2. Ability to challenge and inspire students;

3. Extra-curricular work in chemistry by the candidate, including science fairs, science clubs, and activities that stimulate the interest of young people in chemistry and related sciences;

4. Willingness to keep up-to-date in the field, as evidenced by pursuit of a higher degree in chemistry, enrollment in refresher courses and summer institutes, regular attendance at scientific meetings, and other means of self-improvement.

As many as five seconding letters may be submitted with each nomination. These letters may include careful evaluations of the teacher's effectiveness by a supervisor or principal, by associates, or by local section members who have visited the nominee's classes. Letters from currently enrolled high school students are not acceptable, although letters from ex-students are.

A regional award committee in each of the regions selects the regional award winner based upon the content of the local nominating documents. These committees include current high school chemistry teachers as well as candidates from that region. The award may be withheld in any given year.

Each winner of an ACS Regional Award in High School Chemistry Teaching automatically becomes a candidate for the James Bryant Conant Award in the following year and remains a candidate for three successive years unless a) he or she wins the Conant Award, or b) the nomination is withdrawn by the local section. Candidates nominated by local sections in a region that does not select a regional winner in any given year are placed in competition for the national award and remain candidates for three successive years. Hence, the National Award Committee selects from an annual pool of at least 25 highly qualified candidates each year.

The National Award Committee is appointed by the ACS President-Elect and, like the regional committees, has substantial high school teacher representation. The names of members of this Committee are kept confidential; even members are not informed of the identity of the other members. The Committee bases its decision to award upon the same nominating documents submitted by the local sections for the regional awards. Candidates are rated in order of preference by each Committee member. The lower scores are selected for further balloting, and election occurs only when a candidate receives more than 50% of the first choices.

Each local section may have its own set of criteria for selecting a local award winner. However, the nature and quality of the information provided on the Conant nominating form provides a standard for evaluating the regional and national winners. This information includes:

1. The quality of the candidate's teaching is assessed by examining the following:

a. The way in which the candidate presents material. This may include the extent to which the teacher emphasizes laboratory activities, connects chemical concepts to the observations upon which they are based, relates concepts and principles learned in chemistry to their applications in society, gives students an opportunity to apply their knowledge in decision-making activities, presents chemistry as a relevant discipline for both the college-bound and average student, develops learning packages to reinforce particular skills or interests. Unique ways of organizing classtime are relevant here, and the methods by which the teacher evaluates student achievement of course objectives are also considered important. Committee members look for signs that the teacher is presenting a course which is evolving, and which is designed to address the needs of different groups of students both in terms of content and instructional strategies. The extent to which the teacher is able to individualize the course and provide one-on-one instruction is also a factor.

b. The impact upon the students. Students who are enjoying the experience of learning chemistry, who see its relevance to their future lives, and who are achieving well on standardized tests are clearly being taught good chemistry by an exemplary teacher. Evidence of this impact may be numerical. For example, this could include growth of the program over a five-year period, percentage of the students electing to take a second year of chemistry, and student performance on the ACS/NSTA High School Examination. Evidence of impact may also be based upon classroom observations of student behaviors by an impartial observer, usually a supervisor or local section representative. It is important to recognize that committee members look for an impact upon students which goes beyond academic preparation into the realm of appreciation for the discipline of chemistry and its impact upon student lives.

2. The ability of the teacher to challenge and inspire students is usually evaluated by the committees in terms of career choices made by former students. Again the data presented may be numerical, i.e., number of students studying chemistry or related subjects at university, number of students taking graduate degrees--or more subjective--letters from former students, co-workers, supervisors. A close analysis of the subjective evidence submitted in nominating documents over the past five years reveals a number of reoccurring themes:

   a. The relevance of high school course to the present career goals of the former student;

   b. The depth of understanding achieved at the high school level;

c. The ease with which the student now learns chemistry;

d. The attention paid by the nominated teacher to the personal needs of the students.

3. Extra-curricular activities involving teacher and students are also considered important. Student participation in science fairs and science clubs is accepted as evidence that the nominated teacher has inspired students "beyond the call of duty." Site visits to local industrial plants, laboratories, or other chemically-related locations confirm the teacher's concern for relating chemistry in the classroom to chemistry in "the real world."

4. Finally, the extent to which the teacher attempts to keep up-to-date with developments in chemistry and science is all-important. Our knowledge of chemistry is growing at such a tremendous rate that any teacher who does not attempt to upgrade subject matter competence on a regular basis cannot be teaching a truly exemplary course. The taking of refresher courses, with or without academic credit, is one way to upgrade knowledge. Participation with other teachers in workshops, symposia, and discussion groups is also evidence that a teacher is attempting to improve continually upon his/her teaching skills and is open to ideas and suggestions from others.

Clearly the standards of performance against which each nominee is measured are extremely high. While no one candidate can be expected to meet all these standards, it is a tremendous tribute to our teachers that so many come so close. As can be seen from the description of the course taught by our current Conant Award winner, Mrs. Jan Harris, she is certainly a model high school chemistry teacher, with an extremely innovative approach to motivating and challenging her students. While the Society does not have the temerity to mandate that the Conant Award winner teach a course that students consider enjoyable as well as challenging (how would we measure "iun"?), that is exactly what Mrs. Harris succeeds in doing.

In deciding to nominate the Chemistry I course taught by Mrs. Harris as an exemplary program, the Society was struck by the close correspondence between the goals and objectives of this particular course and the four goal clusters of Project Synthesis. The Society did not choose to define its exemplary program using the Project Synthesis model, nor attempt to locate a specific program to fit the Synthesis criteria. However, if we had, the chemistry course taught by Mrs. Harris at Cy-Fair School would again be identified as an exemplary program. By any set of criteria, this course works well with the mixture of students taught by Mrs. Harris.

4. THE NABT CRITERIA

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The National Association of Biology Teachers actively participated in the Search for Excellence in Science Education by developing criteria, conducting a search, and selecting an exemplary program representative of the best in biology education. As biology teachers and educators, we were fortunate to have recent national guidelines; for biology was the only discipline separately identified and studied by Project Synthesis. Jane Butler Kahle, president-elect and a member of the Biology Focus Group of Project Synthesis, was appointed chairperson of NABT's Search for Excellence in Science Education Committee by Jerry Resnick. Resnick agreed to serve and selected a third person as a committee member. Hence the selection committee included: Jane Butler Kahle, chair, Jerry Resnick and Steven Gilbert. The Committee adopted both the philosophy and goals promulgated by the Biology Focus Group of Project Synthesis to guide their efforts.

The National Association of Biology Teacher's Committee analyzed the historical goals for biology education to establish criteria. These historical goals, as stated by Hurd, Bybee, Kahle, & Yager (1980), were:

Historical Goals

Biological Knowledge:	Biology education should develop a fundamental understanding of biological systems.
Scientific Methods:	Biology education should develop a fundamental understanding of, and ability to use, the methods of scientific investigation.
Societal Issues:	Biology education should prepare citizens to make responsible decisions concerning science-related social issues.
Personal Needs:	Biological education should contribute to an understanding and fulfillment of personal needs thus contributing to the development of individuals.

Career Awareness: Biological education should inform students about careers in biological sciences. (Hurd, et. al, 1980)

Although these goals had been useful in guiding programs and in conducting searches in the past, NABT concurred with the Synthesis group that they were inadequate for the future. Therefore, our search for excellence in biology education would have to be based on new goals. These goals would, then, suggest new criteria for our search. After reviewing the literature, we adopted specific goals to guide our efforts. Hence, for purposes of the 1982 NABT Search for Excellence, the following goals define an exemplary Biology program:

1. Human adaptation in bio-social context will be the organizational structure for knowledge.

2. Social problems and issues will be central to biology programs.

3. Inquiry processes unique to biological disciplines will be added to traditional goals.

4. Decision-making involving biological knowledge in bio-social contexts will be an important goal of the biology program.

5. Career awareness, an integral part of learning, and a variety of science related career opportunities for all individuals will be stressed.

6. Value, ethical, and moral considerations of bio-social problems and issues will be a goal of biology programs. (Hurd, et. al., 1980).

After goals were agreed upon, our next task was to establish the criteria against which we would evalute programs nominated in biology. We decided upon four sets of criteria, three of which addressed specific areas in any biology program and a fourth which addressed overall excellence and impact of a biology program.

The three specific areas were curriculum, instruction, and evaluation. The National Association of Biology Teachers' Search for Excellence in Science Education Committee adopted the criteria promulgated by Project Synthesis in these three areas. The first set of criteria concerned the type of curriculum desired in an outstanding biology program. The following recommendations of Project Synthesis were adopted and applied in our search.

1. **Criteria Set One: Curriculum**

   a. Curriculum will be flexible and involve a variety of resources; it will be culturally and biologically valid.

   b. Humankind will be central.

c. Program will be multifaceted emphasizing many dimensions of biology including local, regional, national and global relevance.

d. There will be greater use of the natural environment; community resources and issues will be the focus of future study.

e. Biological information will be in the context of the student as a biological organism in a cultural/social environment.

The second area in which we established criteria was instruction. Criteria in this category covered all of the instructional methodologies and technologies which would result in an outstanding biology program. The following four criteria were adopted to guide our evaluation of the instructional component of recommended biology programs.

2. Criteria Set Two: Instruction

a. Instruction in biology will be individualized and personalized with use of large and small group as well as individual instruction as appropriate.

b. Instruction will be organized by the biology teacher in accordance with the unique needs of his/her students and school.

c. Instruction will emphasize cooperative work on problems and issues; it will include the school and community as a part of the learning laboratory.

d. Instructional methodology will be based on information and research in developmental and social psychology with special attention to the adolescent.

Since the most outstanding program in biology may be strengthened or weakened by the type of evaluative strategies employed, NABT's Committee adopted a third set of criteria to guide its selection process. This set addressed evaluation in the biology programs. Again, the Committee followed the recommendations of the Biology Focus Group of Project Synthesis. The following criteria were accepted and used in our search for excellence in biology.

3. Criteria Set Three: Evaluation

a. Testing and evaluation will reflect the use of knowledge to interpret personal/social problems and issues.

b. Student evaluation is based on growth in rational decision-making concerning personal and social problems (Hurd, et.al., 1980).

In addition to these three sets of criteria which addressed specific parts of any biology program, NABT's Search for Excellence Committee established a fourth set of overall criteria to guide their search for an evaluation of exemplary programs. This set included the following guidelines.

4. **Criteria Set Four: Overall Excellence and Impact**
An Exemplary Program in Biology must ...

a. Be accessible and open to all students.

b. Present biological information and biosocial issues in a nonsexist format.

c. Be successful in encouraging segments of our population who are not adequately represented in science careers to pursue additional science courses.

d. Contain a viable, active laboratory component.

e. Use field work and develop field experiences.

f. Contribute to the overall level of scientific literacy and awareness in its community.

These four sets of criteria were used to select an example of an exemplary program in biology.

The Committee realized that the most they could hope to accomplish was to identify and to select a prototype program. Both time and financial constrains prevented a thorough search for outstanding programs as well as an indepth evaluation of nominated ones. However, within these limits, the Committee used the Association's network of Regional Coordinators, State Representatives, and State Directors of their Outstanding Biology Teachers Award's program to solicit nominations.

Each program considered for nomination was provided with a single page descriptive summary of the criteria as well as with materials describing how to complete a nomination form. Selection was made by the Committee based on the information contained in the completed nomination forms. As the Committee deliberated, it became even more cognizant of the difficulty of its task. That is, there was no single prototype program of excellence - what was outstanding in rural Iowa might not be unusual or useful in New York City. All nominations contained aspects of excellence and all should be recognized. However, difficult as it was, we were charged with selecting one program. The biology program at Shawnee Mission South High School contained many aspects of excellence and most adequately matched our stated criteria. The National Association of Biology Teachers' Search for Excellence in Science Education Committee agreed that the biology program of Shawnee Mission South High School was one example of excellence which should be of interest to biology teachers, principals, and superintendents. We are proud to have it represent excellent biology programs everywhere.

5. The NAGT Criteria

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The National Association of Geology Teachers was asked if it wanted to participate in the N.S.T.A. Search for Excellence in Science Education by identifying an exemplary earth science program. It should be stressed that due to the limited amount of time in which to make the choice, the program chosen is deemed to be an exemplary program, not the exemplary program. Time and financial constraints limited the search to a very few programs and visitations to only three programs.

Selection criteria were determined by means of a literature review and an analysis of national needs in the area of science education. The four selection criteria identified and used were:

1. The existence of a program; i.e., more than one teacher must be involved;

2. Content which reflects the broad field;

3. Appropriateness of instruction;

4. Positive teacher attitude.

After establishing the criteria, a limited search was conducted, primarily involving telephone contacts with science educators knowledgeable of earth science programs in various parts of the country. The informal search committee consisted of John R. Carpenter, President of NAGT, John F. Thompson from Memphis State University, and Vic Mayer from Ohio State University.

Three programs were selected for site visits. Visitations were conducted in October, 1982, by John R. Carpenter who spent approximately one day visiting each of the programs.

An important aspect of the selection was that more than one teacher need be involved. Several teachers from one school would be the minimum acceptable definition of "program." The reasoning behind this criterion was that several teachers working together have the possibility of establishing a synergistic environment, one in which the sum total of all their efforts would exceed the sum of their individual efforts. Each of the several teachers, even if they were doing essentially the same thing, would bring something unique to the program, to the others, providing all of the teachers with more options from which to choose.

A second consideration was that several teachers working together would form a support network, providing each one with a cadre of other teachers on whom to call in time of need. These people probably would share both new and common experiences, gaining from the experiences of each other.

In many regards, secondary school earth science is one of the most difficult secondary school courses to teach. The difficulty stems from several factors, one of which, however, is that the course has no well defined content limits. It embraces parts of what has traditionally been known as geology, astronomy, oceanography, geography, and meteorology. Further, it requires at least a rudimentary knowledge of chemistry and biology on the part of the teachers. The breadth of the "course" is awesome! A second factor making the course difficult is that few teachers have been adequately prepared to teach such a course. This, of course, relates to the previous consideration - the breadth of knowledge required is difficult to obtain in many teacher preparation programs. Thus, earth science programs tend to be either: 1) very good (due to teacher preparation) or 2) very bad (due to a lack of teacher preparation). Many teachers seek the additional information and training necessary to teach the course well. Others struggle to "get by."

Therefore, one very important criterion used to select an exemplary earth science program was the breadth of content material being taught and the preparation of the teachers in the program involved with teaching.

Further, it was felt that the content should also reflect the following needs:

1. Science literacy;
2. Science appreciation;
3. The relationship between science and societal needs;
4. A decreasing number of persons aspiring to careers in science.

The following sections elaborate on each:

1. Science Literacy.

There is little doubt that the overall level of science literacy in the U.S. has been decreasing for at least several years. Many believe that a part of this problem rests with how young students are taught "science" in the elementary schools (if science is taught at all) and in junior high and high school. Many elementary teachers avoid teaching science, partly due to their poor preparation or lack of preparation. Others who do teach what they call science, teach the students a body of "factual" knowledge. Very little emphasis is paid to science as a process; more attention is paid to science as a product, i.e., "facts."

The same seems to hold true, perhaps to a lesser extent, in the junior high and high schools. More teaching (but not all) at this level has an appreciation of the process of science. In many cases, this gets passed on to the students. Any exemplary earth science (or any other science) program must approach the science literacy needs of the country; and certainly one important part of this need is the need to stress the process of scientific inquiry.

2. Science Appreciation

Partially as a result of the decline in science literacy, there has been a decline in attitude of the general public toward science and scientists. Fewer and fewer people see how science affects them personally. There was even an attitude that developed about 10 years ago that science was responsible for many of the problems that people experienced - pollution, robotics, the threat of nuclear annihilation, to mention a few. Fortunately, this attitude is changing to some extent, but few people see science as contributing to the overall improvement of our total environment.

Thus, a second content criterion was imposed; the program must address the issue of science appreciation. The general public must gain a more positive attitude toward science and scientists; an effective way to achieve such a goal is to demonstrate what science is doing and can do for students in their daily lives.

3. Science and Society

Very closely related to science literacy and science appreciation is the relationship between science and society. While not many people understand that science is a process, even fewer understand the relationship between science and societal issues. In fact, many people see science as "not being bothered with" societal issues. To a large extent, scientists themselves are to blame for this misunderstanding. Also to blame, however, are the teachers who teach the isolation of science or the "insulation" of science from societal issues.

In fact, many scientists are deeply concerned about societal issues and believe that science research can have a bearing on bringing about solutions to societal issues. Teachers must gain that appreciation and must pass on that appreciation to their students if we are to bring about positive attitudinal change in the general public toward science. Thus, a third content criterion that was imposed was that the program selected must discuss societal issues and the role of scientific research and inquiry in the establishment of solutions to these problems.

4. Science Manpower Pool.

There is a fear, apparently well-documented, that this country is facing a shortage of trained scientists, mathematicians, and engineers in the immediate future. If so, it is incumbent upon all charged with science education to do what can be done to increase the number of young people choosing to enter these professions. A necessary, but not sufficient aspect of the solution to this problem, is the increase in science literacy. More people simply must know more about science. To do this, we must address the science appreciation issue and the science-society relationship. Then and only then will science literacy increase.

The next question to face, however, is "How do we increase the number of people choosing science, mathematics, or engineering as a career?" An important part of the answer to that question is the need to educate the students about science careers. "What does a scientist do?" "How much schooling is involved?" "Where do scientists work?" "What kinds of careers are available?" The fourth content-criterion imposed was that the program must deal with these and related questions.

The third large scale criterion involved appropriateness of instruction - to what extent is the instruction appropriate to the needs and abilities of the students. It is often stated in education that different people learn best in different ways. Some learn best in a highly structured environment, with prescribed content and goals. Others learn best in a less structured, more "free-flowing" environment where some content structure is used as a general guide, but where the teacher (or students) can divert from this path to discuss or investigate issues, questions or problems as they arise.

Thus, the program selected would have to accommodate at least these two types of learning environments and perhaps others. Further, the students (and their parents) should have some say in the choice of instructional environments. A strong investigative laboratory component with sufficient equipment for experimentation was also an important component, as was instruction in the scientific method.

