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ABSTRACT

Contained in this publication are abstracts of the various contributed papers, speeches, concurrent sessions, science seminars, forums, and curbstone clinics of the 22nd annual meeting of the National Science Teachers Association. Materials from the affiliated groups: Association for the Education of Teachers in Science (AETS), Council for Elementary Science International (CESI), and the National Science Supervisors Association (NSSA) are also included. (PEB)

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CESI - Council for Elementary Science International

NSSA - National Science Supervisors Association

NSTA National Science Teachers Association

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AETS-NSSA ANNUAL LUNCHEON

HUMANISM BEYOND THE CLASSROOM

Robert E. Yager, President of AETS, Professor of Science Education, University of Iowa, Iowa City

Humanism in the classroom, humanistic education, humanistic teaching are terms which exemplify the interest and concern for "humanism" in the professional community. Use of humanism in terms of specific classroom situations, in connection with teaching strategies, with respect to curriculum patterns does not do justice to humanism as a concept in societies of man.

My remarks fall within three sets of seven points which are likened to the branching and interrelationship of deer antlers. The first set of parts is concerned with the seven major trends which characterize the current educational scene and which are likely to intensify during the years ahead. The second set of points identify major human problems which characterize today's society. The final set of points represent seven ideas which would exemplify humanism beyond the classroom.

It is always difficult at best to predict the future. It is often difficult to analyze the present. However, with all the risks I offer the following seven characteristics of the educational scene both now and in the immediate future. Such a list is not meant to be exhaustive, and it is not meant to imply approval or any other value judgment.

1. School enrollments will continue to decline, reflecting the decreases in the birth rate. During the 1968-70 years the birth rate decreased by 3 percent; during 1970-72 the decrease was 9 percent; the report for the 1972-74 years has not been released. However, the percentages are not even in terms of the socioeconomic levels of men in today's society. The decreases have been more pronounced within the high socioeconomic level than in the low socioeconomic group. The continued decline in numbers and the change in make-up of each new school level will have many implications for the future.
2. The turmoil observed during recent years with respect to school governance will continue. The adversary roles of the top administrative and the instructional staff will become even more pronounced. The awkward position of the middle administrative positions will continue to grow.
3. Problems concerning the funding for education at all levels will increase. This situation will become worse as dollars stabilize and greater emphasis is placed upon cost effectiveness. These problems will result in more complications, confrontations, and competition for the same tax dollars. The conflicts will include public *vs* private, elementary *vs* secondary *vs* collegiate levels, local *vs* regional *vs* state units.
4. Educational goals will continue to receive study and redefinition. Students, community representatives, representatives from organizations, and society generally will become more active and involved in studying the role of schools and educational units in today's society. Such efforts are likely to result in major breaks in the traditions which have characterized education for the past one hundred years.
5. The preparatory function of the elementary-secondary school will again be a primary emphasis. The growth and popularity of vocation-technical post high school institutions will continue. Curricular programs in all educational units will be more varied because of social pressures, the job market, and out-of-school experiences.
6. Super systems for the regulation of all levels of education will be formed. Such an organization will result in less emphasis on fiscal separateness. It will result in new pressure groups and new alignments of regulatory groups, boards, and professionals.
7. Education will continue to ascend as a "power" in society. Education will become more central to the daily workings of society especially in the socio-economic and political arenas.

Basic problems in terms of how modern man looks at himself have educational implications. These "people problems" also affect how we look into the crystal ball for a glimpse of the future. People problems which are important in considering humanism in education include the following:

1. Man has an instinctive tendency to fight change. Change is generally recognized as a constant force; however, we still fight it. This resistance to change comes from fear. It threatens the stability of the known. The reaction of such threats is described as being the same regardless of the time or the situation. People first try to ignore it; next try to rationalize it away; and finally resort to name calling.
2. Man -at least during the past decade- seems to lack faith that all problems can be solved. Throughout the history of recorded time man has had that faith. It has always been impossible to imagine any problems conceived by man that man could not also solve. Ideas are assumed to be as natural as they are inevitable. Ideas are premises for solving problems. Today problems of the economy, food shortages, the so-called energy crisis seem to create feelings of despondency and fatalism.
3. Modern man has become complacent about himself as an individual. He is complacent about education. He assumes that the awarding of degrees is identical to an education. He assumes that our technology makes us a more advanced civilization. It has been said that man is less creative when he has a "full stomach." Modern society itself has bred man's complacency concerning his fate and his thought of his own role in that society.
4. It is all too uncommon to let words do our thinking. An unknown phenomenon can be *called* something and then all too quickly it *is* something. Labels such as liberal, conservative, permissive, individualized, competency based, and humanism are too often used in a variety of ways with a variety of meanings.
5. Modern man assumes that he is a member of the most literate, the most informed, the most intelligent society that has ever existed. It is all too easy to forget our failings, the state of our literacy, the problems that our "advancements" have caused. Ignorance is the basic factor in all of our public problems. We too easily forget that learning need is out-distancing our attainments.
6. A significant number of individuals in today's society seem to lack commitment and a sense of direction for their lives. Too many persons have

remorse for yesterday while fear and apprehension characterize their feelings for tomorrow. Too few realize we need to concentrate upon the only time we have — now. Concentrating on the present is perhaps the best preparation for the future. This lack of commitment for current activities and the maintenance of a healthy sense of direction, particularly, explain the separation of generations. It is easy to criticize what the older generation could have done. In a similar fashion it is all too easy to spend time and effort worrying about what the new generation will do.

7. A major "people problem" is the lack of humility — humility in weighing one's own worth, the value of one's ideas, one's interaction in cooperative efforts. Perhaps the problem is an emphasis upon an ego-centered philosophy. For example, too often the dialogue at professional meetings is really a series of monologues concerning what *we* are doing, *our* program, how *we* resolve that issue. Benjamin Franklin once said that humility was the trait of all the traits of man for which he most yearned. However, he purportedly slowed the search for he feared that once he had the trait he would be so proud of it that it would be lost. Perhaps it is the sincere *search* for humility that should be the goal.

Seven points have been advanced to characterize where education is and where it is going. Seven points have been advanced which represent major problems of man which have slowed his cultural evolution and his ability to meet the problems of today's world. Seven points are now advanced to exemplify humanism beyond the classroom. These seven points may be viewed as ideas as premises that are needed if we are to be learners and leaders in teacher education.

1. We need to remind ourselves regularly of the sizable incompleteness of our understanding of ourselves, of nature, of the world. We should map our areas of ignorance based on the knowledge we have. We should make less of the information explosion and more of the gaps in the information. We should be aware of and concerned for the knowledge which we do not even know exists. Norman Hackerman, president of Rice University, makes this point particularly well in his editorial included in the March 8 issue of *Science*.
2. The knowledge we have, as meagre as it is, should be used for understanding ourselves and our world. The importance of using knowledge to whet our natural curiosity and our innate desire for more knowledge should be stressed in all of our being. This is the fascination of life and the essence of being human.
3. We must begin to use systems and institutions for meeting societal and human goals rather than having systems and institutions as goals. In our own environment in our own series of experiences in the niche into which we are born and in which we live and die we too often forget that the systems and institutions around us are of human creation — created initially to serve man.
4. The community itself needs to become a learning center. The school as a reflection of such a concept can become a dynamic community center where persons of all kinds of all ages from all education levels come together to consider solutions to problems that face us all. The new role for schools is a societal role and one beyond the usual classroom definition.
5. Educators must become professional le.. ... (Teacher as a term and as a concept need. to be abandoned!) It has been said that learning can best be learned from others who themselves are active learners. Michael Marien of the Syracuse University Research Corporation has said that professionalism among educators is merely an act of ego massage until such educational leaders do become learners first and foremost.
6. The lines that separate groups must be lessened if not erased. The interface between students and teachers, schools and communities, college students and high school students, educators and members of other professions, various classes within modern society must be made less distinct. Communication among all is desired if we are to work together cooperatively in solving the problems of our day.
7. New schema for identifying, measuring, and describing progress are needed. Our ideas concerning success and our definition of it must be altered. We need new criteria and new bases for judgment. We must come to realize that we are dependent upon human judgment in nearly all of our human associations.

To accomplish humanism beyond the classroom we need common men with uncommon views of themselves. I am reminded of a favorite story told of the rebuilding of the Cathedral of London after World War II. As you may recall, Sir Christopher Wren was commissioned to accomplish the restoration. On one occasion Sir Christopher decided to visit with some of his workmen who were busy in the court yard. He approached each of the men individually with the same question: "And what, my good man, are you doing?" Each of the workmen responded with a different answer. The first responded, "I am cutting stones." The second responded, "I am building a wall," and the third replied, "I am helping Sir Christopher Wren rebuild the Cathedral." Each man was involved in the same activity and yet each had a different perception of his job. My hope for our NSSA and our AETS members is that we have many who are cathedral builders as opposed to stone cutters. The kind of people we have is of the utmost importance as we consider our futures. As we all dedicate ourselves to the future, humanism (man's respect for man) can and must go beyond the classroom!

AETS-NSSA JOINT GENERAL SESSION II (Abstract) PROMISES AND PROBLEMS ON THE WAY TO 1984

Edward J. Kormondy, The Evergreen State College, Olympia, Washington

These are rapidly changing times whose rate of change will certainly accelerate between now and 1984. Such conditions warrant rapid response from social systems, but, matured by years and structure, most have become so stable and status-quo-oriented as to be largely incapable of speedy remedy. That can and must be altered. The educational system needs to be prescient, risk-taking, and given to crystal-balling. Most importantly it must engage the learning process in the real world of dynamic change if it is to be pertinent to the times and relevant to the learner.

SESSION C

COMMUNITY INVOLVEMENT, COOPERATING AGENCIES, AND INFORMATION NETWORKS

David Archbald, Environmental Consultant, Madison Public Schools, Madison, Wisconsin

The basic processes described in this presentation were published in the 1972 January/February issue of the *Journal of the Wisconsin Education Association*.

The key ideas covered were:

1. Career/environment education interfacing based on the key environmental education concepts identified at the University of Wisconsin and the key career education concepts identified at the University of Texas and Ohio State University. This interfacing was carried out through a Title III ESEA project.
2. The Education Information (EI) System a student operated system so students can match the talents and expertise of community resource individuals and groups with school needs.
3. The key ecological principles for ecology education.
4. Community goal setting and information processes based on citizen feedback with student participation.
5. A simulation to provide hands-on experiences with all of the above. The simulation thus provides a "training and exercise mat" for student entry into real community experiences.

SESSION D

SCIENCE EDUCATION FOR THE FUTURE: TOMORROW NEVER COMES

Gerald H. Krockover, Assistant Professor of Science Education, Purdue University, West Lafayette, Indiana

In a recent issue of *U.S. News and World Report* [1] a series of predictions were made regarding our life in the 21st Century. Several of these predictions are that:

1. Airliners will fly through the stratosphere at 4,000 miles per hour.
2. Education will be a continuous process no longer rigidly compressed into the years of childhood and youth. The number of college students will rise from 9.2 million today to 16 million with many of these students learning off-campus with the aid of television cassettes, study kits, and other electronic teaching devices. The number of community colleges will increase. Pupils of high school age will not be in a classroom at all, but out earning academic credit by working full time at jobs for specified periods. Emphasis on the learning of technical skills is expected to gain at the expense of a more traditional liberal-arts education.
3. Families will be smaller and of varied structure. Genetic engineering will be available so that babies can be obtained with specified hair color and eye color and perhaps other desired physical and mental characteristics. The median age of Americans will rise from 28 to 35. Life expectancy for women will increase from 67 to 75 and that of men from 65 to 69.
4. Six of ten people will live in metropolitan areas of one million or more population (today it is four of ten). The Black and other nonwhite population of the central-city will rise from 22% to 40%. Today's total of 4.4 million farm workers will drop by 55% as machines and chemicals take over most of the farm work.
5. An average work week is expected to be 36 hours instead of 37.2 hours. However, employees will probably be free to set schedules to fit their needs; thus most will squeeze a week's work into three days to provide more time for adult education or recreation. The family income will rise from $13,000 annually to $23,000 annually in 1974 dollars.
6. The energy crisis will be solved through alternative energy sources such as the use of solar converters for home heating, mass-transit for metropolitan areas, and small people mover vehicles. The main shortage in the future will be water as our needs rise from 400 billion gallons daily to over 1 trillion gallons.
7. The diet of Americans will be based upon the greater use of substitutes for protein other than meat.
8. The basic causes of heart disease and cancer will be identified and a way to prevention or a lasting cure will be found. Spare-parts surgery will become commonplace.
9. We will have three-dimensional television, widespread use of tape cassettes for home viewing and computer hookups on which people may obtain information, place merchandise orders, and pay bills without leaving their homes.

As we look forward to these future happenings, we must prepare elementary and secondary teachers as well as college science educators to meet these rapid changes in our lives and in the lives of our children.

In 1972, the Walla Walla, Washington Board of Education established a committee of three students, seven parents, three teachers, and five administrators to develop a series of goals for improving the educational process at the local level. The committee made six recommendations: [2]

1. To seek more community (especially parent) involvement in the educational programs of the school district, that is, curriculum planning, instruction, conferences, extracurricular activities, volunteer programs, and public relations.
2. To promote an increased community awareness in the programs in the local district with particular emphasis on career awareness, interpersonal relationship skills and attitudes, leisure time activities, and the role of students and parents in the important family unit.
3. To promote programs necessary for the development of positive attitudes and skills employed in effective interpersonal and group communications.
4. To promote a continual examination of the learning process with particular emphasis on the following:
   a. how individuals learn,

b. teacher-student relationships (the importance of empathy).
c. activity learning versus a study of fragmented facts.
d. examining the present grading and reporting process at the secondary level.

5. To promote programs that place a strong continuous emphasis on teaching students how to establish successful life relationships in the present and future.
6. To promote the formation of a district-wide curriculum advisory committee open to anyone who can display a genuine positive interest in the students and instructional programs in the district.

Do our present science education offerings attempt to fulfill the needs expressed in these six recommendations?

Albert Baez, Chairman of the AAAS Commission on Science Education, states that most of our pressing problems can be put under the heading of the four P's: population, pollution, poverty, and the pursuit of peace. In addition, he also proposes four C's as educational guidelines for the 70's that will enable us to create a new generation of people who will understand the power, the responsibilities, and the limitations of science. They are: curiosity, creativity, competence, and compassion. Curiosity refers to the spirit of inquiry that characterizes the approach of a scientist. Creativity refers to the spirit of change through creative design. Competence refers to the utilization of one's knowledge and skills to successfully complete a task. And last, but most important, compassion, to insure that science is wisely used for the betterment of humanity. [3] "We will need pioneers who are already endowed with the four C's to invent ways of injecting them into the education of the future."[4] As science educators, are we ready to accept the challenges expressed by the four C's? Have the NSF-generated science programs failed to meet the needs expressed by the four C's? Have the science teachers and educators of the past failed to meet these needs?

In *Science*, Don Phillips states that, "science education, indeed all education, must develop in the students both an awareness of the difficulties facing our society and the capability to contribute toward their solution. A curriculum attempting to accomplish these ends must be multi-disciplinary and must concentrate on developing problem-solving capabilities." He further states, and this is a very important point: "the broadening of the skills required of scientists suggests an additional challenge: the separation of scientists and non-scientists in the classroom at the very least must be delayed until later in the educational process than the middle or secondary grades and at the very best must be based on different or additional criteria other than high IQ's, high standardized test scores, and high grade point averages."[5] Thus, children need to learn at an early age that a scientist is not always the *man* in the *long white coat* working with *test tubes* in the *laboratory*.[6] That chemistry and physics are not just for college bound students. That science is history; science is art; science is music; science is mathematics; science is reading; and that science is for everyone. Most importantly: science is designed to help people learn to think through problem-solving situations.

Will science education programs be able to respond to our needs in the 21st Century? Are the goals just stated any more noble or do they differ significantly from the goals stated ten years ago by the NSTA booklet, *Theory Into Action*? What changes can we make to meet our future science education needs? Will tomorrow ever come?

Perhaps the wonderful words of the 60's and 70's will finally be implemented. Teaching by inquiry, helping children to become decision makers and thinkers must be practiced; not preached!

Perhaps the fine examples set by our elementary science programs such as SCIS and ESS will spread to middle and secondary schools and to the colleges and universities. The elementary science programs allow for integration with other subjects, learning centers individualization, and most important, can be used by *all* children regardless of IQ, reading ability, sex, or age. Most of our secondary science programs are still designed for a minority of students and concerned with the artificial labeling of topics: biology, chemistry, or physics. When will we have a chemistry or physics high school course for all children, not just the 20 percent going to college or designated as "science-interested?" Science teaching must result in scientifically literate citizens. To date we have failed to reach this goal.

Our efforts to improve science education methods courses have been meager to say the least. How much longer can we afford to have a preservice teacher graduate from a science methods course so that he can be trained to use a new science program in an inservice course? The primary weak link in a science teacher's education is his science methods course. Many inservice teachers evaluate their methods courses as worthless![8], [9]

The education of the science educator must be modified to meet the goals and needs of the 21st Century. We will require outstanding science educator teachers in the future, not just publishers or researchers. Doctoral programs in science education should place equal emphasis upon the development of the person as a competent teacher as many now place upon his development as a researcher or publisher.

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SESSION E

NEW DIMENSIONS FOR A PROFESSIONAL SEQUENCE

Patricia E. Blosser, Assistant Professor of Science Education, The Ohio State University, Columbus

In this session, presented by the members of the AETS Committee on Guidelines for the Professional Sequence, an overview of the 1967 Guidelines was presented for reaction, and comments. The major question was: Should these Guidelines be changed to reflect changes in preparing preservice teachers?

One of the emphases with which teacher educators, in science and other fields, have to deal is "performance-based certification" or "competency-based teacher education." Definitions of these terms vary from meaning only that criteria for certification be made explicit to very detailed lists of skills and competencies individuals must learn to exhibit. Is this concern for preparing "competent" teachers a lasting one? Or, will it join the core curriculum, the nongraded classroom, the middle school, and open classrooms as another educational innovation with which people have been preoccupied for a time and which then decreases in concern?

If the real purpose of stressing teacher competencies is that of making teachers more effective, making them better able to help their students learn, then teacher educators need to be concerned with this terminal skill of being able to help learners. Science educators should guard against becoming so preoccupied with transitional skills that they ignore this terminal skill. They need also to guard against stressing only those transitional skills which can easily be measured.

If the science education community wishes to have some new written guidelines for the professional sequence, the members of this community need to devote time to long-range planning as well as to gearing up to meet the demands of state certification agencies and teacher organizations.

SESSION F

DOCTORAL GUIDELINES IN SCIENCE EDUCATION

TEACHER CENTERS: VEHICLES FOR CHANGE IN SCIENCE TEACHING

David P. Butts, Professor of Science Education, Science Education Center, The University of Texas, Austin

Teaching is a lonely task. Although a teacher is surrounded with many other adults and students, the teacher is often isolated from opportunities to share with others the task of thinking about his major responsibility. This responsibility is to the students who are dependent on him for development of their academic ability; awareness of the challenges in the environment around them; aesthetic expressions that can flow from them; and attitudes and values about themselves and others with whom they must live daily. Fulfilling these demanding responsibilities takes most of a teacher's thinking and daily effort. But lonely as the task is, it is not completely unique other teachers continuously face similar isolations. What is needed are ways to permit teachers to come into contact with other teachers who face or have faced similar problems and to exchange professional ideas. The lonely isolated teacher needs time and opportunity to "look over the shoulder" of others.

Continuing education implies that there be a continuous stream of input available for teachers, and experience indicates that this input will be most useful when it is relevant to the teachers' needs. Continuing education also recognizes that completion of requirements for certification does not represent total completion of the need to learn. An engineer's preparation is expected to need complete renewal every five years. A paint job on the outside of a house is expected to need renewal every seven years. What are logical expectations for teacher's preparation or professional renewal?

Teacher centers are one vehicle which can facilitate the renewal of a teacher's professional competence. This renewal requires concern about the amount of input to be provided for the teacher, the substance of that input, and the resources available for that input.

Commonly education of science teachers has been continued through institute programs in which the teacher returned to a college campus for additional training. Participation may have been encouraged by requirements for advanced degrees or stipends from foundation support. Feedback from teachers suggests that the "return-to-college-campus" strategy usually resulted in a greater amount of knowledge than they could assimilate in the time provided. The substance of the input was usually very relevant to the researcher-professor who gave it, but many times quite unrelated to the reality of the teacher's responsibilities. Frequently the resources for providing the input were people whose sincerity was matched equally by their lack of awareness of the real world of teachers. Clearly, an alternative to college institutes is needed.

A second strategy for teacher renewal has been inservice or continuing education programs within the school building or district. Here teachers have many opportunities to share with other teachers who work with similar children and responsibilities. Thus the amount of the input is usually quite desirable. The substance of the input, however, is many times that of consensus or boot-strap lifting. The resources available for the input vary widely. It seems to depend on the priority teacher renewal has in the reference frame of the school administrators or decision makers rather than in the needs teachers have. Teacher renewal based on political expendiency may help, but it usually lacks the depth and direction which teachers state they need.

A third strategy for continuing education of teachers is a teacher center. While examples of teacher centers can be found in both England and America, their origin, operation and target populations have distinct contrasts. As illustrated by the teacher centers in Texas, such as those at the University of Houston, West Texas State, and The University of Texas at El Paso, a teacher center is usually characterized by a group of dedicated college staff working with undergraduate or prospective classroom teachers in a field based competency-based teacher education program.

In contrast, teacher centers in England (e.g., Southampton and Plymouth) are basically a non-university based group of teachers working with quite autonomous school heads involving about 85 percent experienced teachers in cooperative efforts of setting aims, goals, and curriculum alternatives that will fit their own needs.

The contrast or similarities of English teacher centers and their more recent American counterpart, can be observed in comparing the organization, the people, and the program of the two kinds of centers. A common element is their development to help cope with the isolation of lonely educators the classroom teacher.

Organization

English teacher centers are located in a non-university setting. In effect, they are on neutral turf neither university nor public school. They focus their efforts on what teachers perceive as relevant so that through the center's operation, the professionalism of teachers can be both nurtured and encouraged. The parity of the teacher's input and the center's program is obvious. The center has no program other than that delineated by the participating teachers' perception of their needs. A significant aspect of English teacher centers is the readiness of the institution for change. The impetus or stimulus which caused their establishment in many locations is a response to the dramatic reorganization of English schools from the Primary, Junior, Grammar or Comprehensive schools to the new organization of First, Middle, and Secondary schools including mandatory attendance change from age fifteen to age sixteen. Local school authorities or districts and their teachers were faced with a massive reorganization of schools. Through the teacher center, dialogue essential to this transition has been both necessary and useful. Thus, the main thrust of English teacher centers is to assist in defining new goals and programs to fit a new school organization.

By contrast, the teacher centers in Texas are usually found either on a university campus or near enough to be adequately financed and controlled by funds administered by the college. While the input from public school teachers is periodically sampled in some centers, usually the importance of experienced teachers is minimal. Rarely do experienced teachers perceive the teacher center as a place or source for their personal contribution or benefit. The readiness of the sponsoring institution varies. Most current teacher centers are the response of serious and committed college faculty to the requirements for a competency-based teacher education program leading to eventual competency-based certification. Thus, the main focus of Texas teacher centers is on teacher education programs as they are applicable to prospective teacher preparation. Accountability for the performance of the graduates of an undergraduate teacher education program may well be a significant shaping force in the readiness of colleges to change. Present evidence suggests that this accountability has not extended in such a way to meaningfully involve public schools. Thus, the focus of the teacher center is quite separate from public school concerns. If the organizational setting and staff is as important to the success of a teacher center as the experiences in both England and Texas indicate, is it possible for the diverse school-based and university-based centers to be merged into a single functioning unit?

People

In an English teacher center, a full time staff manages the variety of center activities. This staff may include a variety of part-time advisors who themselves are viewed as curriculum development leaders rather than inspectors or supervisors. University faculty's direct involvement in center programs is not common. The success of an individual center clearly is dependent on the vision and ability of its staff. The participants in center activities are mainly experienced teachers. Quite logically the people in the center view educational questions or concerns from an experienced teacher's frame of reference. Closely related to the participation in the center is the teacher's openness to ideas. In the successful centers, teachers come and actively participate because they perceive the program of the center to be relevant to their needs.

Texan teacher centers have substantial university faculty participation. They rarely have a full-time staff unless they are temporarily operating on externally funded grants. As in the English centers, success of any teacher center is dependent on its participants both staff and teachers. Successful centers are characterized by staff and students who invest many more hours and energy in the task than is observable in more traditional programs. This personal and professional commitment is a substantial source of the center's success. In most Texan centers, the focus is on preservice teacher education as most of the participants are prospective teachers. Since prospective teachers are not yet asking many questions for which a center is a place to develop answers parity of the participants is quite a different problem than for English centers. This openness of prospective teachers for new ideas is quite a different order of priority since they are usually participating at their point of entry into the teaching profession rather than from a base of experience and insight into problems for which they desire help.

If the participants in a teacher center are to have parity in their control of the direction of the services of the teacher center, is it possible to build a bridge between the widely separated concerns of experienced and prospective teachers so that the center can serve both groups in a meaningful way?

Program

A variety of operations or focal points characterize the program of an English teacher center. The focus is on real problems as *experienced* by the participating teachers. The dynamics of the program are encased in teachers' sharing and redesigning of problems they have experienced. Thus in many centers the main thrust of the center is serving as a forum for curriculum development. In some situations the school heads are first involved in establishing appropriate goals which their teachers use to develop curriculum.

The program of teacher centers in Texas is usually devoted to competency-based teacher education. The focus of such a program necessarily is on specifying the array of competencies desired and developing alternative modular approaches to enable prospective teachers to acquire these competencies. Because the target population is primarily prospective teachers, a heavy emphasis on field-based experiences is essential. The goals of the variety of activities in the Texan center are usually established by the university faculty responsible for the prospective teacher's performance.

Determining the direction of a program is a significant issue. Should teacher education goals come from teachers or university staff? Can or should responsibilities be shared? Can or should there be common elements in education for experienced and prospective teachers?

SESSION J

STATUS STUDY OF SCIENCE TEACHER EDUCATION

THE PREPARATION OF HIGH SCHOOL SCIENCE TEACHERS

Sidney Rosen, University of Illinois, Champaign-Urbana, Illinois

Up until the last two decades of the nineteenth century, the maximum preparation for any teacher in a secondary school in the United States was the possession of a diploma from some college or university. For some states, notably New England, this was a minimum requirement. The prospectus of the first publicly supported high school in the United States, the English Classical School in Boston, Massachusetts (1821), read in part: ". . .that it be required of the masters and ushers as a necessary qualification that they shall have been regularly educated at some university."[4]

Normal schools essentially trained teachers for the elementary schools. Such preparation usually involved one or two years beyond the high school. It was possible for a Normal school graduate to find a high school teaching position, especially in the hinterlands, but this was the exception rather than the rule. Normal school student bodies tended to be almost completely composed of females, while males dominated the secondary school scene.

Of course, graduation from a college or university did not guarantee excellence in science teaching (nor in any other area). In fact, good science teaching was not even guaranteed at the college level. One is reminded of the chemistry course offered at the Harvard Medical School during the period, 1827-49, by the infamous Dr. John Webster, where: "He gave the class two or three chemical lectures, which were brought to a sudden end by his show experiment called *the volcano* a large heap of sugar and potassium chlorate piled on a slab of soapstone. After he had lighted it with a drop of sulfuric acid, he saved himself by dodging out of the room, and in a very few seconds all the members of his class found themselves obliged to jump out of the window."[26]

The end of the century saw higher education already beginning to be dominated by the concept of the graduate college and the "specialist," imported from Germany. All academic fields of study were ruled by the specialist who, in the words of Arthur Maier Schlesinger, "wedded a skeleton bride, whose osseous kisses and rattling embrace rewarded him with an ecstasy beyond Helen's."[28] With the ability to major in a scientific field, instead of having just a taste of science as a tiny part of the traditional classical curriculum, those college graduates who sought secondary school teaching positions could now come to the high schools not just as "teachers," but as "physicists" and "chemists."

During the years following the War Between the States, there began to be a tendency to change the high school from its elitist position in the educational hierarchy; secondary education began to be seen more as a necessity for the preparation of the informed citizen rather than as the stepping stone to higher education. Educators began to propose that the high school be freed from slavishness to the colleges and universities. One finds, for example, a Maine educator proclaiming in 1868: "If our colleagues persist in adhering to the ancient curriculum in ignoring the demand of the age for practical education, let them suffer the consequences, but we protest against the sacrifice of our High Schools to the insatiable demands of the Colleges for Greek and Latin. The High School should be the grand temple of the common school system, not the vestibule of a college."[16]

The exhibition of products from manual training classes in European secondary schools to the public at the Centennial Exposition of 1876 in Philadelphia sparked a desire to make the high school a vocational training school, where the student would be prepared for "life" rather than for higher education. Such an attitude was supported through the last three decades of the nineteenth century and into the twentieth by the flood of immigrants from Europe to the United States. The children of these newcomers became pupils in the public schools, pupils of vastly varying backgrounds and abilities; this was democracy with a vengeance. In order to teach such children, the high school and the high school teacher attuned to traditional academic niceties no longer served. One teacher in 1905 saw her students as: ". . .the girl whose mother cannot read or write in any language; foreigners who never hear intelligible English at home; the stunted little fellow who carries telegrams till midnight; the sleepy boy who was up at half past four and driving a milk wagon. . .the boy whose father brings home every night a 'yellow journal;' the boy who does not own a single good book. . .our pupils have no inheritance of culture; nor, indeed, does their future promise more than their past. . .Our pupils at graduation leave behind the world of study. They are now to deal, not with books, except with account books, but with machines, with customers, with kitchen furniture, fancy work, and chafing dishes. These conditions the teachers in an English high school accept. . ."[21]

So, beginning with the first established chair of education at the University of Iowa in 1873, there began to be a demand for additional training for high school teachers; that is, a demand for the addition to traditional subject matter courses in the curriculum of courses that dealt with the "art of teaching." Many Normal schools extended their two-year curricula to four and became "Teachers Colleges" that offered the Baccalaurate degree. Liberal arts colleges added "teacher education" programs, so that as much as one-fourth of the instruction could be taken as formal work in the field of education. It was a time when education itself began to be called a "science."[14]

While members of liberal arts faculties seemed willing to cooperate with such agencies as the North

Central Association of Colleges and Secondary Schools and the Committee on College Entrance Requirements, professors in general tended to look down their noses at colleagues who taught courses in educational psychology, educational administration, and methods of teaching. This contempt was further fed by the early admission of female professors to the education faculties. An example of this sign of male chauvinism can be found in the details of the rise of Teachers College at Columbia University: "...In addition, there was the hostile attitude of some members of the University faculty itself toward all courses on education, and toward the presence of women in higher education. Outward manifestations of this animosity were evidenced by the consistent defeat of any measure advocated by Dean Russell (of Teachers College) in the University Council, by hostility to the appointment of a 'normal school' man (David R. Smith) to a professorship, by the public warning to President Butler that the reputation of the University would be jeopardized by further coddling of this parvenu institution, and by the dubbing of 120th Street as 'hairpin alley'."[15]

Such animosity still persists in higher education in this country. Before he became president of Harvard University in 1933, James Bryant Conant found that: "...early in my career as a professor of chemistry, I became aware of the hostility of the members of my profession to schools or faculties of education. I shared the views of the majority of my colleagues on the faculty of arts and sciences that there was no excuse for the existence of people who sought to teach others how to teach. I felt confident that I was an excellent teacher and I had developed my skill by experience, without benefit of professors of education. I saw no reason why others could not do likewise, including those who graduated from college with honors in chemistry and wished to teach in high school. As a joint author, with my former chemistry teacher, of a high school chemistry textbook, I was quite certain I knew all about the way the subject should be presented; I doubted that my understanding was shared by any professors of education. When any issue involving benefits to the graduate school of education came before the faculty of arts and sciences, I automatically voted with those who looked with contempt upon the school of education."[11] In the mid-1930's, an innovative program for the preparation of high school teachers, the Master of Arts in Teaching Program, was accepted at Harvard by both faculties with some initial reluctance; however, it was not until after World War II that this fifth-year program began to flourish under the leadership of Dean Frank Keppel of the Graduate School of Education.

Liberal arts faculties, then, tended to ignore the rise of teachers colleges and education colleges at the same time that these "Johnny-come-latelys" on the scene of higher education were exerting more and more influence on the centers of power where public education was controlled. This influence made itself felt in the increase of state laws passed stating the qualifications necessary for the certification of teachers. By 1911, approximately thirty-four states required seekers of high school teaching certification to hold a diploma from an accredited college or university.[6] Many also required the applicant to take examinations, either written or oral, or both, in liberal arts subject matter areas, as well as in areas of professional education. California, one of the leading states in the explication of certification requirements, used the state university as a standard; that is, the prospective teacher had to have a background of eight years of secondary and higher education, plus one year of graduate study (which could consist of a half-year of advanced study in a special field and a half-year at a "well-equipped training school directed by the Department of Education."[6] The alternative to these requirements was twenty months of experience as a regular teacher or principal "with decided success" in any reputable secondary school.[7]

While Thorndike, in his 1909 study for the Bureau of Education, found that not more than 55 percent of the high school teachers in the country had "an adequate pedagogical training;" the availability of such training was increasing. Courses specifically geared toward the training of secondary school teachers appeared at the following universities during the latter part of the nineteenth century: Michigan University (1879), Johns Hopkins University (graduate work only, 1881), Cornell University (1886), Ohio University, Athens (1886), Columbia University Teachers College (1888), Northwestern University (1888), Clark University (graduate work only, 1889), New York University (1890), and the University of Illinois (Urbana, 1890).[8]

In 1907, the Committee of Seventeen (of the National Education Association) released their historical *Report on the Professional Preparation of High School Teachers*. Briefly, this Report urged that all such teachers follow the traditional specialized curriculum of the undergraduate college in the fields they expected to teach. In addition, there ought to be some dipping into other fields of knowledge for "some insight" and "to avoid the dangers of overspecialization." Teachers ought to have one or more subjects from the social sciences, along with a course in general psychology, and at least one from the area of philosophy, ethics, and logic "for the proper outlook upon education as the development of the individual."[9]

But this was not all. The Committee also recommended pedagogical studies that included educational psychology, history of education, principles of education, special methods in subjects to be taught, the management and organization of schools, and school hygiene. Finally, it was recommended that there be made available the opportunity for the prospective teacher to observe experienced teachers working in the classroom and to do a certain amount of practice teaching themselves. It was suggested that a university might arrange the latter by affiliating itself with nearby schools, or even by creating and maintaining its own secondary school. Such a complex and intensive training program would be best accomplished in four undergraduate years and one graduate year.

The Report of the Committee had a considerable impact not only upon existing teacher training institutions, but also on those to come. In fact, with only a few variations over the years, the average state requirements for certification are based essentially upon such an educational background. In most cases, the graduate year is voluntary rather than required.

Critics of education courses have abounded since the 1907 Report, one example is a book that became a popular "best seller," *Educational Wastelands*, by Arthur Bestor, a history professor (1953) and was considered by many to be the apogee of all attacks upon 'educationists.' Ten years after the publication of

Bestor's book, Conant, after a wideranging study of teacher education in the United States, concluded that: "...*Professors of education have not yet discovered or agreed upon a common body of knowledge that they all feel should be held by school teachers before the student takes his first full-time job.* To put it another way, I have no reason to believe that students who have completed the sequence of courses in education in one college or university have considered the same, or even a similar, set of facts or principles as their contemporaries in another institution even in the same state."[12] In fact, Conant concluded, the one worthwhile element in professional education was *practice teaching*. He suggested that colleges and universities adopt the concept of the "clinical" professor in medical schools by appointing an experienced teacher as a "Professor of Teaching."

It must be admitted, however, that *de facto*, the problems of mass education in the United States were tackled most realistically by the professor of education rather than by the liberal arts professor. It was the influence of the "educationists" that gave final shape to the regulation of final education by local and state centers of power; it was also their influence that shaped the picture of the typical high school teacher in the public mind. As Conant pointed out, liberal arts professors, in general "turned their backs upon the problem of mass secondary education and eyed with envy Great Britain and the Continent, where such problems did not exist."[13]

One would somehow expect that the fantastic rate of change in technology that has occurred during the past four decades would have effected a similar rate of change in the preparation of science teachers for secondary schools. Or, if not the rate of change in technological innovation, the innovative breakthroughs in scientific conceptualization. And what of the effect of the tremendous national and international upheavals on the economic, sociological, and political scene? And how about the impact of the new science courses whose rubrics parallel those of the New Deal: PSSC, CBA, CHEMS, BSCS, HPP, etc.?

It seems somewhat disheartening to find that liberal arts faculties are still being accused of a lack of responsibility for the education of high school teachers [29], and that "education faculties in colleges and universities tend, by and large, to maintain the status quo rather than to change it."[19] Meanwhile, the U.S. Office of Education still finds it necessary to fund a Study Commission on the Undergraduate Education of Teachers (based at the University of Nebraska); Professor Harry Broudy, a prominent educational philosopher, finds it necessary to question the preparing of science teachers by the same undergraduate curriculum used to prepare research scientists [1]; and Professor James Raths of the Bureau of Educational Research and Field Services at the University of Maryland (now at the University of Illinois) finds it necessary to question the validity of much of the research being carried out in science education.[25] So, one is tempted to inquire: what went on during the past four decades in the area of science teacher preparation? What research was carried out concerning the status of the art and what changes occurred in the art itself?

The fact is that there were certain pre- and post-Sputnik publications in science education that had the promise of being watersheds in the field, that contained within them the seeds of necessary change supported by reliable data (or the lack of it) and reasonable arguments. Half a dozen or more of the more prominent ones can be ticked off in chronological sequence: *A Program for Teaching Science* (NSSE 31st Yearbook), 1932; *The Education of the Science Teacher* (Report of the Subcommittee on Teacher Education of the National Committee on Science Teaching), 1941; *Critical Years Ahead in Science Teaching* (Harvard University), 1953; "Course Requirements for Future Science Teachers" (Watson in *Scientific Monthly*), 1957; *Current Concern and Issues in Science Education* (AETS Convention Report), 1960; *Rethinking Science Education* (NSSE 59th Yearbook), 1960; "Unresolved Issues in Certain Fields for Investigation in Science" (Coordinating Committee of NARST and Office of Education Science Specialists), 1961; *Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics* (Teacher Preparation Certification Study, National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science), 1961; *The Research on Science Education Survey* (Harvard Graduate School of Education), 1968.[1]

Each of the documents listed takes a look at the preparation of high school science teachers and finds it wanting; each makes suggestions for improvement or change. The traditional goals of science teaching are stated and restated. Broudy has summed them up most succinctly: "What does the traditional science program promise? First, as a part of general education, it promises a more precise, critical and fruitful way of thinking about the physical world. Science is regarded as essential to the armamentorium of a mind coping with a modern technological society. Second, the study of science is held to be one of the more profitable avenues to the world of work in a technological society."[2] And, Broudy points out that all of this assumes the validity of transfer of training.[2] Such goals, then, ought to be best achieved in the classroom by the teacher whose preparation has moved him successfully through the typical specialized science curriculum in college, emerging with a major, for example, in physics and a minor in mathematics. In addition, of course, the teacher would need the necessary education courses for certification, and a few electives outside of his major and minor fields for "broadening."

There is the beginning of a change in the suggested background of science teachers in the 1941 Report of the Subcommittee on Science Teaching. This committee was headed by Samuel Powers of Teachers College and the Report was largely put together by R. Will Burnett of the University of Illinois in Urbana. Here, for the first time, one finds an awareness of the economic, sociological, and cultural effects of a rapidly changing technology on the United States and its people, and an assessment of how this awareness ought to affect the preparation of the science teacher. The chapter headings tell the story: "The Teacher as an Individual and a Citizen," with such intriguing subtitles as "The Teacher Should Understand Himself and Others" and "The Teacher should Develop Satisfying Conceptions of the

[1] It is interesting to note that for every paper published concerning the preparation of science teachers, there seem to be far more papers concerned with science curricula and teaching methods; one wonders what ratio a count would show.

Good Things in Life;" "The Teacher as a Person with Proficiency in Functional Areas of Science," with subtopics, "The Problem of Specialization" and "The Teacher should Develop a Realistic Understanding of Science and Functional Knowledge of Scientific Method;" and finally, "The Responsibility of Teachers' Colleges and Departments of Education," which includes "The Place of Professional Education in Preparing the Science Teacher," "The Science Teacher and the Community," and "Professional Orientation and Philosophy of Science Education." [22]

The preface to the Report, after a brief history of science education, states: "...Science teachers and science departments have been committed to the development and perpetuation of academic disciplines which, valuable as they are, have been separated from the actual processes of community life of which they are essential elements. Driven by the demands of subject-matter accomplishment and academically imposed standards which all to frequently ignore the relationship of knowledge to intelligent behavior, the teacher with scientific competence has been allocated to, and circumscribed by, classrooms, demonstration halls, laboratories and curriculums, and too seldom catches glimpses of the forces and processes determining the community's destiny."[23] And further on: "The teacher is first of all a person. To the extent that he is intelligent, informed, socially conscious, and happily adjusted in his life and his views, he may become an outstanding teacher. To the extent that he is poorly adjusted, poorly informed, misanthropic, and confused in his personal views and his outlook on life, his teaching suffers. This is true for all teachers, regardless of field. The science teacher may consider himself to be a specialist, but he should not lose sight of the fact that his basic work is to give instruction and that his primary function is to offer aid to individuals and society in meeting their problems successfully."[24]

Sixteen years elapsed and Sputnik I flew in space before Watson's short paper, "Course Requirements for Future Science Teachers," was published. In it, he asked why prospective science teachers needed to have many of the advanced science courses required of the major, courses that were going to be useful primarily to those who would be going into industry, graduate study, and research.[30] He suggested teacher preparation curricula that did not provide a "good solid major" in a single science area; instead, the student would get "a smattering of knowledge in many areas and not too much in any one." The painful realities of public school teaching most often required a "science" teacher to teach courses in more than one area (often, nonscience areas; it took the ROSES Report of 1968 to make that painfully clear). Watson also deplored the lack of background on the part of most science teachers in the history and philosophy of science.[30] The strong belief in the necessity of such a background to provoke student motivation led eventually to the creation of Harvard Project Physics by Holton, Rutherford, and Watson.

In most of the papers that discussed the best possible curricula for the preparation of science teachers, there was still implicit the assumption that the good teacher must work his way through the course requirements for a Bachelor's degree in one major scientific field. The scientific and technological sophistication of many of the projects of science fair winners is considered by professional and layman alike to exemplify the success of teachers who handle the content of a particular science field with comfort and ability. This kind of rating, nevertheless, simply replicates the way college professors are usually rated by students in higher level specialized courses: the good professor "knows his stuff."

It became apparent, for example, with the introduction of PSSC physics (conceived in 1956) into American high schools that such a course could only be taught by teachers who "knew their stuff." Where were such teachers to be found? Not in the high schools of the United States, apparently; for once the course was ready, special training seminars had to be established for physics teachers to learn the "stuff" they had to know. In fact, the impact of the new science courses on teacher preparation curricula does not seem to have been very great. In most cases, it consists of the provision of "Band-Aid" assistance in the form of special inservice and summer workshops and seminars, where teachers may acquire the specialized information needed to teach the particular course.