The fourth criterion, and carrying equal weight with the other three, was teacher attitude. Components of teacher attitude include:

1. Care and concern for the students and their learning;

2. Enthusiasm;

3. Positive self-concept and positive profession-concept.

All teachers, to be effective, must care for and be concerned with the students as individuals; such care and concern must include and extend beyond care and concern about their learning.

A teacher must also be enthusiastic about what is being taught. This enthusiasm must require the teacher to take some risks into areas where expertise is limited. To do this, the teacher must be willing to admit to not knowing everything and to seeing and experiencing the delight of learning with the students, rather than simply teaching the students what the teacher already knows.

Finally, a teacher must feel good about him/herself as an individual and as a teacher. The teacher must value self and value the teaching profession. Often this means understanding that the task is more important than what is reflected by the compensation received.

B. THE EXEMPLARS

1. THE PHYSICS EXEMPLAR

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SCHOOL SETTING

Oak Park and River Forest, two communities with a combined population of 70,000, are residential suburbs adjacent to Chicago. Excellent cultural and recreational advantages, with many hospitals and churches, make this community a people-centered place with extraordinary emphasis on the schools. The total assessed property valuation of the district is sufficient to provide a per pupil valuation of $98,000. The total appraised value of the high school building and equipment is about 61 million dollars. The communities include minority populations of approximately 5.3% black, 1.8% Asian American, and 1.4% Hispanic. Oak Park and River Forest have large percentages (37.7% and 50.6%, respectively) of adults with the occupational status of "professional, manager, or administrator," which indicates an educationally oriented population. Historically, the board of education has been very supportive of excellence in education.

Oak Park and River Forest is a high-school-only district, fed by two separate K-8 school districts. The enrollment in the four year high school is 3,329, and the enrollment trend is downward (from a peak of over 4,400 in the early 1970's). Enrollment is expected to bottom out in about 1985, with a gradual increase foreseen in the future. The per-pupil cost for education is $3,900/year. The certified staff numbers 256, for a student/teacher ratio of 13/1. The main portion of the school building is approximately 50 years old, but many additions/remodelings have been completed since its initial construction. The school district dates to 1873, and claims an illustrious list of graduates, including Ernest Hemingway, John La Montaine, and Ray Kroc. Specialized science facilities are limited to a recently acquired greenhouse donated by a district resident.

PROGRAM DESCRIPTION

The Physics curriculum at Oak Park and River Forest High School (OPRF) provides an offering suitable for nearly all of the college-bound portion (over 77%) of the school population. Specific courses include:

1. Physics 1P

A less mathematical introduction to physics. This course emphasizes the concepts of physics and avoids much of the mathematical formalism of typical college-preparatory physics programs. Paul Hewitt's text, **Conceptual Physics**, forms the basis of this level of introductory physics. Classroom activities are structured about investigations of physical principles and students are encouraged to explore the interrelationships of various physical properties. Present enrollment in Physics 1P is 20 students.

2. **Physics 1**

A traditional approach to high school physics at a modest level of mathematical difficulty. The text of this course is **Concepts in Physics** by Miller, Dillon and Smith, the high school version of the most popular non-calculus college physics text, Miller's **College Physics.** While only first year algebra is a prerequisite for this course, most students have also completed a year of geometry and are concurrently enrolled in advanced algebra. At present, 102 students are enrolled in Physics 1.

3. **Physics 1H**

A first course in physics for the above average student. Nearly all registrants for this course will take the Advanced Placement Level B (non-calculus) Examination at the conclusion of their year in Physics 1H. The present text for this course is Beiser's **Physics.** Enrollment this year is 101.

4. **AP Physics**

A second course in physics for serious science students. All students enrolled in AP Physics expect to take the Level C (calculus) Advanced Placement Physics Examination at the conclusion of the year. Sears and Zemansky's standard textbook, **University Physics** in the choice for this calculus-based physics course. While not strictly a corequisite, all AP Physics Students are co-enrolled in calculus, and many are also co-enrolled in AP Chemistry. The current enrollment in AP Physics is 21.

Another course taught in part by physics teachers is Freshman Science Survey. This course, newly developed by the science department at the school, is an attempt to provide incoming students with some exposure to the broad offerings of the science department at Oak Park and River Forest. Students receive six 6-week units of instruction, taught by different instructors representing the various areas of science education at the high school. During the physics segments this year, students were introduced to problem solving techniques involving the personal computer and scientific analysis techniques for solid, liquid, and gaseous systems. Present enrollment in Freshman Science Survey is 326.

All of the introductory physics offerings of Oak Park and River Forest High School are laboratory based. Physics 1 and Physics 1P employ the

Murphy and Smoot laboratory manual, **Physics: Principles and Problems.** Physics 1H laboratory activities are structured about an original set of experiments designed to complement the laboratory apparatus available at Oak Park and River Forest. Most experiments are standard laboratory investigations performed in college physics laboratories. While the AP Physics course does not have a weekly scheduled laboratory period (the demands for coverage of topics in the AP Physics Level C curriculum do not permit time for weekly laboratory investigations), students are expected to complete quarterly projects that require the development of experimental skills. Project topics for the 1982-83 school year include bridge building, mousetrap cars, and other "Physics-Olympics"-type events.

There is clear agreement among the administration, other faculty, and students of Oak Park and River Forest High School that the prime key to the success of the physics program at the school is the talented, dedicated physics staff. Physics staff members are Richard Novak, Jim Vokac, Margaret Roth, and Joe P. Meyer. These teachers have worked hard to develop a learning environment that encourages all students to consider physics an exciting subject for study. Some team teaching occurs in Physics 1 and Physics 1H, but throughout the offerings the emphasis is on substance rather than strategy.

Perhaps the overriding characteristic of the science program at Oak Park and River Forest High School is the support shown by science teachers of one particular discipline for the offerings of the other areas of science. No student is permitted to enroll in a second year of a particular science without having taken at least one year of the other basic science offerings (biology, chemistry and physics). This emphasis on breadth of preparation, rather than depth in one particular area, is a prime consideration in the identification of an oustanding college-preparatory physics program. Statistics for recent years confirm the degree of support among members of the science department staff for a broad-based science preparation. Nearly 70% of the graduating class of 1981 had at least one year of life science and one year of physical science. More than 70% of the students enrolled in biology as sophomores continued with chemistry as juniors and over 60% of the chemistry students continued with physics as seniors. Including the Freshman Science Survey, in excess of 50% of the graduating class has received at least some instruction in physics. Physics is only one of many science programs with high enrollments. In fact, science, with only a one-year graduation requirement, is second only to English, with a four-year graduation requirement, in terms of course offerings and enrollment! (Over 75% of the student body is enrolled in a science course in 1982-83).

Any examination of the achievement of students in the Oak Park and River Forest High School physics program indicates a high level of success. Students from the school attend a broad range of institutions, from the most prestigious universities to the local community college. Follow-up studies of graduates indicate overwhelming satisfaction with their preparation in science. Of those students enrolled in Physics 1H and AP Physics taking the Advanced Placement Examination in 1982, nearly 90% received scores of 3, 4, or 5.

Probably the most significant measure of excellence of the physics program is the performance of Oak Park and River Forest High School on the Junior Engineering Technical Society Contest over the course of the past three years. The school entered this competition for the first time in

1979-80. The Oak Park and River Forest JETS Team placed as state runner up; in 1983 Oak Park and River Forest High School was the national winner. (The JETS competition involves tests in graphics, English, mathematics, biology, chemistry, and physics. Each team member takes only two examinations. Thus, the overall team score is a reflection of the total program, rather than the extraordinary abilities of one or two students.) Oak Park and River Forest has also provided vast numbers of winners of the Westinghouse Science Talent Search and finalists for the Space Shuttle Project.

The four newer laboratories provide no services to the student work station that is not common to any typical secondary school laboratory. Each two-student work station is equipped with A.C. outlets as well as teacher selected D.C. electrical supply. Two of the laboratories have student work stations equipped with water, gas, vacuum and compressed air in addition to the electrical connections. These two laboratories are used to teach freshman science as well as upper level physical science classes. The four laboratories are also equipped with magnetic chalkboards, projection screens, and ample side storage for equipment and supplies. Each laboratory is designed for 24 students.

The use of the large group instruction room is unique for a high school science program. Each year since the large group instruction room was first completed, it has been used by at least one section of physics classes. Several class sections of a particular course offering are given two large group instruction classes each week. The students then meet for five single periods as a laboratory recitation section. The large group instruction session is often used for the presentation of materials, and at times, demonstrations ~~that~~ require complex set-ups are used. The large group sessions are often videotaped to allow students who are absent or have schedule conflicts to participate in the activity. The use of the large group instruction helps to prepare the physics students for the typical large group lectures in college. Over one hundred students participate in large group physics instruction each year.

The physics curriculum at Oak Park and River Forest High School is determined by the individual teachers in the science department. Large schools with many sections cannot allow total individual freedom in an academic program. The physics program is under continual investigation and review for the purpose of maintaining a teaching and learning climate that works to the best advantage of the faculty and the students. New members of the staff each have something to offer that will improve the effectiveness of the program.

New staff members in physics are assigned advanced classes enrolling the most motivated students without first teaching students enrolled in general courses. As an example, two of our most recent additions, were given assignments in the Advanced Placement Physics and Honors Level Advanced Placement Physics courses. It is by the creative utilization of the faculty that the physics program is able to offer the best instruction to the students.

The physics curriculum is determined by the teaching faculty. Most high school physics is determined by the text chosen and the laboratory equipment available. The text used at each level is reviewed by all physics teachers even if they will not be teaching the particular course involved. Laboratory equipment is selected by the individual teacher, however, all lists are compared to eliminate possible duplication and oversights. The physics program undergoes the most change when the faculty changes. Only secondary to this change is the need for change in text materials. The three levels of introductory physics share but one common goal--to teach a complete course. Every student is given the opportunity to experiment with the equipment and ideas of nuclear and atomic physics. No one area of physics is more often discussed by an uninformed public than the creative and destructive use of the atom as an energy source and weapon. It is the duty of physics and physical science faculties to make solid scientific information available to as many students as possible. The high school physics--physical science class is most often the terminal science course for students.

PROGRAM HISTORY

Physics at Oak Park and River Forest High School is an ever evolving program that makes every attempt to improve through continual change. The total program of the school is directed to the best possible education for the youth of the community. It is difficult to separate any one program and subject it to an examination without indicating the influence and effects of the entire curriculum. Any success that is shown by the physics program must be based on an excellent mathematics program and added to a firm and complete foundation in previous science study. The physics program builds on the well laid scientific foundation of the entire high school.

The physics program at Oak Park and River Forest High School has always been a text-based traditional program with emphasis on student participation. A very high percentage of the physics students pursue a science related field of study in college, and it is the school's purpose to start them on their careers with the fundamentals of the scientific methods. A traditional P.S.S.C. school since 1959, the program added Project Physics in the early 70's to augment the course offering for the student without a keen math ability but a desire for science.

In the late 70's a college text and a very traditional approach was included for the regular sections of the course. Equal numbers of students enroll yearly in each course. The traditional college text was used to allow the student the opportunity to participate in the Advanced Placement program and obtain college credit while in high school. About thirty students each year take the A.P. test in May. Over twenty additional students elect to take the test after completing the 'C' level physics courses in mechanics and electricity during their senior year.

No one day or date can be indicated as the time when a great change occurred; however, a major renovation of the building occurred in 1967. The physics program was moved into four totally new laboratory/recitation rooms. Additionally, the renovation provided the students with one large science lecture room that seats 115 students; this added facility increased the flexibility of the methods of instruction employed. Physics students have used this room on a formal basis for large group instruction since it first became available.

One example of the evolution of the physics curriculum could be the 14 year program of CHEM-PHYSICS. The faculty in the late 60's was concerned that a student was "tracked" out of Advanced Placement courses by the selection of the first course in the program. Many good students were forced to attend summer school to catch up with the honors group. A core curriculum of chemistry and physics was combined into a full two credit course requiring between 12 and 14 class periods each week.

The CHEM-Study and PSSC materials were selected for the course in the early years. A combination of large group instruction and team teaching was used for the course. Sections of each course were selected and interwoven to allow a thorough study of the subjects. The two teachers for the course were qualified and experienced in both physics and chemistry. Seventy students elected to enroll in the program the first year. The second and third year enrollment remained high and included a change in faculty.

By the fourth year, students of lower math background and scientific ambitions were signing up for the course. The class lost its homogeneous makeup and new materials had to be substituted for the more rigorous curriculum. Over the next several years, the enrollment decreased accompanied by an increase in registration in the typical physics and chemistry courses. After ten years the course had stabilized and evolved into a single group of 25 students ability grouped at the level of regular physics and chemistry. One teacher and a single laboratory recitation room was required for the course. By the current school year, the enrollment dropped to fewer than the 15 students required for a full section, and the class was dropped from the curriculum. The students were able to substitute concurrent registration in both physics and chemistry, and were not lost to science. CHEM-PHYSICS will continue for at least two more years in the program of studies; only after an extended period of inactivity will it be officially dropped.

The evolution and demise of CHEM-PHYSICS is typical of curriculum at Oak Park and River Forest High School. The program is flexible and readily changed to meet a need. No great time for study is required; the faculty is encouraged to try new and innovative courses to meet student needs or to give the students the opportunity to study subjects of particular interest to the faculty.

Two major sources of inspiration have been evident in the evolution of the physics program at Oak Park and River Forest High School. First is the Illinois State Physics Project; second is professional organizations. It is only through these sources that the program has been able to keep up with changes in both materials and methods. All members of the physics faculty have been involved with the I.S.P.P. at one time and all belong to and participate in at least two professional organizations.

The most important single outside influence on the physics program is the Illinois State Physics Project. The Illinois Project was started in 1968 by a group of high school and college faculty that saw the need to update and improve the teaching of physics in the state. N.S.F. proposals were written and funded for summer programs at five college campuses within the state. The purpose was to give the physics teachers in the state experience with new methods of teaching physics and to update their study of the subject matter. The institutes which ran for a total of seven years were followed by monthly meetings of teachers to share ideas on the teaching of physics.

Members of the Oak Park and River Forest faculty attended institutes at Lake Forest College, Illinois Institute of Technology, and DePaul University. The institute continued to be funded at the Illinois Institute of Technology through 1977. Six different members of the faculty were involved with the institutes and one staff member taught laboratory activities at both DePaul and IIT for several years.

The program of the institutes was to include continual inservice program of revitalization and information sharing between both high school and college instructors. Now five years after the end of N.S.F. funding, the inservice portion of the program continues on a monthly basis. A group of nearly 150 teachers of both high school and college physics participate in monthly evening meetings at different campuses or high schools. Each meeting is attended by 25 to 50 people. The meeting locations are moved about the geographic area and the evening is changed month to month. Only about 10 individuals seem to make every meeting; however, the group continues to grow. Each meeting consists of a grown-up show and tell. About 10 to 12 teachers appear at each meeting with a paper bag, or a Jensen Box containing some piece of apparatus to show to the group. (A Jensen Box is a cardboard box fitted with a handle on plywood that can be easily carried from meeting to meeting--it is named after the founding father of the ISPP, Harold Jensen of Lake Forest College.)

Harold Jensen probably did more for physics teaching in the metropolitan Chicago area than did Newton and others. Harold coined the phrase that has been the guideline to physics teaching--PHENOMENOLOGICAL APPROACH. His rule for physics teaching is, "If you can't show it, don't teach it." Harold has retired to the Southwest, but he continues to send messages to the teachers in the area. His example is evident in the teaching of the OPRF physics faculty. Teachers at the monthly meetings would constantly challenge Harold with real physics that could not be demonstrated or examined by the student by a laboratory activity. Meetings would then turn into large think-tanks with each teacher trying to come up with some demonstration.

One example that may help describe the phenomonological approach is the teaching of the triple point. The triple point is that one unique temperature and pressure at which all three phases of a substance may coexist. Everyone can relate to ice and water or to water and steam, but three phases present a problem for a demonstration. Harold collected some solid carbon dioxide (dry ice) by firing a fire extinguisher through a cloth. He then placed the dry ice into a small screw cap vial and capped it. The vial was then placed into a shield to contain the experiment in the event of an explosion. After about five minutes, everyone could see liquid, solid, and the assumed gas present in the container. While it would take much instrumentation to determine the exact pressure and temperature, the student can observe the phenomena. The goal of every physics program should be to teach the phenomena.

Earl Zwicker of the Illinois Institute of Technology was the recipient of a Distinguished Service Citation from the American Association of Physics Teachers for his continual work with the monthly meetings of the ISPP. Earl coordinates the monthly meetings and sends out a monthly report of the previous meeting to all members. The **Physics Teacher** now has a feature column, **Doing Physics**, that is edited and written by Earl. **Doing Physics** each month explains a new method of explaining some physical phenomena in the physics classroom.

Each meeting of the ISPP begins at 6:30 p.m. with coffee and rolls furnished by the host school, and the presentation is most often informal with all kinds of questions and suggestions. A highlight of the evening is the free-give-away. Everyone attending meetings is given some bit of apparatus to take to his/her school. These may be a complex meter (surplus) or a bowling pin. One notable give-away was a set of polarizing filters mounted in 35mm slide mounts. The polarization plane was on the 45 degree line rather than an axis. The results were amazing.

The program at Oak Park and River Forest High School is not unique in the Chicago area. Physics teaching in the area is a common goal and the source of a common pride. The teachers know each other, talk on the phone often, and share experiences and needs. The value of the sharing with other physics teachers is invaluable and should be encouraged as the strongest single attribute of a good program in any subject area.

Second only to the local affiliation with other physics teachers is the role professional associations play in the development of the Oak Park and River Forest High School physics program. The school encourages the participation of the faculty in professional organizations. All members of the physics faculty are members of the American Association of Physics Teachers and the National Science Teachers Association. In addition, most of the faculty is involved with state and local science and physics teaching organizations.

The American Association of Physics Teachers furnishes the high school teacher with the **Physics Teacher** which is directed toward the teaching of physics at the introductory level as well as **Physics Today** which allows the faculty to keep abreast of current topics in physics. Many of the articles in each journal are of value to the high school teacher. A recent series on high school texts has been used by members of the physics faculty in evaluating texts for the coming year. Without the journal, the evaluation process would have taken longer, or possibly not have been as thorough.

The AAPT holds two meetings each year, and at least one member of the department attends each of these meetings. The local meetings allow each teacher to share with friends and the national meetings present the teacher the opportunity to compare and contrast teaching strategies on a more formal basis. The display of teaching materials at these meetings is the most complete exhibit of teaching materials for physics. The meetings of the AAPT have done much to influence the evolution of the Oak Park and River Forest physics program.

The National Science Teachers Association has been the other major professional association evident in the formation of the physics program. While the AAPT places a concentrated emphasis on the teaching of physics, the NSTA helps to improve the teaching of science as a total subject. Since the total science program is important in any school, an important role for NSTA is maintaining a total picture of science. The NSTA is currently deeply involved in trying to alleviate the shortage of teachers of physical science. The Association has collected the data that all newspapers and media are continually quoting. It is the constant and never relenting pressure exerted by NSTA and similar organizations that will eventually improve the quality of physical science teaching throughout the country.

The Science Teacher is the NSTA journal dealing with the teaching of science for the secondary teachers. This magazine is the most widely read journal concerned with science teaching in the world. A physics program that is to keep current must stay abreast with the latest technologies in all areas of science teaching, and this is accomplished in part by reading **The Science Teacher.**

The meetings of the NSTA are the largest meetings of any science teaching organization.. Science teachers of all disciplines attending these meetings are given opportunities to attend any of several programs designed to aid in science instruction. Members of the Oak Park and River Forest High School science department attend all meetings of the association. The display of equipment is the largest and most complete anywhere. No program can fail to grow and improve if the faculty members are encouraged to participate in the annual meetings of the Association. Day to day teaching can become life in a box. A trip to a NSTA meeting can do much to expand the dimensions of the educational box.

It is evident that the program of physics at Oak Park and River Forest High School has been evolving, and the evolution is guided by sharing experiences with other teachers. Many methods can be used to improve instruction; however, the simplest is by active membership in the national science teaching associations. It is difficult to discern between improved programs and active membership--which is the cause and which the effect?

The addition of the Freshman Science Survey is the most novel and involved change in science curriculum in many years at Oak Park and River Forest High School. Nearly the entire Freshman course offering was changed. Only the honors level of Biology remained unchanged.

The upper thirty percent of the Freshman class has elected to take Biology F, an accelerated course. The remaining students were able to choose between year courses of Introductory Physical Science (IPS), semester courses in Earth Science, IPS Life Processes (a biology-related course), astronomy, earth science, and combinations of these courses. No question about the appropriateness was evident regarding the offering of Honors Biology to the upper thirty percent; however, no group was pleased with the remaining course offerings. Some parents and students wanted biology to become available to all Freshmen, while the faculty did not feel the incoming students had the maturity to cope with an abstract science course below the honors level. Neither the faculty nor the parents were pleased with the alternative science courses. Members of the department seemed to be isolated and buried in the Freshmen class and these were people well-trained in other subject areas. The course offerings were always changing, but it seemed to be a repainting rather than a complete remodeling each time.

Freshman Science Survey was the idea of Wendel Smith, a teacher of Earth Science and Biology. He attempted to involve more teachers with the students but for a shorter period of time. Each could bring his unique expertise rather than have one teacher try to teach his own area as well as areas of the other faculty members. Oak Park and River Forest High School uses the six week grading system with three grading periods per semester and six periods per year.

Teams of teachers were formed consisting of one physical science, one biological science, and one earth science teacher. The students would change teachers and disciplines as well as teachers and rooms each grading period. The program would change at the end of the semester, and the students would move through the same set of three teachers again. Wendel suggested his idea to several faculty members and a committee was formed to investigate the possibility of establishing a new course.

The committee reported to the department, and after some discussion and a few subtle changes, it was voted upon and passed. The members of the Student Council, Faculty Association, Citizens Committee and other groups were given the opportunity to comment on the program. Within one month of the department approval, the Board of Education passed the program and it is now in its first year with an enrollment of over three hundred students.

Many individual problems that such a program cause still must be resolved. How can an absent student make up work between two teaching sections and teachers? How can a transfer student enter or leave such a program? The first semester has just been completed and no great difficulties have become evident.

Later this year a preliminary report of the program will be made and recommendations will be made for the following year. The program will continue for one more year to give it every chance for success. Initial results indicate the program is exactly as the school anticipated--something that the faculty, students, and parents will accept and enjoy. Only time will tell if it has any effect on improving the selection of science classes for the students in their upper class years.

The process by which curriculum is changed in the science department of Oak Park and River Forest High School is one of the reasons for a strong science program. Many schools place so many hurdles in the path of the teaching faculty that every change takes much too long and must be investigated by too many groups and individuals. In many districts, the only change in curriculum that has any possible chance for acceptance is a change that is presented by a curriculum director or a science supervisor. It is the belief at Oak Park and River Forest High School that the teacher of the courses is the expert in the field and the change should be instigated by the teacher. The school administration works well with the faculty to help with the change rather than set up obstacles toward the improvement of the curriculum.

The work of the committee was to examine the advantages as well as the disadvantages of such a novel course offering. Such an experiment could not be tried with just a section of two--the program needed numbers to be a valid experiment. Typically, one or two sections of courses are offered on an experimental basis and the counselors are encouraged to control the enrollment. Freshman Science Survey would need a minimum of one hundred students and a group in excess of three hundred would be much better. The committee also examined the scheduling difficulties and the method that would be used in determining the semester grade in the course.

The method used to build the enrollment was to drop all of the remaining courses from the program of studies with the exception of one or two isolated courses. This would force the students to elect the Survey course. With guidance from the science department, the administration was able to determine how the scheduling could be completed with little confusion. Grading was to be accomplished by each six week period teacher, while the last teacher in the semester would give the final examination and determine the semester grade. Logistically each teacher would furnish the last teacher with 25% of the final exam and the last teacher would furnish 50% of the test. The final grade involved a discussion among teachers only in the event of difficulty in establishing a fair semester grade.

Each faculty member for the Survey course was encouraged to teach his/her own particular field of interest, and not a short course in physics for example. The survey course was to teach laboratory techniques and the scientific method and not to be specific as to the subject area. The physics would be taught by a physics teacher, and the biology by a biology teacher. Some typical six week units in the physical science were Measurement and the Microcomputer, Selected ISIS projects, Periodic Motion, and Kitchen Chemistry. Biology units were from Fish through Seeds and on to Fowl.

The students in Freshman Science Survey learned a bit about all areas of the department from teachers of the particular discipline. As time passes and the student is faced with course selection for later years in high school, the Survey course will give more information with which to make appropriate choices.

Many of the materials used in the teaching of physics at Oak Park and River Forest High School are unique to the school and built locally. The student air tracks that are used for several mechanics experiments were built from surplus aluminum tubing. Such tracks could be purchased; however, the cost would be high. Several other types of apparatus are homemade. However, this equipment alone does not set the program aside from other such programs.

Commodore PET microcomputers have been added to the physics program within the past two years. State and federal monies for the Gifted were used to make these purchases. Students in physics honors were given about two hours of instruction on the system and then encouraged to write programs to evaluate their data in laboratory activities and experiments. Very little Computer Assisted Instruction materials have been purchased or locally produced. It is the philosophy of the physics program to give the student the opportunity to use the computer as a tool of science rather than another method by which to learn the material.

Laboratory activities and the systematic handling of data are the reasons for the computer in the laboratory. If a calculation must be repeated more than once or twice, it should be computerized. The use of the program is not to create computer programmers or even computer operators, but rather to help the students be computer users.

Students who use the computer in the analysis of laboratory data benefit by receiving additional credit. In addition, the computer conscious student develops a thought process that is invaluable in the solution of all physics problems. The use of a computer by science students forces them into chronological and logical thought patterns that can be of great value in many fields of learning.

The use of microcomputers in the physics classroom should be encouraged in all schools. Students should be given the opportunity to write programs that can save them time and energy.

PROGRAM MAINTENANCE

A parent advisory and a citizen advisory program is supported by the Board of Education and is of some value in evaluation of the program. The effect in evaluation of individual courses is not often sought. However, the school is quite responsive to the desires of the community in the overall education program of the school.

Four groups are required to provide a strong academic program in a high school. Two of these groups are the parents and the students, while the other two are the teachers and the administration. Without the full cooperation and support of all four groups, no worthwhile program can have any real chance for survival. The support of the administration at Oak Park and River Forest High School should be noted in connection with all program successes. Innovation is encouraged at all levels, including the administration. Financial support is provided within limits of the budget. Teachers are encouraged to attend and participate in professional meetings.

Teachers are always given the time to attend meetings without financial deductions. If money is available, funds are provided for registration, travel, food, and lodging. Unlimited travel is not possible, but the school is far above the average in support of professional meetings.

The role of school administration is always described as that of a support service. Oak Park and River Forest High School has an administration that lives up to this goal. Oak Park and River Forest High School is a community of students, faculty, administration, and parents that work together to provide the best possible education for the students of the community.

The decisions are jointly made by the faculty and the administration. However, the ultimate control of the school is by the voters of the community and the Board of Education.

The school motto is "Those Things That Are Best." The basis for all decisions reflect this motto. Fiscal constraints often cause some compromise in decisions that require financial support.

The current total cost per pupil for the year is nearly $4,000 for the full school year. The cost of physics excluding faculty and building upkeep is about $20 to $25 per student. The budget for physics equipment and supplies is never enough. Nonetheless, it is adequate and far above the national average.

Budget requests for the next few years should reflect the addition of microcomputers into the curriculum. PET microcomputers have been in use for the past two years; however, they are not as yet used as devices to gather as well as process information from laboratory experiments. The future of the microcomputer must solve the current human interface between the instrument and the computer. In the future, the student will be encouraged to design a program that will not only manipulate data, but will also collect the data. This technology is not presently available for the high school laboratory. Future budgets will have to reflect the great increase in the cost of scientific instruments.

A physics program in another school would not be a new program, but a rebuilding of an older one. No program can be created for the sole purpose of attracting a student body. If a physics program is to be implemented or upgraded, it must first establish a need with the parents and students. A cursory glance at the job opportunities for the technologically educated can be of great value. If the community and the student body are made aware of the need for a strong science program, the program will be well on its way toward establishment.

After the need and desire is established, the plan must include the present faculty and staff in such a way as not to disrupt the established school. This may require some retraining if trained people are not on the staff.

Very few good programs are the result of spontaneous generation--the help of a local or nearby physics department should be requested. Help from other schools and colleges in the field of physics is readily available. Once established, a good program can be upgraded and maintained by keeping the ties to the other programs in the area.

2. THE CHEMISTRY EXEMPLAR

Jan Harris
Cy-Fair High School
Houston, Texas

SCHOOL SETTING

Cy-Fair High School is one of three high schools in the fast growing Cypress Fairbanks Independent School District in Northwest Houston. The District has a population of 107,000 with 26,000 school children and $175,000 property assessment per pupil. It consists of three high schools, five junior highs, and 17 elementary schools with plans for more of each to be built in the next few years. The 186 square miles in the District was almost entirely rural in 1968 but has now developed into a more cosmopolitan area. There are still vast numbers of acres devoted to farm and ranchland, especially in the Cy-Fair High School area. There are also some light industries and shopping centers. Many suburban communities have developed in the district, with homes ranging from moderate to expensive. Consequently, students come from all socio-economic groups and parents from every conceivable vocation and profession.

The community and school board have been very supportive of education. Bond issues have always passed, including the latest one for 90 million dollars. Teacher salaries are above the state norm and are competitive for the state. Teachers receive extra pay for teaching math, chemistry, or physics. Teachers selected as Master Teachers also receive extra pay.

Cy-Fair High School is the oldest of the three high schools, being built around 1940. It is a rambling, one story building with a number of additions and remodeled areas, including a new science wing which was completed in 1978. The faculty of 150 is a dedicated group that works well together and believes in building spirit and pride in self and school. All teachers support the academic and extra-curricular programs. The principal is well-liked and respected by everyone and encourages flexibility and creativity in all academic programs. There seems to be a generally conducive mood for learning.

The school is practically bursting at the seams with 2,500 students, of which 4% are Black, 4% Oriental and Indian, and 6% Hispanic. About 50% are from blue collar homes while 40% are from white collar homes and 10% from farming communities. About 65% are college bound.

Cy-Fair High School is known for its strong academic program as well as for its strong vocational program. Standardized test results show that the students score above the national norms on annual achievement tests. Each year school athletes compete successfully in various events; students also compete most favorably in academic and vocational events as well. There are usually two to four National Merit Scholar Finalists each year.

Except for chemistry, the science department is housed in a new science wing which contains nine lab/classrooms with small storerooms behind each, a plant room, animal room, science office, greenhouse, and arboretum behind the school. Due to lack of space and money, chemistry is located in an older wing and has two lab/classrooms, one regular classroom, and a large chemistry storeroom, workroom, and office. Four classrooms nearby will be converted into chemistry and physical science labs for the 1983-84 school year.

The science department, consisting usually of 12-15 teachers, offers regular and accelerated first year courses in biology, chemistry, and physics as well as second year (or AP) courses in these same areas. Electives are very popular and consist of aerospace, geology, physical science, marine science, environmental science, and astronomy. The science department has always been known for its dedication, creativity, and spirit. Most of the teachers are involved in at least one extracurricular activity. Over the past few years, there has been a major turnover due to retirement, promotion to science coordinator, and movement to another city with spouses. Only three teachers have been in the department for more than three years, but each of these has been with the district for at least ten years-- one is in each of the three major science areas. Two teachers have Master's degrees in their subject matter area and one teacher has many hours past a Bachelor's degree. The three teachers have a combined total of 55 years of teaching experience.

Although the school district requires two years of science, students have been able, in the past, to count 8th grade science as one of those two years. (This will not be possible for the 1984-85 school year.) However, in 1982-83, over 57% of the students were enrolled in a science course. Students in the regular tract complete Biology I as sophomores and then may elect to enroll in chemistry as juniors and physics as seniors or they may elect to complete one of the senior electives. The accelerated students complete physical science in eighth grade and are placed in the accelerated biology program as freshmen. They may take chemistry as sophomores, physics as juniors along with another second year science course--Chemistry II AP or Biology II. In the senior year they may take Physics or one of the other second year courses. A science seminar class has also been available in the past which emphasized research and covered material in all three major areas. About 30-60 students will graduate each year with 5-7 years of science in high school. About 40% of all biology students complete chemistry while 50% of the chemistry students enroll in physics and 25-35% of the Chemistry I students continue with Chemistry II. About 60% of the students at Cy-Fair will have taken two years of science in high school.

The concept of "teaming" is used throughout the district. All teachers teaching the same course are members of a team that works together to plan the objectives, activities, and tests for that course. In science, the biology team has 6-8 members while the chemistry team has 2-3 members. Some team teaching also occurs whenever possible. One of the current goals of the department is to present concepts in a more relevant way and to involve the students in science in their everyday lives.

The school district now has a Science Coordinator who coordinates science 6-12 and works closely with the Math/Science Coordinator for K-5 to provide continuity in the K-12 science program. Most of the courses have a curriculum guide which includes goals, objectives, and an outline of the material to be covered. Teachers are encouraged to provide students with laboratory experiences 40% of the class time.

PROGRAM DESCRIPTION

The Chemistry I course offered at Cy-Fair High School is designed to be a more relevant program than the typical theoretical course offered at most high schools. The main problem addressed by this program is the problem of student motivation. Many students think of chemistry as "difficult" and/or "irrelevant." The course at Cy-Fair is designed to prove that chemistry is neither of these.

The program offers two levels of Chemistry I--honors and regular--each designed to meet the needs of three categories of students:

1. Those who are interested in gaining a better understanding of the role chemistry plays in shaping our high-technology society;

2. Those who intend to pursue a non-science career but who still need some chemistry background;

3. Those who intend to study chemistry or chemically related science at college.

The course was originally designed for the "average" rather than the "honors" student. Over a period of three years, the honor students complained about not being exposed to the chemistry and society components of the regular course and as a result their program was altered to include these activities.

During the 1982-83 school year, there were six regular classes and three honors classes as well as one second year AP Chemistry class. These classes were taught by two full time chemistry teachers. Over the past four years, the chemistry courses have been taught by two to three teachers--one of whom is full time chemistry and director of the program while the other classes were taught by teachers also teaching some biology or physical science classes. The predicted enrollment for the 1983-84 school year is nine regular classes and four to five honors classes with three full time chemistry teachers. Although the enrollment in chemistry has increased in recent years, it has been difficult to maintain interest on the part of the students and consistency in the program because of frequent changes in teachers.

The students taking the regular course are generally juniors and seniors who have completed a course in geometry while most of the students in the honors program are sophomores or juniors who are enrolled in Algebra II or above. The honors students are usually enrolled in accelerated math and English and about three-fourths of them are science oriented. Most of the students in the regular course are college-bound, but few are thinking of a science career.

The director of the chemistry program, Jan Harris, has a Master's Degree in chemistry while most of the other teachers involved in the program over the past five years have had Bachelor's degrees in another field of science with a minor in chemistry. However, all of the teachers have been active in the local chemistry teacher's association in Houston and have been willing to attend many conferences, workshops, and summer courses to keep up in the field and gain ideas for teaching in the classroom. They have also read on their own in current science magazines.

The chemistry area consists of two regular classrooms and laboratories. Each lab room, about 35' x 40', consists of seven or eight lab stations with room for four students each and cabinets and work area around two walls of the room. Unfortunately, one of the labs is used as a full time clas room as well as a lab room. One more lab room and a large iecture room which had a divider will be ready for use for 1983-84.

Each lab room is equipped with all the appropriate safety equipment--eye wash, safety shower, fire blanket, fire extinguishers, goggles, and lab aprons. Safety is emphasized in the classroom and laboratory. The first week of school is spent discussing safety issues. Students receive a safety packet; they try to gain an understanding of safety through the use of teacher-made slide shows and student role-playing. Every student must pass a safety test with 100%.

Various science posters, student-made cartoons and pictures, current event articles from newspapers, posters displaying the "Chemical of the Week" and "Scientist of the Week" are found decorating the walls of the chemistry room. The lab also includes old issues of **Science Magazine**, current issues of the **Handbook of Chemistry and Physics**, **Encyclopedia of Chemistry**, and **Merck Index**.