It was the Harvard ROSES Report, in the last analysis, that provided the evidence that was hard to swallow: that in the long run, in spite of the papers and reports that had been published, there was very little in the way of objective evidence concerning the effectiveness of science teacher training programs.[17] By 1968, many of the old problems remained unsolved: the gap between the science educators and the liberal arts people, and, worse, the acceptance of most training programs as acts of faith, with no attempt to have feedback or follow-up information for support of validity. The ROSES Report concluded: "the Chaos in the profession. . .is probably one consequence of the inability of science educators to confer about and agree upon the goals and structure of the teacher preparation program in the sciences."[18]

One has only to browse through the pages of the latest Handbook of Research on Teaching (1973) to discover that there is still a lack of replicable, experimental data that can be used to construct a valid, general definition of the "good" teacher, or, for that matter, of what constitutes "good" teaching. One finds Clifford writing that "prevailing styles of teacher preparation have not adequately introduced prospective teachers to accumulated research, spelled out enough of its implications, nor developed attitudes favorable to inservice interest in applied research. The pervasive culture of teacher training is one of, in Mencken's term, 'empty technic,' of vapid methods textbooks, a disinterested educational psychology, of a 'survival-training' mentality among its participants."[10] These are harsh accusations, indeed. McNeil and Popham, in their assessment of teacher competence, conclude: "Teacher educators err when they promote teaching skills that are approximately consistent with scientific conclusions as if these skills were certain, confirmed answers about how a teacher should proceed to effect desirable consequences in learners. Instead, such skills should be regarded as hypotheses to be tested." [20]

Perhaps the above causes one to approach the latest influence on teacher training programs, Performance Based Teacher Education, with a bit of caution. A consequence of behaviorist psychology, PBTE has become fashionable. PBTE springs from a fairly recent concern with accountability in education and essentially has to do with working out a list of skills and competencies that teachers ought to have and to be able to display in the classroom. Such skills can then be made an integral part of the teacher preparation curriculum; what is more, a checker can sit in a classroom and tick items off the list as the teacher is observed at work. The difficulties with PBTE, especially when it assumes the dimensions of a faddist bandwagon are obvious, and one can only predict protracted warfare between the program's proponents and detractors.

What can be said, in conclusion, about the status of the preparation of secondary school science teachers? In somewhat simplified terms, no one seems yet to have provided a satisfactory answer to two vital questions: (a) what should a high school science teacher know? (b) what should a high school science teacher do with what he or she knows?

The general image of the ideal teacher as a kind of superman combination of scientific specialist-child psychologist-sociologist in tune with the times, the community, and the student seems to exist only in published papers. From a realistic point of view, it seems quite reasonable to guess that neither the competence of the prospective teacher in a specific science area, nor his getting an "A" in educational psychology, nor the smattering of humanities he may pick up along the way have very much to do with the ability to, if I may borrow a phrase from the "now" generation, "turn students on to science." Who knows what factors have the highest correlation with student motivation? Rosenshine and Furst have concluded that "...It is possible that the patterns of effective teaching for different ends are so idiosyncratic that they will never be isolated..."[27] In fact, this leads to a third, almost heretical question: does a good high school science teacher (good in the sense of effective) need to have been a college science major?

The above three questions are deceptively simple. The research that has to be carried out to provide valid answers will probably lead to a general questioning of the validity of the philosophy of education that pervades the teacher training curricula and departments of education. It is the same old question: if the philosophy of teachers needs changing, who is going to change the philosophy of those who train the teachers?

As Broudy points out, the entire point of what high school science is good for in terms of the non-school life of the high school graduate must be clarified. "As citizens, we use scientific knowledge, methods, and attitudes not to *solve* (which requires technological knowledge) problems, but to understand them. We use the theoretical schemata of the disciplines to classify, analyze, and to reconstruct the diverse contexts of societal problems. This is the primary use of knowledge by a nonspecialist, but we need research to map out the use of scientific schemata the citizen makes in reading and discussion...We need researched answers on the way school learnings are used interpretively, to build the conceptual contexts in which the nature of life problems becomes intelligible." [3]

If Broudy and the others quoted above are right, then the time has come for a full-scale revolution in the preparation of our secondary school teachers.

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SESSION K

MODEL PROGRAMS FOR SCIENCE TEACHER EDUCATION

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The National Science Foundation, in January 1968, initiated a series of grants that supported the development of 25 models of preservice science teacher education. Eight projects were in elementary teacher preparation, fourteen were secondary, two were intermediate, and one included all three levels.

The projects are additive creating new offerings that will be recommended in addition to current courses in four cases. "Courses" here means instructional experiences not necessarily lectures. Nine projects altered previous offerings, in six cases intending eventually to replace them. One project spent several months in preparatory work, then replaced all its science instruction for prospective elementary teachers immediately. Later changes were made "on the line." In 11 projects, some courses were replaced and others added.

Among the changes instituted by the projects, new instructional activities were the most frequent, with major revision or addition of courses in 17 cases. A few of these instructional changes have been revolutionary with outstanding results. Even some of the less dramatic changes have increased the enthusiasm of students and faculty alike.

Science teaching resource centers, limited to undergraduate use, were created by four projects. More general centers, some with library, laboratory, classroom and all with a well-stocked lending center for inservice as well as preservice teachers, are components of seven projects. These centers seem destined to become the most visible of the traces remaining after the projects assume full self-support. Their impact makes them regional facilities in a very worthy sense.

Formal study of the "new science" or "new math" curricula is part of six projects. We have been informed that frequently undergraduates find science study designed for the elementary grades as challenging as traditional "core" requirements. The problem is to get them to tackle it seriously. When they do, they seem to learn as much science for themselves as they learn about materials for pupils.

Direct and frequent cooperation with schools is a component of 11 projects, with less intense collaboration in 6 others. Early responsible classroom teaching by prospective teachers characterizes six projects. Less formal participation occurs in nine others. Content and methods instruction is combined in 7 projects and there is some linking in 13 others. Classroom teachers are members of project staffs or major committees in five projects, and have lesser responsibility in seven others.

Formal evaluation has been minimal. "Success," judged on the usual intuitive grounds, has been high except in six cases, with some advances even there. Some of the "failures" resulted from uncontrollable external events. Some of the successes were related to an unforeseen degree of enthusiasm in acceptance of the new strategies. No projects failed completely.

For the future, we anticipate a strengthened evaluation component. We already have undertaken a campaign of third party evaluations. Based on the results of these evaluations, we may reduce our investment in exploratory projects, and increase the number of program development efforts aimed at adapting and implementing the earlier advances.

SESSION L

UNIQUE APPROACHES TO INSERVICE EDUCATION

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For the purposes of the position paper, the author defines inservice teacher education as training which occurs subsequent to receipt of the teaching degree, takes place on-site or near the teachers' districts, and consists of summer and/or academic year work while the teacher is employed. Traditionally, this form of training has been sponsored by a school or district while originated by an outside institution such as a teacher's college which provides academic credit. Inservice training has not commonly been established or perceived by the trainees themselves as inseparable from "preservice" in terms of attaining professional growth for its own rewards of increased competence. And, commonly, inservice training has given less attention to the establishment of mechanisms to support and nurture the "innovations" after the trainers have left than to the formal training itself.

Louis J. Rubin's concept of the self-evolving teacher is described as important in advocating what should be a reason for inservice education, and Robert N. Bush's description of the "Curriculum-Proof" teacher and his intrinsic reward system is offered as an alternative goal for inservice education.[1] And, the importance of the practioner-client analogy to the teacher-student relationship is pointed out to reinforce the truism that student needs are the only basic justification for any kind of teaching.

A position is taken that the science education community should emphasize in its inservice training efforts programs which (a) offer generalizability of teaching skills to subject matter in addition to science, (b) include a system to assure that the innovations, or upgraded performances will have a chance to continue when the trainer has left, and (c) can be appraised for their effect in terms of student outcomes.

James C. Stone's analysis of the Ford Foundation's Breakthrough programs is reviewed because it presents a paradigm for the conceiving, planning, implementing, and supporting of innovation and is empirically derived from a review of actual project histories.[2] Several inservice staff development projects are examined in light of Stone's paradigm and the author's position and the suggestion is made that information on new strategies for inservice education of science teachers which address the issue of support for innovations after formal project, institute or workshop experience be accumulated in one place and be made available to the AETS membership.

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SESSION M

THE REGIONALIZATION OF TEACHER EDUCATION: THE NEXT STEP IN PROFESSIONAL DEVELOPMENT

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The curriculum development efforts witnessed in secondary science over the past decade and a half represent one of the most significant efforts in history at coordinating the various parts of the educational system. Never before have academicians, educationists, and practitioners so pooled their energies to produce curriculum materials in such philosophical harmony with the substance and syntax of the disciplines. The marvelous array of textbooks, manuals, and instructional support systems has been developed out of the very best predictions of today's needs in providing the scientific understandings necessary for the fullest and most effective participation in this last half of the twentieth century.

On the other hand, it is now clear that little optimism is warranted over the effectiveness of efforts to implement the national science curriculum into the daily patterns of most schools. Although millions upon millions of dollars have been spent upon inservice training and education programs ostensibly designed and funded for exactly that purpose, many "alphabet" materials suffer either interrment under the dust of storage shelves or perhaps worse, misguided and inappropriate usage.

The issue defined herein concerns the remaining work of effecting real change in school science instruction through the proper implementation of the national curricula and their inherent philosophies and pedagogic strategies. Three points to be discussed are:

1. that the national science curriculum materials represent too abrupt a shift in educational expectations and are incompatible with the basic structure of the American school;
2. that the collaborative efforts among schools and universities, initiated in development of the curricula will be vital to the success of their implementation; and
3. that a regionalized concept of teacher education, both preservice and inservice, shows promise of being an effective agent of change.

The Structure of the School

In his book *The School as a Center of Inquiry*, Robert Schaefer (1967) presents a vivid and realistic picture of the workaday world of the school. Based on an industrial model, the American school of today is a product of an age now past where standardization of skills and jobs was of prime importance. The school is structured as a hierarchy with teachers playing the role of bureaucratic functionaires replaceable cogs in the big organizational machine. The schools ". . .are essentially educational dispensaries apothecary shops charged with the distribution of information and skills deemed beneficial to the social, vocational, and intellectual health of the immature." [7] Alvin Toffler writes: "The most criticized features of education today the regimentation, the lack of individualization, the rigid systems of seating, grouping, grading, and marking, the authoritarian role of the teacher are precisely those that made public education so effective for its place and time." (Toffler, 1970, p. 400)

Being products of the industrial age we have embedded within our national psyche the idea that the industrial model is universally acceptable, is the American way, the way many of us were brought up and thus remains an effective model for education.

Elwood Cubberly articulated this point back in 1916: "Our schools are in a sense factories in which the raw products (children) are to be shaped and fashioned into products to meet the various demands of life. The specifications for manufacturing come from the demands of twentieth century civilization." (Cubberly, 1916, p. 338)

Whether or not Osgood's cultural lag theory fits here is speculative. However, the demands of twentieth century civilization are far different now than they were in 1916.[1] The school as a social institution and to a large extent, the educational expectations of many people, have yet to recognize the need to catch up.

Inquiry as an educational goal for many schools remains largely misunderstood or is viewed as inappropriate, illegitimate, or unimportant. The school is perceived as a dispensary and teaching is thought to consist of prepackaged information distribution. Furthermore, the task is perceived as easy and routine and becomes most cost effective when working with large groups in lecture/discussions. Inquiry on the other hand is expensive, requiring smaller groups, and longer times for the same amount of product, product being defined as that which is most easily measured.

Pseudo-Authority

Consequent to the view of the school as a dispensary and the perfunctory nature of the task of teaching is the fact that teachers are given little real professional authority. The syllabus, the texts, the schedules, the length of sessions etc. are all controlled by supervisory personnel. The teacher is expected to work all day, he suffers from a lack of an analytical and inquiring tradition and in many cases has been trained through a vocationally oriented teacher education program.

A type of pseudo-professional authority does develop however. Schaefer alludes to the quasi instructional freedom that develops from the "isolation of teachers in walled-off classroom cubicles." [7] The teacher has the ability to close the door to other adults and thereby protect his "kingdom" from excessive supervisory control. Through this isolation he enjoys a kind of autonomy that should not be mistaken for developed professional authority. He is free to behave as he chooses in respect to personal teaching style, or individual relations with teachers, so long as he maintains a degree of disciplinary control over his classes.

Institutionally deprived in the analysis of pedagogic issues, the teacher is restricted to a mere illusion of professionalism. Removed from genuine control over his professional life, unaware or uncertain of legitimate theoretical bases from which to operate, isolated, and insecure, the pseudo professional lives in a world of fear and suspicion. He is unwilling to admit to personal deficiencies, and often chooses to hide behind the "wall" of practical experience. His "professional" concerns are limited to a strong, well deserved, but often hard-nosed stance on teacher rights. His rhetoric is often punctuated with cynicism toward those beyond his reach the administration, sometimes the students, and the "ivory tower" idiots at the university.

Dependency on Authority

One major unfortunate consequence of restricting the teacher to a pseudo-professional status is the fact that it strips him of a sense of personal capability for genuine participation in finding the way.

He is often at once authoritarian and dependent upon authority from whom he expects answers to be short, to the point, and without ambiguity. Virtually nothing in his "professional" training provides him with the basic skills of inquiry. More important, nothing in his preparation provides him with a tradition of inquiry. The theoretical and philosophical underpinnings which serve as guide posts in making critical educational decisions lie outside his realm and render him in a sense professionally impotent. Three common responses often encountered when working with secondary teachers and related to this sense of helplessness are:

1. to develop naive dependence on some authority, this can lead to difficulties stemming from unrealistic expectations from the authority;
2. to naively reject all authority, carte blanche; or
3. to vacillate between authority dependence and rejection of authority on the basis of the quality of their respective rhetorics or congruence with predisposed beliefs.

These factors: the industrial model of the school, the vision of schools as knowledge dispensaries, the lack of inquiring tradition in the school and the supression of genuine professional development of teachers are seen as major influences resisting the establishment of inquiry-oriented curricula. Unless this basic structure of the school is understood, unless the school is radically changed and inquiry as well as teaching is emphasized, our national curricula will remain an interesting curio outside the mainstream of mass education. They simply are not compatible with the current consciousness of what comprises a legitimate education.

School-University Collaboration

"There is much of utter triviality of subject matter in elementary and secondary education. When we investigate it, we find that it is full of facts taught that are not facts, which have to be unlearned later on. Now this happens because the "lower" parts of our system are not in vital connection with the "higher." The university or college, in its idea, is a place of research where investigation is going on, a place of libraries and museums, where the best resources of the past are gathered, maintained, and organized. It is, however, as true in the school as in the university that the spirit of inquiry can be got only through and with the attitude of inquiry. The pupil must learn what has meaning, what enlarges his horizon, instead of mere trivialities. He must become acquainted with truths, instead of things that were regarded as such fifty years ago, or that are taken as interesting by the misunderstanding of a partially educated teacher. It is difficult to see how these ends can be reached except as the most advanced part of the educational system is in complete interaction with the most rudimentary." (Dewey, 1899, p. 92-93)

The success of the development phase of a national science curriculum is in large part, a function of the articulation and collaboration among persons representing all phases of the education community. The job of implementation was left up to the institutions of higher learning and textbook publishers. Considering the mass of the problem from the perspective of the radical changes in thinking and school structure, the teachers who were able to receive inservice training were far too few to create any lasting widespread impact. For all practical purposes, in light of the money and effort expended in this direction, implementation efforts over the past ten years or so have failed.

The most important element affecting the success or failure of inquiry-based curricula is the professional quality of the teacher. Further, the most effective means of establishing a tradition of inquiry and higher professional involvement among the "rank and file" teachers is to provide for the close and frequent interaction between school and university personnel.

Herbert Thelan sees profession as being "composed of people who think they are professional and who seek. . .to clarify and live up to what they mean by being a professional." He maintains that the only way to generate the profession is through the interactions of the various parts. "They must give each other information, share, experience, plan together and take part in all that we usually mean by formal and informal communication. They must also engage in reflective and human communion that builds the sense of community."[8]

The successful implementation of inquiry will require the development of a community of scholar-teachers who are organically linked to the academic world through a university faculty (Schaefer 1962). The teacher must intellectually and physically, be a part of the curriculum *development* effort. No matter how complete a "package" may be, its full value lies in the quality of the human intervention of a wise teacher.

The school and university must become active partners in inquiry. As David Hawkins (1970) suggests, teachers must not be shown the way, but must become part of the effort to find the way. If the university assumes a facilitation role in enabling the school to investigate and deal with its own problems, the school in return will become a source of research strength, and an enthusiastic participant in inquiry.

Teacher Education

One of the most fundamental questions now facing teacher education is whether or not teaching is a technical process.[5] For years, efforts have been made to define effective techniques of teaching which clearly show significant advantages as expressed in learner differences. For years the results have been dissappointingly the same no difference or no replicable differences.

A technique, as defined by Ellul [3] is a standardized way to achieve a predetermined end. In spite of the current noise surrounding the issue of competency or performance-based teacher education, few if any clearly defined and measurable skills of real significance have been recognized. In fact, recent studies of the subject show that no entirely satisfactory description of performance-based teacher education has been formed.[2] From all appearances performance-based teacher education can be defined as "a slogan system in search of followers."[5]

Teaching is not a science in the sense that it comprises theory with reasonable powers of explanation; or in the sense that there can be defined a single correct way to accomplish a thing. Unfortunately many professors of education pretend to know what the techniques of teaching are and create false expectations on the part of students who come to their classes expecting to have the closely guarded secrets revealed to them.

On the other hand, we can define the science of teaching as being the continuing and dynamic search for creating more effective learning environments.

Teacher education must become less concerned with information and techniques already discovered and become far more interested in the strategies for acquiring new knowledge. We must consider our goal to be the preparation of beginning professionals who possess the trained capacity and attitudes necessary for life-long learnings, not the production of polished practitioners. [7], [6]

Preservice Teacher Education

The academic preparation of the scholar-teacher should include philosophy in the form of epistemology and the philosophy of science. It should include under psychology: research methodology, experimental design, observational techniques, and measurement. Educational sociology would be another important component through which the perservice teacher would discover analytical tools for understanding subcultures and pupil characteristics. In place of the methods of teaching where one talks about techniques, there should be laboratory experiences and apprenticeships in schools which in turn should comprise the critical analysis of teaching behaviors and the logic of pedagogic strategies.

In short, the beginning professional should enter his field with a tradition of inquiry, a notion of the pressing questions facing him, and a felt responsibility to engage in a continuous search for effective means of intervention with curriculum for enhanced student learning.

Regionalized Teacher Education

Traditionally, many problems interfere with efforts of educationists to gain greater access to the arena of practice the schools. Strangely, the respective missions of each are often perceived as incompatible rather than complementary and mutually supportive. There is a perceivable credibility gap between the school and university that may reflect the gap between theory and practice.

A model of school-university collaboration that shows some promise of affecting the interface between these parts of the educational system is found in Iowa. In 1972 the University of Iowa with the financial support of the National Science Foundation initiated a concept of teacher education known as Project ASSIST.

Simply stated, the basic goal of Project ASSIST is to enhance and further the articulation of thought, manpower, and mission between the schools of Iowa, the State Department of Public Instruction, and institutions of higher learning in an effort to improve science instruction. From its inception ASSIST defined ultimate goal as the improvement of science instruc through the creation of a spirit of cooperation a common mission with the schools of the state. It is a fluid concept that becomes defined operationally at local and regional levels on the basis of negotiation with school officials. Its purpose is to define the needs of the schools and to provide mechanisms whereby those needs can be dealt with. The program seeks to facilitate the professional development of practioners and to assist them in implementing the programs they and their schools perceive as being worthwhile within the context of their local situation.

Regional Involvement

A basic premise of Project ASSIST is that persons closely involved with students and classroom activities need to play a major role in (a) the development of any new approach to the implementation of effective science programs and (b) preservice and inservice efforts to develop teachers with the pedagogical skills and philosophical equipment to teach them.

A regionalized concept comprising 18 centers throughout the state was adopted. Key leaders were selected from the ranks of teachers and science supervisors in each of the centers to serve as coordinators of ASSIST programs. The programs are designed in response to defined needs within each of the respective centers and include needs assessments, program evaluating, inservice teacher education, preservice teacher education, and community involvement. The regional coordinator is a member of the community the center serves, has many personal and professional contacts within the community, and works to ensure that center activities are indeed responsive to the needs of that community. The regional concept has had major impact simply because it has provided a mechanism through which teachers, administrators, students, and community representatives can participate in the definition of needs and become a part of the effort to meet them. Thus plans developed at the regional level are congruent with local expectations.

The Regional Center concept has allowed a greater involvement of school personnel in the process of inquiring into their profession. Conferences and meetings comprised of teachers and administrators served to focus on professional concerns, and the effectiveness of existing programs, and have resulted in a "tooling-up" to meet newly recognized demands. Two major curriculum areas widely defined have been elementary school science and environmental science. Inservice programs in the form of workshops, minicourses, and extension courses have been developed in many regional centers with university assistance and personnel. New life has been sparked into curriculum development and implementation, throughout the state.

A major benefit of the developing close-working relationship between the university and the school at the regional level has been the development of a new avenue for genuine professional involvement by teachers with the support of the university through formal training and consultant services, and most important, the opportunity to share concerns with both university personnel and colleagues both across the hall and across the street.

Cooperative Effort

Embedded within the notion of Regional Centers is the concept of sharing the financial burdens associated with ASSIST programs. The regionalization of services contains many economic advantages related to travel costs and resource sharing that will allow the Project to become self sufficient as it must, if it is to carry on beyond the period funded by the National Science Foundation. Further, as a philosophical point, it is believed that to be receptive and effective, programs require the commitment and financial participation of all involved participants. Things offered for "free" are generally devalued in the minds of the recipient, often interfering with full involvement.

Preservice Goals

The increased communication capability developed through Project ASSIST has functioned to enhance preservice teacher education in many ways.

1. *Interaction Among Statewide Resources.* Meetings and discussions catalyzed by ASSIST have identified the human and material resources scattered throughout the many colleges and universities within the state. Areas for possible sharing of resources to fit regional needs were outlined.
2. *Identification of Master Teachers.* The closeness to the "grass roots" allowed by the regional structure of ASSIST has greatly aided the recognition of programs and of outstanding teachers who are willing to serve as human resources.
3. *Administrative Arrangements.* The Project is exploring means of creating administrative or contractual arrangements between schools and the university which better serve the needs of the preservice teacher and the school. An example would be the arrangement between the Sioux City schools and a local college where master teachers are given release time to participate in a college science methods course in return for the assistance afforded by teacher interns.
4. *Communication.* The enhancement of communication between schools, the university, and the State Department of Public Instruction has been a major accomplishment of the project to date.
5. *Certification Criteria.* The improved communication capability and newly recognized goals and needs have stimulated a scrutinizing of the appropriateness of present certification criteria.

Inservice Teacher Education

The inservice component of Project ASSIST promises to be one of the most important. Clearly, one of the goals of ASSIST is to provide continuity between preservice and inservice teacher education. The early identification of practioners willing to work toward the development of new teachers has already been a rewarding and effective mechanism for enhancing the professional growth of both. Theory and practice come closer together through the harmonious working relationship of a university student and an "Old Pro." To date ASSIST has functioned to create summer curriculum development workshops comprised of teams made up of a practitioner, a preservice teacher, and a graduate student. They developed a new kind of wholesome relationship based upon mutual respect for the complementary skills possessed by each team member. Plans for the inclusion of preservice teachers in the implementation of the instructional packages they helped to develop are now being finalized.

It is important to stress that in Project ASSIST inservice needs are determined at the regional level. The school and the university negotiate the nature of the program on the basis of the need perceived and the resources available. Teachers within the region play an important role by coordinating and by helping to define the design of workshops and other inservice activities.

To date, research involvement of regional personnel has been restricted to the collecting of data for a major needs assessment project associated with the project. The enthusiasm and cooperation of school personnel in this effort create an anticipation of their greater involvement with future research programs within the schools, thus coming one step closer to the development of a completely viable and lasting professional relationship between the school and the university.

The beginning steps taken towards greater integration of the school and university have promise of creating real change in the pattern of science education in Iowa. The national curriculum projects are being implemented in a professional manner by professional practitioners who understand their value and can articulate their worth in terms understood by the school and the community.

Preservice teachers are experiencing the problems of real world teaching through curriculum development efforts and clinical internships with cooperating teachers. Administrators and community leaders are kept involved with current questions relating to the regional educational needs in light of curriculum trends. The effect on kids in classrooms? Time will tell.

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SESSION N

HUMANISM, SCIENCE, AND EDUCATION

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Learning theory has been dominated in recent years by the behavioristic school of psychology. The emphasis has been on observable behaviors rather than thoughts and feelings, on extrinsic pressures rather than intrinsic motivation, and only on those concepts, no matter how trivial, that can easily be evaluated. This influence on positivistic behaviorism has resulted in learning theorists and other persons in education emphasizing *behavior* rather than *mind*.

Basically the humanistic movement is an attempt to consider the individual as a unique person with the ability to experience and interact with reality. This uniquely human ability has resulted in the development of attributes which provide man with behavioral qualities that are the basis of cultural evolution. Choice, self-discipline, imagination, introspection, self-criticism, and thoughts of the future are but a few of the characteristics unique to man.

Perhaps the most basic theory of humanism is that the individual has internal components which affect perception, thought, feeling, and, most important, action. Murray and Kluckhon describe some internal components which might be classified as basic instincts. [26] Maslow delineates a hierarchy of needs. [23] Factors such as life styles also have causal influence upon perception according to Maslow [23], Allport [2], and Murray [25], but must be learned. This is not to say that external factors, as ascribed to by behaviorists, are inconsequential but rather that human interaction with the environment must be considered as a function of internal forces. Cultural and sociological forces, such as peer group and role pressures do not exist outside the experiences of the individual but interact in a complex manner with the internal components.

One of the theories of humanistic psychology of special interest to educators is that of the hierarchy of needs and subsequent forms of gratification developed by Maslow. This theory is presented as a representative of a basic thrust of humanism throughout the remainder of the paper. (This is an oversimplification.)

According to Maslow, the individual progresses through the hierarchy (psychological, safety, belongingness, self-esteem, and self-actualization needs) beginning with the most basic biological needs. Before the person begins to *feel* the safety needs and to react to them, a majority of the physiological needs must be gratified. The individual does not necessarily gratify the needs at one level completely before feeling the needs of a higher level. There may be some gratification of a higher level need before a more basic need is fully gratified. In any case, this hypothesis is a useful basis for a conceptualization of humanistic psychology.

Humanism is not merely a pleasure principle as Smarr and Escoll would have the public believe [32]. Humanism provides the science teacher a basis for better understanding the student, the interaction of individuals, and society with scientific knowledge and processes, and the kind of education students will need to accommodate to a rapidly changing society largely influenced by science and technology.

Science is an intellectual tool created by man as a result of his interaction with his environment. Although it may be true that laws, concepts, and general understanding are results of science and are founded on reality, their interpretations are a function of the mind of man. The humanists would suggest that man's perception, conceptual thought, and inferences are all a function of internal components which determine the individual's response.

The purist who rejects this position and maintains that science is completely autonomous is also saying that science is nonhuman, divorced from values, and intrinsically worthwhile. (A conclusion to be drawn from the related rationale of "basic research for the sake of research" is that even the most trivial research can be impressive when *only* methodological criteria are applied.) This mind set, this religious doctrine, states that value judgments lie outside the realm of science, outside the realm of knowledge and understanding. This doctrine has fostered a public antiscience attitude.

Science may be objective, amoral, and self-correcting. The scientist and science educator, however, do operate within a value system which is neither objective nor self-correcting. Science is not generally considered humanistic [34], however, scientists and science educators can be. A student of science can learn to base decisions on hard data but must also be aware of the significance of his perception as well as related factors such as how the subject under study was selected or what biases determined what data was collected.

Before the current philosophically rigid attitude developed, early science was a means of responding to the basic needs of man primarily motivated by devotion to and love of people. Much of science was related to medicine or to explain phenomena man experiences. Science now deals with a plethora of abstract areas far removed from the lives of man. It might be legitimate to ask the question, of what value is science to the individual?

Science offers the individual a systematic mechanism for objective analysis of reality, the reality of the individual. For example, science might be a vital process for value clarification. It is insufficient to simply ignore values. What is perceived and how it is interpreted is of importance to each individual and his subsequent action.

To expand, if Maslow's theory of the hierarchy of needs is correct, one might test one's own action against the theory in a scientific manner. Not only would such a systematic approach to introspection provide data for understanding *self* but also the understanding of other persons. The needs are theoretically the same for everybody; the means of gratifying those needs may be different for each individual. The behaviors of the student of science, the teacher of science, the professional science educator, and the scientists are all functions of the hierarchy of needs and subsequent gratification.

Maslow and others [4], [7], [28] have suggested that science can be a path to the greatest fulfillment and self-actualization for an individual. While it is true that science is only one means of attaining knowledge of the natural, social, and psychological aspects of reality, it is perhaps the one most potentially available to the masses. The public apparently conceives science as a large body of knowledge. It must be clarified that science is not only a collection of static intellectual constructs but also a dynamic method of understanding appropriate for the perception of *self*.

There are many ambiguities of science which are significant, particularly as related to humanism. Although science is not itself a value system it is a function of values. This notion is particularly well developed by Bronowski [5], Maslow [23], and Barber [4]. Rationality, utilitarianism, and meliorism are cultural values which have a positive congruence with the operations of science. In essence, the position from which anyone operates is *a priori*, determined by a value system.

Another ambiguity of science is that characterized by Cohen [9] when he writes, "... it is not only analytic; it has a synthetic character as well" Science forms a framework in which one attempts to learn bits and pieces of reality through an analytic approach to the separate inquiry structures. At the same time science also is the process of synthesizing such bits and pieces together into an objective picture of reality. It is this latter component of the nature of science which is most useful to the non-scientist. It is not enough merely to provide an individual with the intellectual tools to dissect his life, to identify needs, drives, and other factors of *self*. One must also learn to assemble these bits of information into an acceptable, objective, and holistic view in order to make decisions about the future in a realistic manner.

In science, as well as in technolgic studies, a basic skill is that of optimization. Often a decision must be made based on the data available although the researcher knows the theory or answer developed may not be correct or sufficiently refined. Therefore, a solution or theory is always open to refinement as new data becomes available. Optimization is part of the self-correcting aspect of science and allows for growth.

In humanistic terms, optimization is particularly significant as related to the *self*. It is a unique sensation for members of the American public to believe that what one does is worthwhile. Acceptance of *self* is not easy. Glasser puts it very bluntly when he writes:

> Therefore, all symptoms, psychological or psychosomatic and all hostile, aggressive, irrational behaviors are products of loneliness and personal failure. [16]

Although Glasser would deal with such problems through behavior modification techniques, [15] it is important to point out that for many individuals needs are unfulfilled. Such individuals must learn to deal with reality in an objective manner. Willers [33] has interpreted Glasser to mean that being human results in the rediscovery, redefinition, or reverification of what it means to be free, and to work with, enjoy, and cooperate with others.

Humanism places emphasis on the development of a strong self-concept. This idea is very important but it is a static concept. Singer speaks of the "future-focused role image" [31] which is somewhat similar to the self-actualizing concept of Maslow. Both ideas are predicated on the ability of the individual to assimilate new data and modify his position accordingly. This is optimization of the level of the individual. Persons who have learned this skill will be better prepared not only to accommodate to the future but to make inferences and predictions as to their roles in the future.

The most recent large scale science curriculum movement primarily emphasized discipline-oriented research techniques and learning-inquiry structures of specific disciplines. The current move of the curriculum pendulum is back to problem-centered teaching and learning strategies as well as to a more socially useful understanding of science. The Report of the Estes Park Conference [29] is a call for a school program which is not only problem-centered but based on problems real to the student. The conferees claim that such an approach would be more meaningful to the students, interdisciplinary in nature, and result in increased learning through application of skills in the development of solutions to the problems.

Curricula are in constant states of modification, rewrite, and renewal. The criteria for determining the type of change is based largely within the structure of the discipline. Factors such as critical thinking, scientific problem solving, science, and society have been included among goals for new curricula since the late 50's. However implementation efforts of such curricula focused on the discipline.

In recent years increased attention has been given to humanism and the science curricula. The Environmental Studies Program [13] is one which explicitly deals with humanistic theory and its relationship to the teaching-learning environment. Concern is exhibited throughout the materials for the individual and his experience and the needs of the teacher as well as of the student.

Returning to Maslow, if one makes the questionable assumption that the majority of students have most of their physiological needs gratified (and in many parts of this country and the world, this statement is indeed questionable), then it follows that safety needs are the next to be identified. It is here that the curricula of the 60's, with their emphasis on discovery, inquiry, and openness encountered difficulty in acceptance. If a student has needs of structure, order, and limits which are unfulfilled, then it is difficult, if not impossible, for him to function in an environment which seemingly does not provide for those needs. Perhaps that is why revisions of many of the curricula have resulted in increased order, structure, and limits in their respective materials. The inability of teachers and others (including students) to satisfy personal psychological needs explains at least a portion of the lack of acceptance of the more "open" elementary curricula in favor of the more structured programs.

This phenomena is also of interest in analyzing the writings of science educators such as Romey. [30] These authors have intuitively or by some other means begun working to provide mechanisms which result in the gratification of higher order needs. Again, if I am interpreting Maslow correctly, and if his theory is correct, then it follows that the "belongingness and self-esteem" needs must be in a large part fulfilled before the student (or teacher) can begin to develop his full potential, whether that be critical thinking, creative thinking, or simply becoming a thoughtful scientifically literate citizen.

It is difficult if not impossible for teachers and college professors to *assist* students in fulfilling their various needs when the instructors have not yet attained gratification of their own lower level needs. The teacher who still needs respect through authority, the professor who is not secure in what he is doing or certain why he is doing it, will have difficulty in creating learning environments which will encourage growth in students. References [6], [13], [30] suggest sources for materials, techniques, and models which have been developed and tested to help teachers deal with their own needs, as well as to develop skills which will be usable with students.

The American Association for the Advancement of Science in the national publication *Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics* [3] has recognized the significance of the humanistic movement in science teacher education. The first Guideline of the document states:

Teacher education programs should provide experiences that foster continuous growth in those human qualities of the teacher that will enhance learning by his students.

A. A teacher should show sensitivity to students.

B. Teachers should have self-esteem and confidence.

This statement and the information given in the supporting text clearly indicate that the concern for humane science education is more than the reaction of a few concerned radical educators. The humanistic movement has become an integral part of science education and science teacher preparation.

Self-actualization and teacher characteristics is an active area of research. It has been shown that self-actualizing teachers demonstrate more concern for students. [27] Self-actualization as a teacher attribute has been related to critical thinking done by students. [8], [12] Teacher behaviors of various types have been related to self-actualization. [10] Most researchers suggest that a change in teacher selection and education is in order. Factors related to humanism are significant and should be given serious thought.

The current widespread concern for factors such as belongingness, self-esteem, and self-actualization could not have come about unless a large number of individuals had risen to and gratified those needs. Teacher education programs will respond to the gratification of these needs only at the rate staff essentially fulfill the more basic needs. Then and only then will truly humane teacher education programs exist.

The fact that increasingly large numbers are searching for a success identity is evidence that social institutions, primarily the schools, have provided their participants with neither the necessary skills to deal with reality nor the necessary experiences to achieve gratification of needs. Few individuals have the ability to judge honestly what they are, what they are doing, or where they are going.

Adults have recognized the failure of schools to respond to the needs of young people. The result has been the establishment of a host of alternative schools. A special issue of *Harvard Educational Review* deals exclusively with this topic. It is suggested that the rise and growth of these programs occurred simultaneously with the widespread humanism movement. [17] Pressures which brought humanism to the forefront include: the birth rate, the impact of scientific development, technological skills, accountability, heavy concentrations of urban populations, increasing militancy of all members of the education community, and the broader involvement of all persons in decision-making related to education.

These same pressures mitigate against widespread success of "third force" objectives. Harold C. Hunt has predicted that responses to such pressures will include: a lengthening of the school day, decreased teacher-student interaction, extension of school years, both downward and upward, with an increase in structured preschool programs and the addition of grades thirteen and fourteen. [21]

Societal pressures may be moving schools toward the ends predicted by Hunt. However, it is essential to heed the warning of John Holt.

> Since the jail function (of schools) is not a humane function and works against the humane task of helping learning and growth, since we cannot at the same time and in the same place be in the jail business and in the learning business, we must get ourselves out of the jail business. [20]

Schools should not be considered as a perfunctory mechanism to husband human resources.

Although such pressures and forces do exist it should be remembered that the function of schools is to educate--to prepare our youth for their life as the next generation. Schools, curricula, and administrative decisions should be in response to the needs of youth, not the problems of adults.

As societal objectives continue to fragment, with parallel fragmentation of value systems, the significance of value clarification as related to science will take on increasing importance. Harvey suggests that teachers of science begin by examining their own values and beliefs. [19] Science will take on a personal value to the individual as attitudes and conceptions are clarified. It is then that the science teacher will be able to deal openly with values in the classroom, the laboratory, or in everyday living. Such an approach has been of highest priority in the minds of many science educators. [1], [18], [22] Science teachers trained to deal with values, will more readily be able to help young people through years in which the developing value system is most fragile.

Science education curricula and purposes must accommodate changing school structures, whatever they may be. It is essential that modifications and subsequent programs be thought through and developed now. If changes in the schools are imminent, then today's teacher education programs should reflect the needs for tomorrow's science teaching. If the future is undefined then science teacher education should have built into it a mechanism to help teachers accommodate to as many forms of change as anticipated.

Science and humanism can be the prime vehicles for assisting future science teachers to accommodate to change. If the science teacher uses what Dewey describes as a scientific habit of mind [11] to view himself, he will be in a better position to optimize about *self* and even predict his role for the future. An understanding of needs will foster his own growth, thus enabling him to better work with students and their needs. The self-actualizing future-role oriented science teacher will be a vital ingredient of education in the future.

Although specialization is perhaps biologically, socially, and intellectually necessary, it is not known at what level or to what degree specialization should occur. Should science teachers be trained only to canalize youngsters into specific disciplines of science? Should science teachers be trained to function only as science teachers? I believe that the answer to both questions is, *positively not*! Even though one becomes a specialist he should retain or attain the capacity to function as a generalist. The needs of society are changing, the future of schools is in question, and certainly the role of the science teacher will be modified. The Association for the Education of Teachers in Science might heed the words of John W. Gardner, "... in a world of change the versatile individual is a priceless asset." [14] The difficulty, is, of course, in educating the "versatile individual."

The most likely way of producing the individual with versatility is to foster those qualities which allow him to be creative, independent, and self-reliant. These are qualities that are represented in Maslow's hierarchy of needs as resulting only when the individual has reached the ability to self-actualize. Only then can the full potential of the individual be brought out.

If one accepts science as a significant path to man's fulfillment and self-actualization, it becomes important to consider science teacher education in a new and different light. Instead of having a past orientation or consciousness, future perception would serve the science teacher as an adaptive mechanism. As the society continues to evolve beyond the capacity of the educational system to change, the humanistic science teacher would more readily be able to help young people function in an unstable environment.

How do we educate such super science teachers? I'm not sure. But more exposure to open curricular materials, not less, would help. Greater concern on the part of teacher educators for fostering their own growth and ability to self-actualize, rather than for maintaining the comfortable *status quo*, would help. A lessening of the concern for schooling, with greater emphasis on education, would help. A breaking down of the calcified compartmentalization of science would help. Nourishment of those qualities within man that make him a free and morally responsible being, would help. Realizing that the self-actualizing individual never feels he or she "has arrived" or "has it all together" is the major prerequisite if one is to address one's self to the issues raised. It is then that it becomes clear that: society is not a machine that need only be maintained. It is then that humanism is seen as the prime ingredient of an educational system which provides a society with individuals which continuously recreate it in response to a changing environment.

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SESSION O

SCIENCE TEACHER EDUCATION: WHOSE RESPONSIBILITY?

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The question of the responsibility for educating teachers of science is really misdirected because by any measure the responsibility has to be to be assumed by the individual being trained. What agency can best assist in providing the experience and insights which are most beneficial to achieving the skills necessary to teach science? Traditionally there has been a separation of the activities each institution would provide as its share of the training. The college has taught the general and specific subject background and theoretical portion of the student teacher's professional preparation. The public school has been the location for the practice which was felt necessary to his professional development. Deviation from these roles has occurred in field experiences, in observation, or in mini teaching, but very little has been done to integrate the college and public school portions of the professional education of a student teacher. This distinction can also be made about the education of practicing teachers. Extension and summer school course work accurately describes most college involvement in the inservice education of teachers.

The position of this author is that the education of all teachers, whether preservice or inservice, should be the shared responsibility of all agencies which have a legitimate interest in its outcome. In reality, these agencies consist of the student teachers, the students served by the public schools, the communities which provide these students, the school staff, and the college staff. The institutions which represent these constituents would be the university and public schools forming a cooperative where both have equal opportunity to contribute to the development of the individual strengths of a teacher. Primary requirements of such a cooperative would be the mutual trust of the participants and an acceptance of their legitimate interest in the entire effort of preparing one to be a teacher. Teacher education must be a shared responsibility.

One of the major strengths of any teacher education program is the extent to which it is capable of assisting students to achieve their potential. In a self-actualizing approach to teacher education the student is encouraged to seek as extensive an understanding of himself and his relationship to others as is possible. From this perspective, changes in behavior are seen as the result of experience and interaction.

> Regardless of the differences in educational philosophy, the development of the prospective teacher as a person is an essential responsibility of any teacher education program. Vicarious experiences are desirable and even indispensable to the understanding of self and others, but if insight is to be translated into behavior, prospective teachers must be helped to interact with themselves and some of their teachers as openly and honestly as possible. The process is continuous and painful. Only through open and honest confrontation with self and others can the possibility of growth be enhanced.
> . . . . . What is called for is a shift in emphasis from a curriculum characterized by reliance on external responsibility for growth to one characterized by personal responsibility for growth, and from a curriculum characterized by talking about ideas, values and qualities to one characterized by the discovery and development of ideas, values and qualities through personal involvement in real and open relationships and experiences. [16]

The disparity that exists between theory and practice in teaching has frequently been identified as a major problem in producing effective teachers. [13] The variations in teaching science in the public school as well as the lack of implementation of new teaching techniques in college make it difficult to transfer the concepts developed in methods classes to the reality of public school classrooms. Gallagher [7] suggests that "a significant portion of elementary and secondary school people have difficulty in reasoning from principles and abstractions to actions, and in conceptualizing data and experience from real-life situations." He concludes that science teachers need experience in conceptualizing and reasoning from principles since this skill is a fundamental part of the scientific process.

Whether the failure to find relevance and actual value in the theories commonly taught in methods classes is a result of the disparity between the college and public school experience or the inability of teachers to exhibit skills in formal reasoning does not detract from the point that a viable teacher education program must enable the participant to see the relationship of what he learns while in the program to what he needs to know during his employment as a teacher. Jackson [8] points out that the conceptual language of teacher education must not contradict the teacher's sense of reality if it is to have both explanatory and descriptive relevance. Opportunities to apply many of the ideas one has been introduced to in a methods class are often lacking. That is, at least in part, due to the separation of the college and public school institutions.