The lab is fairly well equipped with such items as an oven, analytical balance, two top loader electronic balances, four pH meters, molecular models, a sprectrophotometer, a muffler furnace, and a nuclear training kit.

In order to cut down on costs, students are not given an equipped lab drawer. During lab periods, equipment for class is placed on carts or at the rear of the lab; each set of students at a table obtains its materials and then returns them at the conclusion of the lab period. A large chemistry storeroom, next to one of the lab rooms, has wooden shelving on 2 1/2 walls. The shelves are abou: 20 inches deep and one yard wide and go floor to ceiling. Chemicals are stored on 1 1/2 walls with organics on one side and inorganics on the other wall with metals in a special section. Acids and certain oxidizers are also kept in special sections. Flammables are kept in a metal explosion proof cabinet. The storeroom will be reorganized according to suggestions by Flinn Scientific. Glassware is in another section; hardware in another. There is a large solution prep area 40" x 40" slate top counter with cabinets below. Also kept in the storeroom is 25 gallons of distilled water which is bought from a local water company. The back wall has shelves above a large counter. Next to that room is a room with a sink. Special instruments are kept here as well as books, slides, and copies of materials for use during the year. In front of this room is the chemistry office with three teacher desks and file cabinets.

The goal of the activity-oriented chemistry course is to bring students and science closer together. This program is designed to give students a basic knowledge of chemical facts and concepts, to relate these facts and concepts to the everyday applications of chemistry in our society, to help students develop confidence in their ability to understand and solve technical problems by analyzing the problems, considering alternative solutions, and deciding on a possible course of action. Students are also exposed to various careers related to science. It is important that students develop a more positive self-concept through success in the science classroom.

Specific course objectives for "Chemistry - A Relevant Course" include several in the area of **Science Skills**. Such objectives include providing the student with an opportunity to:

1. Develop safe laboratory techniques;

2. Become competent in the use of laboratory equipment;

3. Become proficient in the use of the scientific method as a means of investigation;

4. Plot and interpret graphs from laboratory data or given information;

5. Develop mathematical skills in solving problems related to chemistry.

Other objectives deal with **Science Concepts**. Specific course objectives in this area include providing the student with an opportunity to:

1. Solve problems involving the metric system using the factor label method;

2. Understand the basic classifications of matter and methods of separation;

3. Learn about the stages of development of our modern concept of the atom;

4. Understand the organization of the periodic table in terms of electronic structure and apply periodic principles to predict properties;

5. Understand modern concepts of molecular structure and bonding and relate these to properties of substances and use to make predictions of properties;

6. Develop an understanding of how to write and balance chemical equations;

7. Gain an understanding of the mole concept and how to do related problems;

8. Understand the physical states of matter in terms of the kinetic molecular theory and solve problems based on the gas laws;

9. Understand the principles and applications of thermodynamics;

10. Understand the basic nature of solutions and the various methods of expressing concentration;

11. Understand the factors affecting the rate of a reaction;

12. Understand the state of equilibrium and how to solve problems related to all types of ionic equilibria;

13. Understand the nature of solutions and the various methods of expressing concentration;

14. Understand the processes of oxidation and reduction and learn how to balance redox equations and apply these concepts to electochemistry;

15. Understand the basic nature of nuclear chemistry.

A third area for course objectives is in the area of Personal Development of the student. Objectives in this area include providing the student with an opportunity to:

1. Develop an appreciation for the work of early scientists;

2. Develop a more positive self-concept through success in the science classroom;

3. Become aware of the importance of chemistry in our society;

4. Experience the satisfaction and frustration of scientific experimentation.

One special feature of the "relevant" chemistry course is an end-of-year unit on chemistry and crime. The unit was developed by the lead chemistry teacher after she read an issue of Chemistry magazine which focused upon forensic chemistry. Using this article as a starting point, the teachers read everything they could find about the topic and contacted crime labs to talk to the chemists and technicians who actually did the work.

Mrs. Harris has written many units exemplifying "relevant chemistry" throughout the years. These units were developed during vacations. Since an important feature of the course is the currency of the material taught, units are continually being revised and updated. The capacity for learning and the interests of her students are of paramount concern; so the course is flexible enough to adapt to both the slower and the more gifted pupils.

No formal evaluation of this program has taken place, although students have been administered opinionnaires to determine whether or not they found the program relevant, enjoyable, and meaningful. Subjectively, students are enjoying the course and many are enrolling for Chemistry II.

The usual topics taught in first-year chemistry are supplemented by the regular infusion of special relevant activities. Students conduct their own experiments once or twice a week and see teacher demonstrations two or three times a week. The course begins with a special unit on laboratory safety. Although the "usual" topics are then taught, the teacher presentation methods are unique. For example, the gas laws are approached through a discussion of scuba diving and snorkeling. In this way, the relationship between pressure and volume becomes a real-life problem with meaning to the students in the classes. Although the course is rarely the same, the following outline of topics, lab activities, and special relevant activities is offered as a "typical" course description:

Topic	Lab Activities	Special Relevant Activities
1. Introduction: the laboratory and safety	Using apparatus safely	Analysis of safety hazards in the home, work, etc. The role of chemistry and chemists in various industries
2. Measurement	Basics of measurement & the metric system	Change a recipe or sewing pattern into metric units
	Identifying an unknown metal, density and graphing mass vs. volume	Investigate the density of various pieces of jewelry, "light" cooking oils
3. Matter: classification, separation, identification, chemical & physical changes	Separation techniques Analysis of ink using chromatography	Write a computer program on metrics Use the names of elements in a cartoon, saying, bumper sticker Make a poster or collage of chemical & physical changes
	Observing chemical changes	Chemical of the week
4. Atomic theory	Black box experiment identification of an element using line spectra, flame tests Analogy of an electron	Scientist of the week If one quantum number was changed, develop new ideas for this
5. Periodic table	Activities of metals & halogens Predicting properties of unknown elements	Reports on scientists or topics relating to history of science
6. Structure and bonding	Models of compounds using gum drops & toothpicks and balloons Comparing properties of ionic & covalently bonded compounds	Chemical of the week Make models of crystals or compounds
Chemical reactions and equations	Types of chemical reaction	Investigate the chemistry of some common industrial processes Develop a show apprpriate for elementary students which shows types of chemical reaction
8. Calculations involving formulas and equations	Formula of a hydrate (%water) Cu & $AgNO_3$ reaction	Select an industrial process, investigate $'s, amounts used, % yields

Topic	Lab Activities	Special Relevant Activities
9. Gases	Determining the relationship between V and P using a manometer Predicting V of H_2 in Mg + HCL Observing properties of some gases (CO_2, H_2, O_2, SO_2)	Scuba diving & the gas laws Analysis of gas content of soda, etc. Role of CO_2 producing compounds in cooking Investigate air pollution (lab or report)
10. Solids, liquids, phase changes	MP-FP or p-dichlorbenzene (graphing) Making crystals	Make crystals under various conditions Compare surface tension or viscosities of various liquids (syrups)
11. Intro. to thermodynamics, enthalpy, H_f, entropy, G	Heat of fusion of ice Hess's law	Compare H for dissolving of various drain cleaners e. g. Drano)
12. Solutions	Supersaturated solution Polarity and solubility Using solubility rules Colligative properties Colloids	Make candy and supersat. soln. Determine best sovent for various stains Make ice cream and make calculations on amount of salt and ice needed, by FP of solution, etc. Find out the effect of protective colloids in ice cream, etc.
13. Reaction rate & equilibrium	Effect of T, conc, surf. area, and catalyst on rate	Report on various catalysts used in industry Report on optimum conditions needed for various industrial reactions
14. Acids and bases	Analysis of vinegar Analysis of various soda drinks M, N, V of CO_2, pH, caffeine Analysis of acidity of aspirins of analysis of antacids	Acid-base scavenger hunt around home Report on acid rain and its consequences Report on sulfuric acid Make homemade indicators (fruits & vegs.)
15. Electrochemistry	Electrolytic & electrochemical Rx. Contest for best home-made battery	Investigate the properties of various types of batteries, uses, etc. Report on industrial electroplating
16. Organic	Testing properties of HC Making esters	Report on poly-unsat. oils, etc. Report of perfume industry Report on special topics (soaps, food additives, drugs, ag. chem, car chemistry, oils, greases, fuels, cosmetics, etc.).
17. Nuclear chemistry	Using the Geiger counter	Report on radioisotopes, bombs, etc.
18. Forensic chemistry	Analysis of fingerprints, documents, drugs, poisons, soil, and minerals	Report of special interest

The teachers use team games to review topics such as the periodic table and organic chemistry. ("Element-O" and "Organic-O" are close cousins to Bingo that require a thinking effort from the "player.") Each grade period (six or nine weeks), the students are given a list of various relevant activities in chemistry. Each activity is described and assigned a certain number of points. The students are told to do any of the activities they wish as long as their final score adds up to the desired total of points for that grade period. In some cases, students work together and, in other cases, they work alone. Most of the work on the activities takes place outside the classroom. Usually, one or two Fridays are devoted to working on these activities, especially those related to laboratory investigations. All of the student activity reports are kept in a special section in their notebooks and are usually graded in the middle and at the end of the grade period. It is possible for the students to do more activities than required, which gives them extra points. There is, however, a limit to the number of extra points students can accumulate during a grade period. The activities selected may be laboratory investigations; model-making; poster, bumper sticker, or cartoon designing; library research; interviews with staff from local industries, chemists, and similar professionals in the community.

In addition to the on-going relevant activities, students are asked to research a topic of special interest to them, related to the chemical topic then under study, at various times during the year. For example, when studying nuclear chemistry, students might write individual reports on the use of isotopes, the nuclear bomb, nuclear reactors and the waste-disposal problem; or they might hold a class discussion on any of these topics. During the study of gases, students might investigate air pollution, especially within their own community. After organic chemistry, students may elect to learn more about cosmetics, food additives, car chemistry, chemical warfare, over-the-counter drugs, "hard" drugs, and similar "relevant" topics.

Students may present a written or oral report on the topics they select. The year ends with the special two to three week course on forensic chemistry mentioned previously. Students analyze fingerprints, soil, "hard" drugs, forged documents, and other phenomena related to crime detection. The crime-solving unit has been so successful within the community, and of such interest to other teachers with whom the chemistry teachers interact through numerous professional associations, that Kemtec Educational Corporation now markets laboratory kits based on the Cy-Fair program.

Teachers of this course must have:

1. A strong chemistry background;

2. A desire to keep up-to-date with developments in chemistry, current events, and problems of the world;

3. Confidence that this type of program is important;

4. An inexhaustible supply of energy.

Students have taken the ACS/NSTA high school chemistry examination for the last four years. The honors students have repeatedly scored above the

75th percentile, while the average students' score is distributed around the 50th percentile. About 40% of the honors students in Chemistry I take Chemistry II the following year. Student enrollment in Chemistry I, an elective at the school, ranges between 200 to 250 per year. Sixty of these students are taking the honors course. The large number of students taking chemistry because they find it interesting, rather than necessary, is surely an important indicator of the success of the program.

Students are encouraged to participate in the Houston Science and Engineering Fair but are not forced to do so. In 1979, for instance, 30 of the Chemistry II students entered projects, and four went on to win awards at the Fair. In both 1979 and 1980, one of the Cy-Fair Chemistry students received a special corrosion award and a $1,000 scholarship in chemical engineering. In 1981, of six students entering, one placed first in chemistry while others received 2nd and 3rd place prizes in various related sciences.

Physical science is the "feeder" course for Chemistry I. By reworking this elective course to make it more relevant, the teachers increased the enrollment from five classes in 1974 to eight classes in subsequent years. The enrollment in Chemistry I has also increased significantly.

The teachers are also active with the JETS program at Cy-Fair; it has become the largest such program in Texas. The JETS program at Cy-Fair functions very much as a science club and has between 100-110 members at any one time. Cy-Fair students compete in the state-wide testing program of JETS and have been placed as high as fourth position in the entire state.

Another indication of the success of this program can be seen in the reactions of the many students who return to the school after graduation. Students have found the program excellent preparation for college chemistry. It seems to have more relevance for these students since they have learned to apply chemical knowledge in high school. They have had an added reason for learning basic chemistry.

One of the goals of Cy-Fair High is the preparation of students for survival in today's world. The emphasis of the chemistry course is on the application of chemical knowledge in everyday living; the development of logical thinking habits and analytic skills; and the growth of a positive self-image on the part of the students. Hopefully, this emphasis will motivate students to continue learning on their own and to be able to make intelligent decisions which will affect them and their community later in life--surely the only preparation possible for "survival."

The program is fun for the teachers. It is continually evolving and, as a dynamic program, challenges the intellect and creativity of teachers. Boredom with subject matter is not possible. As a negative, teachers insecure about their subject matter or uncomfortable with giving students the amount of freedom and responsibility they have in this program, would not be able to duplicate the success of the program that exists at Cy-Fair. The program is very dependent upon enthusiastic, highly motivated, extremely energetic teachers for its success.

Since the forensic chemistry section of the course is now available commercially as crime kits from Kemtec Education Corporation, the utilization of this portion of the course is easier for other teachers. The Cy-Fair teachers have shared their expertise in program development with other chemistry teachers both within Texas and around the country. Professional papers have been written describing teacher/ learning activities; teachers have conducted workshops and participated in conferences and been generally active in inservice programs. Teaching units have been shared with numerous other teachers. There seems to be a great deal of interest in this type of program among many high school teachers throughout the United States. Since the program is developed around student interest, it is also changing, always improving. Students have an opportunity to succeed at various activities within the program even though they might not be "wizards" at chemistry. The program is fun, but it is continually challenging. Most importantly, the students know why they are learning what they are learning.

The program requires a well but not necessarily over-equipped high school chemistry lab. The program is most helpful for the average students though the honors students enjoy the course and gain from it as well. To make time for the relevant activities and the forensic chemistry unit, teachers must drop some of the factual material they might normally consider "essential" to their course. If teachers are unwilling to do so, or are forbidden to do this by school authorities, then the program cannot be taught because of time constraints. This program is highly dependent on the motivation of teachers to do an incredible amount of extra work. When teachers are currently very much overworked and underpaid, perhaps it is asking too much for average teach^rs to undertake such a program.

The program emphasizes a variety of societal issues. This makes the program, by definition, more relevant to the students enrolled. In many instances, the content and class experiences are related to daily living of students. The content is shown to impact personal needs of students. In addition, it contains strong components of content dealing with career education/awareness.

PROGRAM HISTORY

Before 1977, the chemistry program at Cy-Fair High School was a very traditional approach closely following the textbook **MODERN CHEMISTRY**, Dull and Metcalf, was the textbook used in the course.

In 1977, three additional chemistry teachers were added to the program with Mrs. Jan Harris as the new chemistry team leader. A new textbook had been adopted, **CHEMISTRY: A MODERN COURSE** by Smoot, et. al., and a slightly different approach had been tried in teaching the course. The course was to be more lab oriented with many labs coming from the chemistry programs of the 1960's--i.e., CBA Chemistry and CHEM Study.

Many of the ideas used in the new course came from interactions arising from a three year NSF summer program at Bowling Green University, Ohio, where Jan Harris was a participant. The program was designed to lead to a Master's in Chemistry. Other ideas were developed at Joliet West High School in Illinois where Mrs. Harris taught prior to moving to Houston.

Over the next six years, the program became more and more lab oriented with many of the labs devised by the teachers themselves. The concept of the "mini-lab" was introduced into the program. After a demonstration or short discussion of a topic, students would carry out lab work which required about 20-30 minutes rather than the full 55 minutes. Students seemed to like this approach as it gave them a variety of activities to look forward to as well as more experiences to draw from in learning difficult concepts. Demonstrations were used more often to introduce topics and generate student interest.

Because students, especially the general students, were constantly questioning the relevance of the theory being taught, teachers began to reevaluate the material being taught and tried to include special activities which would relate chemistry to the everyday life of the student. Over a period of five years, special units were included in the curriculum which would appeal more to the students than the "heavy theory" found in most units in traditional courses. These included a unit of scuba diving and gas laws, chemistry and crime-solving, energy vs. pollution, pros and cons of nuclear power, applications of organic chemistry including such topics as cosmetics, car chemistry, polymers, drugs, food additives, and similar topics emphasizing societal and personal relevance.

The setting for the chemistry program at Cy-Fair did not change but the attitude of the teachers did. All of the teachers discovered that not only were their students more interested in chemistry, but so were they! More emphasis on current events and current discoveries in the field of chemistry and the other sciences were emphasized. More magazines and newspapers were brought into the classroom and more trips to the library were taken in order for students to keep abreast of current events and work on special topic reports.

Each high school in the district approached teaching chemistry in a slightly different manner. All of the teachers worked together to develop a chemistry curriculum guide and each worked within that framework. Each school, however, was allowed the freedom to teach chemistry using the approach that seemed more comfortable to the particular team of teachers. Over the past few years, the other schools in the district have begun to emphasize more relevant topics that are closer to the everyday lives of the students. Pinpointing the development of the Cy-Fair chemistry course to a single series of events is difficult. Ideas from a variety of colleagues and from college instructors were developed as experiments with what could be done to counteract student boredom and student questions as to the value of the study of chemistry for its own sake. Explaining how chemistry could be important was tiring for teachers. Some students even asked for examples of the relevance-- not just more talk, more assurances, more "wait-till-later." The program began as an experiment; it began with relatively few examples. As the activities became more exciting, they involved more students. More students showed interest in more "relevant" activities. Many ideas for additional activities arose from student suggestions, investigations, previous experiences.

After a few years of experimentation, a rationale for the program arose. The rationale seemed to suggest other activities, other examples, other ways of gaining student input. The modeling of science study and investigation as ever changing seemed to create more student interest--more desire for information to resolve problems. Suddenly, students were asking for basic information rather than being recipients of teacher reasoning as to why they should learn the basic concepts.

Student and teacher ideas continue to develop. Many arise from issues and problems which appear in the news; many have a local origin, i.e., a local issue, problem, controversy. Students become fascinated with the creativity needed to define and to work on problems. The program tends to model the "never-ending" characteristic of sciencing.

As chemistry is defined as "relevant" study, more students elect it; more request added experiences with it. With new students and new student ideas, there are new activities introduced to a chemistry program for a given year.

Such teaching requires teachers to depart from the textbook and from the context of a highly structured course. In addition, the effective teacher must infuse the relevant experiences with the basic concepts and topics, especially if mastery of such information remains as a primary measure of successful instruction.

PROGRAM MAINTENANCE

There are many factors that contribute to the success of the chemistry program at Cy-Fair High School but the main factor is the teacher in the classroom. Successful teachers of a relevant chemistry course must have a strong background in chemistry and have a good background in math and physics. Such teachers must be willing to do extra reading in science magazines, newspapers, books on special topics; in addition, they m... be willing to spend time going to conferences and workshops to keep up with current advances in the field of chemistry as well as in the field of science teaching. Attendance at such conferences always renews the enthusiasm of the teacher and gives him/her ideas that can be used immediately in the classroom. Sharing of ideas among teachers is very important. Teachers need to be willing to try different approaches in the presentation of material whether they are demonstrations, lecture, discussions, lab work, work on reports, creative thinking on problems, individualized packet work, or review games. It is the enthusiasm of the teacher for the subject matter that is the key to a successful program.

The science coordinator, Susan Ward, was the Biology I and II teacher at our school just two years ago. She is familiar with our philosophy and has encouraged us to share our ideas with others through the use of inservice workshops. Ms. Ward encourages us to go into the elementary schools and do presentations on chemistry to motivate students. She coordinates our inservice activities, encourages teachers from the same subject matter area to work together to improve curriculum guides and to include copies of all our laboratory work. The science coordinator acts as a liaison between the teachers and the administration and the school board. She is instrumental in arranging for funds for special classroom sets of books, special equipment, video tapes, slide shows, and similar materials for enriching instruction. She obtains speakers and arranges for special field trips for teachers and for students. Susan Ward is quite active in the Texas Academy of Science and works with all science teachers in promoting science research by students in such areas as science fairs and special symposia. She coordinates the district fair and helps teachers to prepare students for the Houston Science and Engineering Symposium. She helps to bring continuity into the science program in the district. Many teachers have been encouraged by her to try creative ways of teaching and to develop creative teaching units.

The administration has been very supportive of the science programs at Cy-Fair. We are able to order many things from the district through capital outlay; we are allowed a very healthy budget in our school; and we are allowed to decide what chemistry textbook will be adopted by our district (one of the 5 adopted by the state).

Students are occasionally assigned to our department as laboratory assistants. They help to prepare some solutions, help set up labs, and help clean up after the labs. This has been a great help to the teachers.

The school library has played an important role in developing and maintaining the chemistry course. Sets of books and current science magazines are often taken into the classrooms for use on relevant activities. Classes have also moved into the library to work on research reports. The librarian has ordered a number of slide-tape programs for the teachers and will order reference books and special interest books whenever asked for help.

Various scientific organizations play an important role in the maintenance of the science program of Cy-Fair. The American Chemical Society contributes in a number of ways. First, through its establishment of the Office of High School Chemistry in 1979, it offers high school chemistry teachers a quarterly magazine which informs them of opportunities and reports on others. It provides booklets, pamphlets, audio short courses, and other instructional materials. It has developed a number of creative programs including the new chemistry course for the average student which presents chemistry in view of the community--CHEM COMM. Also available from the ACS are chemistry bumper stickers and other promotion materials such as career booklets, booklets on doing science fair projects, and a booklet each year on what's happening in chemistry. The local ACS section in each area has been encouraged to support the high school teacher by sending them to workshops and ACS Conventions and by sending speakers to the schools and by rewarding good chemistry teaching through an awards program. The Division of Chemical Education has established a High School Chemistry Committee which addresses the problem of high school chemistry teaching and helps to plan special programs for high school teachers at regional and national ACS meetings and promotes continuing education of chemistry teachers. A biennial chemical education conference is held on even years and provides fantastic experiences for high school chemistry teachers. Not only do they learn about recent advances in the field, but they also learn of new demonstrations, labs, and activities which they can use immediately in the classroom.

CHEMISTRY magazine and SCIQUEST have been very useful to chemistry teachers as well as directly to students. The new magazine being published by ACS for use in the chemistry classroom is CHEMMATTERS. It is fantastic! The students are really excited about the magazine and find it easy to read and easy to understand.

We have been fortunate in the Houston area to also have other organizations which have provided learning and sharing experiences for high school chemistry teachers. These include the active Metropolitan Houston Chemistry Teachers Association (sponsors a safety symposium each year as well as other programs on motivation), Associated Chemistry Teachers of Texas, Science Teachers Association of Texas, and, of course, NSTA with its fantastic workshops and speakers at its national and regional meetings.

Teachers need to be learning constantly and changing their programs themselves. This can be accomplished by their attending workshops and conferences as well as attending inservice programs in their own districts.

The Region IV Education Service Center provides a catalog of films available to participating districts. Some of the films are quite current and deal with controversial topics such as pollution, energy crisis, and other "relevant" topics.

The surrounding community has been supportive of the special chemistry program. Many of the area industries invite students to tour their plants and they frequently send speakers into the classrooms.

The major ingredient needed to maintain such a relevant chemistry program, however, is a dedicated teacher--a teacher ready to work with students concerning their ideas, interests, and special projects. Teachers must be inquirers. Teachers must look constantly for new activities, new problems, new relationships to basic concepts of chemistry.

The Cy-Fair program enjoys great support from the school administration, from other science teachers, from the entire school staff. Most importantly, however, is the support of students and their parents. Maintaining student interest through involvement means a happy "following"--persons who support the course because of its demonstrated value and worth.

To be sure, a budget is needed--but no more than that required for the standard course. In addition, there are many more opportunities for input in terms of materials and person-talent with such a relevant program. Students, parents, and people from the community help significantly with program maintenance.

The program requires supportive, contributing, and understanding school administrators. Such administrators are easy to develop, however, when parents and students are so supportive. Most administrators are anxious to support programs which are successful, popular, and prestigious. Such support also helps the program grow even further. Help with special scheduling, special activities, special funding is more readily available when more students are involved, especially students who express great pleasure with the relevant course and course activities which they experience. Program success is the greatest factor in its maintenance.

3. THE BIOLOGY EXEMPLAR

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SCHOOL SETTING

Shawnee Mission South High School is one of five senior high schools in the Shawnee Mission Unified School District #512. The district is comprised of 75 square miles located in northeast Johnson County, Kansas, and is a part of the greater Kansas City metropolitan area. It is bordered on the north and east by the urban school districts of Kansas City, Kansas, and Kansas City, Missouri, and on the south and west by three suburban school districts.

Northeast Johnson County is a collection of fourteen continuous cities. Many light industries are located in Overland Park, Lenexa, and Shawnee. The Shawnee Mission South attendance area is primarily residential, with a major shopping district in the center. Ninety percent of the housing is less than twenty years old. The area has a population which would be considered above average. The median income, the highest in the metropolitan area, is above $31,000. The county is overwhelmingly Caucasian with a minority population of less than five percent. This, of course, is reflected in the schools of the district. South's minority student population is approximately two percent.

The population of the entire school district has declined during the past twelve years by approximately eleven thousand students. This impact has not yet been fully felt at Shawnee Mission South, but undoubtedly the current enrollment of 1,850 students will continue to go down during the decade of the 1980's. The mean mental ability profile of the students attending Shawnee Mission South High School is very good. The average ACT composite of the senior class of 1980 was considerably higher than both state and national averages. State competency examinations given to 1979-80 juniors (1980-81 seniors) ranked higher, percentage-wise, than state percentiles. Science scores for South students on ACT and TAP tests are the highest in the Shawnee Mission District. Students, on the whole, feel their needs are being met and that they are permitted self-direction in pursuing their goals in the program of the school, according to the North Central Association's study last year.

Because of the general metropolitan location, students have access to cultural and educational opportunities not afforded to many students. Many colleges and universities, including a state medical school for Kansas and one for Missouri are located in the metropolitan area. Johnson County supports a two-year Community College. Because of the availability of institutions of higher education and the respect given to education by parents in the area, it is not surprising that 86 percent of the 1980-81 senior class indicated they planned to attend college. About ten miles from the school, adjacent to the University of Missouri at Kansas City campus, is the Linda Hall Library of Science and Technology, one of the largest such libraries in the country, which gives access to many thousands of periodicals in all fields.

Handicapped students have been easily integrated into South because of the multi-faceted program and facilities, the presence of a learning center and specialists to work with students and with teachers in mainstreaming, the Personal and Social Adjustment Center for students with behavioral problems, and the school nurse.

The Shawnee Mission South High building is 17 years old. The student population is approximately 1,850 distributed through three grades (10, 11, 12). The school staff includes 104 teachers, four administrators, and five counselors. The general school atmosphere is conducive to learning. The faculty has a high morale and the teachers are generally supportive of each other's programs.

The Biology faculty consists of six members, each having a Master's Degree in Science. It happens that at present all biology teachers are males, although 2 out of 3 chemistry teachers are females. Two biology teachers and one physics teacher have earned Doctoral Degrees in Education. Teaching experience of staff members in science range from 8 to 25 years, with the average being 18.5 years. Besides being active in classroom instruction, the majority of the staff members are involved in science or environmental activities outside of their school responsibilities. Weekly faculty seminars are conducted within the Science Department for the purpose of sharing information on new discoveries in subject matter and teaching strategies.

The physical facilities for the biology program consist of six indoor science teaching laboratories, three storage/preparation rooms, a science research project room, an animal room, a science learning resource area with the school's media center, and a 24-acre outdoor environmental education laboratory adjoining the school building containing most natural habitats of the area--lowland and hillside woods, stream, pond, grassland, prairie grass restoration, and an enclosure with buildings for some barnyard animals. Laboratory space is adequate for teaching the basic sciences. Staff members feel that science equipment and supplies are adequate for teaching strategies.

Interaction among the teachers within the department served as the most significant inspiration for initiating the current biology program at Shawnee Mission. All are enthusiastic and abreast of current changes by reading journals and going to professional meetings. The most serendipitous aspect of the program was that no single person dominated the flow and direction of ideas. There has always been an excellent flow of ideas and mutual respect among the members of the staff.

However, one individual of the staff should be noted, Richard G. Dawson. After the environmental lab had been established through the efforts of a committee of biology teachers, he was hired to chair the laboratory program. There was a concerted effort two years later by the athletic department and certain people within the administration to convert the lab to football practice fields. Almost solely through the efforts and leadership of Mr. Dawson, overwhelming community support was developed and the coup d'etat was thwarted. Although there have been minor problems since, the biology program has thrived.

During the development years, the presence in the district of former science teacher, Leonard Molotsky, as science coordinator, director of curriculum, and assistant and associate superintendent was also crucial to the atmosphere of acceptance and support for the development of the program. A senior administrator, who understood the needs and opportunities in science education and who was involved at state and national levels and yet who recognized the importance of allowing creative evolution of the program from within, provided an environment for progress. Without such an environment our schools might have been caught in a sterile, lock-step procession with each other.

PROGRAM DESCRIPTION

The need for understanding developments in environmental science and for monitoring the physical and biological changes in the planet as well as for demonstrating the cause-and-effect relationships between humans and other living organisms and systems formed the basis for the environmental problems and world futuristics courses. In 1971-73, a federally-funded, district-wide, curriculum development program, "Project CLEAN," provided incentive and funds for the continued development of science units concerned with the relation of environmental issues to scientific and social contexts. The involvement of faculty in community activities such as the Burroughs Audubon Society, the Kansas City Park Department's Natural Science Camps, the World Future Society chapter, and Missouri Prairie Foundation are a few examples of organizations involved in symbiotic relationship with the program.

Initially, two second year courses were proposed: Biology II with emphasis on open-ended, short-term labs as well as the planning and carrying out of a long-term, individual experimental investigation and Advanced Placement Biology II with emphasis on in-depth coverage of the content of biology in order to prepare students for advanced standing in colleges and universities. The impetus for the Biology I Honors class was the need to motivate gifted students and to facilitate independent research projects, which had been scattered among various courses. The use of high school students as junior counselors in a summer science camp, the availability of our environmental lab, and the need to demonstrate the district's wide use of the 24 acre outdoor laboratory formed the basis for developing the Field Techniques and Environmental Education class to train students to instruct visiting elementary students in ecology and natural resources.

The Essential Characteristics of the Biology Program at Shawnee Mission South (including objectives) are as follows:

1. Biology II

Each teacher tries to cover nearly all of the general biology subject matter normally included in a biology text. We especially try not to neglect two areas:

a. The nature of scientific research;

b. Environmental sciences.

2. Advanced Placement Biology III

The course objectives call for the student to:

a. Be better equipped with facts, concepts, and study skills to be successful in college science courses;

b. Be more likely to be able to earn advanced credit or standing or admissions to honors classes upon college entrance through performance on AP, CLEP, or other placement tests;

c. Expand and deepen her/his understanding of the processes of science through study of current journal articles describing the structure and function of organisms, physiological and ecological processes, and the methods of reaching these conclusions;

d. Broaden his/her view of human responses to life through exposure to poetic, visual, and musical interpretations, and the creation of biological drawings and poetry by the students;

e. Focus on human anatomy and physiology, ecology, and the moral/ethical decisions involved in medical and ecological choices in applications of scientific discoveries.

Content choices for emphasis are chosen by the students on the basis of what they consider they need the most for college preparation, or upon what they want to spend more time. Therefore, these will vary from year to year, but always include emphasis on biochemistry and metabolic processes, and on human anatomy and physiology with special attention to the brain.

3. Biology III

Biology II is designed to help students understand research in two different aspects:

a. Research does not originate in a vacuum. Significant advances in science are the result of a prepared mind and orderly progress.

b. Research builds upon research. As research rejects or supports hypotheses, this information adds to the sum of background information needed for tomorrow's scientists.

The student objectives are more specifically to:

c. Write a paper in which background information is collected from numerous sources (this background information is to lead up to a researchable problem and hypothesis);

d. Identify and design an experiment which would address the above-stated problem and hypothesis;

e. Conduct the experiment paying particular attention to variables, measuring, collecting of data, and keeping of records;

f. Analyze the experiments and the collected data in such a way that this new information should be useful to future readers;

g. Conduct numerous class experiments in which considerable attention is paid to the way background information leads to a new problem. Subsequently, the answering of this problem leads to a new problem;

h. Make life decisions concerning mental and physical health based on the research of others (i.e., what effects do certain activities have on the human mind and body?).

Among the several topics selected for more in-depth study is human pathology, including abuse of alcohol and tobacco and other drugs, improper diet, carcinogen exposure.

4. Environmental Problems

Objectives call for the student to:

(in area of Pollution)

a. Understand some of the causes and effects of air, water, and soil pollution;

b. Understand how pollution can be reduced by actions of individuals, families, companies, and governmental agencies;

c. Monitor and keep tally of her/his own behavior its effect on pollution;

d. Develop a concern for activities that will reduce pollution and a commitment to take positive actions.

(in area of Environmental Impacts)

e. Describe the requirements and the functioning of the National Environmental Policy Act and its requirements for Environmental Impact Statements;

f. Analyze examples of proposed actions and their impacts on the environment, including secondary effects and alternatives.

g. Become more likely to look beyond short-term benefits before making decisions.

(in area of Urban Environment)

h. Describe the land use patterns of Greater Kansas City and the historical factors that have led to them;

i. Understand some of the principles of land use planning, including zoning and the approach of multiple compatible uses, and apply these in designing a plan for suburban growth near the school;

j. Become sensitive to design of residential, shopping, park, office, and industrial areas, and the kinds of topography and locations best suited to each, and to be more likely to take actions that will have a positive effect in building effective community plans.

(in area of Energy)

k. List and describe sources of energy used today, with and indication of positive and negative aspects of different sources;

l. Understand how their own families use energy and analyze their use for areas of waste;

m. Become more likely to make choices of purchases, insulation and intensity of heating, cooling, and driving that will use less energy and require less use of fossil fuel and building of fewer power plants.

(in area of Wildlife Management)

n. List and describe various methods by which humans affect the population and health of wildlife species;

o. Understand how the science of wildlife management gathers and analyzes data to form a basis for decisions in habitat and hunting;

p. Become more likely to support wildlife conservation measures, including understanding the role of habitat management and harvesting of surplus numbers.

(in area of Wildlife and National Parks)

q. Understand the definition of wilderness, the National Wilderness Preservation System, and know some of the variation and types of wilderness areas;

r. Understand the functions and know representative examples of the National Park System;

s. Understand the political process by which parks are created and the general process for enactment of legislation, including citizen input through participating in a congressional hearing simulation.

5. World Futuristicss

Specific objectives include the following which indicate that the student will be able to:

a. Apply the concept of Earth as a Spaceship by listing changes in behavior of individuals, families, industries, or governments necessary to maintain the life support system, and why the current action is inconsistent with the Spaceship Earth model;

b. Forecast future conditions by use of extension of long-term trends which the student expects to continue for at least 30 years;

c. Construct a graph of past population, pollution, or resource use from past data, and forecast a surprise-free projection range for the next 25 years;

d. Describe and use more sophisticated methods such as Delphi and computer simulations, and understand the value and problems inherent in the techniques;

e. Construct one or more scenarios for alternative futures, and identify actions the individual can take to make more likely the desirable alternatives and less likely the undesirable;

f. Understand the importance of preservation, recycling, and wise use of natural systems including the soils, minerals, air, water, protista, plants, and animals;

g. Choose goals in population, food production, mineral resources, energy production, environmental law, waste disposal, industrial activity, land use, transportation, wildlife, world government, economics, or ecosystem preservation, and construct a plan by which she/he can influence people toward actions to achieve that goal during the next ten years;

h. Be more likely to take local actions to support a global systems approach to resource management and environmental problems, and an integrated system of worldwide environmental data gathering and planning for the mutual benefit of all peoples of the Earth;

i. Recognize his/her responsibility as a crew member of Spaceship Earth for the safe operation and maintenance of its life support systems in energy, heat balance, water recycling, air regeneration, food production, waste removal, size of crew, and control.