One of the major causes of the separation of institutions in contributing to teacher education is the often assumed distinction between practice and scholarship. Statements such as "Teachers are educators, not educationists. Their competencies are with children, not with theoretical designs for education" [14] imply an inability of the practitioner to make significant contributions to the conceptual framework of teacher education. This kind of thinking has resulted in the assumption of research as the prerogative of the university and caused the public school to minimize the evaluation of its efforts. The effect has been for the public school to allocate small amounts of money to research and the university to find it difficult to apply the results of its experimentation to realistic situations. The separation of scholarship from practice has been a great dis-service to teacher education–where, in fact, this distinction needs to be minimized.

The question of who is to be responsible for teacher education may soon be academic. Given the present state of teacher militancy, and the ability of teachers to influence legislation controlling entry into the profession, it would appear that there will soon be vast changes in the certification laws. To exclude teachers from this process simply does not make sense. Their contribution should be a strong one based on the legitimacy of their involvement and the competence they possess in developing a teacher education program.

A similar pressure being exerted on teacher education is the desire of the public that educators be held accountable for their product. Koran [9] points out:

> Indeed, if we describe the output of a teacher education program in terms of *beliefs, becoming, security* and *acceptance, meanings* and *subjectivity*, we are describing socialization rather than teacher education and find ourselves with no justification for creating the institution of teacher education for these purposes ..... The ambiguity of these goals or procedures has permitted a sloppiness in the teacher education enterprise which the public cannot and will not tolerate.

To reflect that education is a socializing process may be accurate but to limit its definition to such a large context without specifying outcomes is a luxury we cannot afford. John Hersey's observation that school is not just learning about life it is life itself is an appropriate description of teacher ed icatic. as well. However, to describe the expectation: we have for people we are recommending for inclusion in the teaching profession in non-specific terms is to do a disservice t(them as well as to the public.

The emphasis on accountability that has been laid upon the teaching profession has contributed to our development of competency based teacher education programs. In the arguments which have been made regarding CBTE it is interesting to note that virtually nobody had advocated tha: teachers should be excluded from the process of identifying acceptable teaching behaviors. The logic of including participants in any description of the activities of the profession seems obvious. To exclude them from this process will not only result in a less valuable product, but also, it will perpetuate the separation of theory and practice.

The argument that the preparation of science teachers should include early experiences with students is extensive and not new. This position is supported by Koran (1973), the AAAS guidelines (1961 and 1971), Gallagher (1973), NSTA (1969) and others. The UPSTEP program at the University of Iowa [17] is an example of an extensive effort to provide early experiences with students for prospective science teachers. The trend toward earlier field experiences indicate' that it will be beneficial to form close associations with the schools and community in satisfying the professional preparation requirements of teachers.

The ideas which have been advanced in the first part of this paper argue for a combined effort in preparing science teachers. Practicing teachers have a legitimate interest in who enters the profession and how they are prepared to make a positive contribution and to provide the resources which are necessary for presenting the most realistic instruction possible to student teachers. Howeve. the point should be made that these contributions are not limited to practicing teachers and are equally attributable to college personnel. The distinctions between college and high school teachers are more organizational than they are descriptors of competence.

The primary conditions in forming the type of cooperative arrangement advocated in this paper are:

1. An attitude of trust on the part of each member toward his own and the other members' contributions to the preparation of teachers.
2. An acceptance of the legitimate interest of all members in the preparation of teachers.
3. A willingness of all members to share resources and to invest some of them in the preparation of teachers.
4. The production of an effective program of teacher education.

Failure to observe the first three of these conditions will result in a program which is exploitive of some of the members. Failure to observe the fourth will result in no program since students will elect to remain in a traditional sequence.

The creation of a "new Partnership arrangement" [15] is not sufficient to guarantee the development of an effective teacher education program. The willingness of the university staff to change some of its traditional roles in preparing teachers and of the public schools to accept some responsibility for this activity are not sufficient to produce a viable cooperative. An effective cooperative teacher education program will exhibit the following characteristics:

1. The program offers the student alternatives in the activities he follows and the people with whom he works.
2. The curriculum provides experiences which encourage the discovery and development of ideas, values, and qualities through personal involvement in real situations. Provision is made for experiences which encourage personal growth.
3. The student teacher makes use of a wide variety of resources including some contact with age groups he does not intend to teach.
4. The cooperating institutions have dual staff appointment. College and public school personnel contribute equally to program planning and to decisions affecting the operation of the cooperative.
5. Recommending a candidate for certification is done from the cooperative rather than from either of the institutions alone.
6. Inservice and preservice training are integrated. The role of the university staff in inservice activities is much larger than it is in the traditional program.
7. Methods and other professional courses are taught at the public school site using a programmatic, i.e., experience-based rather than didactic format.
8. The program is sufficiently flexible to provide undefined options to the student teachers and to encourage change within the cooperative.
9. There is relative independence from the bureaucratic structures of the institutions involved.
10. There is a willingness on the part of the staff to share in contributing to the success of the student teacher.
11. Supervision of student teachers is largely done by public school staff.
12. Support is derived from all participating institutions.
13. Grades and recommendations for student teachers are determined by the personnel most responsible for the activity being evaluated.
14. There is some formal commitment of the institutions to the cooperative center; e.g., contract, dual staff appointments, budget allocation etc.
15. The field experience will extend over a period which is longer than the time allowed for student teaching under the traditional program.

The cooperative model characterized above is not the only description available. Eastman's model [5] emphasizes early experiences and a prescriptive type curriculum. The Portland, Oregon, Urban Teacher Education Project [12] has a heavy involvement in minority group and urban teaching. Marker [10] and Clark [3] offer variations in location, program, and length of time. Drozin [4] reviews an NSF supported inservice cooperative specifically to upgrade physics teaching. Ideally, enough cooperative relationships of a distinctive character would be entered into by a college to offer a variety of alternatives to the student teacher. One of the strengths of this approach would be the opportunity to isolate a few variables in teacher education and to establish centers where these variables could be implemented and tested more discretely.

The benefits from shared responsibility of teacher education can readily be predicted from the characteristics listed previously. Some of these would fall in the category of fulfilling legitimate interests, increasing resources, and providing more realistic experiences. However, the purposes of this paper are better served by describing a successful model of a cooperative center -the Cooperative Teacher Education Program (CTEP).

CTEP began in 1971 as an informal cooperative between the University of Illinois and High School District 214 (a district of eight high schools in the suburban Chicago area of Arlington Heights). Initially student teachers from science, mathematics, English, and social studies were enrolled. Since that time it has expanded to include Northern Illinois University, Northeastern Illinois University, and five feeder elementary school districts (25, 21, 23, 15, and 59). The program has also expanded to include student teachers from most subjects commonly taught in high school. Since its inception, over 450 student teachers have participated and have been recommended to teach in secondary schools. The participants spend a full semester in the program and receive credit for the professional education component of their preparation including subject and general methods, history and philosophy, and when needed, educational psychology. Titles only serve to fill the university requirements for graduation as one cannot distinguish program activities or participants on the basis of receiving credit in a particular course. All students live within commuting distance of the public school area and are in the schools for the full 16-week program.

The nature of the cooperative requires that each institution commit staff to the program. The roles of supervision and instruction are primarily assumed by personnel from the public schools. The university staff has direct involvement with the inservice activities of the district. As part of the university commitment, tuition waivers are provided to the public school staff for graduate level course work. Program planning is the shared responsibility of the university, public school, and student teachers. After completion of the program, students are recommended to the state of Illinois for certification through the university where they are enrolled. The program is basically operated from subject-area groupings, but interdisciplinary activities are encouraged as students select alternatives. All participants have contacts with elementary or junior high students by either observation, tutoring, serving as a teacher aide, mini teaching, or choosing a portion of their regular student teaching in elementary or junior high school classes. Supervision and instructional leadership are provided primarily by public school teachers serving as subject area coordinators. These teachers are released from a portion of their regular teaching day to provide this input. At present there are 11 subject coordinators. In addition, one person in each building is given released time to coordinate local activities. There are three public school staff members responsible for the general operation of the program. Release time for subject and building coordinators is provided by interns from the universities. The university staff is in the public school area for three days every two weeks. There are nine university persons presently involved in the CTEP program.

As was mentioned previously, the university staff members work directly with the public school teachers. One of the inservice experiences developed in this manner was a laboratory mathematics program where teachers from all buildings were invited to develop activities and teach students in a demonstration center. Another program was a series of seminars designed to help the public school staff to develop techniques in self assessment. A similar effort used the university staff to teach seminars in administrative techniques and problems. An allied 2-year program for developing administrators has also be initiated. Over 400 teachers have taken graduate course work and received tuition waivers as a result of the CTEP program. An interesting experiment was well received when the university staff was invited to perform departmental evaluations and to report the results to the departments for their analysis.

Possibly one of the most distinctive features of the CTEP program is that it encourages student teachers to select their own cooperating teacher. For approximately the last eight weeks of the program, the student teacher is in an extended group situation with classes of high school or junior high students. He is informed at the beginning of CTEP that he is to establish a set of program goals for this experience and to find public school persons who are willing to work with him in seeking their attainment. The setting of these goals occurs over the initial eight weeks of the program. Assistance is provided by the subject area coordinator in helping to define the goals as well as in helping to locate resources. The evidence by Edgar [6] supports the CTEP staff's notion that this process should produce a greater encouragement for behavior and attitude changes in the student teachers.

The conceptual basis of CTEP is a set of components which describe the teaching behavior expected as outcomes of the program. These behaviors could be used to develop specific competencies, but at this time there is some hesitancy to do so. The reluctance results from an uncertainty as to the efficacy of CBTE in being the best method for encouraging personal growth. A second question which is preventing motion in this direction is whether the anticipated benefit of further specifying behaviors would justify the effort used in writing them.

The following teaching behaviors have been identified along with the activity designed to teach that behavior.

1. To develop the candidate's awareness of the individual needs of students and their responses to curriculum decisions and teaching strategies.
   Associated activity: Mini-teaching.
2. Self Awareness
   a. To develop the candidates's self-perception (particularly as it relates to the educational

profession), and to develop his sensitivity to self-concept development in others.
b. To provide the candidate with an opportunity for communicating with his colleagues about self and group identified needs.
c. To provide an opportunity for reflection on personal teaching experiences in relation to role expectations.
Associated activity: Human Relations Groups

3. To develop the candidate's knowledge and skills in teaching his subject.
Associated activity: Subject Area Seminars
4. To develop the candidate's knowledge about the political, legal and societal characteristics of the institution of school.
Associated activity: Institutional Study.
5. To develop the candidate's insights into the development of children and the progressive changes in their capacities to learn concepts.
Associated activity: Elementary Teaching
6. To provide experience with the mechanism of individualized instruction and its associated benefits and problems.
Associated activity: Individualized Instruction Unit
7. Human and Institutional Awareness
   a. To define the candidate's assessment of his values and strengths through the analytical observation of a variety of schools, teaching fields, and grade levels.
   b. To develop an awareness of the specialized resources and techniques used in elementary and middle schools.
   c. To develop an awareness of the broad individual and social influences on a student emanating from the community he lives in.

   Associated activity: Observation of the community and elementary, middle, and secondary schools.
8. To develop the candidate's ability to make decisions, initiate programs, establish goals, select cooperative colleagues, and succeed independently.
Associated activity: Election of program of extended group teaching and cooperative staff.
9. To develop the candidate's experience with normal classroom management over an extended period of time.
Associated activity: Extended group teaching
10. Self Direction
    a. To provide the candidate with an opportunity to direct his experience in CTEP and to provide leadership to the program.
    b. To increase the candidate's ability to self-determine his activities when controlled by an organized institution.

    Associated activity: Participation in the Planning Committee
11. Evaluation
    a. To develop the candidate's competence in making conclusions about his experience in teaching and its potential for satisfying his career needs.
    b. To assess the behaviors and potential of individual candidates with reference to the teaching profession.
    c. To generate data in order to judge the efficacy of the CTEP model for teacher education.

    Associated activity: Evaluation Seminars
12. Alternative Education
    a. To help the candidate develop the skills necessary for discovering learning experiences available to students within the community.
    b. To develop the candidate's ability to assess the appropriateness of various community experiences.
    c. To help the candidate develop selection criteria for student participation in community experiences.

    Associated activity: Instructional Settings

In more than two years of operation, CTEP has undergone considerable program evaluation. Perhaps one of the advantages of this type of effort is the fertile ground it offers for research. Four doctoral studies have been made and an extensive evaluation of attitude and behavior change was done by the University of Illinois. The evidence which has been collected supports the conclusions that the program is: (a) at least as effective in developing teaching skills as is the traditional program; (b) the participants exhibit a positive attitude toward CTEP; (c) CTEP has generated enthusiasm and behavior change on the part of the involved public school personnel; (d) student teachers perceive the experience as a realistic introduction into teaching.

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SESSION P

OBJECTIVES AND IMPLICATIONS FOR PRE- AND INSERVICE TEACHER EDUCATION

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Probably most educators would agree that measurement and evaluation are two of the important components of the instructional process. There would be little argument over the position that educational objectives and learning experiences are closely related and that in practice the objectives of both instruction and evaluation differ only when the purpose of evaluation becomes the judgment of achievement at the termination of a segment of instruction. However, if you take the position, as I do, that in order to design meaningful instruction and evaluation, objectives should be stated in behavioral terms then controversy enters the scene.

Dissent can serve many positive functions, and certainly the many heated discussions concerning the relative merits and value of behavioral objectives have opened more lines of communication as opposed to closing them. If you are actively engaged in teacher education at either the inservice or preservice levels, the behavioral objectives issue is one that you have to face. You may choose:

1. to ignore them, for passive resistance has been known to do violence to the existing order.
2. to fight them and their proponents and generate statements concerning the triviality, mechanism and lack of humanism that the use of behavioral objectives may promote.
3. to examine the issue in light of an instructional model.

James Popham [2] has listed the following ten reasons educators have against the use of behavioral objectives.

1. Trivial learner behaviors are the easiest to operationalize, hence the really important outcomes of education will be underemphasized.
2. Prespecification of explicit goals prevents the teacher from taking advantage of instructional opportunities unexpectedly occurring in the classroom.
3. Besides pupil behavior changes, there are other types of educational outcomes which are important, such as changes in parental attitudes, the professional staff, community values, etc.
4. Measurability implies behavior which can be objectively, mechanistically measured, hence there must be something dehumanizing about the approach.
5. It is somehow undemocratic to plan in advance precisely how the learner should behave after instruction.
6. That isn't really the way teaching is; teachers rarely specify their goals in terms of measurable learner behaviors; so let's set realistic expectations of teachers.
7. In certain subject areas, e.g., fine arts and the humanities, it is more difficult to identify measurable pupil behaviors.
8. While loose general statements of objectives may appear worthwhile to an outsider, if most educational goals were stated precisely, they would be revealed as generally innocuous.
9. Measurability implies accountability; teachers might be judged on their ability to produce results in learners rather than on the many bases now used as indices of competence.
10. It is far more difficult to generate such precise objectives than to talk about objectives in our customarily vague terms.

Popham has already eloquently addressed himself to each one of the above threat-potentials. There is no need to rehash the same segments here. I do want to attend to some of the issues with which he did not deal and also describe some of the ways that behavioral objectives can be treated at the preservice and inservice stages of teacher education.

Unfortunately some teachers have developed intensely negative attitudes toward behavioral objectives. Many of the negative associations arise from the pressure on teachers from agencies such as state departments of education and school administrations which forced teachers to produce gargantuan lists of behavioral objectives for their specific courses. In most cases, they were given little guidance or direction and certainly no time. The great lists were dutifully produced and subsequently filed in the vast paper polluted offices of these agencies to be ignored more often than not. Since the easiest student behaviors to translate into behavioral terms are at first glance the most trivial, it is not surprising to find that most of the behavioral objectives produced under the above stress conditions tend apparently to deal with minutia. One point to keep in mind when reviewing such lists is that specificity and triviality in stating behavioral objectives are not necessarily the same thing. It is quite possible that, looked at individually, a behavioral objective may appear to be trivial, but the total collection of behaviors may not be trivial.

Ralph Tyler recently stated that the behavioral objectives movement has bogged down [3]. According to Tyler, there are two possible causes for this bog-down. In the earlier part of the century, learning was viewed as the building of connections between specific stimuli and specific responses. This view led to the listing of literally thousands of objectives for a school subject. These lists were short-lived for two reasons: teachers had difficulty keeping so many objectives in mind and studies of human learning indicated that students could generalize learning from concrete experiences[3]. A second possible cause is the confusion between "clarity of definition" and "specificity." Tyler maintains that "an educational objective does not need to be specific in order to be clear, attainable, and capable of assessment."[3]

The notion of clarity and specificity in statements of objectives is an interesting one. Let us assume that the critical triumvirate in the instructional process is composed of behavioral objectives, learning experiences, and measurement/evaluation activities and that behavioral objectives are the main determinant in planning the learning experiences and evaluating them both in terms of instructional success and pupil evaluation. How specific the behavioral objective needs to be is really dependent upon its purpose. For example, if the intent of the teacher is that students recall, identify, or define specifics, then the behavioral objectives of the instruction should reflect this intent. However, if the intent of instruction is that students should apply principles, formulate hypotheses, or analyze problems, the behavioral objectives will be more than a list of specifics.

Whether or not an objective can be stated in the full-blown form á la Mager is probably a matter of the nature of the objective itself. Sometimes it is difficult to state precisely the conditions and the desired or acceptable level of performance for an objective. However, it is essential for the teacher planning instruction to consider the kinds of behaviors he/she expects the learner to exhibit at the conclusion of the instruction. Stating objectives in terms of behaviors helps the teacher to design the appropriate kinds of instructional experiences. It also has the advantage of constantly reminding the teacher to be critical of himself/herself by posing such questions as "where am I going?", "what do I really want my students to be able to do?", and "how do I know if I have succeeded?"

One of the complex tasks both the inservice and the preservice teacher are presented with is pre-stating the objectives for an instructional sequence with which the teacher has not had teaching experience. Assuming such a task is overwhelming, considering all of the commitments on time that the teacher already has. Attacking the task in small steps, however, not only allows the job to get done, it also reduces much of the complexity and anxiety. Instead of demanding that a complete set of behavioral objectives be produced at the outset, it is more reasonable to first have the objectives stated in general terms of the kinds of behaviors desired after instruction and the expected behaviors necessary prior to instruction. More specific objectives can be stated as each segment of instruction occurs. As instruction proceeds the additional objectives that are achieved but were not pre-stated should be identified and added to the set. As the evaluation of learners takes place, criteria for appropriate levels of performance can be determined. By modifying and refining objectives over subsequent presentations of the instructional sequence precise objectives can be produced. Doing a small part of the task of developing behavioral objectives well is far superior to doing 100 percent of the task and producing useless material.

One of the problems I have had to deal with at both the preservice and inservice stage of teacher education is the published lists of behavioral objectives that have been produced. Although many of the objectives may be useful in examining objectives and selecting intents, they generally fail to be useful for the following reasons. In many cases, the objectives have not been written with specific pupils in mind. They divide the behaviors into such minute specific tasks that the relationship between specific learning tasks and the total learning experience is lost. Objectives can be formulated in terms of a specific subject, general student population, and community, but specific course objectives can be written only by the individual who has had experience with the overall goals, individual needs, and abilities of particular students. The teacher should not be required to utilize objectives developed by other people. The objectives he/she uses should be those established by the interactions of the teacher, the pupils, the subject, and the school-community environment.

One method of dealing with behavioral objectives that both inservice and preservice teachers have found useful is to analyze existing instructional materials and evaluation instruments for the objectives or the apparent intent of the materials. If there are statements of objectives that accompany the materials, then these can be compared with the objectives that the individual analyzing the materials has listed. This activity often helps to clarify intents of instruction and also to give direction to the kinds of activities that need to be part of the instruction if the intents are to be realized. The teacher also has the opportunity to question the objectives of the materials to decide whether they are appropriate for the students involved and whether they are important.

With practice most of the inservice and preservice teachers with whom I have dealt become quite adept at stating objectives in terms of behaviors. Deciding whether or not all students should be required to attain the same objectives is another facet of the issue. With the current emphasis on individualized instruction, this is an important question. There are common sets of objectives that all students should achieve. But this does not necessitate that all objectives be achieved by all students or that certain behavioral objectives cannot be designed for individual students. Requiring common sets of behavioral objectives also does not mean that all students must follow the same sequence of instruction. Alternate learning experiences can be provided to achieve the same learning outcomes.

Closely related to the question of whether or not all students should achieve the same objectives is at what level should the achievement be established. If mastery of an objective is a prerequisite to the achievement of subsequent objectives which are deemed essential, then all students should be required to achieve mastery. But if subsequent achievement is not so clear cut, then varying levels of mastery are more appropriate.

If an objective is considered to be important for all students to attain, then the task of the teacher educator dealing with the preservice and inservice teacher is to provide as much opportunity as possible for using and designing alternate methods of instruction. Most texts dealing with behavioral objectives are quite useful in instructing people how to write objectives and as guides of sources of objectives, but few, if any, deal with the alternate pathways of instruction which could be used to achieve the same objective.

Given the variations in the learning styles of individuals, if only one method of instruction is used to achieve an objective, no matter how excellent the instructional method and how well stated the objective may be, it is doubtful that all students will achieve an acceptable level of performance. It behooves the teacher educator to seriously deal with different modes of instruction for the same objectives so that the objectives can really provide more meaningful instruction for the students.

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SESSION Q

LEARNING THEORY AND RESEARCH: ESSENTIAL INGREDIENTS IN TEACHER EDUCATION PROGRAMS

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There are many ingredients which are either advisable in or essential to a teacher education program in science. A knowledge of learning theory and the research which forms the basis for practice are two, among many others, which are a response to a number of realities. First, newly trained graduates of our major institutions for teacher education are, for the most part, no more competent to manage modern science courses than those of fifteen years ago[20]. At the same time, we are entering a new generation of curriculum development and implementation which places greater demands on the beginning teacher. Thus, teacher education programs of the 70's and 80's designed to teach the science of the 60's are largely obsolete. In response to these rapidly changing cultural and educational realities Hurd [20] suggests the following major goals of a science teacher training program:

> 1) developing an understanding of the changing character of the scientific enterprise; 2) developing an understanding of the place of science in society; 3) developing an understanding of the nature of knowledge in the sciences; 4) developing an understanding of the learning of science-based knowledge; 5) developing an understanding of the philosophical basis of science education and the rationale for curriculum choices; and 6) developing and understanding of the valuation of goals and similar topics.

Although these broad goals are interrelated and difficult to consider as separate entities this paper attempts to concentrate on the nature of knowledge in science, the learning of science-based knowledge, and the kinds of science teacher candiates and curricula needed to achieve these goals.

The composition of teacher education programs is a complex and controversial mixture of ingredients as illustrated by the practices of 1,200 institutions in the United States and 100 in Canada.[9] Theoretically, these programs are based on educational needs which in turn dictate the nature of their ingredients. In science education, the aforementioned needs would be paramount. One commonly held objective is that teachers should arrange the conditions for, and produce, student learning. Student learning as Turner[42] describes it is what good teaching is all about: "Teaching may occur without learning and learning may occur without teaching. They are not, however, valuationally independent. Teaching is valued when it eventuates in learning and not otherwise. That is why we spend so much time worrying about teacher effectiveness." (p. 111)

McDonald[29] conceptualizes good teaching in terms of a decision-making teacher behavior model based on Coladarci's[10] concept of the teacher as an effective, instructional hypothesis-maker who facilitates student learning by choosing appropriate curricular objectives and designing instruction accordingly. The resulting plan for learning represents a flexible set of principles that determine the teacher's behavior toward predetermined goals rather than a set of mechancial rules which can only lead to ineffectiveness in the classroom [6], [39]. The success of alternative teaching strategies can only be evaluated in terms of learning situations and the effects they produce.

Since the goal of McDonald's teacher behavior model is to facilitate learning, the model suggests an awareness of the conditions most likely to be successful. By employing relatively reliable and valid information, the teacher increases his probability of success in the classroom. Decisions based on sound theoretical and empirical knowledge are likely to be both rational and responsible.

In a later conceptualization McDonald[30] portrays teacher behavior as a complex interaction of teaching operations, organization of content, and type of content. In short, the successful science teacher must understand, and appreciate, the conditions under which learning takes place with reference to specific goals.

Teachers should be familiar with and able to interpret the results of educational studies and their relevancy to particular learning situations. The need to tie educational theory and research together has been argued in detail as it relates to science education.[19] Koran, [23] 25, Gallagher [15], Welch [43], and Shulman and Tamir,[38] have reviewed selected research and development efforts in science education and generally agree that the present mass of work in the field suggests an absence of theory directed research, or efforts to put the results to practical use. At the same time, Gagné [13], Baldwin [2], Berliner and Cahen [5], and Merrill and Boutwell [32] discuss learning theory and research relevant to classroom practices and conclude that a competent teacher must be familiar with empirically derived relationships between various instructional strategies and learning.

Learning research and theory in science education programs are neglected because: 1. science curriculum and instruction materials from kindergarden to college are written to best display the "structure of science" without regard to whether this is the way science is best learned. 2.

understanding learning as it relates to the science classroom is not an easy task. As Turner [42] points out, it takes a "very intelligent teacher" to make the decisions necessary in an interactive instructional situation. Yet this is the major function of a teacher at any level of instruction. It should also be a major topic in the science methods course. As Clark [8] opines:

> Daily, teachers at every age level present a variety of concepts to from 20 to 35 children. The materials and procedures used by several teachers, each presenting the same concept to his own class, represent startling variation, as does the same teacher presenting two different concepts to one class. Additionally, teachers appear to have considerable difficulty mustering rationale for the materials they select and procedures they follow in any given concept-presenting experience. With this amount of variation and dearth of rationale, some if not many of the procedures followed in classroom concept formation must be less than effective. (p. 253)

Science teachers should understand the theoretical rationales that interpret research findings in the same way that scientists must understand a theory prior to interpreting empirical findings. There is little choice of reactions except in the theories that lead to rational decision making.

Teacher Education Programs in Science

Any program of teacher education in science must take into account the dynamic nature of society, educational goals, the character of learning, the curriculum and the pupils. College professors of science education as well as the teachers they work with require skills that permit them to change with society.

The Teacher

1. Only the brightest, the most highly motivated and committed science students should be recruited as science teacher trainees. Considerable evidence suggests that highly verbal teachers are most effective with all students including disadvantaged and low verbal students. As Jensen [21] and others have found, a highly reliable predictor of a wide range of performance is verbal fluency. Efficient teacher training methods frequently emphasize acquisition of verbal and other skills through verbal communication, again placing confidence in learner verbal fluency and a demand on it. It is not unlikely that if one starts with a highly verbal person, one is likely to optimize the probability of producing an outstanding teacher. Motivation and commitment are important associated factors to consider in a time of an overabundance of teachers.
2. Science teachers should be trained as a decision-maker, a hypothesis tester, and a risk taker to conduct, or participate in quality research relevant to classroom needs. College researchers cannot be expected, nor are they always qualified to ask the most productive research questions and to perform all of the dimensions of necessary investigations. They need the help of in-school personnel. Cronbach and Suppes [12] describe two kinds of research appropriate for classroom teacher investigation: "conclusion-oriented" and "decision-oriented" inquiry. Conclusion-oriented research examines basic and applied empirical questions designed to explore freely a variety of parameters and to contribute, in a general fashion, to understanding of educational practice. Decision-oriented inquiry examines relevant questions related to educational products and is more likely to have an immediate effect on a teacher's decision.
3. The science teacher must not only be capable of mastering data gathering activities, and reporting in professional journals of the practical findings in areas of student learning, instructional design and evaluation, but must also be provided with the skills to permit a critical approach to teaching and learning within and beyond these areas. Each prospective science teacher whose skills and interests permit hypothesis testing in each of the areas represented should be thought of as an extension of the research activities of the teacher training institution.

Concept formation Pella [35], Koran [27] is critical to learning in every discipline. Concept learning requires that the learner associate words or events with objects or characteristics and make decisions regarding which objects or events, because of congruent characteristics, either belong or don't belong together. Low level concepts involve making a common response to a group of similar stimuli.

Concept formation requires observation of a wide range of characteristics, in order to select those which appear similar or different and to attach a name to the resulting "concept" Koran [27]. The processes involved are observing, classifying, inferring, hypothesizing, generalizing within groups of similar objects or events, and discriminating between dissimilar objects or events that characterize the concept or its negative examples. A concept such as system or subsystem would be developed in the curriculum by providing many verbal association and discrimination tasks which the concept would depend on. An ecosystem then, would require acquisition of lower levels of knowledge such as identification of the organisms in it, and biological relationships such as parasitism, or predation, and finally the formation of the concept "ecosystem." This concept is further refined through the use of appropriate non-ecosystem discrimination examples.

Science education should help the teacher trainee to recognize the myriad of concepts in science—their relationships with other disciplines, with the individual and society—and their application in teaching and decision-making. The decisions required demand information from a multidimensional learning and teaching environment which the teacher must be trained to stimulate and derive feedback from. Performing as a filter, information processor, decision maker, hypothesis maker, data collector, and systems designer and redesigner are skills which can be operationalized, taught to teachers, and be identified when learned.

4. The aforementioned discussion suggests that clinical diagnosis is an essential feature of science teacher training. Small group instruction and individual tutorial situations are analogs of microteaching Koran [24] [26]. If the teacher has experienced this approach in his own teacher training program the technical knowledge of microanalysis and instruction can be transferred to use with school pupils. Isolating a small number of pupils with a given set of well-defined instructional materials and

anticipated outcomes permits the teacher to gather data and make subsequent decisions based on the interface between teacher → pupil, pupil → pupil, and pupil → material as observed under controlled conditions.

The Curriculum

Earlier it was suggested that two types of curricula must be considered: the curriculum for the teacher trainee and the curriculum for the teacher's students.

1. Science teachers should gain a technical knowledge of learning theory, the conditions for learning, developmental psychology and knowledge of relevant research findings in these areas from science methods courses.
2. Science teachers should be able to identify and demonstrate their skill in information search, selection, and processing and have practice in decision-making relative to both instruction and curriculum development. Science methods courses should provide the topics, setting, and student challenges for the acquisition and performance of these skills.
3. Science teachers should be able to demonstrate a wide range of verbal and nonverbal behaviors (skills) relative to teaching science, and using the tools of science within science methods courses. Continual feedback from trained supervisors should maintain the levels of behaviors that are acquired for years after training.
4. Science teachers should be able to generate and test hypotheses about the effects of teacher behavior, curriculum materials, and student learning through science methods courses which encompass experiences in instruction and guidance as conditions for learning with schools and children.

The curriculum for the education of science teachers should take place in a context where students are an integral part of the training procedure. Microteaching (Koran[24], [26]) provides one context for achieving many of the above objectives. Multimedia or audio-tutorial approaches, if carefully designed, appear to have both theoretical and empirical support.

The instruction of teachers of science should emphasize those kinds of knowledge that have maximum generalizability. For example, teachers should be familiar with teacher behavior research related to student achievement (Rosenshine [36]). They should be able to identify teacher behaviors that correlate highly with student success and to relate those variables to appropriate goals (Koran [25]). Just as the early curricula in science for students emphasized conceptual and process knowledge to the exclusion of extensive memorization of facts, so must the curriculum for the teacher be developed. It is theoretically and empirically folly to teach teachers how to teach by teaching them the curricula their elementary students or their secondary students will be learning. In the former case the teachers are adults and, if carefully selected, should be in the hypothetical stage of development. Consequently, many of the process responses of a curriculum such as *Science - A Process Approach* are in their repertoire of responses and need only to be identified, defined, and reinforced.

Modular instruction, while it does permit preservice teachers to progress at their own rate, still exposes candidates with a variety of backgrounds to the same materials in the same ways. As Bruce Joyce points our "module nonsense is still module nonsense".[22] This rather cynical evaluation is prompted by the reality that a student learns about one set of materials, in a contextually confined situation without any of the intellectual substructure or theory and research to make the module meaningful. Modular development is costly in time and money, lacks interest for both the developer and the students exposed to the module, and, most damaging, does not present material that has the greatest utility for a student in a usable form.

Similar criticisms could be made for secondary teachers using secondary science curricula. For one thing, most secondary science teachers have a comprehensive background in the content of science and it is insulting to ask them to learn what is in a high school text. For these people, learning theory and the results of studies using science content and learners are critical curriculum components.

In addition, they should learn the verbal and nonverbal skills necessary to use a single concept file, the probing, prompting, and cuing skills essential for managing a laboratory and doing research with a laboratory block topic. For both of these types of teachers-in-training the learning laboratory is their major referent, not the science laboratory. In the learning laboratory, under controlled conditions and with school age students they learn how to use the equipment and content of the science laboratory to promote student learning of the conceptual and process components of science.

Finally, the curriculum for science teachers should emphasize the rapidly changing world and the role science plays here. This prescribes certain types of learning that will facilitate the teacher, as learner, in a changing world and permit incorporation and illumination of continually changing knowledge, values, and conditions in an individual and socal context.

School Students

Our efforts of the late 50's and 60's in curriculum development accomplished their apparent goal of updating the content of school science materials and making it representative of science as the scientist sees it. However most of the materials that have been developed, with the exception of *Project Physics, Science - A Process Approach, School Curriculum Improvement Study* and *Conceptually Oriented Program in Elementary Science*, amply demonstrate the lack of attention to how pupils learn and how materials can be devised to optimize learning. It was fashionable in the "old days" for professors of science whose productivity in their own field had reached a plateau to turn to science education. These people became the leaders of the curriculum revolution and teacher training programs of the 50's and 60's and in our judgment have caused serious damage to instruction in science. While serious learning research was taking place around the country on concept formation (Palla [35]), advance organizers (Ausubel[1]), and observational learning (Bandura[3], [4]); those developers generally acted in a quite unscientific way and utilized intuition (an old educational trick) rather than data to guide their efforts. Where in the textbooks for students do we see the use of advance organizers? Where can mathemagenic behaviors (Rothkopf[37]) be observed? How many curricula took advantage of the elements of observational learning (Bandura, [3] [4]) or the knowledge we have about concept formation (Gagné, [14], Glaser, [16]; Mechner [31]). Precious few. It is no surprise that today, what used to be the most exciting course in the schools, science, has become dull, routine, and cookbook in nature. Textbooks and laboratory manuals are not designed with learning research outcomes in mind, and self-paced programs become a race to see who can fill up the pages in the ISCS workbook fastest. And sadly, teachers have few if any of the skills necessary to design or manage instruction.

The world is rapidly changing (Odum, [34]). Science education is also in need of a revolution. The training of its teachers must become empirically based rather than intuitive and incorporate characteristics which facilitate the teachers' attempts to stay current. Curriculum materials for both teachers and their students should reflect the research taking place around the country (Novak [33], Holliday [18]) and the changes in the world which have science and/or technological underpinnings. And, greater attention must be focused on the school student – the ultimate consumer. It is unreasonable, unethical, and deceptive to continue many of the practices of the 50's and 60's in the 70's and 80's and beyond.

Cronbach's [12] discussion on the importance and urgency of doing educational research reminds us that:

> The improvement of education rests first of all on commitment to the belief that the life of every individual and every nation, and society as a whole, can be lifted to a higher plane of significance through cultivation of the intellect. But improvement will be slight if educational efforts are illuminated by goodheartedness alone. It is a cruel hoax to hail unsubstantiated method as a cure for an educational deficiency; to adopt it is only to delay the search for underlying causes and for treatments matched to these causes ... But the intellect takes up its proper duty when it tells us how education and learning proceed, when it tells us *why* one approach works and another does not, when it identifies the variables that we must adjust to achieve a prescribed effect.

Learning theory and research must be considered essential ingredients in teacher education programs if knowledge about how children learn is to be effectively accumulated, disseminated, and appropriately utilized in the science classroom. Once this small step is taken, both teachers and pupils can walk into the future with the confidence that they can cope.

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SESSION S

A PHILOSOPHICAL-PSYCHOLOGICAL MODEL FOR TEACHING SCIENCE AND ITS ARTICULATION WITH CONCRETE CLASSROOM ACTIVITIES

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"What happens in school is that children take in these word strings and store them, undigested, in their minds, so that they can spit them back out on demand. But these words do not change anything, fit with anything, relate to anything. They are as empty of meaning as parrot-speech is to a parrot." (Holt, 1964, [4])

The ring of truth in Holt's words cannot be denied by anyone who has been deeply involved with schools at any and all levels. It is obvious that students do learn abstract models and they do learn to operate logically with abstract symbols. It is also obvious that students perceive and learn to deal with concrete phenomena, simply out of the necessity to function in a real world. They develop their own personal frames of reference by interweaving experiences unique to them with ideas acquired from others.

Too often, however, abstract models that students learn in school are not working models – working models usually evolve from some other set of experiences. In science it is not unusual for students to defer articulating abstract models with concrete phenomena until they have begun their doctoral research. In education, articulation may not occur even at the graduate level.

Revision of the programs and conditions which have led to this apparent schism between the abstract knowledge and actual performance seems to be the only viable solution. We can improve the parts of the educational system which fall within our realm of influence and which can potentially lead to improvement in other parts of the system. Teacher education programs fall into this category.

Teachers themselves must have a pervasive understanding of science in addition to a facility for designing and employing teacher strategies and techniques that are conducive to teaching specific types of knowledge. They must develop a comprehensive understanding about how people acquire certain types of knowledge.

What is needed is a well-articulated theory of science education that would provide science teachers with a comprehensive and coherent framework for interpreting what is happening in the classroom and for making prudent decisions about what should be done next. Such a theory is essential for the development of coherent personal frames of reference and as a basis for meaningful communication within the teaching community.

The psycho-epistemological model described in this paper is an attempt to bridge the gap between abstract knowledge and concrete experience by integrating some of the ideas presented by psychologists, scientists, and philosophers of science into a conceptual model for teacher use. The model is a genetic psycho-epistemological model of knowledge that integrates the development of a personal knowledge with the development of cultural scientific knowledge.

The ultimate source of all scientific activity is natural phenomena; that is, objects and events (interactions among objects). People with little scientific background have internalized assumptions that are often: (a) independent from one another and applicable only to specific situations, or (b) unduly based upon or influenced by social, religious, or cultural experience acquired through communication with others rather than through direct experience. This lack of direct encounters with natural phenomena often results in inconsistent behavior which tends to be ineffective, inefficient, and somewhat less than satisfying.

Scientists, on the other hand, assume that a systematic organization for perceiving, organizing, and dealing with the structure of objects and occurrence of events directly is both feasible and desirable. Scientific knowledge is the fruit of this effort.

Because science is a human activity, scientific knowledge is a human creation communicated to other persons or stored for future reference through symbols. As a language of symbols scientific knowledge becomes a part of our cultural heritage- to be used, abused, or ignored. Studying this evolution is a genetic, developmental, or historical approach to the epistemology of science. In contrast, logical empiricism, might be likened to taking a "snapshot" of the scientific enterprise at some moment in time and analyzing the logical interrelation of various elements. The genetic approach, best exemplified by Kuhn (1962) [5], and Bohm (1965) [2], is a dynamic analysis of the activities of scientists and scientific knowledge particularly well suited to teaching science to children.

During early stages of development in any field of science, categories of objects and events and classification systems are formulated to facilitate the search for consistency in the types of interactions that occur among a selected set of objects under a given set of conditions. Such a consistent relationship is designated an empirical law.

Though everyone engages in abstracting and generalizing, it only becomes a scientific activity when a decided effort is made to:

1. explicitly state the characteristics that are abstracted;
2. designate the conditions under which they apply; and
3. continually check the resulting generalizations against new observations.

A set of generalizations formed in such a manner provides us with a basis for effectively predicting events under specified conditions.

To avoid extensive memorization, a major quest of scientists is an abstract set of relationships (a theory) which will provide some pattern or order for empirical generalizations. These logically consistent abstract patterns of relations make it possible for scientists to deal effectively with problems that arise in the natural world, provide science with its aesthetic value, and point toward potentially fruitful avenues of scientific investigation.

Usually a mathematical model, such as calculus, provides a logical framework for the assumptions and postulates upon which the theory is based. Meaning *within* the model is syntactic, that is, it is determined by interrelationships among its elements. The model, which need not be linked with real objects or events, consists of rules governing the operations performed to establish or change interrelationships among the various elements of the model.

Theories, on the other hand, are logical symbolic *explanative* systems. Even though logical models are used to provide a logical framework for theories, and though theories do contain abstract elements, a theory *must* contain articulating links which provide contacts between various elements of the theory and experimental evidence, empirical laws, etc. What is important is that one recognize that various elements or segments of the theory must be *psychologically* linked to natural phenomena, whereby these elements acquire semantic meaning.

The fundamental assumptions or postulates upon which a scientific theory is built are not simply abstracted from data acquired through previous experience, as are empirical laws. Sometimes it is possible to explain empirical relationships or to suggest and explain relationships between otherwise seemingly unrelated phenomena by postulating theoretical constructs, i.e., entities or relationships which have not been directly observed. Also, in the process of performing operations which are allowed by the logical model, certain relationships among the various elements often occur again and again. Such theoretical concepts (MV and $\frac{1}{2} MV^2$, for example) are often identified by attaching a name to them (in these cases, momentum and kinetic energy).

There is no scientific meaning for a theoretical construct or theoretical notion apart from the theory in which it is implicitly defined. Even though some terms, like *electron*, continue to be used when the encompassing theories are revised, the meaning of the term changes from theory to theory. This is true simply because entities that are implicitly defined are changed as the assumptions and the postulates underlying the theory are changed.

As earlier stated, some elements of a theory must be articulated with empirical evidence. However, some theoretical constructs have articulated counterparts in physical models rather than in the natural world. Yet these theoretical constructs are used to perceive and interpret natural phenomena becuase they are easier to visualize than a set of symbols, thus concepts may be manipulated more easily. (Weller, 1970 [8])

As described up to this point, the scheme for conceptualizing scientific knowledge could be used with equal justification for conceptualizing almost any kind of knowledge. What distinguishes scientific knowledge from other types of knowledge is the extent to which scientists try to relate these theories to actual phenomena or to organize phenomena so that their perceptions of these phenomena support the theory in vogue. The articulation of scientific theories is accomplished by complex processes of puzzle-solving and experimentation.

Scientific puzzle-solving can be strictly theoretical; that is, concerned only with the manipulation of abstract symbols in accordance with operations allowed by the logical model associated with the theory being articulated. These logical manipulations may lead to another form of puzzle-solving the search for new articulating links. For example, relationships may be hypothesized on the basis of implications drawn from theoretical manipulations. From these hypothesized relationships, new phenomena can be predicted under specified conditions. Once phenomena have been predicted, the scientific investigator attempts to design an experiment that will demonstrate a predicted phenomenon under the prescribed conditions. If the results of the experiment are in agreement with the predictions, then the experiment serves as a confirming instance of the hypothesized relationship and lends credence to the theory from which the hypothesis originated. The argument devised by the investigator to link the original theoretical notion or relationship to the phenomenological relationship may now serve as an articulating link, provided that in this argument elements of the theory have been related to the concrete objects of observation and experiment.

Since theories in vogue at the time usually have the cumulative support of many prestigious scientists, anomalous results obtained by only one scientist are not apt to be received favorably by his peers. The tendency of the scientific community is to question the validity of the experiment—the scientist's argument linking his experiment to the theory, the design of the experimental apparatus, the construction of this apparatus, or the scientist's interpretation of the results which can be made to fit a theory by organizing the experimental data that has been collected.

If this relatively minor internal tinkering, which could lead to minor revisions of theory or experimental design, is unable to square theory with experimental results, then the results are usually set aside as irrevelant or anomalous incidents to be tackled when the theory has become more fully articulated. In this case the scientists who are aware of the anomaly would feel they had encountered something that they had failed to resolve, but the failure was not convincing enough to shake their faith in the paradigm.