6. Field Techniques and Environmental Education

Objectives indicate that the student will be able to:

a. Acquire a working knowledge of some basic aspects of natural history;

b. Adapt material to K-6 grade learning abilities;

c. Develop and conduct 55-minute-long indoor and outdoor instructional programs for small groups (usually of 5) elementary students;

d. Develop instructional materials for use by self and others;

e. Select an outdoor work project or research problem carry it through to completion.

7. Biology I Honors

This course covers the content of the general biology course, with additional emphasis on open-ended, lab investigations, the processes of research, and the planning and carrying out of an individual, experimental research investigation.
This project usually culminates in entering the final paper and/or display in the Shawnee Mission District Research and Development Forum, the Kansas Junior Academy of Science, and/or the Greater Kansas City Science and Engineering Fair.

8. Independent Study in Science

Enrollment in this course is by application to the school's Independent Study Committee.
After a student receives sponsorship from a science teacher and develops a well-defined study or experimental, research design in some area of science, he/she is enrolled in the program.

Self-evaluation instruments, used by faculty, ask students for ratings of the program and its elements. Sophomore biology students play a minor role in their own lesson planning, but evaluating classroom management and decision-making is based on student feedback. Students have a wide choice in enrichment activities--TV, radio, seminars, books, magazines, and the use of such outside resources is an integral part of the educational process, either as points toward a total grading scale that includes the assigned text and classwork, or as a required percentage of the grade for enrichment activities.

In Advanced Placement Biology II, the content areas for special emphasis are chosen making use of student ratings of topics they want and/or need the most for college preparation and preparation for AP, CLEP, and similar tests.

The topics around which World Futuristics and Environmental Problems courses are built also depend on student interest choices; students select the books and articles on which they do major reports instead of having a single textbook.

Some former students in classes, acting as laboratory assistants in succeeding years, play major or even decisive roles as advisors or co-planners with teachers.

We are fortunate to have a high percentage of academically talented students who are, for the most part, motivated to learn. Approximately 83% of each graduating class attend college. Our students consistently score higher than the national norms on standardized tests in all disciplines, and higher than the Shawnee Mission District norms in nearly all cases, including science. Of the 600 graduating seniors last year, 84 were offered scholarships from 46 colleges and universities throughout the country. Over the years, South has been represented six times in the International Science and Engineering Fair as the top winners in the Greater Kansas City Science and Engineering Fair, and several have won regional and state honors in science competitions. In addition, many have gone on to earn degrees in medicine and Ph.D. Degrees in science, become teachers of science, or followed some other science-related career.

The following are the adopted textbooks for the biology courses as they are presently used:

1. Biology I: **Biological Science: An Inquiry Into Life** (BSCS Yellow Version). New York, N.Y.: Harcourt Brace Jovanovich, Inc., 1980.

2. Biology II: **Biological Science: Interaction of Experiments and Ideas** (BSCS Second Course). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1976.

3. AP Biology II: Davis and Solomon. **The World of Biology**. New York, N.Y.: McGraw-Hill, 1979.

4. Supplementary texts available on a classroom-set basis include:

a. **Guide to Study of Environmental Pollution** (Prentice-Hall Environmental Series). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

b. **Guide to Study of Freshwater Ecologyogy** (Prentice-Hall Environmental Series). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

c. **Guide to Study of Soil Ecology** (Prentice-Hall Environmental Series). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

d. **Guide to Study of Terrestrial Ecology** (Prentice-Hall Environmental Series). Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

e. **Introduction to Chemistry for Biology Students** (EMI Programmed Learners). Chicago, Il.: Educational Methods, 1977.

f. Otto and Towle, **Modern Biology**. New York, N.Y.: Holt, Rinehart and Winston, Inc., 1973.

g. **Biological Science: High School Biology** (BSCS Green Version). Chicago, Il.: Rand McNally, Company, 1968.

h. **Biological Science: Molecules to Man** (BSCS Blue Version). Boston, MA.: Houghton Mifflin Company, 1963.

There are also a large number of single copies and sets of up to 10 copies of many other supplementary books including identification guides to plants and animals, and a large collection of books is available in the school library (recipient of a demonstration library grant for science), and many audio-visual materials, both purchased and teacher-prepared. There are **Scientific American Offprints** of many articles available. Some of these materials are assigned, others are available as references for students wanting to learn more in certain areas, and some are used in preparing for research investigations. The school library subscribes to about a dozen scientific journals and magazines, and there is a set of **Biological Abstracts** available for the past six years. There are also many teacher-prepared materials, including those developed in the Project CLEAN program for Environmental Problems and World Futuristics, and the lab manual for the environmental lab.

The biology teachers are very fortunate to have the cooperation of the school library staff in ordering materials that will benefit students. Last year the biology program was allotted funds for purchase of references for specific research projects. In addition, teachers were given a professional leave day to go to Linda Hall Library and other sources to evaluate books and select the best ones to order in each field. The library also contains aerial photographs of 4-square-mile sections of the metropolitan area along with models, charts, and similar general references.

The Environmental Lab is used extensively by each teacher. Student projects (mini-research papers) are conducted by nearly all students at least once a year (often more). Within the building, we have the usual AV (16 mm and 2x2 slide projectors, super 8 loop projectors, VTR, record and cassette players, filmstrip projectors, etc.). Many professionals in science-related fields in the community are also used (MD's, veterinarians, research scientists, engineers) as contacts for students doing research and as guest speakers. Student science competitions are entered and students attend symposia, seminars, and other out-of-school meetings.

The biology classrooms at South are rectangular with a demonstration desk in front of the room equipped with a sink, hot and cold water, gas jets, and electricity. There are eight student lab tables as peripheral peninsulae extending from the other three sides of the room. Student movable desks with arms are in eight rows of four in between these lab tables. Each two rooms share a common storeroom and preparation area. The front wall of the classroom is covered with adequate chalkboards and bulletin boards, along with a display cabinet and bookshelf. The back wall has storage cabinets above and below the counter. One side wall has undercounter cabinets and windows. The other side wall also has undercounter cabinets with a large bulletin board. The preparation room extends out from the building about four feet with glass windows on three sides, providing a small plant growth area. The classroom windows are small and sealed but do provide light for aquaria and plants in front of them. Each team lab station has a central sink with two cold water faucets, electricity at the side and back, and gas jets at the back. There is also a teacher desk and a closet. The large storeroom has shelves on each side and deep shelves down the middle, and most have a refrigerator and either stove or microwave oven. The storeroom/preparation room has doors opening into each of the classrooms it serves as well as into the hallway, allowing access to the storeroom without going through a classroom. In addition, the former biology classrooms have been divided into an animal room and research room for individual student projects.

All chemicals are kept in storerooms adjacent to the classroom. Precision equipment is also generally secured in cabinets. Students are encouraged to use as much equipment as needed and available as frequently as practical. Generally, lab materials and supplies for particular labs are placed in a central location. This allows monitoring the quantity and quality of solutions and chemicals. These may be dispensed from the demonstration desk, or from the lab desk closest to the storeroom, which may be used as a stock table. At the end of each period, each student is assigned an area of responsibility; another student checks each area on a checklist and submits it to the teacher. Laboratory assistants do final clean-up and putting away of supplies in the storeroom, and getting out materials for labs, when possible within the time frame; teachers may also do this on their planning periods or after school.

Each room is equipped with standard safety apparatus, such as fire extinguishers and goggles. Toxic or combustible chemicals are kept in a locked cabinet in the storeroom. Acids are kept on a bottom shelf. Storage and safety equipment is in accordance with, and inspected by, the Fire Marshall's office.

The classroom for World Futuristics, Environmental Problems, and AP Biology II has a stereo record player and cassette player to allow regular playing of a variety of nature sounds and human-composed music, used to demonstrate a variety of responses to the natural world as well as to model the importance of diversity in stable systems. This class also uses a variety of artistic responses to living things.

The classrooms within the buildings could not be considered unique. However, the environmental laboratory is considered an extension of the indoor classrooms and much of the program focuses on this "classroom" outdoors. Some teachers spend as many as 40 days a year teaching material directly related to the environmental lab. Its location on the same property as the school and with direct entrance from the outside building door nearest to the biology labs, allows students actually to be on-site doing field studies for up to 40 minutes of a 50-minute class period. Habitats which were initially present included lowland and hillside woods, young tree/shrub habitat, old field habitat, bare soil, a farm pond and stream, along with gullies draining from the school parking lot into that stream. The biology teachers have added marsh plants at the pond, a prairie grass restoration area, some pine trees, a summer garden project, beehives, and a small barnyard animal area including such animals as goats, donkey, rabbits, chickens. A cable-pulled raft can be used to sample aquatic life from one side of the pond to the other.

PROGRAM HISTORY

The current biology program is a result of a gradual evolution of course content and the philosophy of the teachers who compose the biology staff. When South High School opened in 1966, the four-high-school district adopted BSCS Blue Version as the standard text. Shortly afterwards, with the establishment of our 14-acre environmental science laboratory, with changes in the backgrounds and philosophies of staff members, the program became, and still remains, strongly oriented toward ecology and environmental science. Over the years, there have been many contributing factors that have added to the program; e.g., adoption of BSCS Green Version (1969); the writing of an ecology manual for the specific use of students in the environmental lab by two teachers; establishment of courses in Environmental Problems, World Futuristics, and Field Techniques & Environmental Education, two advanced biology courses, independent study, and honors biology; and the use of many supplemental texts, articles, pamphlets, AV materials, lab blocks, and the science resource center in the library/media center.

Philosophically, the biology staff believes in teaching science as process, using the student text (BSCS Yellow Version at present) as a guide to providing a multifaceted program that allows students to learn by doing as much as possible. Laboratory investigations are taken from all BSCS versions and other texts as well as those devised by the faculty themselves. As stated above, the change was not revolutionary, but a gradual process of growth and expansion developed by present and former members of the biology staff.

Each school in the district chooses its own adopted text in general biology, and room copies have been retained of the texts used in past five year cycles (BSCS Blue, Green, and Otto/Towle). There are standard courses taught in all district schools but others are at the option of the individual school. The Environmental Problems, World Futuristics, and the Field Techniques and Environmental Education courses are taught only at South. In addition, South's Biology I course and the two versions of

Advanced Biology are not taught in the same way as similar courses at other district schools. The biology teachers think that this freedom of choice is a major contributor not only to the success of South's program but also to the success of programs at the other Shawnee Mission schools.

All teachers have considerable freedom to teach their own courses; however, they choose within certain guidelines. Shawnee Mission School District has prepared a scope and sequence chart for all grade levels. This involves general descriptions of the type of skills for which students at those grade levels should be exposed. The district has also prepared a skills test based on the criteria within the scope and sequence chart. Further, South's biology teachers have prepared a content test based on different performance objectives. Within this framework, individual teachers are free to devise individual teaching styles and they make individual decisions on what specific units to emphasize.

Because of the fortuitous location on the commercially vacant parcel of land next door, it became apparent that there was a great opportunity and responsibility to utlize that acreage in an educationally sound manner. This came about at the same time that the national conscience was being pricked by awarenss of pollution and ecological conservation problems. At this point it was apparent that there was both opportunity and need; a response was attempted. Although the initial stimulus (the presence of the land and the national concern for pollution and conservation) was somewhat abrupt, the actual change has been a steady process.

The "seed crystal" for change probably was the presence of the 24-acre, multihabitat land adjacent to the school. This had to be used for some school purpose because it was part of the total block of land purchased through condemnation when the school was planned. The committee for the establishment of that land for use as an environmental lab rather than district football stadium, parking lot, or other use probably was the first of a long and deliberate progression to our present program. The fight to keep the area from becoming practice football fields two years later caused self examination of purpose and rationale for environmental education.

About this time the federally funded "Project CLEAN" curriculum project in the district was implemented for three years, and from that the World Futuristics course was created along with other modules for classroom activities, especially in Environmental Problems. The development of the program first began with the presence of an adjacent 24-acre parcel of land to the school. A committee of biology teachers secured the parcel's designation by the Board of Education as The Shawnee Mission Environmental Science Laboratory. With threats from the athletic department and administration to convert the land to athletic fields, efforts were made to justify the SMESL by involving elementary children of the district. At first, lab assistants and current and former biology students were used as volunteer guides for visiting classes scheduled by their teachers to visit the SMESL. A course (Field Teaching and Environmental Education) was then developed to train high school students to provide natural history experience to the visiting elementary children, in planning and preparing their own environmental education units, and in studying the environmental interactions themselves in greater detail.

A one-semester "Science and Survival" course was begun in 1969 after extensive planning and preparation of a 20-page outline along with behavioral objectives in both cognitive and affective domains. This course was specifically designed to teach students to understand their impact upon and responsibility for the environment as citizens, consumers, voters, family members, and individuals. A modification was also developed by the teacher and taught for many years as a high school correspondence course through the University of Kansas. In 1973, the development of four Project CLEAN modules by the teacher built the material to where the course was separated into one semester of current Environmental Problems and one semester of World Futuristics. The planning and justification that led to the splitting of advanced biology into two variants, and of offering an honors version of Biology I emphasizing an indepth research project followed.

In all cases, a thorough plan, sets of objectives, justification, surveys of student needs, and evaluation of the impact of new courses proposed on the total program of the school was prepared and used in "selling" the program to the school counselors and administration and from there to the district administration and school board.

We regret that another very popular course developed by a former member of our staff, Linda Wiersch Segebrecht, a one-semester Marine Biology course that had six sections a year, was dropped by the district when Ms. Segebrecht left teaching; no search was made to find a qualified person to continue the course. Her position was terminated as a way of reducing total teacher number according to a reduction in student attendance, although Marine Biology would have continued to enroll a number of students.

With our involvement in the education of both elementary and secondary students and with research and science fair projects, two members of our staff obtained their doctorates with studies related to teaching techniques and to the characterisitcs of teachers whose students do individual research. From these events of opportunity, need, and involvement the program evolved to its present state.

PROGRAM MAINTENANCE

The central and school administrative personnel listen to the ideas of the biology teacher and respect their judgments. They do not pressure teachers into any one mold, rather, allow each teacher to take best advantage of that teacher's background and interests. In addition, they are helpful by approving the funds and providing the facilities necessary to implement changes in the program. Some of the specifics funded include: money for science projects by individual students, grants and workshops for writing, extra duty assignments to pay teachers to help with individual science projects, funds for SMESL, release time for SMESL, the addition of a personal computer.

There is a science supervisor who was a former biology teacher in a district high school. He secures funds, approves expenditures, and interprets programs for central office personnel and school board members. He also acts as liaison with elementary teachers, and between the junior high and senior high school science teachers and provides support as needed and allowed. His support for creativity among teachers, rather than attempting to direct how teachers are to teach and what they are to do, and his support for allowing each school to develop its own programs is very important in providing the climate for what we have done.

A community advisory committee was formed for the environmental laboratory. This included college professors, parents, leaders of environmental protection and nature study organizations, and teachers from other schools. This group was of decisive help when a proposal was sent by some athletic coaches and school administrators to place football practice fields on the land of the environmental lab. At that time, the superintendent of schools advised us to give up and accept the loss gracefully because football would always win in an affluent suburban setting; he was shocked at the fact that even the football players and their parents demanded that the environmental lab be maintained in its entirety. The community advisory committee allowed us to survive that one exception to the general support we have had from the administration for the biology program.

Science Pioneers, Inc., a metropolitan area non-profit organization, is directed by the Chair of South's Science Department, Dr. F. Gene Hampton. They sponsor the Greater Kansas City Science and Engineering Fair, a series of biweekly Saturday Science Seminars by scientists in the area, and are involved in coordinating and sponsoring other seminars, field trips, lectures, and contests during the year which are a great help in supporting science education in all Kansas City area schools and in facilitating contacts between students and scientists as advisors in research projects. Their activities also provide a meeting ground for science teachers from other schools and districts, and from university professors and scientists in private industry.

New teachers to the department have worked closely with exisiting teachers in such activities as discussing philosophy, sharing labs being used, and studying the successes of other teachers. The members of the department have always welcomed new teachers and tried to help them in all ways possible to build upon and expand from the textbook provided, and the program already in place at the time as developed by their predecessors. Within the program, the only support staff are high school student laboratory assistants who receive 1/2 unit credit.

Due to the administrative change three years ago, the faculty now feels more secure in making curricular decisions. There is understanding and mutual respect between the science faculty and the administration. Changes in attitude have evolved along with the program, since it developed through interaction of faculty and students, in reaction to the needs of society, and as a result of current research into educational techniques. The belief in the importance of the understanding of science as a part of the human environment, of the mutual responsibility and interconnection between science and society, and of scientific development as a contributor toward the progress and fulfillment of the human species is more pervasive in the program today.

The teachers at Shawnee Mission South are fortunate to have had an associate superintendent with a background and an understanding of science in charge of curriculum during the crucial years of major program development. He was responsible for the original staffing of our biology department, approving the establishment of the environmental lab, transferring key teachers to South High School from other schools in the district, and approving certain funds needed for program development. In addition, we have a director of science who has been supportive of our programs. He currently supplies special funds for materials used in the environmental lab program and student research, and supplemental pay to teachers who work with students on independent research projects.

4. THE EARTH SCIENCE EXEMPLAR

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SCHOOL SETTING

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

The Upper Arlington community of approximately 42,000 residents occupies an area of slightly more than nine square miles. Among the adults (25 years and older) more than 95% are high school graduates and more than 50% are college graduates. Most residents work in governmental, managerial, technical, or educational capacities. The average family income is $34,000. With very few businesses and industries located within the city limits, the revenue available to the schools is almost totally from property taxation. The resulting monies are used mainly for teacher salaries to attract and keep quality staff of whom 60% have a Master's degree or higher. The salary schedule usually ranks among the top ten in the State. The expenditure per pupil is approximately $2,800.

All three levels of the Upper Arlington schools are accredited by the North Central Association of Schools and Colleges. The educational plant consists of a three year high school, two junior high schools (grades seven through nine), and six elementary schools. The 1983-1984 school year will see this structure rearranged into a four year high school, two middle schools (grades six through eight), and six elementary buildings (kindergarten through grade five). This structural change was precipitated by declining enrollment and changing instructional philosophy. The organizational pattern of a middle school facilitates appropriate experiences for 10-14 year olds, based on knowledge of their developmental characteristics. The total school enrollment exceeds 5,800 with a pupil-teacher ratio of 18 to one (excluding non-teaching certificated personnel.)