It is only when a substantial number of anomalous results accrue to a theory, some of which raise fundamental questions within the theory, that a few scientists begin to lose faith in the explanatory power of that particular theory. If a scientist with a good reputation among his peers is able to formulate a new theory which accounts for most of the anomalies accruing to the old theory, explains the important generalizations that were explained by the previous theory, and discounts anomalies with the new theory on the basis that they are irrelevant, then professional support for a new theory becomes a possibility. In the event that enough professional support can be marshalled in support of one of these new ideas then the foundation has been provided for what Kuhn [5] calls a scientific revolution, whereby the science community rejects the old theory as a paradigm for research and adopts a different theory in its place. The transition is usually neither rapid nor smooth. It may take a generation before the vast majority of the science community uses the new theory as the accepted paradigm for research.

The period of transition from one paradigm to another is a time of instability and unrest for many of the scientists in that field. To keep pace in the field requires a complete mental restructuring and a substitution of new structures for old conceptual schemes to which the scientists had been deeply committed for many years. Kuhn (1962 [5]) cites the internal turmoil encountered by Wolfgang Pauli just prior to Heisenberg's paper on matrix mechanics which led to a new quantum theory. Pauli had written to a friend, "At the moment physics is terribly confused. In any case, it is too difficult for me, and I wish I had been a movie comedian or something of the sort and had never heard of physics." A few months later Pauli wrote: "Heisenberg's type of mechanics has given me hope and joy in life. To be sure it does not supply the solution to the riddle, but I believe it is possible to march foward."

This example highlights the intense involvement of individual scientists in a dynamic paradigm which provides both direction for research and meaning for the knowledge which it encompasses. Without practicing scientists, each with a unique filter system provided by a frame of reference that has evolved from a unique set of experiences, scientific knowledge could not be generated. Individual scientists are the originators of the cultural scientific knowledge that is embodied in a subcultural matrix of the personal records of scientists, the scientific literature, and the minds of practicing scientists.

On the other hand, selected segments of cultural knowledge become part of the scientist's frame of reference when he reads professional journals, books, or correspondence, and listens to professional conversations, reports, or lectures. In this way ideas are communicated by means of symbols or symbolic systems that to some extent have common meaning for members of the group using the symbols. Therefore, the frames of reference of individual scientists are structured around models, theories, or conceptual schemes that have evolved in a cultural matrix, usually over long periods of time.

A scientist may interact with other scientists, contribute to or draw upon the cultural knowledge pool, assimilate new concepts or ideas into his existing frame of reference and accommodate these ideas with natural phenomena. Each is influenced directly or indirectly by each of the others. For example, the characteristics of objects and events that occur as the result of human activity are to a large extent determined by the thought patterns or mental structures that have evolved in other segments.

To dramatize how these various elements are intimately related, suppose that a scientist has just observed the results of an experiment that he or one of his associates has recently completed. The way he perceives and structures the objects and events that comprise the results of the experiment is influenced by his frame of reference—being a scientist. Sophisticated structures for perceiving this information would reflect the theories and traditions of the scientific discipline in which he has been trained. Let us further assume that his immediate perception of these new results does not fit neatly into these structures. If the discrepancy bothers him enough he will recall and rethink this particular perception and its relationship to the overall structure. If he is unable to incorporate the particular results of that experiment into his frame of reference, then he may have to modify his concepts and structures that he has used to organize and interpret phenomena in this particular area. Since his concepts and structures are deeply rooted in theory, these conceptual or structural changes may mean that he has to interpret the theory differently or even revise the theory to bring his perception of his most recent experimental results into concordance with theoretical considerations.

During this revisionary stage he might talk with associates who are also familiar with the theory within which he has been working. After hearing their opinions he might slightly modify his argument and refine it until he develops it to the point where he feels it deserves wider dissemination through an article in a journal, a paper at a convention, or a local seminar presentation to graduate students and/or faculty. These papers are read by his peers, pondered over, and usually commented upon by one or more members of the reading audience. As a result of this dialogue, the originator of the modification may again change his ideas slightly. Members of the reading audience might be convinced by the argument and slightly modify their own conceptualizations or interpretations of the theory. But perhaps of greatest importance, there has been a substantial increase in the information and ideas related to this particular theory which have now become part of public knowledge in the form of correspondence, articles, reports, discussions, lectures, etc.

During this dialogue, an experimental scientist who has been reading these various comments may have some idea about how this slightly modified version of the theory can be tested or articulated. The experimentalist undoubtedly perceives what has been written with a frame of reference that is in fairly close agreement with the frames of reference of other scientists within that particular field, but he would be expected to have some unique interpretations. To test or articulate the theory he must develop an argument that ties some aspect of the theory to a specific phenomenon in the external or natural world - to demonstrate the phenomenon which he has predicted. The argument that he develops must employ a language and follow a logical structure that his peers will understand and consider valid and legitimate. Also, his experimental devices and instruments must be of such a nature that his peers consider them valid instruments for this particular demonstration. Both the argument and the devices that are constructed, however, will reflect this particular scientist's individual prejudices or preferences, which in subtle ways influence the way that the results are organized and accumulated. His argument underlying this experiment, a detailed description of the instruments used in the experiment, and a report of the results obtained in the experiment all may be organized and published. The publication will be read by his peers and hence the cycle continues. The overall effect of this type of interaction is the generation and evolution of a body of cultural scientific knowledge.

The individual bits of information, in the form of symbolic statements, are fed into public knowledge through the frames of reference of practicing scientists - in effect, a filter system. Therefore, an individual scientist can influence the development of a theory and many theories carry such marks of scientists' idiosyncracies. The extent to which individuality is permitted in articulating any given theory is controlled in subtle ways by consensus among one's peers through select publication of articles and speakers at various conventions. This control makes it a stable conceptual system where practicing scientists within a relatively narrow field are usually able to communicate quite freely with one another.

It should also be obvious that cultural scientific knowledge affects the growth of individual frames of reference or individual knowledge. Scientists receive their professional training within a science paradigm so they organize the world they deal with in terms of this paradigm. Continual interaction with the world, both natural phenomena and people form the basis for a person to formulate an outlook or to organize a frame of reference through which he views the world. It is through communication that he learns the cultural conceptual schemes which serve as a basis for perceiving natural phenomena and through direct experience that he learns to tie or link the scheme to relevant phenomena.

Continued communication and common experience among communities of scientists is necessary not only for the training of new scientists but for the very survival of cultural knowledge; otherwise there is no way of attaching common meaning to symbols. People who have acquired the interpretations common to the community of scientists (or scholars) who generated this knowledge or are keeping it alive will understand it and will be able to communicate with each other - those who have not, will not.

If we expect students to be able to communicate meaningfully in terms of scientific models, then they must acquire the concepts and understand the models used by the scientific community. The level of sophistication at which they learn concepts and models, however, will vary with the student population. For generations they have been among the premises upon which the teaching of science has been based. It might help to clarify matters if we briefly explore some of the ways that people learn concepts and models and then consider some of the ways concepts and models have been commonly presented to students in school.

The most critical concepts in anyone's frame of reference are those abstracted from direct encounters with objects and events. For example, suppose that each child in a classroom is given a dry cell, a wire, and a bulb and is instructed to see how many ways he can arrange the three items so that the bulb will light. Experience indicates that after a short initial period of exploration and frustration the children do discover and identify different arrangements in which the bulb will light. From these arrangements they are able to abstract only what is common to each case where the bulb lights. This closed loop, commonly called a closed or completed circuit, is a concept that they have abstracted from a set of experiences with concrete physical phenomena. A concept that has been abstracted from experience with objects and events will be called an *intuitive* concept.

Either before or while the children are trying to see how many different ways they can arrange the items so that the bulb will light, symbols such as *dry cell, battery, wire, bulb*, are often introduced by the teacher or students and associated with the objects they are using. When they abstract the concept of complete circuit, either they invent a symbol to represent this concept or the teacher supplies them with a symbol or set of symbols. Even though it is not uncommon for children to invent descriptive names for classes of objects that they observe, the probability is very small that someone will invent his own symbols for concepts that he has abstracted and generalized. More often he associates a previously invented symbol communicated to him by other people at the time he makes his observations and abstracts his concepts. The symbols associated with classes of objects or the concepts that have been abstracted by the group of interacting students provide a means by which the students and the teacher are able to communicate with each other about various phenomena that they encounter.

Regardless of the kind or level of abstraction, of which there are many, a concept can be semantically understood only by someone who has had some experience with the referents from which the concept was abstracted. Concepts such as color, temperature, shape, form, smell, taste, odor, texture, weight, etc., can be understood only when they have been abstracted from sets of concepts of a more primitive order. Color, for example, is a generic term for what is abstracted from redness, blueness, greeness, orangeness, yellowness, etc. But these latter are concepts that are abstracted from instances where objects provided a source of stimuli giving rise to identifiable and persistent visual sensation on the part of an observer. The essence of that particular and recurring sensation abstracted from several encounters with objects which served as the source for that particular stimulus is the concept symbolized by the term red or blue or yellow. When someone has a set of these concepts (though perhaps not the symbols) in his repertoire he is then in a position to abstract out the notion of color. It is meaningless to try to describe the notion of color until one has experienced a set of the more primitive notions that are examples of colors.

If a person has never been able to see, what is the meaning of color to that person? Certainly he could not have the same visual interpretation as does someone who can see, even though we are able to teach him that the symbols red, orange, etc., refer to a property we call color and that all objects that we can see exhibit this property. Similarly, if someone were insensitive to hot and cold, could he perceive the meaning of temperature in the same way as can a person who can actually *feel* temperature changes from moment to moment or can feel the temperature of objects that are of different degrees of hotness or coldness? He could observe a thermometer rising and falling and associate that rise and fall with temperature or he could watch ice freeze and melt and associate the freezing and melting with temperature change, but we would have to agree that these visual perceptions are quite different from the sensations of hotness or coldness that one is able to feel.

There are myriad concepts, especially in science, which can be described in terms of specific relationships among other concepts. For example: *displacement* may be described as a change in *distance* in a given *direction; velocity* may be defined as the rate of change of *displacement* with respect to *time;* and *acceleration* may be defined as a rate of change of *velocity* with respect to *time.* A concept that is described or defined in terms of other concepts will be referred to as a *formal* concept. When trying to teach the above concepts to students, it has been common practice to assume that distance, direction, and time are intuitive concepts in the students' frames of reference and displacement, velocity and acceleration are acquired as formal concepts by learning definitions similar to those above. When a student has learned these definitions, it is *assumed* that he understands them.

The assumption that distance, direction, and time are acquired by students as intuitive concepts before they acquire concepts of displacement, velocity, or acceleration is open to serious doubt. Piaget (1969) [6] has shown that children have intuitive notions of velocity before they have a concept of time. In fact, he argues that the child's construction of time begins with a correlation of velocities.

A second assumption is that a child's intuitive notions are identical with those held by the instructor. Such commonality is rarely the case. Referring to the previous example, a child's early notion of velocity is not a distance/time relationship but "is bound up with that of overtaking, i.e., with a purely spatial intuition involving a change in the respective positions of two moving bodies." (Piaget, 1969 [6]) In a similar vein, children can have an intuitive notion of acceleration before they have a formal understanding of velocity. They can associate it with forces exerted on their bodies and changes in speedometer readings when a car they are riding in "speeds up" or "slows down." To suggest that their intuitive feeling for acceleration is the same as a physicist's formal concept would be delusionary. Commonality of concepts within a community cannot be assumed as a starting point but as a goal to be pursued.

A third implicit assumption is that students apply the same rules for combining the intuitive concepts to derive formal concepts as does the instructor. Rules themselves, or the way words are put together to form rules, are learned implicitly by their use in other circumstances where the various elements that are being related and the way they are related are well understood by the learner. We cannot expect all or even most students to have acquired a common understanding of specific rules or the way that certain words are put together to form specific rules.

It is more often the case that students apply misunderstood rules to combine vague or ambiguous intuitive notions to arrive at even more vague and ambiguous formal concepts. *We cannot understand formal concepts semantically until we have established a common base of intuitive concepts* although we may establish verbal or symbolic connections between symbols representing higher and lower level concepts

It is through the manipulation of symbols representative of perceptions, concepts, and ideas, that man has been able to deal effectively and efficiently with his problems. It allows him to think about many things from the concrete to the most abstract. Relating these things internally and attaching these internal concepts or structures to external referents that can be observed by others provides him with a means for communicating with other people so that each person may take advantage of the other person's thinking. However, having symbols in one's vocabulary and even being able to manipulate within a system of symbols does not imply that a person understands the ideas underlying the symbolic system or is able to use the system in solving the problems for which it was devised.

Symbols go through the same filter process as does other input information. But, if a person has had no concrete experience that can be associated with a substantial number of the symbols that are part of the system he is learning, then his reference frame cannot provide referents abstracted from actual events that he has observed. He will sometimes substitute or invent referents through analogies from things he has observed. This may provide him with totally erroneous ideas about what the symbols represent. As new symbols from this symbolic system are fed in, he can recall previous symbols of the system. He can interrelate the symbols in this system and eventually organize them in such a way that he gets a fairly accurate mental representation of the symbolic system. He can operate quite successfully within the system. Given a problem within the system, he knows what symbols he has to work with and what manipulations are allowed in that system.

For example, consider the nonsense system below. It would not be a difficult task for a student to study the system until it had been memorized, then to answer the questions that follow.

Urg-Jos-rap System

The elements of the system are: *urg*, *jos* and *fap*.

The relationships among the elements are: and

Rule 1: If $a \gamma b$ and b c, then $a \gamma c$; and

Rule 2: If $a \gamma b$ then b a, where a, b and c represent elements of the system.

Given Relationships:

Rel. A: *urg* γ *jos*, and
Rel. B: *Jos* γ *fap*.

Questions

1. In what ways are urg and jos related?
2. In what ways are jos and fap related?
3. In what ways are urg and fap related?

The answers to these three questions may be found below. Answers 1a and 2a require only memorization and recall of Rels. A and B given in the description of the system. More complex processes are required to obtain answers 1b and 2b. In addition to memorization and recall of Rels. A and B, they require the application of Rule 2, a logical operation. The rules prescribe the logical framework for the system and all manipulations in the system must be carried on within this framework. While no new mental processes are required to answer question 3, the logical manipulations are more complex. Answer 3a requires memorization and recall of Rels. A and B and the application of Rule 1. Answer 3b requires the application of Rule 2 to the relationship expressed in answer 3a.

Answers

1a. urg γ jos	2a. jos γ fap	3a. urg γ fap
b. jos γ urg	b. fap γ jos	b. fap γ urg

Assuming that the student has answered the three questions correctly, then he has learned and operated within a logical abstract system. But what does this system "mean" to him? Probably not much if anything at all. If it does have some meaning for the student, that is, if he has attached some significance or interpretation to the elements or relationships in terms of objects or ideas outside the system, then it is meaning that he has invented or supplied and was not suggested by the system itself. The only meaning implied is a meaning internal to the system. It is syntactic meaning that it comes from the relationships among the elements relationships left undefined outside the system, but implicitly defined by Rules 1 and 2. Mathematical systems are examples of such closed logical abstract systems.

It is one thing to learn and operate within a closed logical symbolic system and quite another to use that system to interpret or deal with some aspect of the world external to the system. Especially in science, the theories and ideas about the natural world have been developed in accordance with actual physical and biological phenomena. These theories have been developed to interpret and deal with these phenomena.

A system (model, scheme, etc.) that is learned in isolation from other systems - symbolic or natural may be thought of as an *encapsulated* system used only to make decisions when direct reference is made to some aspect or element of the system and resulting in expressions or statements in terms of symbols contained within the system. Unless some verbal or phenomenological cue from outside the system of models, schemes, theories, etc. can trigger one to think in terms of that system, then the system is encapsulated for that person.

It seems that it has been a basic assumption of educational institutions that if theories, schemes, models and so forth were taught *per se* to students that the students would be able to develop appropriate applications of these systems. The thesis here is that this is *not* the case. Yet much of a student's time in school is spent "learning" symbolic systems which for the most part remain encapsulated. The teacher talks about the model, the teacher has students read textbooks about the model in short, the entire classroom activity is carried on in an abstract manner. These symbol systems are not linked with their referents the real objects and events that are necessary precursors to a semantic understanding of the models. Consequently, students assimilate only the symbol systems and later are able to apply them only in formal instructional contexts.

Tests are designed to determine not if the student can apply the system but to determine if he has memorized the important elements and can operate according to the rules.

When a student is confronted with a real life situation in which a model that he has learned in this abstract manner is relevant, he does not perceive the situation in terms of the model. Certainly in science, where the goal is the development of models to interpret and organize natural phenomena and to explain generalizations about these phenomena, it makes little sense for the lay person to learn the models unless he is able to relate these models to actual objects and events with which he is confronted.

Certainly physics is an abstract system - the degree of abstractness determined primarily by the level of sophistication of the mathematics involved. For those few theoretical physicists whose work consists of operating entirely within a closed symbolic system there may be some justification for learning physics isolated from other aspects of the world. For someone who is not going to make theoretical physics his life work, such isolation becomes very difficult to defend.

How do we teach science to students so they do acquire working models for perceiving and dealing with natural phenomena and are able to communicate with other people in terms of these models? A brief sketch of some of the obvious points is all that can be dealt with here.

Since learning is influenced by reference frames, it is crucial that a teacher assess his students' frames of reference as quickly as possible, ideally through a student's physical interaction with some set of objects and his description of what he is doing while he is doing it. When a teacher has formed some ideas about how his students perceive and organize phenomena related to a certain field of science or even phenomena in general, then he can begin helping his students acquire working scientific models.

For a student to acquire a working knowledge of scientific models, he must be physically involved with the phenomena relevant to the models, consciously trying to perceive and organize the phenomena in terms of the models, and communicating actively with other people, at least some of whom have a good working knowledge of the models. Physical involvement with the phenomena while he is thinking in terms of the model enables a student to articulate the model with concrete referents. In the presence of someone who has a good working knowledge, the student is able to determine if he is articulating the knowledge in a manner similar to the way it has been articulated by members of the scientific community. This latter step requires a teacher skilled in communicating with students and knowledgeable in the ways scientific communities carry on their work. The classroom must have a relatively free and open climate so that they can probe, and assimilate their observations. During these exploratory stages, the students should communicate with one another and with the teacher who, ideally, is familiar with the scientific theories developed to deal with the phenomena under investigation.

When students are confronted with unfamiliar situations (assuming they do not just ignore them), their frames of reference must be accommodated so that various aspects of the situation are perceived and assimilated by reorganizing only what resides already in their own frame of reference or by communication with someone else. For the latter to occur assumes that the frames of reference of the communicants have enough elements in common so that when one describes an idea in his mind, the other is able to recreate that idea. But, in teacher-student interactions, the teacher is often trying to help the student acquire a working model where there is none to begin with. If the student does have a working model it may be so different that there is no basis for communicating about it with mutual understanding. A student often finds himself in a d··mma trying to create an unfamiliar mental model from verbal descriptions provided by a teacher or text.

Mental models are developed slowly, at least in initial stages, through a fusion of concrete example with specific aspects of the model. When students are working with materials such as the b· 'eries, bulbs and wires and creating various circuit: .hey should be encouraged to express their ideas about what they see and what they believe is happening. If one takes time to analyze these student conceptualizations, he often finds that on the basis of the limited evidence, their conceptualizations are just as legitimate and valid as are those which the teacher has in regard to the same phenomenon. In this way, the teacher gains valuable insight to a student's frame of reference and has a basis for meaningful communication with him.

A student should be encouraged to develop a model which is different from the one that is a part of the paradigm in vogue so long as his interest holds and he appears to · gaining experience and there is no illogical step in his argument. If a teacher feels that a certain line of theorizing is unproductive, then the teacher should be able to create a situation whereby the student is confronted with a· v anomalous phenomena. If he is asked to explain them in terms of his ideas, then he will have to face up to the anomaly and recognize that the direction he is taking may be unproductive.

To encourage a student to pursue his own way of conceptualizing certain phenomena does not preclude encouraging him to look at the phenomena in a different way. However, before a teacher can suggest an alternate way of perceiving and organizing something, he must have considerable insight into the student's frame of reference.

If we expect students, through honest "enquiry" to "discover" a way of looking at the world that is identical or even similar to the scientists' models at present, then we are not only deluding the students but ourselves as well. There are a number of ways that we can perceive, and organize what is in front of us. On the basis of isolated personal experience there is no more justification for organizing it in one way than there is for organizing it in other ways. However, scientists have organized certain sets of natural phenomena in particular ways and they have generated theories for perceiving and interpreting those sets of phenomena. Sooner or later we reach a point where we must tell students that if they want to communicate with scientists or with other people about particular aspects of science then they will have to know something about the models scientists use.

To help a student learn a scientific model—not at a scientist's level of sophistication but at least at a descriptive level—the teacher must be in close communication with the student. He must know what the student is thinking, what his symbols represent when he uses them, what his experiences have been so that he (the teacher) can try to determine what physical referents the student has for the symbols and ideas that he expresses verbally. He must play an active role in the student's learning process, not as a dispenser of information but as an analyzer and assesser of what the student knows. It is a role of determining what kind of action is appropriate to help the student acquire understanding requiring sensitivity and creativity on the part of the teacher. He must also be flexible and willing to consider any new evidence which may suggest a modification in approach or of immediate plans.

This individualization should not imply that nothing is ever done with the class as a whole. When a class comes together and talks about what each person is doing a common base of understanding is evolved and eventually the students and the teacher are able to communicate within a common theoretical structure with a common semantic base. On the other hand, there should be time when a student can work and investigate on his own, when he can talk or work with the teacher on a one-to-one basis, or can work with other students in small groups.

At least two projects, the Science Curriculum Improvement Study and the Elementary Science Study, were based upon psychological and epistemological frameworks not unlike the one presented here. However, the extent to which certain approaches to the teaching of science have been developed and promoted in the form of curricula is of secondary concern to the way these and other materials are used by teachers in their classrooms.

The new curriculum materials have proven to be a valuable resource for those teachers who understand and are sympathetic to the psychological-philosophical basis underlying their development. On the other hand, if a teacher does not have the proper orientation there is little hope that he will or even can use the materials in the way intended by the developers. The curriculum developers themselves were among the first to recognize this problem. Some projects provided special courses, institutes, or workshops to help the "trial teachers" develop the "necessary" outlook. In any event, the number of teachers who are able to function in an enquiry-oriented environment without some continuing inservice course or workshop is relatively small. This seems to be true for elementary as well as secondary school teachers and for recent graduates as well as experienced teachers.

Faced with an increasing demand for teachers who are prepared to teach in open and enquiry-oriented school environments, we must create programs that will help them develop the qualities required for a successful performance in that role. There are at least two sets of desirable qualities: (a) the feelings that one has for himself, for others and for his work; and (b) the special capabilities or competencies that one needs to cope with a particular school environment.

Among the first set of qualities are:

1. commitment to the open enquiry-oriented mode of teaching and confidence in its long range benefits to students;
2. a willingness to recognize and tolerate other ways of viewing the world;
3. internal security, that is, the teacher knows who he is, likes what he is, and is not trying to present some phony image of himself to the students;
4. approachable to the students in the sense that they feel at ease when they are talking with him; and
5. an abundance of patience.

Among the cognitive abilities are:

1. a working knowledge of a psychological-espistemological model for teaching science which provides meaning and organization in what otherwise might prove to be a hopelessly confusing and directionless set of activities and events. It allows him to place what he and his students are doing in some overall framework and thereby into some perspective. This perspective allows him to help students plan strategies for growth to a more comprehensive level of understanding. In addition to the natural phenomena which serve as foci for student investigations, the model must account for individual students' reference frames, the interaction and communication among a community of students engaged in scientific activity, and the cultural scientific knowledge which bears on the problem at hand. Moreover, the model must deal with the interrelationships among these various parts.
2. sensitivity to various aspects of the student's world. On the basis of what a student says and does, the teacher must be able to weave together some "picture" of the student's frame of reference with some notions about the influence of motivational and physiological changes on a student's behavior as well as the influence of the social milieu.
3. the ability to communicate with other teachers or educators concerned with similar problems by sharing experiences, insights, and whatever resources at their disposal. It is important that teachers feel they are a part of a concerted effort to solve problems with which they are confronted.
4. considerable practical experience in interpreting real situations with students in terms of the psycho-epistemological model. As students of teacher education develop a better understanding of the role for which they are preparing and as they gain confidence in their ability to perform in that role, publicizing the desired traits and providing feedback to students about the traits they seem to be projecting might help them modify their personalities to some extent. However, it would probably be overextending the role of a teacher education institution to attempt to change these personality characteristics (affective feelings) in a direct way. Therefore, our efforts should be directed toward building a program designed to help teachers develop the cognitive traits.

Teacher education programs following present practices cannot provide prospective teachers with the experience and comprehensive understanding necessary to cope with an enquiry-oriented school environment. Today, a typical prospective teacher's fragmented and compartmentalized educational experience is based on at least two assumptions which serve as obstacles to the integration of knowledge and experience.

Change in verbal behavior reflected after students have read or been orally supplied with some information does not necessarily become part of their functional frame of reference (i.e., use of this information in future decision-making and interpretative processes). Yet, nearly all of our educative efforts are directed toward changes in verbal behavior with the implicit hope that other behavior will change as well. Even though teachers, especially college teachers, have extensive interaction with students this interaction is almost exclusively verbal–often limited to a closed abstract system. Furthermore, changes in verbal behavior can be detected and quantified under classroom conditions–hence effectiveness in verbal learning can be demonstrated and measured with relative ease.

Our teacher education programs have become encapsulated. Unquestionably there is a dearth of feedback loops from teaching performance to preparatory programs. As a consequence, success within a program often proves to be a poor indicator of success later in real teaching situations. The criteria for success have been weighted too heavily on willingness and capability to manipulate symbols and not enough on the ability to use these symbols to interpret and deal with concrete aspects of the world.

The second assumption is that each course taken by a student is supposed to represent a different piece in a puzzle contributing, by the end of his college career, to a comprehensive and coherent frame of reference including social, political, philosophical, and professional elements. However, it is a rare individual who is able to modify, transform, or reject pieces until he has developed an internally consistent and functional big picture. It is the tragic individual who attempts to fit the pieces together just as he received them and thinks that he has the big picture. The usual result–a great number of students who are confused, frustrated, and even angry.

Presenting students with a unitary point of view which would preclude any contradictions would certainly be an undesirable solution to the problem. On the other hand, exposure to ideas in the seclusion of classrooms, where the range of experiences provided for the student is rigidly controlled and a student's behavior must conform to the expectations of a single instructor, has the effect of glossing over any incompatibility that these ideas may have with other ideas. Students form the habit of finding out what each teacher wants them to do and attempting to do it. If they took time to scrutinize what they were doing, and there are few rewards to do so, they would often find that their performance in one class is at odds with their performance in another. Many instructors are reluctant to praise students for pointing out ideas that are incompatible with the ones they are trying to promote. If a student recognizes contradictions but suppresses any urge to comment on them or to alter his behavior, this does little for his self-image. Diversity should be recognized and students helped to deal with it.

A teacher education program should be organized around the concept of community – continuing communication among all participants in the program – prospective teachers, master teachers, and specialists. All members of the community would not be together all of the time, nor even most of the time, but would be expected to meet on some regular basis as a group, and would be engaged in similar activities when they were not together as a group. The size of the community should be large enough to provide a critical mass but not so large as to be unwieldy.

Included in the program should be the opportunity for extensive and varied experiences with different groups of children at different age levels in a variety of learning environments.

A scholarly or reflective atmosphere should pervade the community with students and staff engaged in some ongoing research which would provide both incentive and focus for intensive involvement.

Feedback loops should be built into the program at all levels. The student-scholar should not only receive feedback that has been filtered through others in the community, but he should be learning how to improve his own techniques for direct feedback from his students. Staff and students should use feedback to assess the effectiveness of the program and to make revisions.

Finally, provision should be made for individual planning and programming within the broad guidelines established here. A prospective teacher should be allowed to choose the type or types of teaching roles he wants to be prepared to fulfill. Some speculation about how a specific teacher education program might be modified to incorporate the desired characterisitcs described above would provide at least a basis for further discussion.

At the University of Illinois, an undergraduate candidate for a certificate to teach science at the secondary school level is required to complete approximately twenty semester hours of education courses. These courses include educational psychology, history and philosphy of education, principles of secondary education, an introductory course in science education, a science teaching methods course, and student teaching. The candidate is also required to take approximately seventy hours of science or science related courses (history or philosophy of science, mathematics, etc.), none of which are specifically designed for teachers.

If we modified our program at the University of Illinois by pooling all the education courses and twelve hours of the science or science related courses, we would obtain thirty-two semester hours which would give us the time and flexibility needed to create an integrated program of scholarly activities and concrete experiences. Spread over a two-year period, a participating student could concentrate about half his total study time upon the integrated program.

All the basic ideas covered in the pooled separate courses could be covered in the new program by integrating them into a unifying framework – the psycho-epistemological model. The new program would be a dynamic activity involving professionals and scholar-apprentices working on common problems within a common theoretical framework. A continuing seminar and concrete experiences with children, schools, and materials would provide a focus and a realistic base for this activity.

Each community would be composed of approximately twenty students plus the participating faculty – master teachers as exemplars of good teaching, and specialists in psychology, sociology, history and philosophy of education, philosophy of science, science education, and the various science disciplines. The faculty, as a group, would be responsible for planning the requisite experiences, for setting the standards or criteria for success within the program, for constantly evaluating student performance and providing feedback to the students, and for assessing program effectiveness and making revisions when warranted.

The seminar would meet for two to three hours at least twice a week for the duration of the program. Each staff member would be expected to attend at least one general session each week. The seminar would provide a forum for students and staff to present and compare points of view and discuss teaching experiences within the context of the underlying model. Each specialist would interpret experiences common to the group using models characteristic of his particular discipline or specialty. The similarities and differences among the various interpretations and the compatibility of a particular interpretation with the psycho-epistemological model being developed would be pointed out and discussed. Even though the community is committed to a particular model with specialists sympathetic to that model, we would expect to find considerable disagreement among these "experts" with regard to particular interpretations or applications of the model. These differences would be discussed in the presence of the students who are encouraged to participate in the discussion. Under these conditions, a student would have the opportunity to recognize contradicting viewpoints, judge the various interpretations and assimilate those ideas consistent with other views that he holds, and perhaps, to recognize that some fundamental ideas pervade many different fields, and that other people might hold different but equally valid points of view.

Equally important are the experiences with school children and teaching environments. A student's first encounter with children should include one-to-one interviews or "tutorials" at the primary, upper-intermediate, junior high, and senior high levels. By working with children over a broad age range, a prospective teacher acquires experience with various stages of intellectual development of children and adolescents.

The primary purpose of the one-to-one encounters is to provide novices in the program an opportunity to analyze children's frames of reference in terms of the psycho-epistemological model. Therefore, the children, not the prospective teacher, should do most of the talking and acting. Preferably, the child should be engaged in some physical activity. By observing a child's verbal and physical performance at the same time, a careful observer often acquires insight into how the child's mind is organized with regard to a particular object. The student then reports his observations and his interpretation of these observations in writing or orally to one of the specialists who, in turn, expresses how he would interpret the same situation. The reports and related discussions provide feedback to specialists and students so they can judge for themselves whether or not they are operating with similar frames of reference. The specialists must observe, either directly or by video tape recordings, enough of the encounters with children to provide a common experiential base for the discussions.

When faculty and students feel that they are speaking the same language and have articulated it to common concrete referents, then the student's experience should be expanded to include groups of children and a variety of teaching environments. In addition to analyzing individual frames of reference, the student should search for patterns in the ways children respond to environmental and social influences. Following the same format of observation-analysis-report-feedback, the student gradually expands his conceptual framework so that he is able to interpret and respond in a consistent way to specific classroom situations. Because the community is developing a common framework for interpreting a similar set of experiences and acquiring a common language with a common semantic base, the students benefit from sharing verbal descriptions of different individual experiences.

During the second semester of the program, students should have organized and articulated their ideas to the point where they can anticipate what is apt to happen in a particular classroom with specific children under certain conditions. Then students should have the opportunity to experiment with their own teaching strategies and styles in their own mini-classroom environments of four or five children. By continuing to expand this teaching experience under the supervision of master teachers and other specialists students should be able to manage 25-30 children at one time.

If school administrators and teachers are directly involved in the planning of activities, their suggestions are listened to and given serious consideration and weight, then facilities and children are usually available. The master teachers are an essential part of the program for they provide the children and classroom facilities.

Another important set of experiences deals with the study of scientific knowledge—the epistemological dimension of our model. We cannot expect many students to enter our program with a background in science appropriate for the type of science teaching they are being prepared to do. The way they have learned science has left them with the impression that science is a static body of knowledge, they do not see scientific knowledge as being intimately tied to the minds of practicing scientists. Nor do they interpret objectivity in terms of common experience, modes of communication and faith in a paradigm by members of a scholarly community.

The contradictions between former ways of viewing science and viewing it in terms of the psycho-epistemological model will surface during the first seminar sessions. New insights can be developed by discussion within the seminar or in ad-hoc groups created to pursue particularly intriguing or confusing aspects of the new model. These new ideas must be linked to concrete objects and events, preferably through activities common to the group. Therefore, a science laboratory must be accessible to the students. In this laboratory, available for the whole program, materials appropriate for teaching in an enquiry-oriented science classroom may be designed, tried, and tested. The science subject specialists would have primary responsibility for this aspect of the program. Another major problem which they could work on with the students would be how to teach advanced concepts of science from an elementary viewpoint.

The laboratory and resource facilities are obviously a crucial factor in conducting the necessary activities and maintaining a sense of community. Ideally, the seminar room, the library, the laboratories, etc., would be in one central complex, accessible to staff and students during the day and until some reasonable hour at night, such as the Science Teacher Center at Austin Peay University. Extensive curriculum materials—books and other written materials, apparatus, supplies, and video and audio taping facilities would be available. The surrounding and atmosphere should be as pleasing and friendly as possible to make staff and students feel welcome and comfortable.

The desirability of establishing a scholarly or reflective atmosphere within the community was expressed earlier. A coordinated program of research designed to articulate the psycho-epistemological model which would involve both students and faculty would provide such a scholarly atmosphere. When someone becomes involved in research concerned with a particular aspect of a theory, there is strong incentive to understand how this aspect is related to the rest of the theory. The researcher must understand the whole framework in order to understand the part he is working on. Any attempt to acquire greater understanding of the psycho-epistemological model will increase the number of student discussions carried on ourside the seminar and the number of unassigned books and articles related to the model that are read by the students. The mutual searching for and sharing of insights would give students not only a better working knowledge of the model, but greater insight into the epistemological structure and evaluation of models in general. Research completed by the students might or might not contribute significantly to knowledge outside their own community. However, the experience that students would acquire by conducting the research would give them more insight into science and scientific knowledge than all the books they could possibly read.

Research conducted by students and faculty can also serve an important function in regard to the dynamic program. The faculty as well as the students would be constantly learning. On the basis of continual reappraisal and various research projects, the program could and would be revised if the evidence, as interpreted by the community, supported the need for a change. If students are aware that their ideas and research findings are important enough to lead to revisions in the program, interest and incentive increase greatly. Studies that follow up what happens to graduates of the program would provide feedback to suggest ways that the program might be improved.

Student evaluation, like program evaluation, must be a continuous and integral part of the program. Because of the types of activities provided and the involvement of the faculty in all these activities, constant evaluation of actual teaching performance is possible. This constant evaluation, which is immediately fed back to the student, provides him with a basis for improving his performance. In addition to staff evaluation video or audio taping of interviews or teaching sessions are excellent ways for a student to record what happens so he can review and evaluate himself. Reviewing the tape recordings with an experienced teacher or staff member for the first few times often helps the student focus on important aspects of the session.

Evaluation of a student's performance in teaching situations is also necessary for faculty decisions about whether or not the student has the qualities requisite for a teacher. Students that do not exhibit the necessary qualities should be informed of the opinion of the faculty as soon as they have formed an opinion. If the faculty feels there is little chance to develop those qualities, then the student should be encouraged to pursue some other career. In this program, the license to pursue a career in teaching would be controlled by a team of professionals who had worked closely with the student in a variety of teaching situations. Moreover, they would be able to recommend with considerable credibility the types of teaching environments in which a particular student could be expected to do his best work.

Students should have considerable autonomy in determining their own programs. Because this program is designed to help teachers acquire certain understandings and experiences that would prepare them for a specific teaching role, we would assume that participants in the program would be willing to follow the general format described above. Undoubtedly there are students who would like to prepare for different teaching roles and we would assume that there are other avenues open to them. For those students who have chosen the route described, there is still opportunity for the choice of the types of teaching environments within which the student wishes to acquire experience, and the choice of research topic, within certain limitations. If a student were able to present a convincing case that he could acquire, through activities different from those prescribed in the program, understandings and experiences similar to those provided by this program, then the program should be flexible enough to let him follow his own route. Whether or not he actually accomplishes his objectives would, of course, still be subject to the combined judgment of the faculty.

The hypothetical program just outlined was designed with secondary science teachers in mind, however, a similar model would be just as appropriate for elementary teachers preparing to teach in open classrooms, open schools, or in individualized programs.

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SESSION T

ELEMENTS OF SCIENCE TEACHER EDUCATION (abstract)

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This paper attempts to systematically abstract information from the fifty contributions comprising the ERIC-AETS publication *In Search of Promising Practices in Science Teacher Education.* It also includes expressions of general impressions of the contributions to the report and takes a position on its merits as a source for developing a futuristic science teacher education program. A fourteen-item check sheet was utilized by the author as a principal mechanism for abstracting information. Based on the results of utilizing the check sheet plus general impressions of the document, it was concluded that *In Search of Promising Practices in Science Teacher Education* is not in itself an adequate basis for synthesizing a science teacher education program model for the future. However the document would be highly useful in planning a good elementary or secondary science methods course. It also reveals a great deal about the state of the art in science teacher education which could be useful in establishing priorities for action by individuals, faculty teams, institutions, and professional organizations.

SESSION U

TEACHING FOR MEASURABLE OUTCOMES

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Before a case can be made for the desirability of teaching for measurable outcomes in students, there must be agreement upon the purpose of formal education in our society. There are numerous approaches to the analysis of the purpose of the American educational enterprise. Many dedicated and thoughtful persons have tried to formulate statements of the goals of formal education. Individuals, some from within and some from without, the ranks of professional education have proposed many diverse and varied statements of the purposes of education. These statements range from developing moral character, attitudes, adjustments to life and self-confidence, to developing a happy individual.

To support this case, the educational enterprise as it is today must be examined. What is going on in the schools? What are the schools doing best? What are the personnel in the schools trained to do? By focusing attention on the activities and students in the schools it is soon apparent that the activities, content, and procedures of the school are geared for the purpose of facilitating learning and the school functions best in this capacity. It also becomes clearly evident that the schools are not functioning well in curing the ills of society. Many uninformed people would like to delegate this function to the schools but the schools are not equipped to handle most social problems. To believe the whole responsibility for moral character, life adjustment, self-confidence, and happiness is the responsibility of the schools is very naive and unintelligent.[2],[3]

What type of training do the professional personnel in schools have? Again, they are trained for the purpose of facilitating learning. This is what they do best and to imply that their time should be devoted to other areas is foolish.

Tyler points out that the purpose of formal education in the school is to set the stage for the potential change in an individual's performance.[5] This definition should be expanded to include the observations about the schools just discussed. The school is an institution designed to facilitate learning and promote a change in an individual's performance. Unless one accepts this viewpoint there is little reason to engage in the arduous task of specifying measurable outcomes.

There are still those who would say that the purpose of the school is to develop attitudes, values, self-concept, and a happy individual. Critically consider these possibilities. First of all, a person's attitudes, values, self-concept, and happiness are strictly a personal matter. They are ends in themselves and not functions.

Examine some of these common experiences. No matter what it is, the better one can do something, the more one knows about it, the more one enjoys it, the happier and better the attitude is towards that activity. No "duffer" gets the pleasure out of a golf game that the expert does. No "hacker" in the handball court enjoys the game as fully as a trained player; no "chopstick" pianist can find equal satisfaction in a piece of music to that of the virtuoso.

Nobody will attain the deep pleasure of proficiency without hard work and possibly some boredom. Attitudes and values do not come easily and are not guaranteed.

Learning is a perpetual tension between the polarities of work and pleasure. The more someone grapples with a problem, the more enjoyable and satisfying the resolution of the problem. The most fun and best attitudes seem to come when a person works the hardest to accomplish a specific goal. The best the school can do is to facilitate the internalization of knowledge which will give the student the necessary tools to becoming happy and to developing positive attitudes.

For those who would insist that the development of a good self-concept is one of the primary functions of the school one must consider how a person's self-concept best be developed.

Everyone knows the empty feeling that exists when a completely new or foreign situation is encountered. One does not feel very confident about successfully handling the situation and the individual's self-concept is not very positive. Self-concept in this situation becomes more positive as the individual increases his understanding of this foreign situation. Self-concept seems to be a many-dimensional force in one's personality. It can be very positive for certain situations and negative for others. A person's self-concept seems to improve as he becomes more knowledgeable and experiences some degree of success in a given area. Purkey, in his review of the research on self-concept, indicates that there is a significant relationship between a person's academic achievement and his self-concept. A change in one seems to be associated with a change in the other.[4] Studies have shown that the students who experience success are more likely to develop positive self-concepts and feelings about their abilities and those that experience failure are most likely to develop negative views of themselves.

The best way the school can help develop a positive self-concept in an individual is to help him succeed in the process of acquiring usable knowledge.

What Makes a Good School System?

The question of what makes a good school system has been answered in different ways. The old answer was that a quality school system maintained the highest standards of physical plant and equipment, had a small student-teacher ratio, had most teachers with advanced graduate training, and was in-step with new curriculum developments. This yardstick for measuring the quality of a school was all right so long as those characteristics were in a one-to-one correspondence with learning. Through years of educational research it has been found that this simple, direct relationship does not exist.

A school system can no longer be judged by the number of things it possesses. There is a great pressure on the schools to be accountable for the education of a child. The question of whether children are receiving a quality education will only be answered when attention is paid to the performance of students. Bloom suggests that the criteria for judging the quality of a school and its educational functions would be the extent to which the school achieves the objectives it has set for itself.[1] It is evident that the success of a school cannot be measured by school characteristics or by fixed national norms, but by the results achieved by the school on specific and well-defined measurable objectives set to meet the needs of the particular school and the particular set of students in the school.

Why Teach for Measurable Objectives?

All activities of a school system should be means to accomplishing basic measurable objectives. By stating objectives, a school is able to systematically and intelligently assess their educational program and the degree to which they are accomplishing desired objectives. These objectives should be statements of specific and measurable behaviors which indicate what the student will be able to do following instruction that he was not able to do before participating in an instructional program. These objectives then become the criteria by which materials, activities, teaching strategies--in short, the whole instructional program--is evaluated. Objectives which are so vague that they are impossible to measure are not likely to be of much value to the teacher or the student and are extremely difficult to defend as being important educational outcomes.

It is also important for the teacher to understand that one of his important roles is as evaluator of student achievement. Decisions about student achievement can affect a student for a long period of time; in fact, those decisions may affect a student's entire life. Therefore it is important, when making decisions about a student, that the information on which the decision is based be supportable reliable evidence of his progress.[6] The evaluation of specific measurable outcomes also enables the teacher and student to know exactly where they are and where they are going. To teach without evaluating is unthinkable.