Approximately 300 academic and vocational courses are offered to students in grades 9 through 12. There are concurrent university studies for accelerated students, as well as foreign exchange, back-to-back, and travel study programs. There is a full range of services and classes for gifted and handicapped students. The career education program is a nationally recognized K-12 program which includes internships, career shadowing, intergeneration learning, and exploration activities. At the elementary and junior high 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. Cocurricular activities include music, drama, debate, journalism, academic clubs, intramural sports, service activities, Youth in Government, and interscholastic athletics.

Students are very successful scholastically and athletically because of the involved commitment from all segments of the community. The strive for excellence is evident within student ranks as well as within the teaching staff. Upper Arlington students captured first place in the 1983 Ohio Test of Scholastic Achievement in General Science for the fifth time in the last six years. This year and last year they also captured first place on this same test in French I and Spanish II and have earned first place in previous years either in Spanish I and French I and/or French II. The eighth grade scores in reading, mathematics, and science ranged from 3.9 to 5 years above grade level. Individual student honors included eleven 1983 valedictorians with a 4.0 grade point average, nine National Merit Scholar finalists, and a national Presidential Scholar. The SAT composite score was 1,001. Eighty-five percent or more of Upper Arlington graduates attend college and at least five to six percent more continue their education with vocational or technical training.

Outstanding achievements in the extensive extracurricular sports program in 1982 included State championships in such sports as boys and girls tennis, track, swimming, and football. Yearly, the community honors individual teachers for their classroom expertise with the Golden Apple award. Recognition and awards also come from various professional and educational organizations at the local, state, regional, and national levels. The 1982 National Teacher of the Year is a seventh and eighth grade mathematics teacher from the Upper Arlington system.

The earth science program, part of an overall interdisciplinary school program (House Plan), is the eighth grade component of a mandatory junior high science sequence. Life science is taught at the seventh grade level and physical science at the ninth grade level. Each junior high science class meets five days a week for 48 minutes. The science teachers at each grade level have made an attempt to provide laboratory experiences for the students, although most of the science classrooms for the seventh and eighth grades are traditional rooms without water or natural gas outlets.

The earth science faculty consists of seven teachers, two of whom also teach either seventh grade life science or mathematics. The faculty is stable. Six of them have taught earth science in the Upper Arlington system from 11 to 16 years. All members have a Master's degree except one who has graduate coursework beyond the bachelor's, and one has a Ph.D. in science education. Five are certified to teach earth science as well as other sciences. Of the remaining members, one has Ohio comprehensive science certification and the other one has elementary certification.

PROGRAM DESCRIPTION

The earth science program encompasses the general school philosophy as well as the philosophy guiding all science programs. This philosophy is presented in the K-12 Science Curriculum Guide as follows:

1. Education of the individual members of a democratic society becomes increasingly important as that society becomes more complex. This education will be successful only if each individual can be brought to a concept of self-realization involving a positive attitude toward learning. The attainment of this self concept depends upon the availability of a variety of modes of learning so that individuals can attain success in the mode in which they learn best.

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

This philosophy complements the components and major objectives of the K-12 science curriculum. The components include the nature of science and its values, the processes and concepts of science, science and society, interest in science, and manipulative skills. While all of these are viewed as important and not neglected in the earth science program, the earth science objectives focus on the processes of science, the concepts of science, and the instructional units. These objectives were determined by means of a three-dimensional matrix incorporating the processes of sciences, the concepts of science, and the instructional units along 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 intersect of observing (process), change (concept), and astronomy (unit of instruction).

The process components of the earth science program are listed below. Under each process is listed the expected student outsome(s). These outcomes are used as guidelines and are adapted and/or replaced by the individual teacher. The following listing describes the Upper Arlington program:

1. Observing. Involves using one or more of the senses in a personal experience of environmental perception. This skill is employed in every phase of daily living. When direct observation is inadequate or impossible, indirect methods are used. Observations may be influenced by the background and previous experiences of the observer.

   Outcome: Recognizes cause and effect relationships after observing related events.

2. Classifying. A systematic procedure used by a person to improve order on a collection of objects or events.

   Outcome: Selects and uses classification schemes appropriate to the data being organized and its intended use.

3. Measuring. Involves developing a comparison or quantitative description of such properties as length, area, volume, weight, temperature, or pressure. Both standard and nonstandard units are used in the development of the skill.

   Outcomes:

   a. Differentiates among concepts t. it are one-dimensional, two-dimensional, and three-dimensional;

   b. Uses tools to make precise measurements;

   c. Correctly applies the concept of scale in making dimensional interpretations from a model;

   d. Uses various indirect techniques to measure a factor when a tool may not be directly applied (e.g., volume by displacement of water, distance by triangulation).

4. Communicating. Any one of several procedures involving various media and which carries information from one person to another.

   Outcomes:

   a. Uses communication skills to facilitate group processes;

   b. Communicates inferences or predictions with the supporting data.

5. Inferring. Reaching a conclusion on the basis of observation and/or past experiences.

   Outcome: Realizes that inferences may need changing on the basis of additional observations.

6. Predicting. Predicting what future observation will be on the basis of previous information, which distinguishes it from "guessing."

   Outcomes:

   a. Suggests the outcome of future observations based on inferences that were found valid;

   b. Uses interpolation and extrapolation to make predications from trends in data.

7. Questioning. To raise an uncertainty, doubt, or unsettled issue that may be based on the perception of a discrepancy between what is observed and what is

known by the questioner.

Outcome: States questions in such a way that they can be answered experimentally.

8. Hypothesizing. Stating a tentative generalization that may be used to explain a relatively large number of events but which is subject to immediate or eventual testing by one or more experiments.

Outcomes:

a. Modifies hypotheses on the basis of controlled experiments;

b. Realizes the relationship between hypothesis, theory, and law.

9. Experimenting. Planning a series of data gathering that will provide a basis for testing a hypothesis or answering a question.

Outcome: Designs and conducts a series of controlled experiments to evaluate the effect of more than one independent variable.

10. Processing and Interpreting Data. To find a pattern or other meaning inherent in a collection of data. Leads to stating a generalization.

Outcomes:

a. Uses mean, median, and range in processing data;

b. Identifies patterns in data organized in tables and graphs;

c. Makes valid generalizations from a body of data.

11. Formulating Models. Constructing 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 interrelatedness of subjects, or express abstract ideas.

Outcome: Adapts or modifies a model to aid in the solution of a given problem.

The following concepts are covered by one or more of the earth science units. The expected student outcomes which serve only as guidelines are listed under each concept.

1. Cause-effect. A relationship of events that

substantiates the belief that "nature is not capricious." Once established, it enables predictions to be made.

a. Applies the relationship of the orbital distance of an object to its space and period;

b. Identifies human activities that may alter the environment;

c. Applies the geologic processes of vulcanism, weathering, erosion, and drift in explanations of the earth's structure and features;

d. Lists and describes factors that would influence air pressure and humidity;

e. Identifies variables that affect the rate or amount of energy transfer in a simple system;

f. Identifies factors related to the current energy crisis.

2. Change. Everything is in the process of becoming different or something else. The rate at which it happens varies from very fast to very slow so that it may be unnoticed in these extreme cases, or may involve several stages of development.

a. Describes the apparent motion of the stars at night and through the seasons;

b. Outlines the history of the earth's climatic change throughout geological time;

c. Compares life forms common to different periods of geological time.

3. Cycle. The apparent pattern in which certain events or conditions seem to be repeated at regular intervals or periods.

a. Describes the appearance of lunar and solar eclipses and explains how they occur;

b. Explains the reasons for the phases of the moon and for seasonal changes on a planet;

c. Relates how a rock may change from one type to another in the rock cycle;

d. Diagrams the pathways of carbon dioxide, oxygen, and water through the environment;

e. Diagrams the major wind patterns and ocean currents.

4. Energy. That which enables something to be moved or changed.

   a. Explains the process involved with the fusion reaction of stars;

   b. Compares energy forms in terms of advantages and disadvantages of "seeing ability;"

   c. Discusses fuel sources including fossil fuels, solar power, nuclear power, hydropower, tidal movement, current movements, and use of the thermocline;

   d. Applies thermal dynamics in explanations of the wind, water cycle, and ocean currents.

5. Matter. Any material that has mass and occupies space. It exists in the form of units which can be classified at different levels of organization.

   a. Identifies rock types as igneous, metamorphic, or sedimentary in origin;

   b. Explains how salinity, temperature, and pressure affect the density of a liquid.

6. Equilibrium. That state of affairs in which changes occur in opposite directions, exist, or happen at equal rates, or are of the same magnitude.

   a. Discusses heat transfer between cold and warm air masses in the atmosphere;

   b. Explains how the density differences in sea water result in ocean currents.

7. Evolution. A series of slow changes that can be used to explain how something got to be the way it is or what it might become in the future. Generally regarded as going from simple to complex.

   a. Relates a probable sequence for the evolution of a star;

   b. Explains the historical evolution of the calendar;

   c. Compares and contrasts the historical growth of understanding in the fields of astronomy, meteorology, geology, and oceanography;

   d. Charts ancient events on a geological time line;

   e. Reviews the changes in the earth's crust according to plate tectonic theory.

8. Force. A push or pull.

   a. Relates gravitational force between two objects to the mass of the objects and the distance between them;

   b. Describes the gravitational effect of the moon, sun, and other astronomical bodies on the earth;

   c. Compares and contrasts the speed and wave motion of primary and secondary earthquake waves;

   d. Explains the effects of Coriolis force on the direction of winds, high and low pressure systems, and water gyres.

9. Model. A more or less tentative scheme or structure which seems to correspond to a real structure, event, or class of events and which has explanatory value. Includes the ideas of theory and scale.

   a. Compares the big bang, steady state, and pulsating theories of origin of the universe;

   b. Summarizes Alfred Wegener's theory of continental drift;

   c. Demonstrates an ability to interpret the relief of land using contour lines.

10. Patterns. The belief that there is either order in nature or that man is able to impose order is expressed according to various schemes. Includes the idea of symmetry.

   a. Detects patterns in given data presented in tables and graphs;

   b. Differentiates between the relative luminosities and temperatures of giant, main sequence, and dwarf stars using the Hertzsprung-Russell diagram;

   c. Classifies galaxies by shape according to Hubble's classification system;

   d. Classifies clouds using the following terms: nimbus, stratus, cumulus, and cirrus;

   e. Identifies the basic characteristics of western ocean boundary currents, eastern ocean boundary currents, northern hemisphere currents, and southern hemisphere currents.

11. Organism. An open dynamic system which is characterized by the processes of life.

    a. Describes three processes involved in the formation of a fossil;

    b. Identifies five common fossils of Ohio;

    c. Compares and contrasts the growth of a mineral crystal and a living cell;

    d. Relates limiting factors of marine organisms including sunlight, pressure, nutrients, and temperature.

12. 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.

    a. Uses detected trends in data to predict by interpolation and extrapolation;

    b. Attempts to predict weather conditions using simple meteorological equipment.

The instructional units which the earth science program emphasizes are the traditional units of astronomy, geology, meteorology, and oceanography. In addition, individual teachers have selected topics from these broader units and/or grouped certain concepts and processes to form additional units. Examples of teacher-developed units include Using Data, Energy, Discovering with Instruments, and Natural Disasters.

The adopted textbook is **Exploring Earth and Space,** Laidlaw Brothers, 1980. Other earth science textbooks available in sets of 10 to 30 for each classroom include **Interaction of Earth and Time,** Rand McNally & Co., 1972; **Investigating the Earth,** Houghton Mifflin Co., 1973; and **Spaceship Earth/Earth Science,** Houghton Mifflin Co., 1973. Reference books and science magazines and journals for use with specific units are borrowed from the school and nearby public libraries. Some of the teacher-designed modules include the necessary reading materials.

The teachers use a variety of teaching/learning methods such as lecture, demonstration, class discussion, individual and group projects, laboratory activities and investigations, library research, audiovisual presentations, guest speakers, and computer drill and practice exercises and simulations. An attempt is made by each teacher to maintain student interest and motivation by using more than one technique during a class period whenever possible. Students are usually required to record data, complete questions, and maintain an organized notebook of assigned work.

The number of student activities that have been locally written or modified from existing sources is extensive. A list of activity titles and objectives would no doubt be very similar to activities and objectives used in other earth science programs. For example, in "Tin Can Planetarium" the students construct a simple device for illustrating the obvious constellations and brighter stars, in "Identifying Minerals Using a Mineral Key" students apply classification skills in solving a problem, and in "Law of the Sea" students simulate political problems involved in determining territorial limits. The success of the activities within the earth science program in the Upper Arlington schools is probably the result of several teacher traits including an awareness of the cognitive developmental levels of the students, the result of adequate planning, experience in writing and evaluating activities, the frequent sharing of classroom experiences, and superior backgrounds in science.

The earth science budget is approxiamtely $3.00 per student. These monies are used judiciously by the staff and portioned carefully to procure new equipment, replacement of supplies, rental films, and other general supplies. Additional monies have been available from time to time from grants and special funds and were used by the teacher who wrote the proposal for special teaching units or projects such as salt water aquaria.

One storeroom houses most of the earth science equipment and supplies. Only minimal space is available in the classroom for storage and this space is usually needed for temporary placement of the equipment and materials being used for the unit in progress.

PROGRAM HISTORY

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 senior member of the earth science faculty recalls that during the early days of the earth science program, students read from the textbook, the teacher lectured, and, whenever possible, the teacher demonstrated various concepts and processes. The teachers during these early days of the program, however, quickly realized the need not only to use a variety of learning/teaching techniques but also the need for students to become actively involved in their own learning. Worksheets were written, audiovisual presentations of filmstrips and science films were used, investigations were borrowed and revised from various laboratory manuals, and the creative teacher designed new and original learning activities. Saturday field trips and in-school field trips were instant successes because of careful planning. The "new" activities or investigations and the successful techniques were passed to other earth science teachers in the system.

In retrospect, 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. To recapitulate from the early days to the present, the developmental progress was facilitated by a number of mechanisms which are identified below.

One mechanism was teacher enrollment and participation in university courses, predominantly at the Ohio State University (OSU). There are at least two obvious reasons that participation in courses at OSU is especially attractive to Upper Arlington teachers. The OSU and the Upper Arlington City School District have a reciprocal arrangement involving the student teacher training program. The District's teachers can attend classes tuition free and the District's salary schedule provides for pay increments for graduate work beyond the Bachelor's level and through the Doctoral level. The second reason involves the actual university courses in which the District's teachers enroll. Many of the unviersity courses are designed and perceived by enrolled teachers to meet their immediate needs such as unit development, classroom management strategies, and current topics within the science disciplines. The teachers not only update their knowledge of earth science but are also able to have an immediate product to use in the classroom such as teacher-designed activities. In return, the extensive field-based student teacher training program at OSU assigns students at various levels of training to teachers within the 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 has been 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. Particpation in projects such as these provide both intrinsic and extrinsic rewards and offer 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 is yet another mechanism. The earth science program is one part of an interdisciplinary teaching approach that has been termed a "House Plan" by 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 within a time frame of four school periods. This team has the flexibility to schedule students and plan student activities to promote improved articulation. The team members share a common planning period and are encouraged to develop units that are not only exemplary for their subject area, but also facilitate the transfer of basic skills and concepts from one academic area to another. The intent of the interdisciplinary structure of the team is that this transfer is a targeted outcome of instruction, not an incidental outcome of the overlap of the areas.

A fourth mechanism has been the development of a K-12 science curriculum guide. During preparation of this guide, teachers at all grade levels were actively involved in various phases of 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, 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, a topic outline for each unit, suggested classroom activities, behavioral 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 the 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.

To this day, the earth science program continues to evolve and change because each of the above mechanisms is still in place and active and because each earth science teacher is a professional educator who is striving for excellence.

PROGRAM MAINTENANCE

The earth science course, required of all eighth grade students, is taught in two buildings where the enrollment is between 700 and 800 students per building. The eighth grade enrollment is between 200 and 300 students per building with five and one-half earth science teaching positions in the system. The overall student enrollment is declining.

Each building has a science department chairperson who has responsibility for constructing the department budget, supervising department expenditures, serving as a liaison between the secondary science coordinator, department members, and building principals, and supervising the Upper Arlington Science Fair. The science fair, consisting of participants from the two buildings, has over three hundred entrants yearly. The building department chairpersons received no release time or salary increment for their added duties.

The secondary science coordinator has a variety of responsibilities for the science program in grades seven through twelve and works with the elementary science coordinator on maintenance of the K-12 science program. The secondary coordinator's duties involve the areas of curriculum and staff development, budget, and communications among twenty-eight staff members and fourteen different courses. The science coordinator receives one and one-half hours per day for coordination duties and a small yearly salary increment. The science coordinator and department chairpersons are jointly responsible for the maintenance and improvement of the science program.

The expendable budget for the science department is administered through each building. The earth science program is budgeted at approximately $2.00 per student per year. The budget for new or replacement equipment is minimal with the science department of each building receiving approximately $400 per year.

The science facilities in each building have consisted of classrooms designed for lecture-demonstration purposes. Several science classrooms have a demonstration table with the standard utilities but have no provision for student lab work. Other classrooms are also used for science instruction where the only science addition is the existence of a portable demonstration table. Teachers developed hands-on activities with these physical and budgetary limitations in mind.

During the summer of 1983 the science facilities will be remodeled although there are certain limitations imposed by budgets and by remodeling existing classrooms. To accommodate a hands-on instructional program better, each classroom will be designed to have peripheral student lab stations. Wall-hung cabinets will improve storage capability, but the problem of a limited expendable budget is yet to be addressed.

While the maintenance of the earth science program is the responsibility of the science coordinator, department chairpersons, and building principals, the evolution of this exemplary program is the result of an exemplary science staff. This program was brought to fruition by the sheer commitment of the teachers who designed and implemented the program. The continued maintenance of this program will depend on the ability of the school system to keep and attract staff of this quality.