A systematic approach to curriculum design is also made possible through the development of well-defined measurable objectives. The learning experiences developed by teachers can now be geared to the accomplishment of stated measurable objectives which will help the student see more clearly where the instructional program is going. This increased clarity should also increase student achievement because the student knows in advance what performances are expected of him. He will also be able to better relate classroom experiences to these stated performances. The lack of measurable objectives often shifts the emphasis to the activities rather than the purpose for which the activities were designed.

The specification of measurable objectives will make it possible to evaluate the objectives of a particular program as to their contribution to the total curriculum. One of the basic criticisms of a curriculum based on measurable objectives is, that the teachers will only concentrate on the trivial outcomes and lower level cognitive objectives and avoid the higher level objectives. This is an unfounded criticism because the stating of objectives makes it possible to evaluate the content of these objectives and discard those objectives that are trivial and meaningless. It is also possible to analyze the cognitive levels of these objectives and a more intelligent assessment of their appropriateness becomes possible. This content analysis is not possible unless the objectives are specified for the educational program.

This approach to the teaching-learning process also makes systematic monitoring and reporting of a student's progress possible. This quality control function made possible by the specification of measurable objectives and the evaluation of these objectives allows the teacher to indicate to parents and students which objectives the student has mastered and which objectives require additional prescriptive assistance. The parents and students can understand with greater clarity where deficiencies occur.

The diagnostic and prescriptive function of teaching is made possible through the specification and evaluation of measurable objectives. Through the use of well-defined measurable objectives the teacher is able to use the evaluative process as a means of diagnosing deficiencies and prescribing appropriate remedial work leading to the eventual mastery of a set of learning objectives.

The approach toward the gathering of output data will lead to the strengthening and support of effective programs and to the elimination of weak programs. This can happen through the use of cost-effectiveness analysis of existing programs possible through the development and evaluation of measurable objectives. The actual cost to the school system can be determined for any program by examining this cost factor in conjunction with the degree of success of a program in meeting its desired objectives. More meaningful and intelligent decisions can be made when dealing with the appropriate data.

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CESI OPENING GENERAL SESSION

ETHICS, MORALITY, AND VALUES IN SCIENCE AND SCIENCE EDUCATION (ABSTRACT)

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The subject is approached from a scientific point of view. We start with the statement and definition of two boundary conditions: our awareness of *self* and of *other-than-self.* We also know that we are not independent of our habitat, but depend upon it for life. A related pair of boundary conditions is that there is a personal, subjective, *private* inner reality inaccessible in any direct sense to others, and the *public*, objective reality of science that can be validated directly by others. The clinical and theoretical work of Piaget and co-workers has shown how these two realities develop. The newborn infant does not distinguish itself from its habitat. As it acts, at first randomly, then in a more directed way, it gradually comes to realize and construct an outer reality. We may consider that the individual, during growth, constructs both an inner set of frames of reference and an outer set, and endeavors to make them correspond. In this process of construction the individual discovers invariant relations between the frames. Science is most successful in this respect. The constructs and the laws that connect them and make up scientific theory serve well to deal with external reality. They form a pattern that carries great meaningfulness and that confers meaning and a sense of identity on scientists in teaching and research.

In inner reality, also, there are invariants. These are absolutes that serve to bound and give meaning to the range of relative values, morality, and ethics. Like all absolutes they cannot be attained, yet are as definite as data and a theory that allows extrapolation to the limiting absolute can make them. Scientific knowledge, too, is relative. This can be seen because scientific knowledge is not an end in itself. It will be used. The ends for which it is used may be good or evil. This being clearly the case the scientist is individually responsible for his work.

The applications to science education are many. Students may properly be taught the relativity of science. They may be shown the bounding absolutes that give

meaning to and control over this range. Values are properly introduced: honesty, integrity, responsibility, concern for consequences, and so on. If these values were also demonstrated by the teacher, science education would have its greatest impact in helping the scientist and layman to become a better person. *Better people through science education.*

CESI CONCURRENT SESSIONS

SESSION C-3

CHILD-STRUCTURED LEARNING IN ELEMENTARY SCIENCE: HUMANISM VERSUS BEHAVIORISM

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In introducing his book, *The Hidden Persuaders,* Vance Packared wrote the following in 1957:

> It is about the large-scale efforts being made, often with impressive success, to channel our unthinking habits . . . and our thought processes by the use of insights gleaned from psychiatry and the social sciences. Typically these efforts take place beneath our level of awareness; so that the appeals which move us are often, in a sense, hidden. The result is that many of us are being influenced and manipulated far more than we realize, in the patterns of our everyday lives.

Of course Packard was writing about behaviorism as it applied to massive advertising campaigns to create markets for products for which there existed no consumer demand. The truth of his 1957 predictions are frighteningly obvious as we see our 1974 environment under serious threat of pollution and depleted resources.

I am concerned with the increasing use of behavior management techniques for the purpose of manipulating children who have not yet had the opportunity of developing their own unique personalities, interests, and needs. This paper and the associated videotapes and demonstrations are intended to communicate a set of systematically developed educational alternatives—alternatives to behaviorism. This systematic development and dissemination of these strategies seem of critical necessity if we make a reasonable assumption (or observation) that the following 1957 statement by Packard applies in 1974 to our treatment of young people in schools:

> Some of the manipulating being attempted is simply amusing. Some of it is disquieting, particularly when viewed as a portent of what may be ahead on a more intensive and effective scale for us all. Co-operative scientists have come along providentially to furnish some awesome tools.

In connection with these concerns, I should like to deal in this paper with two problems.

Problem 1. For several years, I have been hearing my colleagues in psychology telling teachers and teacher candidates, "Show me an undesirable behavior in a child and I'll tell you how to extinguish it in two weeks." More recently, I observe my colleagues in elementary education, early childhood education, and in various fields of special education and secondary education devoting numerous courses and many hours to teaching these behavior management techniques to inservice and preservice teachers. Fortunately, these university-level educators are not very skilled in the use of the very techniques they are advocating. This results in fairly few teachers becoming effective in the use of techniques identified as positive reinforcement, contingency reinforcement, behavior mod, etc. So far, the children are relatively safe. But soon the teachers of teachers—and subsequently the teachers themselves—will get it worked out. This will render the children completely vulnerable. For how many teachers will resist the pleasant, gentle, and effective "laying on" of their values to the children by the oh-so-convenient and completely-acceptable techniques the "experts" have taught them? Add to this the observation that many school systems are requiring teachers to attend "behavior modification workshops" and then to demonstrate the newly-learned techniques in their classrooms; you find that there is not only no escape for the children but no escape for the teacher either.

Problem 2. Many teachers have never had opportunities to analyze their own motives for working with children and subsequently to develop interactive processes which are consistent with these motives. Consequently many teachers use instructional strategies which are consistent with behaviorism when they, in reality, have motives which are humanistic. Within this incongruent framework, they communicate erratic and confusing messages to children and accomplish little more than the alienation of themselves and their students. Teachers are exhausted at the end of the day and feel defeated in their teaching—truly feeling as if they've been trying to sink 30 inflated balloons for six hours.

In attempting to communicate my ideas and feelings specifically associated with these two problems and generally with the conflict between behaviorism and humanism in education, I shall present the framework from which my ideas and feelings evolved. The remainder of this paper describes 1968-74 activities of two related research and development projects which have influenced—and have been influenced by—all the teaching of elementary, secondary, and college students I have done during that period. The CSLA Project (Child-Structured Learning in Science), which I directed from 1968-1972, has gradually evolved into Project LEO (Learning Environment and Outcomes), of which I am currently co-director. The CSLS Project developed humanistic strategies and materials and Project LEO has developed quantitative definitions of these CSLS Strategies—which are now identified as "student-structured learning in science" (SSLS). Project LEO has also identified and defined quantitatively a set of frequently used behavioristic instructional strategies which are identified as "teacher-structured learning in science" (TSLS). Project LEO[1] is now studying differences in environments and outcomes associated with these forms of behavioristic and humanistic teaching.

[1]Project LEO investigators are Ron Good, Jim Shymansky, Pat Kolebas, John Penick, Jane Leonard, Tom Allen, Dorothy Schlitt, Charles Matthews, and a number of teachers and teacher candidates at FSU.

Child-Structured Learning in Science, 1968-1972

The CSLS Project was an effort to identify and implement activities and materials which would facilitate maximum affective and cognitive learning in science. The project began in 1968 with initial funding from the Georgia Department of Education and the National

Instructional Television Center. Funding was subsequently received from Florida State University and the Florida Department of Education. Much of the effort which went into this project, however, consisted of donations of time and expertise by psychologists, scientists, science educators, students, and teachers in many parts of the United States and Canada.

The CSLS Project reflected the following assumptions [19], [20]:

1. It is possible to logically derive learning conditions from goals and characteristics of learners.
2. Learning conditions must reflect what is *not* known as well as what is known about student.
3. Teacher behavior and learning materials are the dominant factors in determining learning conditions–since these two factors communicate to the students both conceptual and operational meanings of learning.
4. Learning how to learn can be facilitated by school experiences.
5. Self-actualized learning is the most important goal of education.
6. Learning conditions can be tested by studying interactive processes and outcomes of educational activities.

The broad goals of CSLS activities are outgrowths of value judgments made by several hundred scientists, science educators, human development specialists, teachers, parents, and students. These goals can be characterized as "humanistic" in intent because they: (a) focus on the development of the individual's full potential, (b) facilitate individuality in learners, and (c) are associated with productive learning under conditions of maximum freedom.

CSLS goals emphasize conceptual learning over skill learning. According to CSLS, skill learning can result from imitation (verbal or non-verbal) but conceptual learning grows out of the cognition and affect of the student. Conceptual learning is that learning which is created or structured within and by the student. All CSLS activities have the following long term goals:

1. To enhance systematic and creative thinking abilities of students in pursuit of investigations or solutions to problems.
2. To enhance students' beliefs that they can interpret and manipulate their own environments–that they are part of their environments and dependent upon them.
3. To facilitate for students the development of positive self concepts with regard to independent learning and responsible manipulation of their environments.
4. To facilitate individual development of interests, attitudes, personalities, and creativity in order to enhance the continued development of individuality in students.
5. To facilitate students' tendencies to accept other individuals–especially those who have ideas and values which are different from their own.

These long term conceptual goals are operationally defined by more specific statements of desired affective and cognitive learning. CSLS affective objectives are associated with the development of positive self concept with regard to independent learning. Within the CSLS Project, this means that students:

1. Identify themselves as persons who can successfully study their environments, and choose to use what they learn about their environments.
2. Describe learning in terms of activities which make sense to them and feel comfortable with these descriptions.
3. Accept their own explanations for natural phenomena and modify these only when they cease to be compatible with their own interpretations of their environments.
4. Feel comfortable in stating alternative explanations for observed phenomena.
5. Identify and accept tentativeness as an important characteristic of knowledge.

CSLS cognitive objectives are associated with the goal of communicating how creative and systematic thinking relate to solving self-perceived problems. Students should be able to design activities without prompting and complete activities without instruction in which they:

1. Manipulate objects or systems in ways which are dependent upon self-perceived properties of the objects or systems.
2. Identify relationships among properties of objects or among the factors which affect the behaviors of systems.
3. Manipulate objects and systems to test the usefulness of the relationships which they have identified.

Although CSLS activities obviously take into account physical characteristics of learners, the research base for CSLS activities is associated primarily with emotional and cognitive characteristics of learners. The work of numerous researchers has shed considerable light on the emotional characteristics which most people have in common. The following research based statements have relevance to CSLS activities:

1. The human being is characterized by a tendency toward learning. Unless barriers have been erected, a person will choose to learn. [25]
2. "Need to know" is insatiable and continually forces persons to rearrange ideas into patterns which make more sense to them. [9]

Cognitive characteristics of students are those characteristics associated with the thinking which is available to students. The Piagetian school, Bruner's group, and certain of the Soviet psychologists envision these characteristics as representation systems available to individuals for dealing with future encounters of the organism with reality [24], [5], [29]. A brief listing of research supported statements on cognitive characteristics which grew out of Piaget's work is given below [24]:

1. The cognition of human beings progresses through stages characterized by increasingly powerful representation systems.
2. The ordering of these stages of cognitive development is constant and has been found in all societies studied.
3. Chronological ages associated with stages of cognitive development vary from one person to another.
4. Interpretation of the environment and problem solving associated with this interpretation are limited by representation systems available to individuals.

CSLS takes into account the following well known examples of resaerch supported statements associated with facilitative classroom behavioral patterns:

1. Openness and self-directiveness characterize environments which tend to facilitate goals associated with creativity in the sciences and wisdom in those fields with social concern [28].
2. Students tend to copy the behavioral patterns

exhibited by the teacher. If the teacher tries to dominate students, students try to dominate each other; if the teacher accepts students, students tend to be accepting of each other [2], [3], [4].
3. Directive teaching behaviors tend to produce disruptive anxieties in students and reduce the learning of new concepts [7], [6].
4. Constraint teacher behaviors tend to produce a high level of dependency of students on their teacher [12].
5. Directing students to engage in manipulative or verbal operations which they cannot engage in mentally tends to erect knowledge superstructures which crumble under the slightest cognitive stress. [1]
6. Long term learning seems to be characterized by personal involvement, self-initiation, a sense of discovery, pervasiveness, self-evaluation, and meaningfulness. [25]

In identifying CSLS materials, the following two research based statements were heeded.

1. Knowing an object requires acting on the object—modifying it, transforming it. Learning seems to result from what one does to objects in the environment and the doing must be both physical and mental. [24]
2. Logical thinking does not derive from verbal learning but, rather from a total coordination of actions on object. [24]

This led CSLS to distinguish between representational and non-representational materials and to place almost total dependence on non-representational materials—until the student initiated an interest in the use of representational materials. Objects were used for themselves rather than as representations of other objects, events, or ideas. A blue glass marble, as a non-representational object, is whatever the student perceives it to be. It is not presented as a representation of glass objects, blue objects, spherical objects, or any other class of objects. Obviously, it is not used to represent an atom, a nucleus, or a molecule. Printed or pictorial materials, as representational materials, give way to manipulative, non-representational materials Words are used but never substituted for objects or events by CSLS teachers.

A major activity of the CSLS project was the derivation from goals and student characteristics of a set of learning conditions. CSLS classroom conditions, which grew out of the previously stated goals and research on student characteristics are characterized by:

1. student access to a variety of materials with freedom to use or ignore them in an environment, that allows, but does not require, interaction with the teacher and/or other students:
2. unprescribed specifications for what students must learn or how they must learn since a teacher cannot know a student's precise cognitive levels.
3. sessions with no specific beginning, middle, or end;
4. student freedom to use the materials in any way desired so long as other students are not disturbed or materials damaged unnecessarily;
5. student termination of the sessions determined by each individual;
6. student decisions about whether to work individually or in groups with the option to change.

The role of the teacher is to:

1. make available the greatest possible variety of materials for student use.
2. respond to what students are doing rather than giving directions for students to follow. Printed materials do not prescribe or give directions.
3. respond to *individual* students rather than giving a generalized response to groups of students.
4. respond by asking questions or making neutral (nonevaluative) comments, to which students may respond or not as they choose.
5. avoid rewarding or evaluating students for their activities, as these acts would communicate to students that the teacher wants them to discover the secret objectives of the lesson.
6. accept (but not reinforce) both "correct" and "incorrect" statements by the students. To do otherwise would suggest that the teachers know what the student's perception is better than the student knows himself. Neither does the teacher provide printed feedback for the purpose of establishing "correctness" of the student's perceptions.

Investigations [16], [17] conducted during the 1968-69 school year compared three different science programs for children within the age range 5½ to 6½ years. Nineteen teachers and 570 students were studied for the purpose of comparing: A textbook-based program, *Science–A Process Approach Part A* and *CSLS Level One*. [19], [20]

Utilizing the Science Curriculum Assessment System [18], teacher behaviors, student behaviors, and student cognitive developmental characteristics were studied. Examination of the data from these investigations made it obvious that *CSLS Level One* involved decidedly less teacher directiveness and decidedly more teacher interaction with individuals and small groups of students. The study also made it clear that *CSLS Level One* students did more self-initiated and self-designed activities with no increase in disruptive activity or idleness. Data on cognitive developmental levels of students revealed no significant differences among programs and placed the majority of students at Piaget's preoperational level.

Project LEO, 1971-1974

In September 1971 a project was initiated to study learning environments and outcomes associated with the strategies developed previously in CSLS. These were to be compared with a contrasting set of strategies which had been observed to be in widespread usage for K-12 science teaching. The two sets of strategies were identified as "student-structured learning in science" (SSLS) and "teacher-structured learning in science" (TSLS). Although these strategies are defined quantitatively in terms of contrasting teaching behaviors, the overall framework for the study is better understood in terms of contrasts between SSLS and TSLS goals and activities—as well as teacher behaviors.

SSLS goals are identical to those given previously as "CSLS Goals." TSLS goals are derived from the practices of numerous K-12 science teachers and reflect what the Project LEO investigators consider important contrasts with SSLS goals. Whereas SSLS goals emphasize conceptual learning and an open (humanistic) environment, TSLS goals emphasize skill learning and a closed (behavioristic) environment. When implementing TSLS strategies, the teacher investigators of Project LEO generated behaviors from a framework in which *learning selected skills was of major importance and training the* *student in these skills was a major goal.* More specifically, TSLS long-term goals are to enhance and facilitate:

1. the verbal and manipulative skills of students in the pursuit of activities compatible with the structure and processes of science and the competencies of the student as perceived by the teacher or other experts.
2. students' beliefs that their careful attention to directions based on the judgment of authorities will preserve their environments.
3. the development of positive self-concepts in students with regard to following directions in the manipulation of their environments.
4. the development of interests, attitudes, and personalities which fit into the expert's perception of societal needs.
5. student tendencies to seek ideas and values which can remain unchanged throughout their lives.

These long-term, skill-oriented goals are operationally defined by more specific statements of desired affective and cognitive learning. TSLS affective objectives are associated with the development of an accurate concept of self with regard to skill learning. Within the TSLS framework this means that students:

1. Correctly assess and accept their own science skills relative to those of their peers.
2. Accept science as overt verbal and manipulative skills and correct knowledge.
3. Feel comfortable in stating what experts recognize as correct explanations for natural phenomena which they have covered in their science program.
4. Feel comfortable in stating the explanations (for observed phenomena) which have been detailed previously by the teacher or another authority.
5. Identify and accept correctness as the most important characteristics of scientific knowledge.

TSLS cognitive objectives are associated with training students in the skills of science and how these skills are used in efficiently and correctly solving practical problems. Students who complete the TSLS program should be able to follow instructions which require that they:

1. manipulate objects in ways which correctly identify and measure the properties of the objects.
2. correctly identify relationships among properties of objects or among the factors which affect the behaviors of systems.
3. use expert sources to check the correctness of properties of objects, the relationships which they have identified, and general knowledge.

A modification of teacher behavior categories developed by Matthews [18] in 1968, was utilized to define SSLS and TSLS teacher behaviors quantitatively. SSLS teacher behaviors are essentially responsive (non-directive) and neutrally accepting (non-evaluative) toward students. Both SSLS and TSLS teacher behaviors include questions and observations.

An important condition for SSLS and TSLS is the number of students with which the teacher interacts at a given moment. Although group size for both SSLS and TSLS was 25-30 students, 99 percent of teacher behaviors involved interaction with fewer than seven students usually one or two. Therefore, the teacher was essentially "roving" among students. Both SSLS and TSLS are "individualized science," TSLS being prescriptive and SSLS being non-prescriptive. TSLS teaching narrows alternatives for students to those which the teacher identifies as most efficient for the student; SSLS teaching maximizes alternatives (short of endangering the rights of other people).

SSLS and TSLS Activities

In studying the effects of contrasting teacher behaviors on students, all other conditions were held constant. This included materials and other physical facilities. Since all materials for SSLS and TSLS are identical, the differences in the activities result from the differences in the teacher behaviors.

During the summer of 1971, quantitative definitions of SSLS and TSLS teaching behaviors were finalized and the teacher learned sets of contrasting behaviors and demonstrated these consistently within the ranges shown in Table 1. Activities were identified, materials were collected and pre- and post-test instruments were developed. Research assistants were trained for data collection.

Beginning in September 1971, a pilot study was conducted with 52 students ranging from 9½ years to 10½ years of age. Twenty-six students were randomly assigned to SSLS and the remaining 26 constituted the TSLS group. Students were assigned with a class ranking restriction on randomization to insure a range of students in each section. Using the *California Short-Form Test of Mental Maturity* and fourth grade achievement grades, students were privately designated as high rank, middle rank, and low rank. During daily SSLS and TSLS sessions students were observed individually and their behaviors were coded on a modification of SCAS Student Behavior Categories [18]. Utilizing Forms A and B of the *TAB Inventory of Science Processes* students were pre- and post-tested. These two studies were consistent in findings, yielding the following conclusions [26], [23]:

1. SSLS low- and middle-ranked students did as well as SSLS high-ranked students in problem-solving.
2. TSLS high-ranked students did about the same as SSLS high-ranked students in problem solving.
3. TSLS low-ranked students did not do as well as TSLS middle-ranked students and TSLS middle-ranked students scored lower than TSLS high-ranked students on problem solving.
4. When SCAS behaviors of SSLS and TSLS students were compared to the TSLS students:
   a. did more "observing the teacher".
   b. did more "following teacher directions".
   c. did less "self-designed activity".
   d. did more "initiating interaction with teacher", and
   e. did about the same amount of "lesson-related behaviors" as did SSLS students.
5. SCAS BEHAVIORS OF TSLS low-ranked students were different from other TSLS students in that the low-ranked students:
   a. exhibited less "lesson-related" behaviors,
   b. "observed the teacher" more, and
   c. "followed teacher directions" less.
6. SCAS behaviors of SSLS low-, middle-, and high-ranked students were about the same.

Based on these findings and utilizing new or modified instruments, a 1972-73 study was designed and implemented with 250 students ranging in age from 5½ to 10½ years and with 50 high school students enrolled in first-year general chemistry. During the 30-week SSLS and TSLS treatment, students were studied in the following ways:

1. *Classroom behaviors.* Utilizing SCAS student be-

havior categories, students were observed individually and behaviors were coded. [13]

2. *Problem-solving ability and confidence.* Utilizing an individual interview students were pre- and post-tested for ability and confidence in the solution to ten selected problems. [15]
3. *Cognitive developmental characteristics.* Utilizing an individual interview students were pre- and post-tested on conservation and similar tasks. [8]
4. *Self concept with regard to science and independent activity.* Utilizing a group-administered instrument (with individual assistance and monitoring), students were pre- and post-tested on their feelings and tendencies regarding science and other independent activities. [27]
5. *Information acquired.* Utilizing a set of standardized tests students were pre- and post-tested on science information acquisition and information acquisition in general. [14]
6. *Teacher impressions.* Teachers made subjective judgments and kept daily logs of what they considered significant events. [11] Participating teachers and investigators met once each week to discuss these and to plan for the next week.

To summarize briefly the findings indicated that, after one school year of SSLS and TSLS conditions, SSLS students exhibited higher levels of:

1. ability to solve certain problems,
2. confidence in their ability to solve certain problems,
3. self-initiative and self-directiveness in engaging in learning activities, and
4. verbal creativity.

TSLS students exhibited higher levels of:

1. listening to and watching the teacher,
2. carrying out teacher-designed activities,
3. copying other students, and
4. initiating interaction with the teacher.

In general, it can be stated that the investigations conducted thus far have consistently indicated that *students are more independent and fully functioning under SSLS conditions than under TSLS conditions with no increase in disruptive behaviors.*

The 1973-74 school year is devoted to a second-year study of 52 of the elementary school students who were studied during 1972-73. These 52 students were retained in their original groupings and are currently continuing under SSLS and TSLS conditions. Additionally, two new groups of high school chemistry students are being studied--one group under SSLS and one group under TSLS conditions. Data will be analyzed in Fall 1974.

The 1974-75 school year will be devoted to comparative studies of more subtle contrasting strategies within the SSLS framework. In addition to continuing the investigations of learning and outcomes, Project LEO will:

1. provide consultation services to groups who wish to conduct their own research or who wish to implement SSLS- or TSLS-related teaching strategies, and
2. publish instruments, techniques, findings, and implications of CSLS and Project LEO investigations.

I believe the purely cognitive arguments and research presented in this paper clearly support the following statements:

1. It is possible to differentiate quantitatively between humanistic environments and behavioristic environments.
2. It is possible to identify differences in the educational outcomes associated with humanistic and behavioristic environments.
3. The freedom associated with humanistic learning environments does not result in the chaos and irresponsibility that many people fear.
4. Children develop more positive self concepts in the absence of overt verbal and other rewards which many behaviorists advocate as essential.
5. Skill development and information acquisition do take place in environments which do not require students to engage in specific skill development and information-oriented activity.
6. Teachers can establish humanistic environments through systematic efforts to channel their behaviors into patterns which are consistent with their humanistic values, motives, or goals.

There are alternatives to behaviorism in the elementary school classroom. These alternatives, once learned, can be implemented without high risk to teacher or student. Teachers can develop congruency between values and instructional practices. Through systematic effort and introspective analysis, teachers can communicate consistently and continuously to students, "I love you; I am concerned for your welfare; and I believe in your responsibility to yourself."

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SESSION CC-4

THE ROLE OF FUTURES RESEARCH IN PRE-COLLEGE SCIENCE INSTRUCTION

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As science educators increasingly emphasize "science for citizens," the methodologies and the findings of futures research are becoming important in science instruction. Over the last 20 years, the gradual emergence of futures research as a new field of knowledge has been paralleled by an increasing concern among science educators and students for including in the science curriculum material about the impacts of science on society. The research that I have been doing leads me to believe that incorporation of selected elements of the tools, results, and structure of knowledge of futures research could greatly enrich science education for science students and non-science students alike.

Briefly, futures research can make three major contributions to science instruction. First, through learning the strengths and weaknesses of methodologies for long-range technological assessment (such as the Delphi technique, the cross-impact matrix, and sophisticated trend extrapolation), students can themselves begin to evaluate the validity of contemporary predictions about the population explosion, ecological catastrophes, extensive biological manipulations, and similar effects of science and technology on society. Through this knowledge, students will become better able, as citizens, to make intelligent decisions when conflicting claims are made about the likely impacts of a technological discovery.

Second, some of the alienation many students feel towards required science courses may stem from feelings of individual powerlessness to affect the future of society and from a sense of having no influence on whether science and technology are used for good or for ill. Through utilizing simplified versions of futures tools, students in science courses can evolve their own participatory forecasts of how science and technology may affect society in the next generation. Further, using normative forecasting techniques, students can choose from among those alternative futures they personally consider most desirable. By then collectively discussing policies which they can use as citizens to bring science and technology closer to their desired futures, students can gain a sense of potential control over the impact of science on their lives.

Third, science educators can use the findings of futures research to fulfill their responsibility of preparing students to act as responsible citizens over the next half century. The major schools of thought in futures research are a powerful resource for assessing what science-based skills and information students are likely to need to make intelligent decisions within our democracy. To teach students about the energy crisis is a worthwhile focus of the science curriculum, but far more valuable would be teaching them about the likely technological crises we will face in 1990. If we had only incorporated material from the 1958 federal projections on energy resources in the post-Sputnik science reforms, we might be in better shape today!

For these reasons, futures research is an important source of information and ideas for science education. Before summarizing the work which has been done thus far on utilizing futures tools in the science classroom, a brief outline of the current status of futures research as a field of knowledge seems appropriate.

Early work on disciplined prediction of the future began at Rand Corporation in 1952, a product both of the growing field of economic forecasting and of the desire of the military for long-range assessments of likely developments in weapons technology. During the last twenty years, futures research has developed a large number of methodologies unique to the field and has expanded into specializations in economic, political, social, technological, industrial, and educational forecasting. The goals of all these different types of forecasting are identical:

1. the systematic determination of the major alternative futures which can emerge from our present, and
2. the delineation of how our present actions can influence which of these alternatives will occur.

Remarkably little fanfare has accompanied this growth, partially because most serious futures work takes place in think-tanks and goes directly to high-level federal decision-makers without much public distribution, and partially because futurists are naturally concerned about the field's developing the prerequisites of a discipline before it receives extensive media exposure. Of course, a growing number of so-called "futures experts" are attempting to seize the public limelight (Alvin Toffler being perhaps the best known), but their work bears little resemblence to sophisticated efforts in the field.

My own background in futures research comes from having served as Director of the Program for the Study of the Future in Education at the University of Massachusetts. The program is not a futures think-tank, but rather is one of the few groups in the country acting as a "translator" between futures researchers and the lay public. For the last four years, we have been selecting from futures research those methods and results which seem to have major significance for education. We then disseminate this information through an inservice consortium of teachers interested in "futurizing" their curriculum, a preservice teacher training program, our own masters and doctoral degree programs, and a free newsletter. Because my own professional commitment centers on improving science instruction, my work in the program has focused on those aspects of futures research which speak to issues of science, technology, and society.

The major futures publications easily accessible to science educators that I have found most useful are:

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7. *Where the Wasteland Ends*. Theodore Roszak, (New York: Doubleday, 1973)
8. *Alternative Futures and Educational Policy*. Willis Harmin, (Menlo Park, CA: EPRC, Stanford Research Institute, 1970)

Out of these works and a large number of more technical publications I have prepared a three-hundred-page report on the implications of futures research for the secondary level science curriculum. Briefly, the report argues that post-Sputnik reforms to date do not contain enough material on science/society issues (such as biological manipulation) which will be of importance when present students are decision-makers in the society. Specific suggestions are made in the report about what needs to be added so that the appropriate skills and information are communicated.

As one step towards putting some of these ideas into practice, during the past year I have been working on the formation of a Science Education Task Force at the University of Massachusetts which will integrate the efforts of the various natural science divisions, the professional schools, and the school of education. The first goal of this task force will be to design a model for a new three semester core curriculum in science, organized around the futures conceptions I have outlined.

In addition to working on this theoretical framework for what cognitive skills science education should convey, I and the program have been experimenting with adapting futures research tools to classroom use [a good summary of this work is contained in "Teaching About the Future", *Instructor*, Vol. 83, No. 1. (Aug/Sept. '73) pp. 65-67]. The tools which seem most productive for instructional use in science are the Delphi technique, the cross-impact matrix, scenario construction, and the futures wheel. We have also invented some instructional techniques (such as the "Build Your Future Body" exercise) which speak directly to science/society issues. In-field-based tests of these instructional strategies in elementary schools, high schools, and college courses have been very encouraging, although of course these modified tools are most productive when used as part of an integrated unit on science and the future. [One such excellent two-week unit on environmental forecasting has been produced at Shawnee Mission High School, Kansas (discussed in the December, 1973 *Science Teacher*)].

To summarize, through evolving a new framework for the content of science education, we can incorporate skills both from the scientific disciplines and from fields of knowledge such as futures research. Further, by utilizing futures methodologies in the science classroom, within this framework we can help students to gain a sense of potential control over science and technology. This integrated approach will enable us to better prepare scientists competent to serve society and citizens able to decide how science should affect their lives.

NSSA CONCURRENT SESSIONS

SESSION N-4

INSPIRATION IS NOT ENOUGH–A REPORT ON AN ONTARIO MINISTRY OF EDUCATION INSERVICE

PROJECT IN ELEMENTARY SCHOOL SCIENCE TEACHER PREPARATION [An illustrated seminar]

Mitchell E. Batoff, Associate Professor of Science Education, Jersey City State College, Jersey City, New Jersey
John G. Cornfield, Assistant Head of Science, Ridgemont High School, Ottawa, Ontario, Canada

The central thesis of this presentation is that inspiration and knowledge, obtained in an inservice elementary school science course, are necessary but insufficient to change a teacher's style of teaching once he or she returns to the classroom after the course. In addition to a desire for change a tangible ingredient is also needed. Fundamentally, the missing element is a pump priming effort.

Many a program funded by the National Science Foundation,[1] as well as courses sponsored by other agencies, has left teachers inspired, perhaps a little more knowledgeable, but terribly frustrated. They returned to their classrooms at the end of the summer no more able to implement some newly acquired grandiose ideas than prior to the course. Their teaching style remained about the same as before the inservice course. They wanted to change (which is an indispensable first step) but lacked the wherewithal to implement materials-centered inquiry-oriented teaching which was often the focus of the summer program in which they participated. The tangible ingredient of hardware was lacking. Accordingly, "wet laboratory" situations were still nonexistent. Talk and chalk still predominated. Manipulative-investigative materials are needed in any viable elementary school science program including those which utilize the natural environment. Inspiration is not enough. This is a fact of life, a bald reality.

Surely this presentation offers no panacea for a complex multifaceted problem (involving hardware *and* other factors as well) but does show the efforts of a novel summer program offered in 1972 and 1973 by the Ontario Ministry of Education. The writer believes that the participating teachers' style of teaching may have been modified, at least a little, as a result of an innovative pump priming assignment built into a certificate course in elementary school science. This belief is based on the evidence so far accumulated in a five year follow-up study (in progress) of the summer program at Owen Sound in 1972 and Ottawa in 1973.

The innovative pump priming effort was one of the following, required of each participant as the principal assignment and major project for the course:

1. A Unit Box
2. An Inquiry Centre[2]
3. Some variation on #1 or #2

All three of these options are shown in the slide presentation. The video tape vignettes give some flavor of what the participating teachers derived from this assignment as well as their anticipated implementation strategies back in the classroom. The slides and narrative fully depict the Unit Box Experience. Further details on this are delineated in a paper available from the author.

[1]Prior to the CCSS Program of NSF which sought to alleviate this shortcoming.

[2]Patterned after a prototype designed by Doug M. Jolley of the Ministry of Education.

The Ontario Unit Box Project is an unexpected spin-off of six years of experience with this approach at Jersey City State College, where the writer has had 784 Unit Boxes assembled in thirty-seven classes taught over an eleven semester period (including 51 currently in progress during the Spring 1974 Semester).

SESSION N-5

PROCESS CONCEPTUALIZATION FOR THE SCIENCE COORDINATOR–MODELS

Virginia Way, Science Coordinator, School District No. 50, Westminster, Colorado

A coordinator, new to the job, faces many problems. Out of a personal need to conceptualize some processes for myself and others, I found that by constructing "models," the steps in a process or task became clear to me and those with whom I work.

Four of these "models" are included in my presentation:

1. A model for operation of selection process involving a committee.
2. A model for program evaluation and implementation.
3. A model for EFS, a Title II project.
4. A model for development of local environmental education projects.

NSSA CURBSTONE CLINIC N-1

SCIENCE EDUCATION: SMORGASBORD OR BANQUET STYLE?

Gary E. Downs, State Science Consultant, Department of Public Instruction, Des Moines, Iowa

Each of six discussion leaders gives a three-minute presentation relating how their education responsibilities fit the "Smorgasbord or Banquet Style." Foods, menu planning, balanced diet, basic foods, variety of foods and specific foods will be the "themes" used to tie the discussion together.

For the "Smorgasbord" phase of the session the participants will be divided into six equal groups. A discussion leader will initiate discussion relating to *Science Education Topics.*

The participants will be regrouped for the "Banquet" phase of the session. Discussion leaders will initiate and guide the small group discussions focused on specific topics:

1. Individualized Instruction
2. Inservice
3. Management and Organization
4. Local, State, and National Science Professional Organizations
5. Humanization
6. Curriculum, Projects, and Programs

"All" good ideas initiated in the group discussions will be compiled and mailed to each participant following the Convention.

An evaluation exercise completes the session.

NSTA GENERAL SESSIONS AND BANQUET

GENERAL SESSION I*

SCIENCE EDUCATION FOR THE POST-INDUSTRIAL SOCIETY (ABSTRACT)

Daniel Bell, Professor of Sociology, Harvard University, Cambridge, Massachusetts

We are now seeing the emergence of a post-industrial society. The lineaments of this society are appearing and will work themselves out in the next 30 to 40 years. There are five dimensions to this society:

1. Change from a goods producing to a service society--65 percent of the labor force are now engaged in services of a professional, technical, and human nature.
2. Preeminence of professional and technical classes in the society–skills are primarily educational skills.
3. Centrality of theoretical knowledge as the source of innovation and policy formulation–theoretical knowledge becomes the directive force in society.
4. Possiblity of controlling the consequences of technology and doing technological forecasting and assessment.
5. Creation of a new type of intellectual technology.

In this post-industrial society we will be increasingly dependent on theoretical knowledge and service to society. Our conceptions of science will be as a method of conceptual innovation and conceptual renovation. It is a constant reordering of knowledge, of seeing knowledge in different ways. It will be marked by the search for common attributes of what is studied.

At present, our national science policy is a shambles, and we will be paying the price in the next 10 years or so.

The crucial element in the post-industrial society is human capital, talent, brains, skills. We know how to raise money capital, but we don't know very much about human capital, nor about how to husband human capital–also a very important question.

We are witnessing a disjunction between science and the rest of society. We must be concerned with the relation of technology and various kinds of institutional support systems. The automobile, for instance is a technology, how we use it in society–our regulation or non-regulation of it–is a support system. A single technology can be embedded in different kinds of support systems. If we recognize that there are various kinds of support systems available, we can try to choose among them and base our choices on alternative costs and alternative consequences. We may have various institutional systems utilizing the same technology. There are no imperatives of technology–only ways that people organize and use technology. Machines can't have judgment. The distinctive charactertistic of human beings is their ability to generalize, to formulate group rules, and to innovate. We must maintain the ability to keep open creative imagination. What applies to all education whether you call it science or literature, whether it is in a preindustrial or postindustrial society is fundamentally the ability to open creative imagination. Any enterprise that can keep that going is essentially one which continues the human quest for knowledge.

*The full text of addresses by Daniel Bell, Harold G. Shane, Edward B. Lindaman, Leslie W. Trowbridge, and Harrison H. Schmitt are available on cassettes. Write to NSTA for details.

GENERAL SESSION II

EDUCATION FOR TOMORROW: OUR TASKS AND RESPONSIBILITIES (ABSTRACT)

Harold G. Shane, University Professor of Education, Indiana University, Bloomington

Futures research has been of interest to men for a long time; in fact Louis XIV of France commissioned the first study of the future. That commission did a fine job–but it failed to predict the French Revolution!

The important thing to recognize about the future is that there are many futures and that there are many cross-impacts among disciplines.

The significance of the future for education must include consideration of such current problems as inflation, the impact of the energy crisis, and the food crisis.

Better tomorrows are not merely todays with their promises removed. We must be prepared to be startled by changes.

Our tasks in education for tomorrow include:

1. Development of lateral thinking–we need to have at least a 180° spread in our choices.
2. Development of social thinking.
3. Decisions on topics such as: What are we going to do about technology? What are we going to do about our human surpluses?
4. Development of transnational policies.
5. Behavioral life choices.
6. Restoration of credibility.

We need to alter the structure and content of education and to get rid of red tape and fragmentation. Education should be a seamless continuation of experience.

A compulsory age for leaving school should be dropped in favor of open access to education at any time in life.

We need to substitute content in education–to introduce young children to models and computers and to ideas such as music as a means of communication; and to increase attention to non-verbal learnings and to body language.

In education our responsibilities also include doing a better job of teaching children of all ages what is happening in the world:

1. Enriching our inner resources
2. Sensitizing children to social traps
3. Developing awareness of alternatives and consequences
4. Creating tacit learning in the young
5 Rediscovering some of the old values.

GENERAL SESSION III

EVERYPERSON'S GENESIS II: OPPORTUNITIES IN APPLIED FUTURISTICS

Edward B. Lindaman, President, Whitworth College, Spokane, Washington

Concern about the future is an obsession of the human species that ranks second only to obsession about the present.

And that's essentially why mankind is in its present predicament.

Earth's inhabitants have kept one eye open to the future—while both feet were solidly cemented in the present.

At the personal level, this is typified by the fellow who "charts his future" with a horoscope and whose long-range planning is a matter of choosing between having a beer while watching "Wide World of Sports" on TV or mowing the lawn.

Institutionally, symbols of our present-tense lifestyle are everywhere: polluted skies and streams, cost of living indices which tell us what our checkbook already knows, automobile lots crammed with excessive inventories of luxury-loaded gas guzzlers . . . .

One way of conceptualizing our predicament has been advanced in memorable terms by William Irwin Thompson. He wrote in *At the Edge of History* that the lightning revelation of the reality of our moment in cosmic time has already occurred and "now we sleep in the brief interval between the lightning and the thunder."

The lightning, we might say, heralds the flash of the possible. It is preparing us for a new mentality and enables us to get in touch with a world that might be.

What could the thunder be? Each of us has a private, unique vision of what lies ahead. Perhaps it is that time when everyone suddenly recognizes reality for what it is, that moment when we see and do the possible. What a critical breakthrough that would be, for *it is only when we assume a future that we make it at least probable*. Unless, of course, that future is the unplanned but logical consequence of the present. And who wants that, really?

Why not think in terms of a Second Genesis? Why not assume the future we want for our world so that we can invent that future?

The psychologist tells us we can re-invent our marriages, for example, by acting upon some basic assumptions about our partner, ourselves and our relationships with each other. Similarly, we can re-invent our approach to the future.

We might begin our first chapter of Genesis II by taking another look at the Genesis I story in the Bible. God, we are told, admonished his first created male and female to "Be fruitful, and multiply . . . and have dominion over every living thing that moveth upon the earth." That's how we remember it. Conveniently, we block out the phrase that tells us to "Be fruitful, and multiply, *and replenish the earth* . . . ."

Century upon century we succeeded at being fruitful and populating our world without paying much attention to replenishing the earth. But now we've reached that point when worldwide production and population growth are conditional upon how well and how soon we replenish . . . .

For the scientist, for the educator, the task of creatively assuming the future rests upon the formidable business of phasing out old images and phasing in new ones.

The word "science," I suggest, is archaic. It should be indexed "old" and "new." The old science is Newtonian: the universe is a big machine, it's mechanistic, everything is geared together, the rules are fixed and clear, one has only to build—build bridges, trains, cars, snowmobiles, skyscrapers, shopping centers. . . .

The new science is a host of mind-boggling concepts we've just begun to understand: relativity, quantum physics, high energy physics, depth psychology, pulsars, quasars, etc. It's a whole new game that's much more complex than we imagined. The content of science isn't the only change. It's clear that how we know and how we live in response to what we know are now post-Newtonian. We've moved from mechanism to processes and synergistic relationships.

Mankind has moved beyond the macro-world of the seen. We're into the micro-world: shaping, cooking, blending, tuning, melding, welding the realities we can't see. This is where the action is in science today. And in the meta-world, the world "out there" we are probing our solar system, and beyond. Pioneer 10 in 80,000 years will approach our nearest star. Scientists are assuming exploration of the universe in fusion-powered ramjets which will travel near the speed of light—and this within 100 years.

Future consciousness isn't really such an alien idea. We haven't gone too far beyond reading tea leaves and gazing into crystal balls, but it is fair to say that an awareness of our power to create the future has become widespread in the western world. We're asking a new question in the public arena: "What kind of world do we want?" We are past doing something just because we can. Now we ask, "Why do it at all?"

This really is applicable at all levels. Recently, in conversation with a group of grade school teachers, the question was raised, "Can a sixth grader have a future consciousness?"

I proposed that one way to ensure that the answer is affirmative might be to approach a lesson or a subject from a new direction. Why not, for example, while teaching U.S. history have students take the Lewis and Clark expedition across the continent in 1990? This sort of angle opens the future.

To explore our own philosophy of the future, we should grapple with these kinds of questions:

1. Is the future predictable? Honestly, what is locked in about the future and what isn't locked in?
2. Are there experts on the future? Who do you listen to; who can you believe?
3. Is civilization as we know it coming to an end? Or will the future be more of what we now have?
4. Is utopianism useful? Of what value is utopianism in setting images of the future?
5. Who is best prepared to meet the future? How does one prepare?

Generally, our views of the future fall into three categories. One view is to say that it will be an extrapolation of the past, i.e., the future will be the future of the past. We will move from an industrial society to a super-industrial society.

Another view sees mankind swept up by powerful trends already set in motion and moving helplessly into the future.

A third perspective is that the future is not controlled by the past or present, but that men and women everywhere can invent the future.

Those philosophic positions generate a variety of rationalizations and justifications. And, at the gut-level, one notes several typical kinds of behavior in response to one's perception of the future. One we hear a lot about is summed up by those who counsel a "return to the good old days." Another is based on the premise that the problems would go away if only we would stop being so complex and get back to the simple, basic truths. Still another response is to avoid dealing with the "whole mess" by losing one's self in a specialty.

There is a different response that supports the view that we can invent the future. This is a willingness to exploit uncertainty. It sounds contradictory—but it means that we are active, probing surgically into our doubts and fears, daring the impossible. It means breaking out of molds and locked-in categories in order to make transdisciplinary models of the kind of future we want.

We have several models to consider for this world of the future. The industrial model is most familiar; after all, this is "where our world is at." This model presumes ever-increasing gross national products: taking more metals and fossil fuels out of the ground; manufacturing, distributing, and selling more products; and on and on.

A second model has considerable currency: this is the person-oriented model. Relationships get lots of emphasis. Material possessions are played down. We sing and dance and play. We value community. We devalue structural authority.

The knowledge model has had some exposure, too. We still build, we still value relationships under this model, but the basic concern is learning and information exchange. The learning mode is dominant.

A fourth model is earth-centered. The major emphasis is to care for the earth. We build, relate to one another, and learn, but the stewardship mode is our first concern.

Of course, other generalized models exist for guiding our investment of time, energy, and resources. But cutting across all these models are shattering effects of what has been termed "transnational macro-technology." Seemingly innocent technology, mismanged for peaceful purposes, has the potential of doing more damage to the earth and its inhabitants than large scale wars. Weather modification is but one example. Consider some others—satellite direct broadcast systems, the space shuttle, genetic stockpiling, drug controlled emotions.

Each of these technologies has the potential of doing unimaginable harm or incredible good. We are seeing what we didn't see before. We are asking what we are doing to the earth and to each other. We have begun the excruciating process of shouldering responsibility for the future. More and more of us are trying on for size the habit of thinking ahead one, two, or more, generations.

Of course this beginning won't immediately wipe away the crises of our time. The crises are real and we must deal with them. The point is that there is substantial evidence that hope for the future is entirely appropriate for us. I'll cite just one example that is close to me—the thrust at Whitworth College to become a college for the future.

As a liberal arts college, we have made a commitment to creating an environment for human development. That is our specific, campus-wide goal: to foster balanced growth in the intellectual, spiritual, emotional, and physical dimensions of all members of our community. Further, our faculty and staff take seriously their responsibilities to serve as facilitators for the attainment of basic competencies such as learning how to learn, using one's style of learning to best advantage, screening and synthesizing information, and making input into the system.

Taking a cue from systems management, Whitworth has instituted a student development program that integrates in-class and out-of-class learning modes. The residence halls, for example, are deliberately and effectively used to help students discover their personal values, struggle to gain autonomy, attain interpersonal skills, and appreciate differences. All of this happens through a process-model approach, rather than either of the two traditional models of acting as substitute parents (prolonging adolescence and provoking anti-authoritarian behavior) or simply as operating on-campus hotels.

These large and small changes of focus and application have moved the college experience at Whitworth closer to what it must be if graduates are to be architects of the future instead of its victims.

But inventing the future cannot be the work of a few—done only by college graduates or any other group. All of us must be participants in the process. We need not all share the same dream, but we must share in the same hope that for all of us history has caused the future to take place in the present. In Kierkegaard's words, "He who fights the future fights a dangerous enemy. The future is not. It borrows its strength from the man itself and when it has tricked him out of this it stands beside him as the enemy he must meet." The future is within each one of us; it only has to be pulled out of us in some way.

In a very real sense, attitude and outlook become activity and new reality. Our world is crowded with proof that the frontiers of the possible aren't determined by the limits of the actual. All of us can invent the future with confidence. After all, everything that is now possible was at one time impossible.

SPECIAL GENERAL SESSION

A DECADE OF PROMISE

Leslie W. Trowbridge, NSTA President 1973-74, Professor of Science, University of Northern Colorado, Greeley

As I have met with science teachers this year, I have been happy to note a vitality and enthusiasm for science teaching that bodes well for the decade ahead. The large attendance at this Chicago convention in spite of energy and inflation problems is evidence for this. Last fall, we had area conventions in Portland, Norfolk, and Boston that were well attended and of very high quality. So far this year we have had 14 drive-in conferences scattered throughout the United States, with 14 still to be held before the end of the school year. The total attendance at these conferences is estimated at over 5,000 teachers.

This is indicative of a vital, growing profession. Science teachers around the country are not shirking their duties in preparing themselves to do a better job of teaching science than ever before. There is ample reason for optimism about the decade to come.

The program planning committee for this convention in choosing the theme, "1984: Minus Ten and Counting" was conscious of the need and the opportunity to put science teaching back in focus during the next ten years. The theme underlies the urgency of this by reminding us that certain forces seem to be at work—in the environment, in society, in politics, and in education—that could, if left to chance or mismanagement produce a world in the next decade that is too near to that nightmare projected by George Orwell in his book *1984*. [5]

Science is a large part of that world. Recent months have shown us clearly the burgeoning problems caused by energy shortages, environmental concerns, and the depression of the human spirit caused by prolonged fixation on political and governmental malfeasance. The communication arts have reached such an advanced stage that we are in a state of perpetual bombardment by various news media. Today there is a minimal time lag between actual occurrence of an event and the documentary or analytical reporting of it. Assimilation time has been reduced to nearly zero. No longer do we have the leisure for reasoned, calculated decision-making. Our reactions are frequently on an emotional level—instead of on a rational level. As a result we see rapid swings in the scale from positive to negative or vice versa in popularity polls, opinion polls, polls on urgent problems, and the like. The communications media have an unprecedented power which requires our best thinking to resolve the problems of balance, propriety, and responsibility in keeping the public informed.

How does this relate to science teaching? Science teachers are not divorced from the world. Many of the pressing problems of today are science based or technology based. The development of a scientifically literate public, attuned to the concept of interrelatedness between scientific, technological, political, and sociological endeavors, is to a large extent the responsibility of science teachers.

What does it mean to be scientifically literate? The Curriculum Committee of the NSTA dealt with this in 1970 in its publication, "School Science Education for the 70s." [7] According to that committee, the scientifically literate person, among other attributes,

—uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment;

—distinguishes between scientific evidence and personal opinion;

—identifies the relationship between facts and theory;

—recognizes the limitations as well as the usefulness of science and technology in advancing human welfare;

and continues to inquire and increase his scientific knowledge throughout his life.

In addition, scientifically literate persons will use the achievements of science and technology for the benefit of mankind.

The document emphasizes that "Science, because it is a human undertaking, cannot be value-free. Emphases on values and on the social aspects of science and technology must be integral parts of any science curriculum." In *Future Shock*, Alvin Toffler underscores the extreme problems of adaptation, assimilation, and maintenance of one's equilibrium in a society enmeshed in rapidly accelerating change. [9] With reference to our rapidly changing society, the committee admonished that, "All teachers, and especially science teachers, are challenged to educate young people to expect, promote, and to direct societal change."

Mortimer Adler, in a speech entitled "The Future of Man," described four revolutions man has lived through or is about to participate in. [1] The first of these, which occurred about 35,000 years ago, was the revolution brought about by man's transition from the primitive Stone Age to the age of iron and bronze. This was a technological change and began to spell the difference between living in a brutal condition with ineffective hand tools and a primitive human condition where animal power could be harnessed and small permanent villages or walled cities were developed.

About 6,000 years ago, the second revolution occurred when human slavery became an institution of technological advancement. Unpleasant as it is to comtemplate, the class division into free man and serf provided the time and opportunities for a *few* individuals to engage in pursuits above the level of toil for pure survival and thereby initiated the beginnings of "civilized" activities in the arts, music, philosophy, sciences, and other areas. Fortunately, as an institutionalized form, slavery has largely disappeared in the world, but one might reflect on the residual forms of slavery still remaining in effect due to economic, sociological, and political influences extant today.

The third revolution, according to Adler, is still with us. It is the democratic-industrial revolution of rising affluence among the world's peoples. Or perhaps more accurately it is the trending toward a universal equality of conditions. This revolution of course has tremendous implications for energy use and distribution, and for an affluent nation like the United States the prospects may be disconcerting because of the possible leveling downward. Basically this revolution would provide the good life for all, not just a few lucky or privileged peoples. Today's problems of energy procurement and distribution are part of the birth pangs of this revolution. The ultimate realization of its goals may be in the distant future, but the problems of its execution are with us now.

Adler's fourth revolution need not concern us greatly here now but indicates a direction toward which man may be moving. It is a future thousands or millions of decades ahead of us in which man finally is able to exploit the full potential of the human mind. The matters of wealth, resources, sustenance, and work will be solved technologically. Human thought will reign supreme. Adler closes his remarks by saying, "It's a future in which men will spend all their time in teaching and learning, learning and teaching one another, and this after all is the only really distinctive mark of the human race."

But the theme of this convention is not concern for a period a thousand decades in the future but for the very next decade. We have sufficient problems to occupy our time and require our best thinking in the immediate future.

One of these problems is the highly mobile nature of our society. Dudley Kirk of the Food Research Institute put his finger on this problem in a recent article in the *Stanford Observer*. He says,

> We have become a rootless people, without the stability of a lasting community life. More and more we are becoming a people without long-standing personal relationships, without the informal sanctions of shared values that keep us in line without the coercion of the law and the police ....
>
> Often we no longer live in a community of friends and relatives; we live in a community of strangers ... Many of our young people, especially our most idealistic young people, are turning to life styles in which they attempt to recreate the more human personal commitments of the past. They are reaching for roots and for the deeper levels of human association that characterized more stable communities. [4]

As science teachers, how are we coping with this problem? Are we even aware of it? Does it not tell us something about the importance of establishing warm, human relationships with students in our classes? Are we not obligated to put our science teaching in the context of human interrelationships instead of in terms of mere organization and structure of subject matter?

A related problem is that of science for all students - not just those who aspire to scientific pursuits. Bentley Glass referred to this problem in a recent edition of the *Pacific Science Education Newsletter*, when he said,

> It is obvious that only a small proportion of all citizens will ever become directly engaged in scientific and technological pursuits. Should science education, then, be concerned mainly with the training of professional scientists, engineers, and technicians, or should it be directed more appropriately at the far larger numbers of future citizens who will live in a world molded and changed by science and who must make political decisions affecting every aspect of their lives? [3]

Glass identifies some of the shortcomings of our recent past efforts in science curriculum reform by stating,

> As I see it, the fault of our new science programs of education is that they have largely ignored this need to instruct all children, without exception, in the nature of human life in a world that is so rapidly and progressively modified by science and technology, by man's own power to change and to destroy as well as to create. The alternative would be a technocratic society run tyrannically by an educated elite. That way lies madness, war, and the end of human civilization. [3]

Our thinking in recent years has been affected by the impact of serious technological problems. Confusion abounds with respect to the differences between science and technology. Many people look at these two facets of our modern life as synonymous. The lines between them have been blurred, and science has been blamed for many technological problems. The highly beneficial aspects of both science and technology have been overshadowed by the specter of calamity in certain sectors of our life.

Kenneth Dowling, specialist in science education at the Wisconsin Department of Public Instruction, has expounded the point of view that science is dead, that "the beneficient image of science created and accepted by the non-scientific public has been pummeled and cast out with little chance or reason for revival." [2] Yet Dowling reports that

> Science and technology have brought higher aspirations and the possibility of a materially better life to the masses, but at the same time a host of domestic and international problems have arisen highlighting urbanization, population explosion, and environmental collapse.

Paul Saltman, vice chancellor for academic affairs and professor of biology at the University of California, San Diego, has commented on the "intense and polarizing struggle for man's mind between the forces of faith and mysticism, and science and reason." [6] Yet, says Saltman, "this is the very moment when the fundamental problems of man have a base in science and technology and cannot be solved without them." He believes that mysticism and reason need not be polarizing forces. Saltman believes that few scientists and technologists recognize and are willing to admit the acts of faith that underlie the very scientific methods that they employ. Among these are three underlying assumptions of faith that every scientist holds—there is order in the universe, man can understand that order, and it is good to understand that order. The recent rising interest in astrology, the supernatural, and occult societies, particularly among many young people, causes us to reflect on the directions we in science education must take to restore science to the realm of the rational and the forefront of reason in society.

In the face of the multifarious problems and forces at work in our society, what hope is there for the future? Are we faced with magnification of the problems of environment and energy, repetition of crisis after crisis in our daily existence, and continued downgrading of the human condition? How does science education fit into the picture? How do science teachers and their students begin to cope with some of these dilemmas?

There are some significant signs.

Dudley Kirk reports that the birth rate in the United States has been going down since 1957, is the lowest in our history, and is still going down. Population distribution, mobility, and affluence have become much more serious problems than total population and growth rates. The NEA reports that there were 15 percent fewer children under age 5 in the United States in 1970 than in 1960. Since 1970 the birthrate has continued to plummet so sharply that the Census Bureau now reports fertility is below the replacement level. This means there are fewer births than are necessary to replace the parents and compensate for premature deaths. However, the total U.S. population will continue to grow well into the next century, because overall births will still outnumber overall deaths for the next several decades.

We see a responsiveness to serious problems by the general populace. Witness the cooperation in regard to speed limits, car pooling, alternative forms of transportation, lowered thermostats, and the like, in our present fuel shortage. It seems we can count on people to pitch in and cooperate when they understand the seriousness of the problem. Young people in our science classes have in many cases led the way. Some examples are the student-initiated "earth days" and "clean up weeks" we experience each year. Science teachers have a responsibility to provide opportunities and encouragement for student efforts at coping with problems of energy conservation and reclamation of the environment.

We see a growing awareness of the need for humanistic science teaching. Count the sessions at this very conference relating to humanism. A quick glance at the program yielded eight titles of major sessions involving humanistic approaches to science teaching. There are probably many more. The Earth Science Teacher Preparation Project was a significant effort at bringing student needs and interests into consideration and of providing alternatives in their education at the college level. Countless other activities along the line of humanizing science teaching are evident at elementary and secondary levels as well.

Now what of the future? Can we see any directions emerging for science education in the next decade? Perhaps some of the following projections will seem more like hopes for the future than true indicators. However, I think there is evidence to substantiate each of them.[1]

1. There will be more concern for children, their progress and self-concepts. Our present trend toward humanization of teaching and learning is evidence for this.
2. We will see greater cooperation and recognition between disciplines.
3. Teachers will be better prepared in content, in psychology, in methods, and in ability to relate to children.
4. There will be more recognition of the multiple talents of children and adults.
5. Schools will put more emphasis on success and less on failure.
6. There will be more emphasis on environmental problems and their solution.

The next decade can be very exciting. Decisions we make and directions we take today will set our course for tomorrow. This is not the time to throw in the towel or retreat from goals that seem remote because of the difficulty of the road. Nineteen eighty-four can be a bright date in the future. Dream for a moment with me about what education in science could be like in 1984:

Children will enter their schools with anticipation. While there they will be provided with a stimulating personalized education, with a reasonable balance between prescription and freedom of choice.

They will have many options and alternatives. The open school, after a shakedown period, will become a viable option among others. We have had considerable research in child development, maturation and growth of self-concepts. We know the benefits of a good self-concept and the productive potential of self-actualized persons. We understand much about the psychology of maturation and growth. This knowledge will help us provide education in science that will nurture interest and positive attitudes and combat the antiscience attitude frequently encountered among many youth today.

[1]These points were further developed in Dr. Trowbridge's address to the convention and in his article on "Trends and Innovations in Junior High School Science Teaching in the United States," which appeared in the May 1974 issue of *The Science Teacher.*

It is almost certain that we will have smaller school enrollments. The NEA reports that smaller enrollments due to declining birth rates will be experienced by some districts this fall and will become widespread by 1976, continuing at least until the end of the decade. [8] If the birth rate maintains current levels, the age structure of the population will change and the school age group from 5 to 22 years will become a smaller and smaller segment of that population. This does not in itself insure smaller classes, however; and it is important that teachers continue to defend smaller class sizes in science and to resist movements to economize by reducing the number of teachers and allowing class sizes to grow to unwieldy and educationally unsound numbers.

School support by the lay public will probably improve, not only in terms of financial suport but also in moral support of the educational enterprise as well. We find that more bond issues are passing these days, indicating a reversal of the recent downward trend. Teachers salaries are still improving, although not yet matching the annual cost of living rise, and it appears that state legislatures are becoming less reactionary after passing through a period of severe cutbacks as a result of the student uprisings of 4 to 5 years ago. Some viable solutions to the financial problems inherent in the use of property as the whole basis for school support will probably be found in the next ten years.

It is likely that the oneness of science with other school disciplines will become an accepted fact by 1984. The fragmented nature of our present curriculum particularly at the secondary level will begin to disappear. Teacher training for the secondary level will begin to foster interdisciplinary teaching approaches in order to prepare teachers for their proper role. The general education function of the secondary school will probably prevail over the highly specialized function we frequently see today. Non-college-preparatory students will begin to receive increased attention in accordance with their larger numbers in our schools and in recognition of the multiple pathways to success in life; not exclusively that of the college education route.

Teaching status will be achieved by qualifying as a *master science teacher*, not only as a chemistry, physics, or biology teacher primarily interested in subject matter. Preparation of teachers in these specialities will continue with a broadened base of understanding and development of ego involvement in the total teaching profession. The influence of the competency-based teacher-training movement currently underway will have resulted in better prepared teachers with skills in communication, classroom management, and development of teacher-student rapport, as well as subject-matter competency. It is likely, however, that the highly mechanistic plans for teacher training using Skinnerian methods will be rejected in favor of an overall humanistic approach to the complex problem of teaching.

Colleges will begin to recognize their responsibilities to the total education process. It will become as respectable to teach as to do research. To accomplish this, the reward system for promotion and salary advancement at the college level necessarily will recognize good teaching as well as other talents. The multitalent approach will pervade all educational levels in the form of differentiated staffing or whatever term best applies to efficient and effective use of all the varied talents embodied in the professional teacher.

The foregoing remarks are not merely wild dreams for the future. We have the expertise with us already to accomplish every one of the proposed goals. Our responsibility is to set our sights on these goals and direct our efforts toward their achievement. This is not an impossible task, and the year 1984 could find us well advanced toward achieving most of these desirable objectives in science education.

We are in an exciting field of endeavor. I can't imagine a more satisfying career than science teaching today, where we have potential for growth, excitement, recognition, and no dearth of worthwhile problems to challenge us. It is a high honor to represent this outstanding organization as it strives for better education in science for all of today's youth. I congratulate you in your choice of profession and for your dedication to its high ideals. I am proud to be one of you.

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NSTA ANNUAL BANQUET

THE EARTH AND HISTORY (SUMMARY)

Harrison H. Schmitt, NASA Astronaut and Pilot, Apollo 17 Lunar Module, Lyndon B. Johnson Space Center, Houston, Texas

From the vantage point of the moon, an astronaut can find enhanced awareness of what was so willingly left behind on the earth. Astronauts can only explore, others will make decisions. Man must always satisfy his curiosity by seeing for himself.

Visiting 16 foreign countries (since the moon) surpassed all of my previous education. The hopes and feelings, the chance for these people to leap into the twentieth century impressed me.

The "education crisis" though not so well known as the other ones is upon us now. We must examine the consequence of choices. We are slipping backward in education—reading comprehension, historical comprehension, and technological awareness are not entering our consciousness. No longer will the consequences of man's actions or inactions be postponed beyond that generation.

How will history view our explorations. As most unusual. There has been a revolution of scientific thought about the moon. Our debt to the men and women of Apollo is incalculable. Our children will be the beneficiaries of the discoveries from this exploration and others of space. Solutions to our problems will require the dedication and imagination of everyone.

We must protect freedom. We must carry the seeds of freedom to the solar system. If we cease to be the leading explorer of space the freedom, the light, will be lost. There is no greater legacy to posterity than the preservation of that freedom which is impossible without the aid of technology.

Historians will write of this decade as singular in the history of the world, in the evolution of the mind. Man found that his reach could include the stars. That was no mean accomplishment.

NSTA-SUNOCO SCIENCE SEMINARS (Abstracts)

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WATER IN THE GEOSYSTEM: PHASE RELATIONSHIPS

Ira W. Geer, Professor, Department of Earth Sciences, State University College at Brockport, State University of New York

The temperatures and pressures at and near the earth's surface are such that water, ice, and water vapor can be found anywhere around the globe. While the major oceanic, glacial, and atmospheric "reservoirs" of water are more or less permanent in quantity, water is constantly on the move.

The flow of water through the liquid, ice, and vapor reservoirs of the earth is often called the hydrologic cycle. This cycle can be explained by the existence of water in the three states of matter and the relative ease with which water can change from one phase to another within the temperature and pressure ranges found in the earth environment. Evaporation, condensation, sublimation, freezing, and melting are processes inherently part of the hydrologic cycle. The formation of clouds, fog, dew, and frost, the initiation of precipitation, and the transformation of snow to glacial ice are only a few examples of these processes in action as components of the water cycle.

A detailed understanding of the hydrologic cycle and the processes resulting in phase changes require knowledge of water phase relationships. A phase diagram for pure water, depicting wide ranges of temperature and pressure in which the various phases of water can exist and co-exist, is helpful to gain this understanding. However, being based on assumptions of pure substance and flat interfaces between phases, the phase diagram cannot be used to explain all the mechanisms involving phase change in the hydrologic cycle. The initial growth of cloud droplets and the aging of snow are examples of situations where mechanisms can be acting due to the presence of impure water and/or non-planar interfaces between phases.

NUTRITION AND COGNITIVE DEVELOPMENT

Elie A. Shneour, Director of Research, Calbiochem, La Jolla, California

The human brain is most vulnerable to chronic malnutrition during the earliest period of life. Its growth during gestation is one of the earliest, most rapid and most extensive developments of the whole organism. After birth and during the first year of life the brain weight increases threefold, and thereafter continues to grow at a faster rate than the rest of the body. By the time a child is four years old his brain will have reached 90 percent of its adult weight, while the rest of his body will have barely reached the 20 percent mark. During these critical periods much more than just an increase in weight is involved. Maturation of the brain involves profound and complex changes in its anatomy, metabolism, and physiology. These processes require the availability of a sustained supply of a wide range of nutrients without which the rapid development of the brain may be impaired. There is a growing body of indirect but significant evidence which suggests that the consequences of such chronic early nutritional deficiencies may be demonstrable for a long time and might even be permanent. The U.S. Senate Select Committee on Nutrition and Human Needs (1969) has defined malnutrition as "an impairment or risk of impairment to mental and physical health resulting from the failure to meet the total nutrient requirements of an individual." This definition is particularly significant in its recognition that the brain can be impaired by malnutrition.

Structural deficiencies are likely to be accompanied by dysfunctions involving cognitive potential. A number of responsible investigators in this country and elsewhere have reported striking correlations between chronic early malnutrition, brain damage and mild-to-severe mental retardation.

While it would be misleading to suggest that chronic early-life malnutrition is the sole environmental factor influencing later mental functions, that relationship among disadvantaged human populations has been abundantly reported. That there are hereditary differences among human beings is an undeniable fact. That we are all, individually and collectively, the product of our genetic heritage is equally certain. But it is also well established that expression of genetic factors can be strongly influenced by such environmental factors as chronic malnutrition and the lack of social stimulation. Thus the existing evidence does not sustain the argument that superior mental ability might be the favored province of any one human group at the exclusion of others.

RADIATION AND SOCIETY: A PROBLEM OF INFORMED CHOICE

Edward I. Shaw, Professor and Chairman, Department of Radiation Biophysics, University of Kansas, Lawrence

The development of nuclear power as an alternative source of energy has generated many heated debates over the questions of reactor safety, radioactive waste disposal, land usage, possible environmental contamination, and the expected consequences of exposing populations to low levels of radiation. This course is concerned with the presentation, evaluation, and use of the available information in the quest for the achievement of a balance between conservation of natural resources (land, water, air quality) and their use in the production of energy and goods. Special emphasis is given to the evaluation of hazards and risks associated with both nuclear power generation and medical and industrial uses of radiation, and their biological and environmental implications. These will be compared and/or contrasted with the hazards and risks of alternative processes.

Toward this end, the nature of radiation and radioactivity is discussed to develop a basis for understanding the mechanism of production of radiation effects in biological material. The relationship between radiation dose and the frequency with which somatic (leukemia and cancer) and genetic radiation effects are examined with the objective of determining the level of risk associated with particular levels of radiation exposure (natural background, medical, industrial, and nuclear radiation sources). The solution to problems of radiation exposure from development of radiation associated technologies (such as nuclear power) cannot be developed in isolation from problems of population, levels of current energy usage, the levels of reserves of fossil fuels and other scarce resources, the allocation of scarce and depletable resources, environmental deterioration, etc. These problems are all interrelated and action upon one will affect the others. What are the possible courses of action that might be taken to meet energy needs? What are the costs (or risks) involved for the benefits to be derived from a particular course of action? When the consequence of all possible choices are known, how can a decision be made which is generally considered acceptable? What is the role of value judgements? What is the role of a science teacher?

THE SOIL AS AN ECOSYSTEM (ELEMENTARY)

Albert Schatz, Professor of Curriculum Instruction, College of Education, Department of Elementary Education, Temple University, Philadelphia, Pennsylvania, and Most Distinguished Professor, University of Chile, Faculty of Chemistry and Pharmacy, Santiago

The soil is literally the basis of our environment, and an ecosystem which schools have not yet adequately exploited. Soil science can be profitably used in teaching biology, chemistry, geology, physics, and other subjects. Studies of the soil have a particular appeal to students who are concerned about pollution. Many of them have become interested in the organic movement, which begins with the soil, because they believe it can contribute toward alleviating environmental problems. Some important educational objectives of the organic movement are indicated by the philosophy expressed by J. I. Rodale: "The organic way is the golden-rule way. It means that we must be kind to the soil, to ourselves, and to our fellow men."

The soil-food-health chain links man and Mother Earth as two components of the ecosystem in which we live. The fertility and productivity of soils have made possible the rise and decline of civilizations, influenced the kinds of cultures which developed, and determined the survival of some animal species such as the Giant Sloth. The fertility of soils can also affect the nutritional quality of foods produced on those soils, and in that way can influence the health of man and animals which consume those foods.

From the point of view of the classroom teacher, many soil activities require only simple, inexpensive, familiar, and readily available materials. Children themselves can bring in much or all of what they need to do the experiments. Also, no special preparation such as workshops, in-service programs, summer institutes, or "awareness sessions" are necessary. Teachers can read about soil activities one day and begin doing them in class the next day or so. It is not necessary to order expensive, prepackaged, commercially-produced materials which increasing numbers of school systems can no longer afford. Soil activities offer teachers "instant science," which is a "Do-It-Yourself Science" that students find interesting and relevant.

POLLUTION

Thomas H. Keil, Associate Professor of Physics, Worcester Polytechnic Institute, Worcester, Massachusetts

The flow of energy, resources, and waste in modern high consumption society is discussed in a general way. The discussion centers on the eight strategies available for designing waste disposal systems consistent with the societal goals of pollution control, conservation of energy and resources, and material wealth. The eight strategies can be applied in varying mixes to the disposal problems associated with a variety of wastes, including solids, liquids, gases, noise energy, and thermal energy.

A particular solid waste management problem, that of designing a system for the disposal of municipal solid wastes is also discussed. Technological constraints established by the current state-of-the-art and economic constraints are considered as part of the design process. It is observed that, although optimum designs are fairly easily obtained, the designs are rarely implemented for a complex mixture of social and political reasons. The implications of these implementation problems and prospects for the future are discussed.

NSTA FORUMS

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FORUM I
POPULATION

Thelma Wurzelbacher, School of Natural Resources, University of Michigan, Ann Arbor

Minus 10 and counting. Counting what? Counting 3.8 billion people in the world. Counting 210 million people in the United States. Counting 800 people in this room. Counting 6 people on this platform. Yes, counting populations, and experiencing issues related to the number of people, their locations, and their needs.

By United Nations declaration this is World Population Year. The World Population Conference will be held this August in Bucharest. This will be the first worldwide gathering of delegates to speak out on population concerns in the name of their government. Four symposia have been held to prepare materials for the international meeting. The symposia dealt with population and economic development; population, resources, and environment; population and the family; population and human rights. Proceedings from these four symposia will be used by participants in the World Conference.

The urgent task of World Population Year is to make people in every country aware of the complexity of the issue of population growth. Global population policy is in the making.

This forum is challenged to highlight World Population Year for science educators. Our goal is to encourage you to deal with population education, to help you learn a few basic facts and trends, to share with you a working model, and to provide you with teaching resources and selected materials.

THE BALTIMORE EXPERIENCE IN POPULATION EDUCATION

Caroline S. Cochran, Coordinator; and Lester McRae, Director; Urban Life Population Education Institute, Baltimore, Maryland

The enormity of the population situation has come upon us so suddenly that few people have dared to face the terrifying realities. However, the 1965 National Academy of Sciences' report on the *Growth of U.S. Population* urged the inclusion of population studies in the curriculum of secondary schools; and, since that time, the Baltimore City Public Schools and the Planned Parenthood Association of Maryland (an affiliate of Planned Parenthood-World Population) have accepted that challenge. Their most recent effort has been through experiments with the Urban Life-Population Education Institutes (ULPEIs) to find ways in which awareness of the population situation can be brought in a non-threatening way to all of the children in the city school system, many of whom are poor and Black.

Population education is the process by which students investigate and explore the nature, meaning, and effects of population growth and its various characteristics, thereby learning that individual acts have demographic consequences for their immediate and future lives. Although knowledge of reproduction and contraception are integral parts of both population education and sex education, population education is not sex education. Our experience has convinced us that efforts to combine these two necessary areas of knowledge dilute the effectiveness and importance that each deserves.

Since it is a relatively easier process to bring population education to the suburban child than to urban children who are already feeling population pressures firsthand, a new approach had to be developed to deal with and explore the basic fears and racial sensitivities of people in a realistic and humane manner. We, therefore, concluded that, until teachers intellectually grasped and personally understood the implications of the population dilemma, they would be unlikely to teach it.

Our pilot Urban Life-Population Education Institute (ULPEI) for thirty selected Baltimore City Public School teachers, K-12, was held in June, 1971. During the three days we not only discussed the problems of the city but also dealt with the many pros and cons of the population situation, including genocide, white fears, and whether the United States should or should not change its immigration policy. We never tried or asked for consensus; all discussions were open-ended, a fact some teachers found rather unusual.

The response to this pilot ULPEI was gratifying. The participants felt that population education should be included in the public school curriculum, K-12. And there were resounding pleas for all variety of materials to assist them.

On the basis of our initial experiment, the Rockefeller Foundation gave Planned Parenthood Association of Maryland a grant to continue their work with the Baltimore City Public Schools.

The population education program in Baltimore started with several principles:

1. All teachers in the school system should be given the opportunity to receive training in population education regardless of their particular area of competence.
2. Education in population processes can and should occur at all grade levels from K through 12.
3. Population education is meant to educate, not to propagandize or indoctrinate. Population is not viewed as a problem to be solved but a phenomenon to be understood.

Nine Urban Life-Population Institutes (ULPEIs) for thirty teachers each were held during the 1972-73 school year. All teachers in the system could apply for the three-day session which was held during school hours. (A major portion of the grant was used to pay for substitute teachers.) An evaluation team from the Population Dynamics Department of the Johns Hopkins University School of Hygiene and Public Health randomly selected the 270 participants by computer. Those who did not attend served as the control group in our follow-up.

During the three days the problems of our city, Baltimore, were divided into four major categories: Living Problems (housing, family, neighborhoods, recreation, density, pollution, crime, justice); Health Problems (medical care and services, nutrition and hunger, mental health, drug abuse); Public Problems (education, employment or the lack thereof, transportation, fiscal and legislative matters); Attitudes (suburban vs. urban, white ethnic, welfare, and in the role of Black women).

For each of the aforementioned areas we invited three local experts to hold brief panel presentations. These were followed by discussions with the teachers who had been divided into groups of ten. We consider our discussion on attitudes our most important feature. It had a large impact as it exposed a teacher to different strongly held attitudes and beliefs.

At the end of each ULPEI the participants were asked to make a formal and informal evaluation. The formal one was for the Johns Hopkins University evaluation team. The preliminary results have demonstrated that there was an increase in knowledge about population and its effects as well as a constructive change in the teachers' attitudes toward population. The informal evaluation, for the purpose of updating and improving the quality of the ULPEI, showed that the teachers felt the ULPEIs were thought-provoking, educationally sound and rewarding.

In summer 1973 nine imaginative and creative Baltimore City classroom teachers, all of whom had attended an ULPEI, developed materials for curriculum use in grades K-12. We have received an additional grant from the Rockefeller Foundation to continue our work through the 1974-75 school year.

The materials developed during the summer of 1973 by the nine Baltimore City classroom teachers are being piloted in the Baltimore City schools during the 1973-74 session. Hopefully, after evaluation and revision, most will prove acceptable and will become an integral part of the school curriculum. The materials on the elementary level, while primarily designed for the social studies curriculum, can also be used in mathematics, science, English, music, and poetry. The secondary package is designed for a twelve-week unit, a minicourse, or a tri-semester. It has six self-contained units entitled:

1. Mathematical science is an integral part of demography.
2. Population is a world problem.
3. Population exacerbates urban problems.
4. Family life and composition affect the individual.
5. Personal decisions and life-styles have social and demographic consequences.
6. The earth's natural resources are finite in relation to the infinite demands of continuing population expansion.

Each of these two-week units is complete with detailed lesson plans, bulletin board instructions, evaluation devices, games, and various types of audiovisual materials.

In addition to these self-contained packages for the secondary level, packages on population (POPS) have been developed. These packages are designed for students to use independently at their own level and pace.

It is significant to note that there are many principal problems and obstacles in the introduction of population education into a large urban system.

1. There must be a person within the sytem, who knows the system, and an interested outside person to cut the red tape. Face-to-face contacts must be made.
2. Those in charge of the system must be involved in the initial planning of the program and kept informed about every step in its development.
3. Teachers should be notified by staff publications, word of mouth, and at departmental meetings.
4. Most large urban systems have a severe shortage of funds. Therefore, most materials that you will use for teacher awareness must be compiled and duplicated in-house. If teachers are to be released for training, substitutes must be paid. Thus, you can see the need for outside funding. If it were not for the Rockefeller grant and the help of Planned Parenthood, our program could not have been successful.
5. In order for teachers to relax and actively participate and vent their true feelings, an area outside of the school must be utilized. In our case, the Planned Parenthood facilities in downtown Baltimore were used.
6. The community must be made aware of the program. We received publicity from the *Sun*, *News Post*, and *Afro American* newspapers and inquiries from various community organizations. We answered queries successfully, thereby eliminating any adverse reaction from the community.
7. In a population awareness program the issue of genocide and the varying attitudes of the community must be presented. We further believe, in order to be aware of the population problem, that teachers must be taught some basic demography.
8. When planning for teachers, one must be aware of the ability levels of the teachers. That is, 50 percent medium, 35 percent good, and 15 percent imaginative and creative teachers. Materials must be geared for all teachers.
9. We believe the teachers are the best indicators of levels and grades at which population education should be taught. We, therefore, asked the teachers. They responded, "K-12" and, believe it or not, "shop, music, physical education, and foreign language." We also contacted standard subject-matter heads, who offered assistance (social studies, science, mathematics and English).

Our efforts in the Urban Life-Population Education Institute have been highly illuminating and full of impact. The response of the participants sustains in us the belief that we have set in motion an exciting and meaningful curriculum effort. The knowledge and skills that our participants have obtained will be of inestimable value in the classroom setting. Our efforts, to be sure, have been pragmatic.

It is our belief that additional resources, support, and time will enable us to prepare teachers to form a potent cadre to teach and buttress population education in the Baltimore City Public School system.

POPULATION: FACTS AND MATERIALS FOR THE CLASSROOM

Carl A. Huether, Department of Biological Sciences, University of Cincinnati, Ohio; Director, 1973-74 National Science Foundation Summer Population Institutes, Cincinnati, Ohio

My objectives for today are: (a) to provide some basic understanding of population dynamics with which you may not be familiar, and (b) to maximize the possibility that you will vigorously and enthusiastically implement population education upon your return to the classroom by discussing and presenting some excellent pop. ed. materials to you. (Although a pretest was given to lecture participants it is not included here due to space limitations.)

One of the first items necessary in understanding population change is to have an overview of where we've been, where we are now, and where we might be heading on a worldwide basis. A five-minute film originally produced by the United States Information Agency for showing to our Latin American neighbors was an attempt to encourage them to slow their own rates of population growth. This edition is the same as the original, except pictures of the earth have been added by the new producer, Southern Illinois University.

This is a superb visual display of how our population has increased dramatically within the recent past. Population distribution, population reductions during various periods, are also clearly shown. It is one of the excellent pop. ed. materials available for use at almost any grade level. The film is entitled: *World Population*.

The film makes it very explicit that we have had, and are still having, a population explosion on a worldwide basis. Thus, without getting into semantics on the definition of a fact, I will state that the population explosion in the world today is a fact. However, I also feel that whether there is a population crisis is opinion rather than fact, an opinion which each of us must decide for himself.

The emphasis placed in the film on the finiteness of the earth is a very important point. While we have known this elementary fact for a long time, and were introduced to the concept of a "Spaceship Earth" by Buckminster Fuller more than two decades ago, it seems to me we have only very recently begun to understand and accept what this means. The opportunity finally given us in the late 60's to observe our own spaceship from a smaller man-made one poignantly brought home the realization that our biosphere clearly has limits. The pictures afforded us by our astronauts, such as the one shown in the first slide, were an important trigger of the Ecology and Earth Day movements beginning in 69 and 70.

In terms of population size and growth, it helps us to formulate what are, and are not, the important questions. No longer is the proper question: "Should we have a zero rate of population growth, or ZPG?" for on a planet of finite size, it is obvious that nothing can grow indefinitely. Charles Darwin was the first to give this concept biological meaning through his views on natural selection and survival of the fittest. It is interesting to note that his thinking was significantly influenced by a contemporary named Thomas Malthus. No population in nature continues its growth for long periods, but rather, comes fairly quickly into either a stable or dynamic equilibrium with its environment.

The questions we should be asking are: "When should we have a zero rate of human population growth, and How? On a worldwide base, the *how* is by births equalling deaths, which means either birth rates must go down or death rates up. Since none of us will realistically argue the latter, the only significant question is *when*. For those who believe population change to be a crisis, their answer would be as soon as possible. For those who believe population not to be a serious problem, the answer is generally somewhere in the relatively distant future. At a current world population size of 3.86 billions and a yearly increase of 2 percent the projections for the year 2000 are approximately 7 billions. Clearly, these rates cannot persist for many future generations.

Two slides show estimates of population sizes and growth rates throughout man's history, and current population figures for 1973. While these data can only be taken as approximations of the truth, they are viewed by both anthropologists and demographers as representing the correct scale of magnitude.

The next question is obvious: why has this explosion in population numbers occurred over the past 200 or so years? The answer is perhaps surprising; but is because of rapid reductions in death rates rather than increases in the birth rates. In simplified terms, these death rate reductions were brought about by the development of the industrial revolution; the advances in food production, and the advances of modern medicine in controlling disease. The availability of food and medical technology to infants particularly, allowed a dramatic reduction in infant mortality rates. The countries which brought about and experienced the industrial revolution are generally termed Developed Countries. A slide depicts an idealized graphic representation of how their death rates dropped over a period of roughly 75-150 years. As industry and technology were further developed, social changes also occurred in these countries to cause a later reduction in birth rates. One of the important sociological changes involved where people lived and worked; they moved away from the farms and into urban areas where better jobs could be found. This shift changed children from being an economic asset to an economic liability, and encouraged parents to have fewer children. The change from high death and birth rates, which had been the norm for all of man's history, to low death and birth rates is called The Demographic Transition. Modern technology was transferable to underdeveloped countries which were not developing the industrial revolution on their own, so during the early and middle 1900's, many UDCs were also able to realize a drop in death rates, but one much sharper than that experienced by DCs. Because the technological advances were developed externally, UDCs have not experienced the sociological changes found in the DCs, so that their birth rates have remained high. They have yet to complete the demographic transition, so their yearly rates of growth are currently very high.

As a class activity, you can generate data on your own which demonstrates firsthand for your students the significant reduction in infant mortality which has occurred. This is accomplished by taking your students on a cemetery field trip. We have done this for three years with secondary teachers at National Science Foundation Institutes on Pop. Ed. at the University of Cincinnati. It is a way to get the students actively involved with data collection and analysis out of the classroom, and at the same time to demonstrate an important demographic principle.

Our next point is to understand what effect a rapid reduction in infant mortality has on the age structure of a population. A slide shows the age structure pyramid for a rapidly growing population such as India. Reduced infant mortality means an expanding base of the pyramid, which in turn means a higher percentage of the population will be reaching reproductive maturity themselves. As the percentage of the population which is reproductively active increases, if they have the same number of children as their parents, or even significantly fewer, they contribute to a continually expanding population base because of their large numbers. This then produces a positive feedback cycle, and results in the population explosion.

So far, I have tried to cover briefly: (a) our demographic past, showing little or no growth in population size throughout essentially all of our history,

(b) our recent control of death, particularly in reducing infant mortality, has been the cause of our very recent and rapid increases and (c) UDCs have not yet been successful in reducing their birth rates to complete the demographic transition. Here it is also true, however, that the great majority of DCs have not as yet brought their births down exactly equal to deaths either.

If the discussion has been clear to you so far, you have a general understanding of why the world has experienced such rapid population increases in the recent past. Now to concentrate on the United States alone.

Three slides show how birth rates have dropped almost continuously in the U.S. throughout our history; yet population has increased at a rather substantial rate. This is due to an even more rapid reduction in death rates, and also to a large amount of immigration. This emphasizes the third human activity which must be measured besides births and deaths to determine the growth of a country's population–migration–both immigration and emigration. This of course has no current meaning when discussing world growth rates.

The next slide shows births and death rates per 1000 population (called "crude" birth and death rates–not because they are uncultured, but because they do not take into account the age structure of the population). This shows our levelling off of death rate decline in the past 30-40 years, and also how violently our birth rates have fluctuated during this period. This information is critical to understanding the reasons for current growth of the U.S. population. Throughout the decade of the 30's we had a low birth rate, brought on principally by economic incentives not to have children at that time. Rather than not having these children at all, couples decided to delay having them. Thus, births began to climb again during the second world war as the economy regained strength, and of course, birth rates shot up dramatically after the war, producing what we all know as the post war baby boom. These high rates continued from 1947 to approximately 1960, with the decade of the 60's showing once again a declining birth rate. Perhaps the two most important reasons for this are: (a) that the births delayed in the 30's and early 40's had all occurred by the end of the 50's, and (b) the lower number of births in the 30's meant a low percentage of females in their prime reproductive years of 20-30 during the 60's. This is dramatically emphasized in the slide showing the age structure pyramid of the U.S. population in 1960. Certainly the introduction in the early 60's of the pill, as the most effective temporary means of fertility control, contributed as well to the declining birth rates.