C. COMPARISONS AND ANALYSIS

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The discipline-oriented exemplars represent some of the best programs in the nation organized around central concepts of specific science disciplines. These four exemplary programs include offerings for the entire secondary science program. The physics and biology exemplars selected by their respective associations are particularly rich in the wide spectrum of courses and a wide variety of students involved. The chemistry and earth science programs selected and described in this monograph are more restricted to a single course for a given grade level. This difference is no doubt peculiar to the exemplary programs selected for this first effort and not indicative of inherent differences among the discipline areas. Nonetheless, it will be interesting to study this phenomenon further as more extensive searches are made and multiple exemplars in these areas of science are identified for NSTA's Search for Excellence in Science Education program.

In one sense, the rich series of courses within each discipline of science may tend to create separate "departments" of science within the total school program. This does not seem to have occurred at either Oak Park River Forest or Shawnee Mission probably because Meyer and Hampton view their roles as physics and biology leaders as a part of a total science effort. Their respective involvements in all aspects of the school and its science program attest to this. However, if a strong physics, biology, or other "discipline" person were to develop an area at the expense of others and regardless of the best interests of students, such an expansion of offerings within one discipline of science across grade levels could be a problem.

The four discipline-oriented programs all represent programs that have developed over a period of several years, that have involved an exceptional staff, and that have been very stable in terms of teachers and the place of science in the total school program. The teachers have not had immediate answers, a specific inspiration, a complete plan ready for implementation. Instead they have sought outside ideas; they have been involved in significant staff development activities; they have been extremely active professionally. As a group they represent the best of the profession--teachers striving to improve and to find even better ways of motivating and involving their students. The teachers involved in the four programs are proud of their accomplishments; they seem satisfied with the directions they have taken in their respective schools. Indeed, to have been selected by their ~~national~~ professional groups as exemplars is noteworthy, impressive, and a situation where pride is expected. However, a healthy skepticism about goals, directions, and the current situation is desirable--especially in science. The activities within professional societies on the part of the teachers involved in the four exemplary programs is in itself exemplary. Their use of professional journals, conventions, and other services is remarkable. Perhaps such quests for more knowledge, more skills, better materials, new ideas, and growth are essential features of teachers who are to be associated with a program designated as exemplary.

As would be expected, a common feature among the discipline oriented exemplars is their focus upon the four disciplines of science; there is an attempt in each case to survey the particular discipline and to use such a structure in defining courses and/or course series in the particular program. Such an organization of science offerings is the traditional one-- especially with respect to the secondary school programs. There is a certain pride in sharing outlines of the particular discipline view developed in specific courses and programs. There is a focus upon process skills, a kind of focus that permeated the national curriculum developments in science of the past two decades. Many of the objectives reported by the leaders of the discipline exemplars can be traced directly to stated goals and process lists from similar discipline "curricula" of the past. And this is not too surprising since the programs developed throughout the 1960's were all discipline-oriented and involved the top leadership from scientific and teaching ranks. Further, the major support for staff development efforts (NSF institutes) during the 1958-76 period focused upon science as specific disciplines and with the disciplines defined in ways consistent with the national curriculum efforts of the time.

The physics and chemistry programs are unique in that they are traditionally college preparatory and enroll only students in the upper half of a given grade level. In recent years the percentage of students enrolling in such courses has declined d matically. This kind of problem has been eliminated (or perhaps has never existed) in the schools of the two exemplars. Some clues concerning reasons for this happy situation are available from the preceeding sections which describe the two programs. In both cases there is a planned program for encouraging student enrollment and specific course features designed to attract students. There is an effort to include activities, projects, experiences that are meaningful and relevant; the word relevant is even used in the title for the chemistry exemplar.

The goal for physics is to enroll fifty percent of the students of a given grade level in a physics course. Even though this is a goal of enormous proportions (when one considers the typical percentage of students enrolled in physics across the entire U.S.), it is minor compared to the stated goal for ACS--that of enrolling all high school students in a chemistry course. The chemistry program at Cy-Fair seems to be progressing with this goal. Infusing the standard course with a variety of activities which are interesting and relevant and which require significant student involvement is an excellent way of increasing student enrollment.

The variety of offerings in biology at Shawnee Mission is designed to meet the needs and interests of a variety of students. Although biology is the typical course used by most students to complete graduation requirements, it has not attracted many students for any other reason. The Shawnee Mission program is obviously appealing to a wide spectrum of students as to age level, biological focus, degree of student involvement, and ability levels.

As indicated earlier, biology is the only one of the four disciplines that was also one of the original focus areas for Project Synthesis. (The five areas were: elementary science, biology, physical science, science as inquiry, and science/technology/society). In the NSTA search, there were fewer nominations/applications in the area of biology and physical science and fewer exemplars named at both the state and national levels. And, those that were named proved to be less innovative and met the criteria less well than programs in the other three search areas. This may be explained by the difficulty of using a discipline orientation to realize goals of instruction other than ones associated with further study of the discipline. Many of the NSTA exemplary biology programs tended to be specialized programs such as a summer extension of the mainline offering. The breadth of the offerings and their availability across grade levels is an attractive feature of the Shawnee Mission program. However, the great focus upon the typical concepts and processes tends to detract from its effectiveness (or potential effectivenss) in meeting other goals of science teaching.

The exemplary earth science program is an integral part of a junior high school program. However, it stands alone as a model effort in the area of earth science where it was selected as a program judged as meeting the stated criteria in an exemplary manner. The program at Upper Arlington is an integral part of a mandatory junior high program with specific program features and goals carefully elaborated in the curriculum guide for the school. The guide stands as a record of what is done, how it is done, and how it is evaluated. The program meets the content criteria established by NAGT in an exemplary manner. Unfortunately, however, the outlines and program descriptions do not illustrate how developing science literacy in statements (as defined by NSTA) or how science for meeting daily personal needs or for resolving current societal problems are accomplished and/or related to the course structures.

The fact that earth science as well as biology are offered for all students make these two exemplars different from chemistry and physics which are generally elective and thereby only for college-bound students. While chemistry and physics teachers must work diligently to attract students both in terms of publicity and course changes, earth science (when in the junior high school like Upper Arlington) and biology teachers have captive audiences. In one sense, it should be expected that earth science and biology would include more relevant topics and student activities automatically. However, the NSF Status Studies revealed that this is not the case generally.

When viewing the four discipline exemplars, one is immediately impressed with the dedication of the staff of each of the four districts. One is also impressed with the extent of the programs, the amount of time, effort, and creativity that have been expended. Excellence does not seem to be something which results quickly and/or easily. It requires dedication, continued growth, new ideas, the ability to practice science in its most basic sense, school and public support.

Each of the four programs presents an elaborate design, original ideas, significant support from administrators and the communities, a dedicated staff, satisfied and involved students. The physics program enrolls considerably more students than expected in typical schools; the program exists across multiple grade levels. The chemistry program is designed to interest and attract greater numbers of students; it is structured to illustrate chemistry as an area of great importance, interest, and relevancy. The biology program is designed to meet students divergent needs, interests, and abilities; it is a complex series of courses with a great variety of activities and ways of involving students.

Like the physics exemplar, it is a program consisting of a rich set of courses. The earth science program is one part of a three year junior high program. It provides a good view of earth science as a field while reinforcing certain views of science as inquiry and certain outcomes of a total science program as a part of a general education plan.

An analysis of the four discipline-oriented exemplars can also be extended to include comparisons of other exemplary programs where different criteria were used. Although AAPT, ACS (Education Division), NABT, and NAGT endorsed the ideal state descriptions advanced by Project Synthesis, each proceeded with its search in manners described earlier in this monograph (See Criteria Sections). Even biology which was a part of the original synthesis effort altered the set of goal clusters and the descriptors of excellence to a degree. And, the individual joint task forces (NSTA and the discipline organizations) had not completed their work on specific criteria of excellence as the search for the discipline-oriented exemplars was undertaken for this NSF-supported project. This explanation and qualification is included prior to the following analysis in which the four discipline exemplars are compared with the collective features of excellence that were developed late in 1982 and early in 1983 as another feature of the NSF-sponsored Search for Excellence in Science Education project.

The extensive visits at the six centers of excellence that were central to NSTA's 1982 Search for Excellence in Science Education provided some generalizations about exemplary science programs that can now be used for further analysis and discussion of the discipline-oriented exemplary programs described in this monograph. The results of such visits comprise the contents of another volume in this monograph series. A total of 18 visitors spent a total of 118 person days at the six centers reviewing the features of the programs judged as excellent, the factors attributing to their development, and the conditions necessary for program maintenance/continuation.

The six centers of excellence were chosen because two or more of the synthesis committees (i.e., elementary science, biology, physical science, science as inquiry, and science/technology/society) selected the program in the particular district as meeting the criteria best (one of the ten national exemplars). The centers selected included science across the K-12 levels as well as a variety in terms of school size, geography, and socio-economic levels. Therefore, there is evidence to believe that the generalizations synthesized from the portrayal reports are valid. The major generalizations arising from the site visits which may be useful as an analysis is accomplished can be specified. For example, excellent science programs:

1. Are designed to be excellent;
2. Involve several years of focused, intensive inservice;
3. Use a locally developed curriculum;
4. Do not place textbooks in a central position;
5. Emphasize team teaching;
6. Have a science supervisor who plays a key role and

who is active in profesional organizations;

7. Have strong central and building administrator support;

8. Provide visible impact on other school programs;

9. Follow well-organized plans for development and implementation

10. Have close ties with higher education;

11. Are still evolving;

12. Have a strong community involvement and support;

13. Have teachers who are extremely active professionally;

14. Are recognized as excellent in the particular district;

15. Have unique features which provide observable local ownership and pride.

Many differences between the four exemplars described previously in this monograph and the programs represented in the six centers of excellence are apparent. There is much more emphasis upon the content of science in the discipline-oriented exemplars; most depend upon textbooks to a greater degree. However, the text programs represented by the four discipline-oriented exemplars have been expanded with many special adaptations for the particular school.

By and large the programs of the centers of excellence tended to begin as a major departure from an existing course and/or program. They tended to be more revolutionary than any of the four discipline-oriented exemplars. Often, they were a new focus and/or organization for science at a given level and represented a new idea that had to be "sold" and allowed to develop. In the case of the discipline exemplars the process leading to the exciting current situation was much more a matter of evolution and improvement rather than a sudden new idea. The staff development activities are more traditional in terms of professional societies, NSF-supported institutes and workshops, and district-wide efforts when comparison is made with the situation in the six centers of excellence.

The discipline-oriented exemplars are more often an adaptation of a national curriculum effort--often one of the NSF-supported projects. The science included in the discipline-oriented programs is generally not the product of a specific new science curriculum developed locally. The course organization and specific activities within the courses tend to describe the extent of the innovations. Textbook programs are more visible and represent the organizational scheme for a given science in the discipline-oriented program. The specific textbooks are identified by the discipline exemplars and are used to describe the content included in the courses. Another difference is the fact that the department chair is more visible among the discipline-oriented exemplars than is the case in the centers of excellence.

One similarity between the discipline-oriented exemplars and the situations found in the NSTA centers of excellence is the team approach to instruction. Seemingly, there is a certain collegiality among the staff in excellent programs. This feeling of common goals and concerns extends to the administration for a school and a district. A certain positive environment exists for education and for the science program. The exemplary science program is an acknowledged strength in the school and impacts other programs and the school as a whole. There is a well-developed plan for continued staff development, student evaluation, and program evaluation in both the NSTA Centers and the discipline-oriented program.

Although not precisely a difference or a similarity, there are other differences in degree. There seems to be less involvement of higher education personnel and/or interns from colleges in the discipline-oriented programs than was the case for the NSTA Centers of Excellence. At the same time specialized experiences in colleges and specifically staff from nearby colleges were identified as major sources of inspiration and assistance in several of the discipline exemplars. There is certainly community support for all exemplary programs; however, this support is more tangible, more planned, more significant in each of the NSTA centers of excellence. In the discipline-oriented programs described in this monograph there seems to be a more passive support for excellence in the science program--almost an expectation of excellence. There is far more support for science instruction in terms of basic content, topics and courses in the discipline-oriented programs. In the case of the NSTA Centers of Excellence, community involvement and support was cultivated to a greater degree. Community support was "expected" in the four communities represented by the discipline programs; the nature of the four communities was such that excellence was sought and maintained by tradition. Good schools (and programs) exist in good communities.

Teachers are a strength in both sets of exemplary programs. However, there is more evidence of added involvement of other educational and community leaders (apart from regular classroom teachers) in the NSTA centers for excellence. In all instances the teachers are extremely active professionally at the local, state, regional, and national levels. Teachers in all the exemplary programs tend to be extremely energetic--perhaps they can be described as "workaholics." They are viewed most favorably by students, school colleagues, and citizens in the community. There is feeling of ownership and great pride in the particular exemplary program in every case.

The criteria established represent some specific differences among the four disciplines. As implied earlier, the chemistry (ACS) and biology (NABT) criteria are more congruent with the Goal Clusters defined and developed by the Project Synthesis researchers. In both instances, there is concern for societal issues, for meeting the personal needs of students, and for assisting students with an awareness for the wide array of career possiblities in science/technology at a time when society is so influenced by science and technology. Although preparation for further study is recognized as a legitimate goal, it is not viewed as any more important (or as important) as the other goal areas specified and illustrated for biology and chemistry. Such goals are described prominently in the criteria for excellence in earth science. However, evidence that such goals are being approached is not apparent in the descriptions of the earth science exemplar.

The criteria for excellence in earth science teaching provide an interesting gradation between those advanced for biology and chemistry on one hand and physics on the other. There is concern for program size and comprehensiveness. There is also concern for content--but not in the traditional narrow view of content in the discipline. Part of this is to be expected in terms of the nature of the "discipline" of earth science. In a real sense it is a discipline while drawing from and relating to several others. Since it is commonly an offering at the junior high school level (as in the case of the exemplar selected for this program), the content must be appropriate for all students enrolled in a given school. The inclusion of content designed for enhancing scientific literacy, appreciation of science, science-society dimensions, and the need for more persons for "earth science" careers represents a broader view of content than used in the determining appropriate physics. Nonetheless, the focus of the exemplary "program" described remains upon content per se.

The inclusion of teacher instructional patterns/modes and attitude in the criteria for excellence in earth science as two equally important parameters with program and content dimensions provides a further link between the chemistry-biology and the physics positions. New instructional approaches are particularly noteworthy in the case of the chemistry exemplar.

The four discipline-oriented exemplars meet the criteria of the respective discipline organizations which specified and elaborated the criteria. In a sense, the four program descriptions provide accurate and reasonable examples of the four sets of criteria. The surprising situation occurs for chemistry which has been viewed traditionally as a college preparatory offering. To have the team call for chemistry teaching and a chemistry program appropriate for all demands a major change in program design, focus, and approach. In a very real sense the ACS pronouncements, curriculum development efforts, workshops and conferences represent major new directions for school science (chemistry).

Biology and earth science are more typical science courses--generally regarded as general education offerings, i.e., appropriate for all students. In a sense the great dependence upon the content dimension in these two areas is more of a typical situation and less "exemplary" than the two criteria statements would suggest. This situation is similar to that encountered with the eighteen exemplary programs selected from the NSTA Search in the areas of biology and physical science. The programs nominated and/or the program staff which responded with an application seemed much more tied to traditional courses, instructional modes, grade levels, observed goals (as opposed to stated ones), and evaluation techniques.

The criteria for high school physics teaching and the exemplar selected represent the least departure from goals and programs judged as exemplary in general and over a span of several years. Physics as viewed as a part of the high school program seems to remain primarily as a preparatory offering for further study when the AAPT exemplary program is described and studied. In this sense physics is largely a vocational subject in terms of preparing persons for successful college-level study. As a result, physics is not a course contributing significantly to the science/technological growth of all students.

The NSTA biology and physical science exemplars tend to be much more like the four discipline-oriented exemplars reported in this volume than the programs described in the other three focus areas. (See Volume 1 of NSTA Focus on Excellence series which includes five issues in areas of inquiry, elementary science, biology, physical science, science/technology/society.) They tend to be further from the generalized ideal state described by the synthesis researchers. This is not unexpected since the synthesis researchers envisioned a curriculum which was problem-centered, flexible, and culturally as well as scientifically valid. They saw the human as central, including all the applications of science and technology. They saw an exceptional program as one which was multifaceted where local relevance was great and a variety of the dimensions of science were used as course organizers. They saw nature itself, as well as students, as foci for study instead of textbooks, curriculum guides, or teacher-organized materials. And above all, the synthesis researchers saw all science information arising from the context of the student; there was to be an emphasis upon the cultural and social environment. The traditional disciplines would lose in importance, especially as major organizers for courses and curriculum patterns. Hence it is not unexpected that the picture provided by the four discipline-oriented exemplars fall short of the ideals synthesized by the Project Synthesis investigators. Nonetheless, the programs identified with the constraints of having a "discipline-orientation" do represent excellence; they do provide models for teachers and schools not ready for abandonment of a discipline structure.

D. EPILOGUE

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Many general features of exemplary science programs in the secondary school arise from the Physics, Chemistry, Biology, and Earth Science exemplars including:

1. Programs attempt to utilize the best views of practicing scientists from a particular discipline;

2. Programs involve students directly in the particular science by means of laboratories, field experiences, and community related projects/activities;

3. Programs continue to evolve and involve teams of teachers as well as other school and community leaders;

4. Programs involve teachers who continue to grow and to be involved, who add a personal dimension to the program, who seek new ideas;

5. Programs are viewed as meeting a variety of goals and needs;

6. Programs have specific plans, formats, parameters; they revolve around a special structure--often the essence of a particular discipline of science;

7. Programs are concerned with the affective domain and all-round growth of students;

8. Programs are designed with science applications in mind and with the use of the content included and considered;

9. Programs include much tradition, student and public popularity, and a [illegible]g teacher ownership component;

10. Programs utilize the best of current thinking from the current leadership, es[illegible]ially that associated with national curriculum developments.

Specific criteria for excellent programs in the areas of biology, chemistry, earth science, and physics were developed with science teaching societies which cooperated with this initial effort. Future searches are planned where a full year will be available to publicize the criteria, seek applications/nominations, and select state and national exemplars. After these more extensive searches, the generalizations attempted here can be tested. Further, the programs described can be reassessed in terms of the carefully synthesized criteria which were not available as the current effort was undertaken.