A slide shows in detail what has happened to birth rates since 1970. Other than a slight increase in the curve in 69 and 70, the birth rates for the U.S. population have been falling steadily, not only in the 60's, but also in the 70's to date. The drop of the past few years has been labeled the birth dearth because the birth rate was expected to rise as a result of the post World War II baby boom children coming into their reproductive years. This is shown in the age structure pyramid for 1970 on a slide. The black outline shows the 1970 pyramid, and indicates the very large percentage of females now in or approaching the reproductive years of 15-45. (While we understand males are a necessary part of producing children, females are the important demographic determiners.) With this high percentage of fecund females, if they had averaged anywhere close to the number of children their parents did, we would have experienced a second baby boom. But right now, they are averaging only 2.03 children per family, which is actually below the replacement level of 2.1. Does this mean we are actually a nation experiencing negative population growth? The answer is no, because our current age structure is so very different from that which would be needed to have ZPG if the average number of children were 2.1. The necessary age structure to allow equating 2.1 with ZPG is shown in rust color. This is one of the two key reasons why we currently are still a growing population even though women in the reproductively active years are producing only an average of 2.03 children–they are simply a large bulge in the population! This is a point that far too many public media newscasters miss, which leads them erroneously into writing we are not now replacing ourselves, or are therefore below ZPG, because they see the 2.03 figure.

Slides dealing with demography show exactly how ZPG and growth rates are calculated, and give actual figures for 1973. This is our natural increase for the year (1,177,000) to which 375,000 legal immigrants must be added resulting in a 0.74 percent growth rate. The population of the U.S. is currently 211 million, our growth rate percentage is 0.74 per year. As of 1973, it would take about 93 years to double our population at this rate. The current U.S. population, since our average of 2.03 children per family is *below* the replacement level of 2.1, yet we still have a growing population, and 24 percent of our current growth is attributable to immigration. Besides our peculiar age structure, this is the other important component contributing to our current growth. I should stress that this is only legal immigration being included; estimates are that an additional several hundred thousand aliers may enter each year.

A final demographic slide shows the projections made recently by the Census Bureau. Since demographers have been notoriously wrong in their past projections, the Census Bureau tries to overcome this by presenting a series of projections, a series that will hopefully "cover the waterfront." For reasons we will not go into here, their Series F (at 1.8 children per family) is closer to our current fertility rates than is series E (2.1 children per family). However, even series F projects a population size of 250 million in the year 2000.

You might ask: "is all this demography really necessary to teach pop. ed.," or another question may be "is this all there is to population education?" In answer to the former question, I believe teachers must have a general grasp and comprehension of the broader view of population change before they themselves can expect to educate others. Additionally, while it is true we seem to respond more to local population concerns which are closer to our own self-interest, this self-interest is considerably affected by what happens on the national and international levels. On the latter question, there is of course much more to pop. ed. I have spoken mostly to the causes of population change, and not to the consequences and ramifications of these changes; e.g., correlating population with environmental deterioration, resource depletion, energy needs, food demands, high density problems, etc. These are lifelong pursuits, but we have materials and activities to be distributed which will aid you considerably in beginning.

You may want to look at population politics, or perhaps encourage your social science teachers to do so. If you do, you will find that while President Nixon was the first president to deliver a message to Congress specifically on population, and the first to appoint a Population Commission, he also has largely ignored the Commission recommendations, except to state flatly that he disagreed with two of the 69 they presented. I want to close with a resolution of particular interest to this forum passed at the last meeting in July, 1973 of the National Education Association in Portland.

> The National Education Association recognizes that population change in our communities, our nation and the world have continuous implications for our lives both professionally and personally. The processes of population changes whether local, national, or global are difficult to understand. Schools can play a vital role in educating the students and general public by presenting facts and alternatives for future growth patterns; thus enabling both students and the general public to make wise decisions concerning population growth.
> The Association shall make available data about population change. The Association and its state and local affiliates shall encourage public schools to include studies of population education in their curriculum.

FORUM II
WOMEN, MINORITIES, AND CAREERS IN SCIENCE

WOMEN AS SCIENTISTS

Helene N. Guttman, Professor, Department of Biological Sciences, University of Illinois at Chicago Circle, and Professor, Department of Microbiology, University of Illinois Medical School, Chicago

Should young women consider becoming scientists? Why not? There are so many different branches of science, each with their own requirements for type of specific knowledge, that a wide array of interests and personality types can be accomodated.

The more timely question for you is why you feel that the question is a fitting one to ask about your women students and not your men students. The answer reveals all the societal pressures and mixed messages received by young women students with aptitude for the sciences or for any other profession in which women role models are scarce. Thus career advising is an important pivotal point in the development of young women scientists in that it can either reinforce negative societal pressures or supply the necessary encouragement and direction at a crucial time. Clearly, you are aware of these problems and are here to help institute corrective measures or – as we say these days – to institute an affirmative action plan which will insure equal opportunity for all based upon their merit. As a Woman who is a scientist and an officer of the Association of Women in Science, I am pledged to work with you to accomplish this. Only in this way can we fully utilize the most precious natural resource of our world community, the intellectual capacities of *all* people.

Now that my career is more than half over, I can speak about some of the past excitements and aspects of my own developmental pattern so that you may use some of my own experience to serve as the basis for your questions and discussion and as a means of selection so that we can try to pass on only the most supportive aspects to current and future student generations.

The *sine qua non* for an experimental scientist is curiosity. In my case, this was manifested by an early desire to have some one read to me and then to read to myself. Many embryo scientists can be recognized by their collections of dead and live plants and animals and this was indeed the pattern exhibited by my 13 year-old goddaughter who is here today to help me field your questions. My parents however were not nature enthusiasts and I grew up in a city with summers by the sea shore. My outdoor interests ran to all sorts of games and sports with omnivorous reading sharing time with art and modeling as rainy day activities. I read Amelia Earhart's biography and admired her. But flying always seemed to be an avocational adventure, not a career choice, so that only now have I finally attempted to find time to learn to fly. At age 10 I read *Microbe Hunters* by De Kruif and found my childhood hero, Louis Pasteur. As the years passed, I unconsciously gravitated towards his pattern of being a microbiologist and also a multidisciplinary scientist. Other interests in art, history, politics, and writing remained as potential careers for some time because these were areas in which I had some ability and were then thought to be more appropriate careers for a young woman. Because of the mixed societal pressures, I was forced to reconfirm to myself continuously that my desire to be a scientist was stronger than other possible career choices.

To be a scientist is every bit as creative as to be a painter or modeler. In all instances there are techniques you must learn first for they serve as foundations for the more imaginative work. For both the arts and sciences one can choose to be either a technician or an innovator for our world needs both of these types of people. Early in my career, I was fortunate to have been exposed to an unusual research laboratory environment in which beginners sought their own more advanced colleagues and through such exposure and individual study, could advance at their own pace. In addition, working hours were flexible because our lab was poor and most of us held other jobs to support ourselves and at the same time went to graduate school. Such an arrangement tested my desire to be a research scientist and taught me how to compartmentalize my life so that I would not have to sacrifice any of my avocational interests. In retrospect it prepared me for the ever increasing tempo of our technological society. Because our poor laboratory was not air conditioned for several years, two of us developed a summer work schedule which included working early in the morning, swimming all day long, and returning to work in the evening. We ended our first summer tanned, happy and with our first major scientific contribution although neither of us had yet completed even our first graduate degree.

Because I was allowed to find myself scientifically in a somewhat unorthodox laboratory, my own laboratory always has been open to young people who want to learn even if they are not technically registered for a course I am teaching. In my university career, however, I have worked to restructure courses and curricula so that young students can acquire, within the normal school framework, the type of foundation information, opportunity for research, and conversation with interested senior people that I picked up largely outside the classical academic environment.

For me, continued association with universities is the foundation of youth. Since my research areas are fast moving, I will be a student all my life and so am one with the people I teach except that I am physically older. Training young people in one or more of my areas of interest and then following their contributions towards making this a better world is my connection with posterity even more than the papers I write.

FORUM III

THE ENERGY CHALLENGE–1974 AND THE FUTURE

COAL–A NEW LOOK

George W. Land, Director, Market Research, Amax Coal Company, Indianapolis, Indiana

In the 1840's, fossil fuels supplied only 5 percent of the world's energy–men and animals 94 percent–one hundred years later, fossil fuels supplied 93 percent, men and animals 6 percent. Coal made up more than half of the fossil fuel. But in the U.S., this was down from 89 percent in 1900, and the decline is still going on. In spite of the fact that coal reserves represent 88 percent of all proven energy reserve in the United States, in 1972 coal supplied only 17.2 percent of the total energy used here.

The United States now has an energy supply problem of major magnitude. It was not unexpected, nor did it develop overnight. It can be overcome but not overnight. If the United States will make a commitment to research and development, manpower, and dollars of the same order of magnitude made to the man-on-the-moon effort, we can achieve energy independence by the mid-eighties. One principal ingredient in this accomplishment will be coal's new look–clean energy from coal through improved combustion systems–combustion gas emission controls and clean gaseous and liquid fuels made from coal can supply basic energy not only for stationary but also mobile prime movers. Coal will have a new look and once again become "king" of the fossil fuels.

ELECTRIC ENERGY OUTLOOK

George A. Travers, Executive Assistant, Commonwealth Edison Company, Chicago, Illinois

I. Introduction: Electric energy is not a raw material, but a manufactured product. Its supply is, therefore, determined by two factors – the availability of fuel and the capability of power generating equipment.
   A. The data in this presentation is limited to Commonwealth Edison Company, serving 8 million people in Chicago, and northern Illinois, and its interconnected companies, the Mid-American Interpool Network.
   B. The presentation includes an appraisal of the demand for power in the next decade, the planned power supply to meet that demand, and the long-range future of power generating techniques and sources.

II. The Demand for Electric Energy: Historically, for the past few decades, the demand for electricity has doubled every 10 or 11 years in the Chicago land area. In the next decade we expect this to continue, with some possible slowing down in the decade to follow.
   A. There are present and foreseeable social and economic elements that will act as deterrents to electric energy usage in the years ahead.
      1. Saturation levels are being approached in certain high-usage commercial and residential loads. The growth rate of air-conditioning, for example, for the past 20 years cannot be expected to continue for the next 20.
      2. There is abroad in the land a resurgence of the pioneer conservation ethic: "Waste not, want not." This will tend to reduce consumption, not only by householders, but by better energy management in plants and offices, by better design of structures (glazing, insulation, etc.), and by better utilization of equipment.
      3. Assuming some elasticity of demand, any increase in the price level of electric energy should have a negative effect on consumption.
   B. Conversely, there are offsetting social and economic elements that will spur the future use of electric energy.
      1. The gradual rise in population, families, housing units, jobs, and gross national product will exert continuous upward pressure on the demand for electricity.
      2. The increased attractiveness of using automation, electronics, and other power-consuming hardware to replace and augment human labor will cause industrial and commercial usage to rise. Similarly, the use of electric vehicles, from fork lifts to "second" automobiles, whose batteries are charged at night, will add useful load without adding to the peak load problem.
      3. Recycling solid wastes, re-processing glass, reclaiming paper, reusing metal, and increasing municipal sewage treatment all use large amounts of electric energy Better water waste management, increased precipitation of stack emissions, and other clean-up devices will add further to industrial demand in the years ahead.
      4. The goal of increased and vastly improved mass transit systems in large urban and suburban areas will also add a sizable electric energy load in the future, replacing petroleum consumption.
   C. The net effect of these many complex and, at present, unquantifiable vectors appears to us to be an upward usage of power of between 7 percent and 8 percent annually; we expect this to be several percentage points lower during the present Arab oil embargo.

III. The Supply of Electric Energy: Commonwealth Edison now has a total capability of producing approximately 16,500 megawatts of electric energy. About 5,000 megawatts of this is in nuclear units; over 9,000-mw in conventional fossil-fired plants; a little less than 2,000 in fossil-fired peaking plants; and 500 from the pumped storage facility in Michigan.

A. Edison's fuel budget for the current year is roughly: 20 million tons of coal; about 3 million equivalent tons of coal in the form of oil and natural gas; and about 12 million equivalent tons of coal in the form of nuclear fuel; or about 35 million equivalent tons of coal, in all.

1. We have long-range coal contracts for both Illinois and western coal which will be sufficient for the foreseeable future. The total national coal reserves are equivalent to something over 500 years' supply.

2. We will be importing low sulfur residual fuel oil for a great many years to come. The present oil embargo will, of course, have an adverse effect on our ability to use foreign oil. Premium oil and natural gas will also be used for peaking units. Our use of these domestic fuels will be subject to the limitations of our suppliers, just as for all other users, and this may reduce our generating capability from time to time.

3. The nuclear fuel suppliers do not foresee any serious difficulty in mining ore and processing the fuel for the present generation of reactors. The development of the breeder reactor and its salutory effect on the supply of fuel holds great promise for the future reserves of domestic uranium ore.

B. Commonwealth Edison's planned additions of electric generating facilities by the end of 1982 call for some 4,300-mw of fossil-fired units, and about 9,000-mw of nuclear capacity.

1. An additional coal-fired unit at Powerton (840-mw), near Pekin, will be installed in 1975, and an entirely new oil-fired station will be built on the Illinois River near Morris, capable of 2,500-mw (five mw-units). Both will use cooling lakes. An additional 1,000-mw will be installed at Will County Station, using cooling towers in 1977-78.

2. Eight nuclear units – four pressurized water reactors, two boiling water reactors, and two as yet undesignated – will be placed in service before the end of 1980; these include Unit 2 at Zion Station on Lake Michigan; LaSalle County Station 25 miles down the Illinois River from Dresden; Byron Station, using cooling towers, 18 miles southwest of Rockford; Braidwood, 25 miles south of Joliet on abandoned strip mine property; and two near Savannah, Illinois on the Mississippi River.

C. The total capability at the end of the decade should approximate 29,000-mw, about half of which will be nuclear. During these years, generating reserves (capability in excess of peak load) will range from about 12 percent to over 20 percent, based on long-range load forecasts and anticipated start-up dates for new equipment.

D. The availability of both firm and emergency power from our neighboring utility companies provides additional capacity should we be caught short by unforeseen delays or unplanned equipment outages. The amount of energy available will vary from day to day and year to year, depending on a variety of factors, including weather conditions.

IV. Conclusion: We foresee no shortage of electric energy if all our plans for new construction are met; delays in construction and equipment delivery, over-long hearings and other procedural delays in the regulatory process, and selected fuel shortages of oil and natural gas could all have a bearing on Edison's ability to meet the demand during a given period of time. We remain optimistic about our ability to meet customer's demands throughout this decade.

A. Many of the governmental and private projections of the long-range energy supply situation in this country include a great deal of conjecture and depend to a great degree upon undeveloped technology. At present, the breeder nuclear reactor appears to be the most promising next step in energy production with minimum impact on the environment and natural resource reserves.

B. Beyond the breeder in the nuclear area is the great promise of fusion, which is now developed only in theory. Escalation of the theory to workable bench models and prototypes to commercially operable machines is at least 25 to 30 years away.

C. Natural energy sources – hydro, solar, geothermal, winds and tides – all hold some promise for limited local energy supply by the end of the century, but cannot be depended upon as meaningful supplements to man-made electric energy.

D. Exotic man-made generation concepts, such as magnetohydrodynamics and electrohydrodynamics, are also promising for limited, localized usage, but do not now appear to hold any hope for replacing present large-scale methods of generation.

E. Coal gasification and desulfurization could be a very significant development in years to come in optimizing the use of the great coal reserves of this country. Research and development is already well underway in this area and a large prototype system is expected to be in operation by the end of this decade.

F. In summary, the energy "crisis" is not imminent, as far as Commonwealth Edison sees the situation; but there are many unknowns, many variables, and many challenges to which Edison's management will have to be constantly attentive and vigilant.

NSTA CONCURRENT PANELS AND SYMPOSIA

SESSION A-3

PERSONALIZED SCIENCE– A HUMANISTIC APPROACH

IS KNOWLEDGE OF SCIENCE SUFFICIENT?

Michael Gonzalez, Science Learning Specialist, Hillsborough County Public Schools, Tampa, Florida

The human mind can endure many taxing stimuli in a hostile and toxic environment, but only through some meaningful and reinforcing experiences will it be able to combat this milieu. Whether this situation becomes a tragedy or not depends on the empathetic responses that other minds have for this one struggling primate. May we all recognize the real human predicament of every individual living with today's ecological frame-of-reference.

The educational environment certainly is recognized as a more sophisticated niche than the noneducational one. Ironically, we continue to proclaim that the total environment in which we live should be educational, but being human we continue to separate the total environment into niches. Unfortunately, we have not allowed ourselves to perceive the repercussions.

Can we really communicate totally with an individual if his knowledge within the science spectrum is the only thing that interests us? It would be totally absurd to think that the attitude of a student toward science has no effect on his accomplishments. Should we not be concerned about his attitude toward the subject matter? I distinctly remember that science was a subject that I strongly disliked throughout my junior high and high school years. I can also relate the reason for this most unfortunate experience. No one really cared whether I liked science or not until I started to attend the university. Interestingly enough, my hospital job, not my academic experience at the university turned me on to science.

It has been my experience that human beings are extremely alienated from each other. One prime example of this alienation is the apparent separation between the young and the old. It seems to me that many of us can be held accountable for depriving human beings of happiness. The young are regarded as lost hippies; the old are regarded as hopeless, unhappy, depressive, forgetful people.

It so happens that both the young and the old are filled with feelings. They aren't feelings that can be measured. So the result is that a hearing loss implies that there is also a loss of feeling for life. Why do we continue to behave so illogically?

The teacher alienates himself from the student as he does from the rest of humanity.

The teacher faces in the classroom the same type of tragic experience that he faces in the "outside" world. As a matter of fact, considering the classroom as a completely separate entity from the rest of the world is even more convincing evidence of alienation. Recognizing a student simply through his credentials is the same as recognizing a human being solely through his nationality. They are both very objective characteristics of the same kind of being. It distinctly reminds me of the attitudes that one encounters on a trip to a foreign country. Most of the people on the trip are traveling from one country to another country without getting involved with the unique features of the second country. This is a cold fact, but that is typical of the American tourist. As long as we can report on the physical aspects of our glorious visits, that is sufficient. These trips apparently don't teach us anything about what to do in the classroom. Wouldn't you think that the recent report by the Civil Rights Commission on the academic status of Chicanos in American classrooms would be felt by American educators? Is it really a sin to speak the mother tongue in an American classroom? Maybe English sounds like a cleaner language than Spanish. It surely does make the poor souls feel alienated.

The only thing that seems to matter is that we are able to see the highlights that typically happen in the classroom.

The highlighting characteristics indicative of Troy are:

1. He does his laboratory work.
2. He never answers back.
3. He always does his homework.
4. He gets "A's" on his tests.
5. He dresses nicely.

It doesn't really concern us that he may have some inner feelings that are trying to jump at us. That isn't part of our role. Our role is to objectively report the status of this being in the classroom.

I submit that it is part of our role to get involved. It isn't enough for me to report on the physical beauty of another country, because that isn't all that interests me. I am interested in the human beings that make that country what it really is. What they laugh at, what they do throughout the day, what they think, and everything that is characteristic of them as human beings is important to me.

Troy isn't just someone that has received an "A" on a test. He is also someone who cries, laughs, thinks. Should we be concerned about his thoughts? Would it be feasible perhaps to become more empathetic with Troy? It may mean that we would have to spend more time relating to him. Could it be possible that Troy makes an "A" on his test and really dislikes science? How can a human being do well in something he dislikes? Our means of measuring Troy's success is knowing how well he memorized the specific subject matter.

But, have we ever wondered how he feels about the subject matter? How does he feel about anything? Should that be a tabu territory?

In my own experience certain things excited teachers and professors in science courses:

1. How well I could memorize the names of the phyla and their respective characteristics,
2. How well I could regurgitate the locations of the origins and insertions of mammalian muscles,
3. Whether I could identify all of the given unknowns in a chemistry laboratory,
4. Whether I could solve a Mendelian genetics problem,
5. Whether I could apply a mathematical formula to a physics problem,
6. Whether I could draw "pretty" pictures.

I learned to do these things well, and the only reinforcement I ever received was a "nice" grade on a test. I never was asked if I liked what I was doing. A recent anecdote amused me no end since it related beautifully what I sincerely feel is happening in the classroom today. At a recent visit to my optometrist he told me that a young man had posed a question to him concerning his profession. The young man said, "Doc, do you like what you are doing?" Wouldn't it be great if all students were asked that particular question? As a matter of fact, the doctor enjoyed this question and remarked that he thought about his role for the first time in a deep sort of way.

Suppose a student dislikes science. That would be somewhat shocking to a teacher if he became aware of the fact at the end of a science course. I'm sure Troy didn't start disliking science at the end, but due to psychological alienation, the teacher wasn't concerned enough to know this. It is important to know how Troy feels about science, since the climate within that science classroom should be a happy one and not a torturous one. It is our job to placate Troy in every possible way.

There are several factors to consider in relating to Troy as a fellow human being and some of these aren't easily measured. The following are some of my beliefs:

1. The student has feelings, and these feelings undoubtedly influence his behavior in every respect.
2. It is our duty as educators to have respect and empathy for his feelings, since he does become part of *our* life, and *our* life should be part of his.
3. To be able to listen patiently to the expression of his feelings isn't enough. We must also live those feelings.
4. The classroom environment is not separate from any other environment, because the human being doesn't live in isolated places. He lives the whole day, and the whole day encompasses everything that is part of him.
5. It is most important that his attitude about learning become part of his total life and not just a classroom attitude.
6. We should be concerned about his attitude, but not in the sense that we are going to force our attitudes on him.
7. We should all be in the business of growing and this is an art that should never cease expressing itself.
8. Let our dreams be forever heard, since they are part of us. It would be a gross injustice to humanity to deprive human beings of the beauty of dreaming.
9. Let us be proud to offer ourselves to each other.
10. It isn't enough simply to care, we must also show that we care.

Maybe I'm asking that we all become Don Quixotes in our own unique way. That includes students, too. We each have a dream that is beautiful. No one wants his dream to be destroyed. Socrates wanted to help the young by getting them to think. Martin Luther King wanted human beings to express their love for each other in every possible way.

Would it be totally illogical to think that some students may want their total environment to be like Camelot and that what happens to them in that classroom can destroy that real dream? They want to be shown that their likes and dislikes are part of the make-up of Camelot. It is important to know how they feel about everything since that is part of being a human being.

There is no end to the diverse topics that can be covered with students. They are filled with meaningful facts, and they can express themselves in an indefinable manner. There is a sincere feeling behind each verbal expression and their faces epitomize the "realness" of humanity. The uniqueness of each student never ceases to amaze me. They are individuals with hang-ups, beauty, feelings, prejudices, logic, love, and all of the things we often use to describe "other" human beings.

Recently, one of my students who happens to be a Black prisoner, gave me a poem to read, which really turned me on. Willie felt good about his poetry, ready to tell the whole world about it. What he desires is for someone to recognize this personal ability or trait, being part of him and constituting a unique element in his life. Does it take much to tell this soul that you dig his poetry?

Another prisoner was quite depressed about his environment, which he indicated was extremely cold, sterile, and boring. He said to me, "Mike, if only we could have some contact with our visitors. It doesn't have to be sexual, but only to be able to touch someone and know that there is some concern for us as human beings." The longing for acceptance through the sense of touch is not a new phenomenon in human history and yet we continue to deprive each other of this beautiful means of communication.

These human beings are declared losers, having become social failures, similar to the academic failures that are produced in many classrooms today. For some reason, we continue to believe that academic problems can be solved through the penal systems of grades that have been so beautifully built into our academic environment. It's ironical that we seldom talk about the students that have succeeded, but only about those who have failed. It isn't necessary to fail any student. Why can't a student simply receive an "X" grade, if the teacher feels that he hasn't absorbed enough facts? The "X" can be changed to a passing grade when he reaches the proper point of success. Of course, some teachers may be more interested in thinkers than in regurgitators. That kind of student is probably more difficult to grade on a standard grading scale.

Maybe the point of arrival is when educators realize that the classroom is not only a place to gather facts, but a place to orient one's self. One can memorize the name of every muscle and bone in the human body, without ever realizing or knowing how they work together to produce movement of the body. It reminds me of an episode that recently occurred within an ecology class while I was in the middle of a lecture. A student in the class suddenly developed an epileptic seizure without my immediate observation. There was a deep silence, indicating that something had happened. Finally, the students informed me that the boy was in the middle of a terrible seizure, and I panicked internally. Fortunately, I was sensible enough not to show my fear and I proceeded to ask the others what usually is done for the student. I laid him down and put my kerchief between his teeth. It took me a few minutes to decide what to do. Human physiology happens to be an important area of interest for me. Epilepsy can be defined in a most sophisticated manner and the proper steps for taking care of a person developing a seizure have been appropriately memorized. Yet, I became very fearful, not knowing what to do and even lifted the student before he had finished having the complete seizure. Another interesting feature of this true story is that I didn't even realize that there was someone having a seizure, since I was so wrapped up in developing a wonderful ego trip with my fancy lecture on the "chemistry of life."

Is it really that important to know a fact without having any feeling for that fact? Maybe the role of the educator is developing some empathy for his environment instead of destroying the humanity of that environment with the distribution of cold facts.

A student comes to our unique environment with a sincere motivation to learn. A humanistic atmosphere should be provided that will allow him or her to create the kinds of things that can only be found within his or her inner self. He needs affection, love, and understanding. He should be recognized as an individual with feelings.

The academic environment cannot be separated from the total environment. Only through the actual encounter with the psychological and sociological stimuli existing within his real world can the student learn to appreciate the educational stimuli also found in this world.

Here he will be able to communicate with his own peer group, which undoubtedly helps him to adapt in a sound manner. Our primary goal is to try in every possible way to create a situation where humanistic learning takes place and thus happiness can be found by each human being.

I sincerely submit that we owe it to ourselves to appreciate the "love" within the students in our class and also share our "love" with them. It is our responsibility to establish an empathetic relationship with them, since they have added to this life of ours as much as every living organism.

We need them as much as they need us. Let us all meditate on this important responsibility.

SESSION A-5

GENERAL SCIENCE AND SCIENTIFIC LITERACY

VALUES, INFORMATION, AND STRATEGIES TOWARD LITERACY IN SCIENCE

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It is the responsibility of schools to produce an intelligent citizenry. The ability of our citizens to understand national and international problems is dependent in part upon their scientific literacy. The layman is surrounded by scientific developments and is bombarded with much scientific information. A literate individual must have some *understanding* and *appreciation* of science in order to make valid judgments as a citizen. It is really this aspect of *appreciation* which I would like to address in the framework of scientific literacy.

Young people in the 1970's view life individually and uniquely. They're developing a variety of life styles that provide alternatives for the planning of their lives. Especially in the age group which is taught general science, many students want to plan for themselves and their future. Whatever the attitude of a young person his options have increased over former times. The greater the number of opportunities the more likely a person is to find personal satisfaction. More options, however, do make the task of deciding among them more difficult. More values are in conflict, more variables have to be considered, and a greater amount of information is needed. This is true today in the environmental and science areas as well as in the career areas and in many others that junior high, middle, and high school students face. Forced to choose without adequate information based on objective data or personal experience, without a feeling for future consequences, without sufficient skill or practice in the process of deciding, the person may choose unwisely.

An important part then, of scientific literacy is a strategy to make decisions. I think all of us find ourselves making pervasive and important decisions in a nonsystematic or haphazard fashion. Generally our schools have not provided the means by which people can learn a conscious process for making decisions. School counseling attempts to help students learn how to make decisions but a major portion of the time spent in counseling is developed by supplying information to the students or obtaining information about courses he's taking.

I propose that a decision-making strategy be taught within the framework of science as a means to obtaining scientific literacy. Science teachers have traditionally avoided values as an unscientific component of developing knowledgeable citizens regarding science. How you feel about an issue (such as energy consumption) is not important. One is taught to be objective, one is taught that a process is more important than the person doing it. Just as we know that the teacher variable is much more important than the program, I also feel that the aspect of how students process information relative to themselves and others is as important as the concepts which are taught to these students in science courses. Any science program of a general nature which is designed to develop scientifically literate citizens should have an aspect of decision-making that allows students to practice these skills based upon the best evidence available.

Decision-making courses have become fairly common in social studies departments as senior or upper level high school courses in our local school systems. A program developed by the College Entrance Examination Board in 1972, authored by Gelatt, Varenhorst, and Carey approached this at a junior high level and hoped to use decision-making concepts and skills to clarify for the student what is necessary to make good decisions. This type of decision-making rationale and principles should be incorporated into general science courses, applied to relevant problems for students, and be practiced as a part of the curriculum to develop scientifically literate citizens.

A decision does not exist until there is more than one course of action, alternative, or possibility to consider. When decision-making is skillfully utilized it's more likely that the outcome will be satisfying. A skillful decision-maker has more personal freedom in his life because he is more likely to recognize, discover, or create new opportunities and alternatives.

We have asked our citizens to make decisions regarding environmental, social, scientific, personal, and public concerns without formally addressing in an educational or systematic manner the way in which these decisions are to be made. Two people may face a similar decision but each person is different and may place different values on outcomes. It is the individual who makes each decision unique. Learning decision-making skills increases the possibility that each person can achieve that which he values.

In the process of deciding, the program I previously mentioned outlines three major requirements for skillful decision-making. *One*, the examination and recognition of personal values. *Two*, the acquisition of knowledge and the use of adequate, relevant information. *Three*, the knowledge and use of an effective strategy for converting this information into an action. It is these three requirements that I see as *part* of a general science program that would lead toward literacy in science. Hence the title of this presentation, *Values, Information, and Strategies Toward Literacy in Science.*

Values are the foundation and the integrating framework of the complete decision-making process and for this reason should be a part of every consideration in the classroom. We all realize, I think, that science teachers seldom take up value laden issues in the classroom. Values determine what is satisfying and this helps a person to set objectives. Values also dictate the action to be taken to reach those objectives. Before relevant information is applied, personal values must be examined and recognized by the individual. Trying to use some systematic decision-making process is a value. A person facing a decision involving a conflict of values accompanied by strong emotion knows he faces an important decision, one requiring skill to decide satisfactorily.

A general science course should take students through a consideration of these topics. First, the importance of values in the decision. Be it an environmental issue or a scientific controversy the part played by human values has to be recognized. Second, the individual or personal nature of the values that are exhibited. That all people have values and that they differ widely has to be acknowledged. Third, a definition of values. A picture of how values differ from understandings and what they are is essential. Four, recognition of these values in others. Five, clarification of one's own values. Six, identification of values of groups. Seven, converting values into objectives for use in making the decision.

There are many different definitions of values. The definition of values that appeals to me is something a person prizes, cherishes, esteems; something he expresses consistently in his behavior. Defined as such, it is broader than specific interest, feelings, beliefs, or attitudes. The reason that general science has avoided values is that it is difficult for a science teacher to introduce such a personal subject as values without bringing to the students his own subjective ideas. Despite these complications the consideration of values cannot be neglected if we want to be honest with students and encourage them to make sound decisions. Prizing, cherishing, and esteeming lie in the affective domain. Education has traditionally concentrated on the cognitive with the neglect of systematic consideration of affect and, therefore, values. Values are learned. They are appropriate subject matter for the classroom. Students will be better educated, more competent, and more independent if they learn the source of values, how they were acquired, values of other people, and respect for differing values. Student values and the studying of these values allow the student to know more about themselves, have a clearer picture of their own values, give greater commitment to those that they choose, experience the satisfaction of achieving what is valued, and become more effective decision-makers. This, in my estimation, would be one giant step toward establishing scientific literacy.

There are some sensitive areas in the addressing of values (identified by Gelatt) that also apply to science. *First*, students may find it hard to be honest with themselves, their classmates, or the leader as they begin to look at their values. Values define the uniqueness in the individual for each person. Fearing judgment on the part of others or on the part of the teacher may cause students to withdraw from a public revelation of their values. *Second*, a teacher could indoctrinate students with his own values and, of course, should avoid doing so. The fear of indoctrination has often prevented any discussion of values. We are as science teachers, objective; therefore the value question has been omitted from our program completely. A teacher is less likely to indoctrinate students by remembering the following: There are no right or wrong values. Values can only be judged by the individual for himself and the teacher's own values may be respected less by some students than by others. *Third*, the leader is less likely to indoctrinate the students if he remembers that values are learned and that a person who has only one set of values that are applied automatically without being examined would be functioning like a machine. Such a person would not be capable of determining his unique life style as would be the person who thought about his own values.

In terms of environmental education and science education there are three major causes of problems. One, the *external effects*, the unintended, the side effects that cause environmental or scientific problems. Be it a new drug or a manufacturing enterprise. Unintended side effects may be found that could be desirable or undesirable. Some values must be looked at in this context. Two, another cause of problems is *patterns of decision-making* in regard to resources. Resource ownership may be thought of in terms of private, corporate, public, or no ownership. Any owner brings to the control of those resources, personal values. The same is true of public and corporate decision-making processes. Values that exist must be recognized. A third major cause of environmental or scientific problems lies in the area of *value conflicts*. We don't address this, however, in any course in systematic form because it is not considered a part of general science. Concerns about what are the best values for individuals, what are the best values for society, and how conflicts are to be resolved have been avoided. This causes environmental problems. This causes scientific problems. Of course everyone feels "your goals are inferior, my goals are superior," without an examination of "your goals or my goals" and their value input. In a final discussion of this idea of values it is important to note that there are four approaches to values as identified by people such as Don Oliver, Sid Simon, and Irv Morrisett. One, *indoctrination* – "Don't examine but you better agree." Two, *value clarification* – "You have a set of values, you get them clear in your own mind." Three, *value analysis* – "How do my values relate to one another? Are there contradictions? Are there consistencies?" Four, *value commitment* - "Get with something, do it, take some action." It seems to me that without an examination of values we cannot expect general science courses to address the problem of scientific literacy. We ask students to apply science knowledge that we give them without exploring the context of that information.

General science also should teach students to find and evaluate **information**. The scientific information and the processes by which this scientific information was obtained have been well done in my estimation during the last round of curriculum developments. Learning to find information about each of the alternatives to make a decision; where to go, what to ask, or what to look for and then evaluating that information are skills that are essential to a decision-making process. These vital skills must be dealt with in the science courses and they fit most advantageously into a general science course.

Information could be divided into four parts. One, *possible alternative actions* that could be taken regarding some decision about science. Two, *possible outcomes or consequences* of these actions. Three, *probability of the outcomes*, the relationship between the actions and outcomes, and four, the *desirability of the outcomes*, the personal preferences. A person who has a decision to make regarding science, the environment, or his personal life, may think he's deciding between the only alternatives available. But if his alternatives could be increased in number he would increase his freedom of choice. An individual seldom knows all the alternatives that exist nor has the time to find or consider them all. A few years ago a middle school in my home town was built as a result of using arguments by two opposing forces both of which wanted other alternatives, not the middle school. A creative individual who saw another alternative looked at the arguments for the presented alternatives (location of a high school) and used these arguments to support the building of the middle school in a particular location. An alternative that remains unidentified or rejected on the basis of insufficient evaluation might as well not exist.

If a group of students were asked to write down individually all the possible alternatives available to them upon leaving high school a large number of alternatives would probably result. By reviewing the list to discover the alternatives that actually were not alternatives, students would not only appreciate the importance of having a number of alternatives in decision-making but also the need for information about each.

The location of nuclear reactors, the support of Skylab and future NASA activities, the additional support of scientific research, and chemical additives in our lives, all require information about alternatives to the decision for the person to be literate regarding that choice. A scientifically literate person needs to think about the kind of information necessary to him in order to give direction to this search for information. He may find he does not want to read all that is available. He may want to make a phone call. He may want to refer to an individual he respects. The kind of information that is sought influences the evaluation of possible outcomes. The sequence followed to get information may even determine the decision to be made. A boy who talked to his father about whether to go out for baseball or track is getting information. If his father advises him that he would not be able to keep his car unless he gets a job after school to support the car he now faces a new decision—is he going out for sports or is he going to get a job. Because information affects the decision, a person should consider his sources, interpret the information, its objectivity, and its relevance.

Another point regarding information is that ignorance about what information is needed to make the decision may cause the person to make the decision on irrelevant data. It may be very impressive to know that 80 percent of the students attending a certain university drive Ford cars. What, however, is the significance of this data to a person in making a decision between a Ford or a Chevrolet?

The third important part of developing literacy in science through general science is the application of **strategies. The final phase of the decision-making process** that people would use in a science context requires the calculation of risks associated with each considered alternative, and applying what has been learned to making a decision—integrating the previous steps of values and information requires the use of a strategy. Estimating the risk involved in each possible alternative ties together the personal values and the information that has been gathered. Most decisions involve some risk in terms of possible outcomes. Knowing the personal importance of various outcomes determines the degree of risk a person is willing to take to achieve them. Few human decisions are made under conditions of certainty.

The conditions under which all decisions are made by individuals can be divided into four classifications—*certainty, risk, uncertainty*, and *combination. Certainty* is where each choice leads to one known outcome. If you jump from a building you will fall. With *risk* each choice leads to several possible outcomes with known probabilities. For example, when a person decides to flip a coin to make a choice he knows he has a 50 percent chance of getting heads and a 50 percent chance of getting tails. *Uncertainty* means that each choice leads to several possible outcomes with unknown probabilities. When the astronauts first landed on the moon there were several possible results but no one knew the exact chances for each outcome occurring. The *combination* involves both risk and uncertainty. For example, when a person decides to apply to a college he doesn't know for certain if he will be admitted but he can use data to make an estimate of his chances of being offered admission.

The strategy is a plan for converting values and information into a decision. This should be addressed in the general science course. In this sense there is no such thing as not having a strategy. So we either try to systematically teach decision-making strategy regarding scientific and environmental issues or we take what we get.

Several commonly used strategies discussed by Gelatt and Varenhorst involve such strategies as the *wish* strategy, that is you choose what you desire the most. A person chooses what he wishes would happen. If I vote for the nuclear reactor then my electric bill will go down. This is the same as choosing the long shot in a horse race. It's easy to use this strategy. All you have to know is what you desire the most and have some information about the outcome. You don't need to know probabilities at all.

The *safe* strategy, choose the most likely to succeed. Don't build a nuclear reactor because there's a possibility it's dangerous. In a horse race the choice would be the favorite. It's a little more difficult to use this strategy. A decision-maker needs to know his objective and have some information about possible and probable outcomes. At the same time he is required to be somewhat more specific about his objective.

A third strategy is the *escape* strategy—choose to avoid the worst. It is sometimes called the minimax strategy, because it minimizes the maximum disaster. It escapes misfortune. It is relatively easy to use this strategy. A person merely needs to know a little bit of information about outcomes and what he consideres the worst outcome. The nuclear reactor could have an accident, therefore we vote against it because of its potential disaster.

A fourth strategy is the *combination* strategy, that is choose both the most likely and the most desirable. This is the combination of the wish and the safe strategies. The strategy suggests that someone suggest the course of action that has both high probability and high desirability. That is the highest expected value. This seems the most logical and reasonable; it is the most difficult to apply and it presents several problems in terms of making scientific decisions. First, it requires that the person knows, his personal values and has some objectives. Second, it requires knowing alternatives and having the ability to predict possible results. Third, it requires the ability to estimate probabilities. And fourth, it requires the ability to designate the relative value of something.

In talking with science teachers and in looking at the trend of the times regarding social science, science, environmental education, drug education, and career education, we have been searching for a good deal of time for ways to get at scientific literacy. Today's era of humanistic approaches has relegated science to something less than the most popular course in the curriculum. By presenting students with issues and problems that are available, that are controversial, and asking them to investigate their own values, it appears that a good deal of the problem towards scientific literacy can be overcome.

This also assumes a more humanistic approach to science teaching. It is not just 800 terms to be learned, nor 45 experiments to be completed, nor lab books and lab reports to be written carefully, but it is addressing the human element of the enterprise of science.

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The NSTA publication, "School Science Education for the 70's," contains the major goal, defined as "The development of scientifically literate and personally concerned individuals with a high competence for rational thought and action." Further, we find that among other things, the scientifically literate person: "recognizes the limitations as well as the usefulness of science and technology in *advancing human welfare;* understands the interrelationships between science, technology, and other facets of society, including *social* and *economic development;* recognizes the *human origin of science* and understands that scientific knowledge is tentative, subject to change as evidence accumulates." Also, to promote scientific literacy, science curricula must contain among other things, "the *social aspects* of science and *technology* and *values* deriving from science." Further, the publication states that, "all teachers, and especially science teachers are challenged to educate young people to expect, to promote, and to direct *societal change.*" These are the areas of "Scientific Literacy" to which I would like to direct my remarks after a look at "General Science."

General science today is not the same course most of us suffered through little more than a decade ago. About the only thing that held the course together was the cover of the book. Remember the great enthusiasm with which you read several pages, did several exercises designed to test your comprehension, had a little discussion with a possible demonstration now and then, and finally had a mastery test which did little more than confirm your reading ability? I believe that "General Science" as presently taught in the middle and junior high schools today consists of topics arranged in such a manner that there is a spiral sequential nature to the curriculum along with an entirely different manner of learning. Science ability is no longer 1 to 1 with reading. Most science classes have hands-on experiences for young learners and many teachers use different testing means than the old memory-recall method.

Today's general science is more topically organized with many schools teaching units organized into life science, earth science, and physical science. This type of arrangement allows prepared teacher-specialists to teach in their area of major concentration and other teachers to concentrate on one area rather than several.

Looking at integrated science, meaning those courses with all sciences taught as interrelated disciplines, we find very few if any that are truly 'integrated' even though Dr. Leopold Klopfer predicted in 1966 that "we shall soon witness a strong movement toward integrated science courses in our secondary schools."

What happened to this bold prediction of 8 years ago? Why is it that only one curriculum project, as yet with no materials available and only beginning to be organized at Florida State University in Tallahassee, has attempted to enter this area, and why is it that at this time I would predict that integrated science has about a 25 percent or less chance of success?

My thesis is that it makes no difference what the curriculum is, or what the goals of curriculum development are. Whether topically organized general science, or integrated (by any stretch of the word) science, with or without scientific literacy, the most important ingredient in any curriculum is the *individual classroom teacher.* A coordinator I once knew said, "let me choose the staff, and the curriculum will take care of itself." I believe that statement more and more as I work with professional staffs.

Going back to our goal of scientific literacy, If we wish to attain this goal for our present students at the junior high/middle school interface, the most important person we must reach is probably not in this room. He is the classroom teacher.

Most science teachers, who have been in the field for at least a decade, take great pride in the fact that we put men on the moon before the Russians. Remember the big curriculum upheaval after "Sputnik." Every science teacher took a personal vow to beat the Russians to the moon and we began to crank out curriculum designed to meet this goal. However, if we really analyze the situation, how could a 12-year-old science student of the late 50's do much if anything to put man on the moon by 1969 when he was barely out of college? Now we are being called on, after the great social emphasis of the middle to late sixties, to develop a scientifically literate person who will achieve the great goals listed in the initial paragraph of this paper.

How can science, either general or integrated, develop in the general population an understanding of the impact and direction of science in our society if we have teachers who on the one hand say they are, "aiming at inculcating the beautiful, the good and the true, while their test questions inform the students that he is really aiming only at the memorization of a bunch of facts and trivia." (Bently Glass)

I believe integrated science or any other kind of science curriculum which has as its goal the development of scientifically literate people with heavy emphasis on humanism is doomed before it begins by the backgrounds of the science teachers involved.

Looking at some fairly typical science training, we find that most states, administrators, teacher-training institutions and even teachers themselves are unsure of what constitutes adequate preparation of junior high/middle school science teachers. This, is a very neglected area. For example, in a study I did I found that:

1. Over 10 percent of a national sample of secondary teachers reported they were teaching in a subject area in which they did not feel qualified to teach.
2. Certification standards for 43 of the 50 states do not spell out requirements for junior high/middle school teachers.
3. About 20 percent of Wisconsin school district superintendents believed that the junior high group of science teachers was adequately prepared for their assignments.
4. Graduation requirements from most institutions require proficiency in only 1 or 2 usually closely-related areas for certification. This is fine for specialty-area teachers but obviously poor for the general or integrated science teacher.
5. Even NSF institutes for the most part, failed to work on this vital area of the curriculum and even perpetuated the gap between the junior high and high school science instructor.
6. Besides not being adequately prepared in their science area, (40 percent indicated this choice) science teachers at all levels are not prepared either cognitively or affectively to implement courses that are socially relevant, scientifically literate, or humanistic.

The present training of science teaching specialists has produced an abundance of teachers who know a lot about a very special area of science. These teachers, are being employed by school districts whose administrators, in many cases, select specialists because that's what they are. This is not to say that the teachers are at fault. Many have been encouraged to enter a science area by former teachers and counselors, then when confronted with over 750 semester hours of science offered at a medium-sized University, opt for a specialization with a related minor. If the student is going to be proficient in his area he must of necessity neglect other subjects in the humanities which would give him the broad background to teach towards scientific literacy.

In this respect, the teacher training and certification institutions are at fault in requiring a certain minimum preparation in subject areas with a corresponding lack of requirements in the humanities. I'm certainly glad to report that at one institution, the University of Wisconsin-Green Bay, a course entitled "The Conscience of the Scientist" is required for all science students. This however is only a small beginning in the development of students who will be able to teach towards the goal of "Science for the 70's." Unfortunately, we still require that all science teachers take the same specialized courses as those students working towards becoming researchers, technologists, and engineers. Couldn't we design courses which give the background information needed by secondary teachers or more specifically middle and junior high school teachers which also included work in technology, social issues, moral values, ethics, history, etc? How can we expect teachers, who have had to take the same courses as future scientists and engineers, and who have the backgrounds found in my research, to develop in their students a feeling of social relevancy or appreciation for technology when they have never been exposed to it themselves.

What can we do *now* to move towards the goal of scientific literacy whether we teach topically organized general science courses, integrated courses of our own design, or any other kind of science course?

I believe that to achieve the goals envisioned for science education in the 70's we can no longer spend great amounts of time stressing knowledge for knowledge's sake at any level of education. The explosion of knowledge, over 300,000 words per day in science alone, makes accumulating masses of knowledge impossible. The most important task will be to direct scientific knowledge toward the improvement of the lot of humanity. How can we develop a sense of appreciation of science for today's youth? I believe the first efforts should be made in organizing the curriculum from within, crossing discipline lines not only in science itself but also in other departments as well. Why shouldn't we teach social studies, English, history, math, and science together in the same way in which we live?

It is fairly apparent that today's curriculum even at the junior high/middle school level, cultivates two groups of students. C.P. Snow calls them the two cultures; George O'Hearn calls them the "within science" and the "without science" groups. One group has a strong science interest but no great knowledge of the humanities; the other has a strong interest in humanities but little understanding of science. I believe we should leave the specialized training of scientists and technologists to the colleges, universities, and technical schools and move towards integrating unified 'general' science into the twelve years of general education.

Today's science teachers need to be retrained to include the vital areas of scientific literacy. I am personally acquainted with a junior high science instructor who is so specialized that he really belongs in a college job. Yet this same individual is supposed to make all areas of science interesting and relate science to humanism, social values, technology, problems of man, etc. This individual is very definitely influencing hundreds of students, many towards anti-science attitudes because what he is teaching is not relevant to their world. His overall goal seems to be the development of every single student into a miniature scientist. How he was trained, I can understand. How he was certified is the fault of our present state certification procedures. How he was hired is the classic story of the decision being made by administrators who have no background in science and are impressed by college grades out of proportion to their worth. Now, how do you improve his attitude or failing that, move him out of the classroom? He really belongs at a much higher level of education and is presently a frustrated junior high teacher waiting for something to open up.

We must all ask ourselves what are the important points of humanism, and social values in science? How do we reach the great numbers of people in science teaching or planning to enter teaching?

The immediate answer of how to provide meaning and humanism to dead and irrelevant science courses is inservice training, team-teaching, and new and up-dated courses for teacher training programs at our colleges and universities. More than any other program, inservice education, if properly planned, would reach the greatest number in the least amount of time. The inservice training program I envision would be continuous, conducted by a committee made up of members from the various science disciplines and other subject areas, including members at the elementary, junior high, high school, and college levels. This would not only allow diversity, but would ensure a program that reached all levels. The traditional lectures, discussions, practice lessons, etc., are needed, but more important, work experiences in industry, business, and the professions should also be included. How much better attuned one becomes when he actually experiences the areas in which the students he teaches are required to work. All educators may not agree, but I believe more education about people and life takes place outside the classroom than in them. Districts might need to pick up the expenses of these training sessions and even pay teachers to attend them. This may sound absurd, but industry does it all the time. Neither should this be a one-shot affair as is so common in education. Teachers should be required to attend compulsory inservice training from the day of their appointment to the day of retirement.

Although there appears to be a rift in how social studies and science teachers view each other, we must encourage team teaching in these two areas. We must also convince social problems teachers that more emphasis needs to be placed on the role of science and technology with their attendant problems on the future of our citizens. A mere reference to the atomic bomb and the joblessness created by automation is not enough when these students will be called on in the near future to make intelligent decisions on how far we should proceed in space exploration and at what pace; are nuclear power plants safe; shall we ban the internal combustion engine from the cities; can we permit pollution to continue unchecked in this or any other country; when should we turn off the machine which is prolonging a life and who will pay for it; and a hundred other questions that are being created everyday. Team teaching with social studies would give students the opportunities to learn about cultural and social implications of the science they are learning. Some science teachers might ask why team with social science when we can teach human values, human welfare, social and economic development, etc? The truth is that teachers, regardless of what specialty, tend to be so tied up in their own little world that they can't see the forest for the trees. It is my suspicion, based on many observations, that once that teacher enters his classroom and closes his door he is in his own world. And, more often than not the way in which he was trained is the way in which he teaches his course.

Courses in science education must change at the college level as well if we are to change teacher attitudes. No longer can we be content to certify a four year graduate in the sciences after a course or two in teaching methods. I am not suggesting watered down college graduates for junior high science, but I am suggesting a more realistic, more relevant curriculum for this, the most important stage of childhood development. We can no longer except a dissatisfied, frustrated, unqualified secondary teacher in junior high/middle school science classes. For those already in the schools, we must retrain them or remove them. For those in the education pipeline or coming up we must change their preparation now. No longer can we be content to certify a four year graduate in the sciences without a full background of humanities, and more time in the nature, philosophy, and history of science. A former president of NSTA said, "Another area of teacher preparation which concerns me at both the secondary and the elementary level is understanding of the history and philosophy of science. Few teachers entering the profession today have any background whatsoever in these most vital areas." Programs of this type may take five or more years compared to the current four undergraduate years and will surely meet with resistance. Those teachers already practicing in the field must also be continually upgraded in philosophy and subject matter. However, courses in subject matter fields will have to be changed if we expect experienced teachers to take the courses, for after a few years absence from the college campus, few teachers have the desire to pursue graduate level work in a new area or the background to start at the graduate level.

In this complex world, a specific education may provide one with the tools needed to provide for himself and family quite adequately. But, the ethical education which helps men resolve the confusion which exists as we try to find ways by which men can live together in their environment—this is the challenge which faces us today. We, as science educators must realize that: "In teaching science we must not forget, that it is simultaneously social study and creative art, a history of ideas, and a supreme product of aesthetic ingenuity."

SESSION A-8

INDIVIDUALIZED SCIENCE—LIKE IT IS

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In examining the continuum between individualization and independence, there seems to be a greater ease of movement in one direction than the other. Observations on students seem to indicate that they can generally individualize quicker and more comfortably than they can move toward independence. For example, in a new senior high school program, when students are offered complete freedom as to the sequence of materials, they *all* opt to follow a traditional pattern, page by page and section by section.

Even when self-diagnosis mechanisms indicate that the ensuing material is known, students elect to plow through all of it anyway. At the same time, they are willing to work individually on choosing the units and on setting the pace at which they will travel through them. Only in self-evaluation (and the remediation that results from it) do students seem to achieve a greater degree of independence.

A possible reason for this behavior is the traditional school pattern of teacher dominance. We have espoused the philosophy of "accept the student where you find him," (individual differences) but we have insisted that only we can make the decisions as to the means of progress from there. Whether he works individually or in a group, we will prescribe the pathway.

The Individualized Teacher Preparation program (ITP) is complete, with the final modules now at the printers. Their usage in teacher-readiness programs has increased steadily. The so-called strategy modules seem to enjoy more popularity and greater use than the content modules.

The Individualized Testing System (ITS) is also complete. It furnishes a means for student evaluation in which test items based on performance objectives can be assigned on a completely individual basis. It also provides for individualized remediation.

The modular Level III program has always had the capabilities for independence and individualization to a greater extent than that found in the Levels I and II texts. The next logical step toward further individualization of the materials would seem to be the modularization of the first two levels.

Work is progressing on the interdisciplinary, modular, senior high school science program called the Individualized Science Instructional System (ISIS). This program uses individualized diagnostic tests and individualized project work. Choice of modules (called minicourses) is completely free, but once the student has selected a minicourse, he or she is responsible for all of the core material. Excursions are graded and optional. Resource units are used in place of remedial excursions for students who need help on techniques or concepts that are common to two or more minicourses.

INDIVIDUALIZED SCIENCE–LIKE IT IS

John F. Thompson, Principal, Flexible All-Year School, Research Learning Center, Clarion State College, Pennsylvania

Issues

1. To change science teaching, you must change the people doing it.
2. To change the people doing it, they must want to change.
3. For people to want to change, they must first know who they are and where they fit.
4. With this view, a person can then make some choices.
5. If a teacher has not internalized "individualization" for himself, his success in "doing" it to others is doubtful at best.
6. The techniques for individualizing are numerous and tested.
7. We have the seeds and the know-how to grow a sunflower. The question is whether we want to grow it or not.

New Developments

1. Elementary Learning Center, Flexible All-Year School.
2. Using science in music, art, and guidance.
3. Flexible Secondary science.
4. Learning science by teaching.
5. Who hid the science?
6. Sunflowers–Who wants them?

SESSION A-10

STRENGTHENING TEACHER CAPABILITIES FOR EDUCATIONAL INTEGRATION

Jay Lemke, Assistant Professor of Education, Brooklyn College, City University of New York

College professors scheme and dream, but it is the teacher in the school who bears the burden of our philosophizing. Educational integration, the philosophy of a truly humane education, often means for the science teacher an upstream swim against the current of specialization. He is encumbered by the traditional school curriculum and far better prepared by his education to stick to his own subject and leave the integrating to someone else. If it is desirable that future generations learn science as an integral part of man's adventure on the earth, then ways must be found to strengthen teacher capabilities for integration.

Science makes its proper contribution to humane education when we teach science in its total human context: as an activity of men living in history and society, searching for meaning in life and solutions to problems that threaten their dreams. Science is a mode of human expression capable of beauty and subtlety, of being personal while striving to be universal. As a human activity it poses moral dilemmas, has social consequences, and is not immune to ideology, faction, or politics. Science in its total human context has as close a connection with music, art, and poetry as with mathematics, technology, and engineering. It is no more distant from law than from medicine, and rather close at times to theology.

Those who accept this vision of the role of science in man's life and thought, and who believe that it is only when science is taught at all levels in its total human context that students will genuinely understand it and be able to judge it intelligently, should also bear responsibility for preparing science teachers for such a task. Definite and specific proposals are needed, now, for providing teachers with the intellectual base, the teaching techniques, and the public and professional support they will need for the job. In each of these three areas, the philosophy of educational integration itself suggests the kinds of assistance the science teacher will need.

For most science teachers college science courses provide the only intellectual base for their science teaching. Those courses did not evolve to meet the needs of teachers or generalists; their internal logic, rationale, and ultimate justification are based on the needs of future science specialists. Such courses emphasize problem solving techniques at the expense of deeper analysis of the origin, function, and limitations of general concepts. They anticipate the needs of students who will use parts of their content as elements in a further specialization, not students who seek to establish the relationship of that content to still broader areas of human life and understanding. Our graduates can calculate the efficiency of heat engines, but not describe the limitations of the second law of thermodynamics; they can recite the stages of mitosis, but not discuss the possible evolutionary origin of the cell's capacity to divide. And if we should ask them how thermodynamics can help us make sense of the tendency of living organisms to remain stable in a changing environment, or to explain the seeming paradox of increasing order in living systems against the trend to disorder in nonliving systems, we would be lucky if they could understand the questions!

To venture outside the narrowest definitions of science: How well do we prepare them to teach science with regard for its social implications? What contribution could they make to discussions of technology and the environment, national energy policy, or the development of music and the visual arts in the twentieth century? How would they fare in helping students arrive at positions on such controversies as: the neo-creationist critique of evolution, the evidence for and against ESP and other aspects of parapsychology?

In examples such as these, the question for science education should not be: What does all this have to do with science? but: What does science have to say about all of this? How can we help provide science teachers with the intellectual base needed to teach science in its total human context? Traditional specialist science teaching at the college level will continue, in the immediate future at least, to dominate all learning in science. We must discover, then, how to build upon existing courses, how to help the teacher transform the content to meet his own needs.

First, we can try to meet the need for a "critical second look" by the teacher at the science content itself. We can provide retrospective seminar courses for the teacher which turn back to the great intellectual principles of their conventional science courses, to highlight them, to foster critical examination of their foundations and broad implications, to do what the first science courses never have the time to do and the students insufficient motivations and intellectual maturity for. The only way past superficiality in understanding is to set time aside for selective, critical, reflective discussion of basic principles.

Second, we can try to broaden the science generalist's intellectual base to include elements needed to see and articulate relationships between science and other disciplines. We can provide the science teacher with courses that focus on widely applicable strategies for integration and synthesis. The methods of systems analysis, the techniques of structuralism and cybernetics, the concepts of symmetry, order, equilibrium, evolution, stability, and the many other tools of the generalist, can be made real and immediate for the science teacher in genuinely interdisciplinary courses that bridge between science and the problems of man in society, between science and the questions of value and meaning posed in the traditional humanities.

These courses must be required; they are part of the professional preparation of the science teacher. They can be developed in both preservice and inservice forms, in both baccalaureate and masters degree programs, available to teachers as part of their continuing education. Their importance should be reflected in policy on teacher certification under state and local codes. We must insist, not on science credits, but on science understanding from our teachers, and not on science understood in isolation, but understood in its total human context.

Science teachers must not only understand, they must be able to communicate, to transfer understandings and stimulate student inquiry. How can we provide them with this second of our three components: the teaching techniques they need?

If there is truth in the old saw: You teach as you have been taught, then the two proposals for supplementing the teacher's own science education will already have begun to provide, by example, part of the needed teaching techniques. The nature of educational integration, however, suggests two further proposals, ones whose implementation belongs traditionally in the domain of the schools and departments of education. Teacher training and teacher certification are presently moving toward an ideal which requires that educational theory, so long useless to so many classroom teachers, be taught predominantly in the context of experience and participation directly in the elementary and secondary schools. It is in this context that these next two proposals are offered.

The first is a call for increased emphasis in the preparation of science teachers, both at the preservice and inservice levels, and again this can be done in both baccalaureate and master's degree programs, on the techniques of team teaching. The full burden of teaching science, or any other subject, in its total human context is too large for the single teacher. Increasingly, as trends in cirriculum move toward an education at all levels that is more relevant to the specific needs of our contemporary society and its problems, the science teacher will find himself a member of an instructional team, bringing his own background and the special insights of his discipline to bear on questions that require an interdisciplinary perspective. We can help the teacher learn how to participate effectively in the more complex pattern of interactions that occurs when two or more teachers must co-operate. We can help meet the need to learn how to follow as well as to lead as a teacher, to pass a student's question to a colleague or receive one referred, to open up room for disagreement within which students can explore alternative positions on issues, and to criticize a thesis outside our area of expertise and be responsive to criticism in turn from those outside our own. Indeed learning to teach science as part of an interdisciplinary team may become a contribution of science to the total curriculum as re-evaluated by students, parents, and educators.

A new teacher, for example, should not carry a full teaching load in his first year, but should devote part of his efforts to mastering the curriculum and finding his and his subject's place in it. That first year can be the capstone of a liberal education for the teacher who learns to listen to his more experienced colleagues, not just in the sciences, but in the other subject areas with which science is to be integrated.

The second proposal calls for an emphasis on problem-oriented science teaching, not teaching problem-solving methods for idealized problem types, but teaching science in the context of non-idealized, real-world problems. The field trip to park, beach, or nature preserve; to power station, refinery, or computer center, is never an idealized exercise in one subject for the student. The conventional separation of subjects and disciplines is less easily maintained in the face of what is for the student a unitary experience. We can help the teacher make the full experience a learning experience, richer for the integration of disciplines by emphasizing techniques for real-world teaching. The restriction of education to the largely artificial and frequently sterile environment of even the best-equipped classroom has led to such paradoxes as the poor quality of education at school situated in the heart of urban agglomerations of learning resources. The bus is mightier than the textbook, but less emphasized as a teaching tool. Extra-mural education enforces on the aware teacher the need to integrate and help his students multiply the meanings of their experiences. The special teaching techniques must include in-class discussion of science's part in real-world understanding and problem-solving.

Up to this point we have considered proposals to provide the science teacher with the intellectual base and with the teaching techniques needed for educational integration. The science teacher needs, no less than these, active public and professional support. Science teachers are men and women enmeshed in a total society and in the enormous social organization we call our educational system. They are members of two professions: science and education, with duties and allegiances to both in varying individual proportions. These professions define for the public and for the teacher the prestige and status allotted to every activity within their scope. they are the arbiters of legitimacy, and they are, like all social embodiments of convention, archly conservative.

The science profession has sanctified specialization in the public mind and labeled the teacher and the generalist unprofessional as scientists. The education profession has also lionized the specialist and legitimized a hierarchy of authority that makes it encumbent upon the professor to tell the elementary school teacher what and how to teach, but unthinkable that the reverse should happen. We cannot expect qualified individuals to choose careers as science teachers at all levels and academic educations as science generalists, unless the science and education professions provide the needed support. Meaningful public and professional support for educational integration requires radical changes in custom, convention, and attitude.

First, there is need for academic recognition of the legitimate value of advanced generalist education. The glory of specialization in the public mind is inextricably linked with the prestige of the PhD. This certification of the specialist confers an authority out of all proportion to the effort required. We have made no provision, however, for a corresponding degree for the generalist, of equal prestige and, inevitably, inflated authority, as a counterweight to the voice of the specialist in our society. In recent years, as the failure of the specialists and of specialist training in areas that belong properly to the generalist, notably in teaching and in advisement on public policy, has become more apparent, the proposal has been advanced in various quarters for what will probably be known as the Doctor of Arts degree. Its Doctors will be trained in research, authors of scholarly publications, broadly learned with in-depth knowledge of several specific areas, but prepared to serve society and the profession as the specialist is not: by synthesizing and integrating, by planning and designing on a scale that requires an overview of many specialties. They will be our teachers and critics, watchers for the increasingly frequent danger signs that appear in a complex society where specialists produce effects whose consequences rapidly spread outside their areas of expertise.

The argument that a PhD's training is not well utilized in the elementary school would not be valid for the Doctor of Arts' training and abilities. The establishment of a Doctor of Arts degree would create the academic context for professional acceptance of and public support for educational integration and the science-generalist as teacher. The science teacher may not need a Doctor of Arts degree to teach science in its total human context, but he may well need the help, encouragement, and support of colleagues who do hold such a degree to do it well, with conviction, and with public support.

The second proposal calls specifically for the education profession to move in each of the states toward general teacher certification. This proposal will seem radical exactly in proportion to one's faith in the doctrine of specialization. General teacher certification calls for teachers to be certified without discrimination as to grade level or subject. This policy has been a workable system in effect for several years in the province of Ontario in Canada. Such a system can encourage the public to view teachers, and teachers to view themselves as concerned with students and with instruction rather than with ages or subjects. A man or woman is a teacher first, and secondarily one who knows quite a bit about science, or who may be trained to work with very young or with handicapped students. This policy, insofar as it militates against the kind of "biology teacher" who thinks that he can be an excellent teacher knowing nothing but biology or against the "elementary school teacher" who thinks he doesn't need to understand science as well as the "secondary school teacher" does, is strong professional support for educational integration.

There in brief, are six specific proposals to help provide the intellectual base, the teaching techniques, and the public and professional support needed to teach science in its total human context. They are all based on the assumption that we can reduce obstacles to humanistic education by strengthening a science teacher's capabilities for integration. There is a very good laboratory for testing that assumption and it is as close as ourselves.

SESSION A-12

INNOVATIONS IN COLLEGE BIOLOGY

DOUBLETHINK IN BIOLOGICAL EDUCATION

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In George Orwell's world of big brother the concept of "doublethink" referred to the ability to hold two contradictory beliefs in one's mind simultaneously, and accept both of them. [6] The party member in this scenario was exposed, from early childhood, to mental training based on this concept, so that by the time he assumed his role in the party, he, understandably, was unable and unwilling to think too deeply on any subject whatever. To make this system work, the slogan of the day was uniformity; uniformity in dress, speech, and most important, uniformity of thought. The most serious crime against the state was thoughtcrime. The crime of not thinking along the lines approved by the state.

When I received an invitation to participate in this conference with the theme "1984-10 and counting" I did some thinking and came to the conclusion that perhaps we are closer to 1984 than we would like to admit. To preface my remarks I would like to point out that problems in biological education cannot be considered in a vacuum, but rather must be placed in context with the whole educational endeavor and with the larger society that supports it. However, this in no way reduces the responsibility of biological educators to seek solutions to these problems.

To get back to the concept of doublethink, let us first examine some of the fond hopes we like to express for the behavior of our students, and then compare them with the methods we are using to evoke these behaviors. High on the list of expectations is the hope that we will develop in them the ability to think independently—intellectual autonomy. This goal has been stated in various ways: for example, to develop the ability to think critically, to develop intellectual honesty, to develop an inquiring mind, or to develop the ability for self education.

Let us look, now, at the methods we use to develop intellectual autonomy in students, and let us begin with the curriculum. There is a phenomenon in biological education known as the core curriculum. This usually takes the form of a collection of courses which are required of all biology majors. The core curriculum was defined in CUEBS Publication No. 18 (1967) as "... that body of knowledge essential for all students of Biology." This statement is so omnipotent that one hesitates to mess around with it, but let's do it anyway.

It is not unusual to find biology programs in which students can exercise freedom of choice in only one or two courses, and in some instances the whole undergraduate program is prescribed and required. The usual rationale is that students are incapable of planning programs that will best fit their needs. (Actually, most core curricula are designed to prepare the student for graduate school). In the absence of competent counseling this may, in fact, be the case, but this whole issue raises a very basic question: "What is school for?" The prime function of school is to prepare students for the future. If it does not, one must question the whole idea of school. A required curriculum thus suggests that the faculty can foretell the future better than the student. A census of the number of PhD's pumping gas, (or trying to find some gas to pump) suggests that our batting average at foretelling the future is not all that could be desired.

What are the consequences of abolishing the core curriculum? At worst, the student may make mistakes in judgement which he will have to learn to live with. However, this is an improvement on having to learn to live with someone else's (the faculty's) mistakes. Besides, my personal experiences indicate that learning to live with one's mistakes is highly educational. On the other side of the question, however, and most importantly, a rigid required curricular structure stifles intellectual autonomy by submerging the individual, forcing all students into a common mold and introducing an assembly line effect to biological education. It appears, then, that our practice of requiring a curriculum is incompatible with our goal of developing intellectual autonomy.

Next, let us examine the teaching methodology that we are using to develop intellectual autonomy in students. The almost universal method of presenting undergraduate biology in this country is in the lecture-laboratory format. The main function of the lecture is to transmit information and that of the laboratory to illustrate the subject matter presented in the lecture. The laboratory experiences usually consist of prefabricated exercises with standardized procedures and predetermined outcomes.

Lecturing as a means of transmitting information became obsolete with the invention of the printing press in the fifteenth century. In comparison with the books, journals, films, computers, and teaching machines available today it is a very inefficient way to transmit information. In addition, a major side effect to lecturing is that it deprives the student of virtually all responsibility for using his own mentality to weigh, compare, and decide what is important for him to learn. Therefore, if one of the aims of biological education is to develop intellectual autonomy, then students *must* be given an opportunity to *exercise* intellectual autonomy.

It may be that you, as I, have experienced difficulty in trying to get students to exercise intellectual autonomy. I teach a course in general ecology for biology majors that is presented as a series of self instructional modules. Each module has clearly stated instructional objectives. Early in the present semester a student complained to me that she did not know what was expected of her in the course. After explaining to her that I had stated as explicitly as I could, and in writing, what was expected of her, she admitted that she was accustomed to having the teacher tell her the important things to learn. She dropped the course.

This is what I referred to earlier when I stated that many of the problems of biological education must be shared with the whole educational establishment. Do you know that there are public schools that administer drugs to "hyperactive" children, to calm them down so that, among other things, they will listen to the teacher? Stephen Chorover [1], who is professor of psychology and brain science at MIT states "I doubt that anyone really knows how many American children are being treated with daily doses of stimulants. One practitioner who uses them estimates that the number exceeds 250,000 nationwide." Chorover further states that, "We are laying the groundwork in childhood for the psychotechnological control of adults... As the tools grow more powerful, the prospects are vanishing for saving our children and for saving ourselves from this dehumanizing chemical and biological welfare."

I'm quite sure the young lady I referred to earlier was not a victim of drug abuse in the public schools. She has become addicted to the teacher through normal classroom practices. I don't even like to think about a college population that has been preconditioned to intellectual passivity by drugs. It has been my personal experience that a great many, perhaps most, college students are already addicted to, and are over-dependent on the teacher. Compare this situation to our goal of developing intellectual autonomy. It seems to me a clear cut case of doublethink.

Now, let's look at traditional laboratory instruction. The fact that in many biology courses the lecture and the laboratory are scheduled as separate entities suggests that there are aspects of biology that cannot be pursued in the lecture. Chief among these are the processes by which biological information is generated. Prefabricated laboratory exercises in which the student follows a set of detailed directions to arrive at the "right" answer do little to enhance his understanding of these processes. Striving for predetermined "right" answers brainwashes the student into a false concept of the way biological information is derived, because we all know there are no "right" answers, but only varying degrees of probability. Furthermore, this technique has the effect of standardizing and depersonalizing the laboratory experience so that all students are performing uniform tasks in the same ways and at the same rates.

Unfortunately, it seems that few biologists have addressed themselves to such basic questions as "what constitutes a valid laboratory experience?" and "what is the optimal laboratory experience for a given course?" In practice there seems to be a form of "Parkinson's Law" operating to the effect that the number of laboratory exercises performed by students increases in direct proportion to the number of laboratory periods available. The prevailing assumption seems to be that a prescribed number of hours in the laboratory results in an equal learning experience for all students. In reality, an intensive two- or three-week period of investigation is a better learning experience for some students than a full semester of "official answer" exercises. The point is that learning is an individual process and cannot be treated with assembly line, mass production techniques. When it is so treated the student's individuality is submerged and he is reduced to jumping through academic hoops.

Conventionally taught biology courses are typically instructor-centered in the sense that they provide the student with little opportunity for self-initiated and self-directed study. McKeachie [5] has cited research reports which indicate that learning is strongly influenced by teaching methodology. These reports show that for the achievement of more complex educational outcomes such as long term retention, critical thinking, changes in attitude and motivation, all of which are part of intellectual autonomy, student-centered teaching methodologies are superior to instructor-centered ones. Thus the lecture-laboratory format as traditionally used is antithetical to the goal of developing intellectual autonomy.

Another practice which biological education shares with the whole educational establishment, and which I think is contradictory to the development of intellectual autonomy, is the practice of giving letter grades. I have heard grades defended on the basis that they give us a measure of academic achievement. But this is circular reasoning because academic achievement has no independent meaning: it is defined in terms of grade point averages. In practice each instructor has his own interpretation of academic achievement for each course he teaches. In the grading process he may evaluate student performance on a variety of activities, e.g., oral and written expression, laboratory performance, class attendance and other activities he considers relevant. These are then all summarized on a single scale and issued as a letter grade. The grade, however, gives no information about the evaluation that lead to it, and the information it does transmit is difficult or impossible to interpret.

Grade point averages have been used for such varied purposes as admission to graduate and professional schools, scholarship awards, determination of draft status, eligibility for veterans' benefits, eligibility for extracurricular activities and as qualifications for employment. It seems absurd to me to even suggest that each of these purposes requires the same kind of information. That they are so used suggests that grades mean everything to everyone. One is tempted, therefore, to accept the corollary to this, i.e., that they therefore mean nothing, because "When no meaning is conveyed variation in meaning cannot be observed." [10]

When instructors are required to turn in grades ranking the relative accomplishments of students within the time limits of a college term, they commonly, arbitrarily, choose a body of information that they think will fit the time period. The information and learning activities are then organized so that grades can be determined in the simplest way. In order to get a better comparative measure this often means that all students do the same things in the same ways and at the same times. Thus, individual interests of students and individual rates of learning become secondary to the bureaucracy of grading. The result is that getting grades rather than learning becomes the reason for taking courses.

Ironically, there is evidence that giving grades has a negative influence on the learning process. Psychologist Edward Desi [3] reported on experiments which showed that when students were either rewarded (as with an "A") or punished (as with a "D" or "E") in a learning situation, they showed less interest in the learning task after it was completed than did students who performed the task for their own satisfaction, when no reward or punishment was involved.

Grades have become so firmly established in American education during the past fifty years that both students and teachers have developed a great dependency on them. We persist in identifying our best with "As" and "Bs" on the assumption that they will become the leaders of our society. Unfortunately, this does not appear to be the case. The Newman Report (1971) indicates that a number of studies covering students trained in business, school teaching, engineering, medicine and scientific research have found almost no correlation between course grades of students in these fields and their on-the-job performance.

I would like to emphasize the distinction between grading and evaluation. One of the essential functions of school, as an institution, is evaluation. [8] In the absence of evaluation, by definition, you do not have a school. In much the same way, without guards, by definition, you do not have a prison as an institution. Faculty evaluation of student performance, however, can be accomplished without recourse to any system of grading. In fact, as we adopt more open curricula in which the emphasis is on self-initiated learning, evaluations of learning situations are likely to include summary statements about the student's progress and performance along with samples of his work. This is, by no means, a new and revolutionary idea. Unless the school has modified its philosophy in the past two years, the transcript of students graduating from Evergreen State College in Olympia, Washington, will consist of a 32-page booklet; a much more meaningful record than a symbolic one consisting of letter grades. Some instructors may give brief and uninformative evaluations, but it is hard to imagine an evaluation summary more brief and uninformative than an "A", "B", or "C". The practice, then, of giving letter grades, while holding on to the goal of developing intellectual autonomy in students, is another classic example of doublethink in biological education.

Curricular structure, traditional use of the lecture-laboratory format, and grading, are nothing more than conventions used by biology departments and schools to achieve their goals. Conventions can be changed without destroying the basic functions of these entities. I'm not willing to go as far as Ivan Illich [4] who proposed the elimination of schools in favor of informal learning centers, because I think this is unrealistic. That conventions can change is illustrated by Evergreen State College, Governors State University, Hampshire College, and State University of New York at Purchase. Whether or not the existing establishment can change its conventions is a moot question. It will not be easy. However, one sure way to avoid the world of "big brother" is through a citizenry of autonomous thinkers. If biology departments and schools have the slightest commitment to the future, I think it is imperative that they change some of their conventions and avoid the anomaly of doublethink.

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SESSION A-14

THE ROLE OF THE SPECIAL SCIENCE TEACHER IN IMPLEMENTING THE NEW BALTIMORE COUNTY SCIENCE PROGRAM

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As a special science teacher I help implement the new science program in my school, and more recently, assist neighboring schools with their programs. My responsibilities encompass the actual teaching of science and the preparation of materials for myself and other teachers.

The new science program has brought with it an avalanche of science material which has to be ordered, received, stored, and organized, distributed when the classroom teacher needs it, and finally inventoried at the end of the school year. In schools without a special science teacher, these jobs are usually handled by the Administrative Assistant, a faculty science committee, or by selected faculty. These tasks can be very time-consuming and tedious if the system of organization and distribution of the material is ineffective and confusing. Just recently I met with science representatives from neighboring elementary schools to assist them in organizing their science material as efficiently as possible. We established a system of equipment exchange between schools so that no school has to drop a unit or an activity because of lack of equipment.

The manipulation of science material is really secondary to the actual teaching and learning of science. During the first week of school each year, I meet with the classroom teachers from each grade level to do several things. First, to establish a science schedule; to determine when and what units will be taught during the school year, so as to eliminate the simultaneous use of limited science supplies and to co-ordinate the science program with the social living program. Second, it gives me a chance to familiarize new teachers with the organization and distribution system of science material and reacquaint returning teachers with this procedure. Third, I can introduce and familiarize teachers with any new units or materials which have been received at their grade lvel.

When we establish a science schedule, we determine what my teaching responsibilities will be during the school year. Of the five or six science units written for each grade level, I will teach two to each classroom. The choice of the units I teach is at the discretion of the classroom teacher, with the understanding that the teacher will teach two to four of the remaining units herself. Usually the classroom teacher will ask me to teach new units, with which she is unfamiliar, or units that she, for various reasons, feels uncomfortable with. When I teach lessons from the science units, the classroom teacher remains in the room and observes, assists, and generally acquaints herself with the procedures, concepts, and materials of the science activities.

During and following the activities, we discuss the methods and materials being used, and if she or I aren't satisfied with the procedures or the results, I offer ways to modify the activity and suggest extensions and alternatives from other programs, including AAAS, ESS, SCOPE, etc., or from any other source at my disposal, provided that the modification or alternative meets the needs of the teacher and the children. By teaching two units in the classroom, my primary responsibility is to demonstrate to the teachers, some of whom may be unsure of themselves because of scanty science backgrounds, or because of the diversity and quantity of science material, that the science program in Baltimore County is not difficult to teach; that it can be enjoyable and rewarding for children and teacher.

From time to time, a teacher may desire a special demonstration lesson to kick-off or culminate a unit, or on a subject which is not necessarily part of the formal science curriculum. I try to make myself available to assist, gather materials, or actually teach the lesson.

When I'm not teaching or helping teachers with science problems, I spend a good deal of time preparing science materials for the other teachers who normally lack time to prepare for themselves. A crew of student science aids helps me prepare and distribute the science material.

Since field trips often serve as valuable supplements to the formal science program, I also offer suggestions and help in their planning, and if my schedule permits, I enjoy going on them. Our county also has established a program of intervisitations between our secondary and elementary sch ols. If an activity from the elementary curriculum re tes to s nething similar being done or capable of being done in a secondary science lab, the elementary teacher can plan to take her class to that school, usually in the same vicinity, to observe or work with the secondary teachers and students. Secondary teachers and students are also invited to visit the elementary schools to assist or just become familiar with what's happening in elementary science. It is one of my responsibilities to co-ordinate these intervisitations and keep an ear to the ground on what's happening in the secondary schools.

Some of my other responsibilities include ordering and picking-up any live specimens needed by the teachers from the resource centers in the high schools. I also try to keep the classroom teachers informed of any inservice or regular college science courses which may interest them or help them in their present teaching situations. One of my current projects is trying to establish special interest groups, such as a Rocketry Club, Geology Club, etc. for children with a curiosity or interest in these areas.

Not all special science teachers in our county follow the same procedures and patterns. They function, as I do, according to the needs and wants, as they perceive them, of their teachers and children.

An example of the variations in teaching patterns among special science teachers is the rather unique "Explorer" program of Gil Smith, special science teacher at Villa Cresta Elementary School. Gil devotes his entire afternoon to investigation sessions with individuals and small groups of students, in contrast to the familiar procedure of teaching entire classrooms. He breaks his afternoons down into 15-20-minute time blocks. Between one to six children may sign up for a time block, or several time blocks if needed, through their homeroom teachers. When these children meet with Gil in his science room, which is well-supplied with equipment and a mini-science library, they can "explore," with Gil's assistance, any science problem or topic that they wish. The science topics his students usually choose to investigate are closely related to the curricular science program, but may also include topics of scientific interest outside of the program. Besides assisting teachers and running his "Explorer" program, Gil also maintains a live-specimem center which supplies county schools with mealworms. Bessie-Beetles, and daphnia.

Two of the other special science teachers in our county, Doris Ensminger and Amy Behan, are involved in rewriting and adapting activities from selected science units so that these activities can be done by individual students at their own rate of speed, according to their own capabilities.

I think it is safe to say that while the interpretations of needs and methods of teaching may vary among special science teachers, we all agree that our main function is to promote the teaching and learning of science in any way possible in our schools and communities.

SESSION B-1

THE SECONDARY SCHOOL-COLLEGE INTERFACE

SCIENCE AND FUTURE SHOCK

Robert E. Cook, Associate Professor of Biology and Education, Southeast Missouri State University, Cape Girardeau

Back in the summer of 1973 when I was first invited to address this group on the topic of secondary school-college science interface, I would have said in answer to the main question. . . "Yes, many; in fact, too many college freshmen courses are a repeat of what the student has had in high school." Furthermore, I would have, with all the arrogance I could muster, decried this repetition as a *sinful waste* of precious educational time.

Now before I go on, it is necessary to explain the setting for the formulation of such a statement. For the past seven years I have been in Southeast Missouri trying, with very little success, to move a few teachers away from rote memorization toward a higher plane of teaching. The stock answer from our majority of the teachers is of course, "We're doing all right; "X" number of our students went to college and got high marks in biology, chemistry, or physics," or "John went to engineering school and did all right, so why change?" Another common answer is, "We're pleased with our system, most of our teachers are graduates of this school and after four years away still want to return to the good life."

It would not make any difference to these teachers what was taught at the college, they would spend the class time allotted, priming their students with facts so that the student will be able to take freshman chemistry or biology and obtain his or her "A" for the course.

With this in mind, one should look at the classes being taught at college, aside from the traditional. I'm sure you can cite college biology classes that are not blood and guts type courses. We have one where I am employed which we call Life Science. It is taught by several individuals whose main concern is social and political change or upheaval. I'm sure we can find high school classes geared along these same lines. I seriously question whether we should call these classes biology. Students (nonmajors) moving from such a class into physiology can express their feelings about abortion, premarital sex, the occurrence of VD among teenagers, etc., but know nothing about cell anatomy or physiology. I'm not sure they even understand ecology, pollution, or waste. They go out collecting glass bottles from roadside parks or rightaways and then waste gallons of hot water cleaning them for the recycling centers. There are also minicourses, A-T courses, open classrooms, field classes, etc., all of which have counterparts at the high school level. Most of which start with the cell and go to organisms or start with the organism and go to the cell.

The bulk of the introductory college classes have still not changed their basic teaching techniques of lecture, memorize, and regurgitate. Laboratories function in two capacities; (a) to verify principles presented in lecture and (b) to add additional material which because of time cannot be presented in lectures.

Now there are some of yo who are thinking "What about all those inquiry courses that have been developed since 1957? Aren't these different from the college class just described?" Well, PSSC is, for all practical purposes, a bad "four" letter word, and Harvard Project Physics is only whispered about outside of college methods classes. As for BSCS, its Green Version is taught as one might expect to see any 1950 blood and guts biology taught. I'm talking about the majority of teachers, not the minority. However, for all the merits of the BSCS and CHEMS materials, students don't want to think if they have to explain their ideas based on concrete evidence. The answer to such questions as "Why did you use this?" or "Why did you do that?" is "Because the book said I should." It is not uncommon for students to comment "Why don't you tell me, you know the answer." These types of responses infuriate me. In other classes students are taught that creativity and emotions are one and the same. They are encouraged to express themselves regardless of how weak their arguments are.

Recently I was again jolted back into reality on the topic of "Scientism." For those of you unfamiliar with the word, it was used by Eastman to describe the mistaken idea that science can solve all the problems of society. Can you imagine, fifteen years after the birth of BSCS and PSSC and we still have students with this idea? This was a straight "A" high school student, but these ideas are still prevalent, unintentionally of course, in our college classes. We present such diverse problems as digestion and enzyme activity or transport of materials in plants and then immediately tell the student what to do to get his answer. Furthermore, at both levels we have students cut up dead frogs, crayfish, or cats so that they will have a greater appreciation of living things. About the only real appreciation they have is for the pungent smell of the preservative. Students still walk out of our classes thinking of biology in terms of dissection and vocabulary lists.

In answer to the first question presented to this panel, "Yes, under many disquises, high school and college classes are repetitious and I still feel it is a waste of education time."

Now to examine the second problem posed. What are the major barriers to changing this situation, if indeed change is necessary, and I believe it is necessary. The first to come to mind is the failure of college professors to admit to themselves that high school teachers can and do practice some good teaching. I'm aware of the CLEP's test and Advanced Placement test which can be used by colleges. I'm also aware of professors that would place the standards so high that only the very gifted could pass. I'm also aware of the argument put forth to the effect repetition is the basis for learning. But I'm really not all that concerned with the college classes; these kids come to college with the idea in their minds to learn only enough to pass the course tests and then move on to the next class, especially if the class they are taking is a required service course.

I'm also not all that concerned about the classes for majors. These students will also do what is required of them in order to obtain the desired grade. They know they must play the professor's game and as long as the rules are laid down and adhered to the students will accept them. Obviously, I really don't expect the format of college classes to change.

The change, I would hope, would come from the secondary schools. We now have a situation where a liberal arts degree is not to be prized by everyone. More students are going on to technical schools. In addition to the students that choose not to go on to college, there is a percentage, much to the dismay of college presidents, that start college and drop out. These people will need science courses that will support the para-professions of their choice.

How are these changes going to come about? What is it going to take to get the secondary teachers to meet the needs of the students? Not so long ago I attended a seminar on the preparation of teachers. When the fourteen-carat scientist from the panel finished with his blurb, the session was opened for comments from the floor. Almost to a person the science teachers wanted the colleges to offer more courses in the science disciplines but did not want to take any courses in the academic field of education. Yet they had the gall to say they wanted to take science courses that would show them how to meet the diverse needs of their students. Maybe you have had a science course which taught you how to look after the diverse needs of students. I spent fourteen years getting my doctorate and have taught in colleges for twelve years. I have attended colleges in the midwest and west coast and have talked to others about this problem. They agree that such courses are not in their experience. What these people need to do is stop teaching science and start teaching individual students. I know this sounds like a cliche but just stop and think how often you say "I teach biology, or physics," and think in terms of subject matter. Teachers will insist that their course is on "top of it" because they gave written behavioral objectives in all three domains. I'll give odds these objectives are written in terms of the teacher's concept of what he could do and not what the student will need when he or she gets out in the real world.

How many of you have actually tried to find out what you students knew before they got to your class. Have you ever looked at a course for elementary and middle school science. How many of you have tried to get materials your student can understand? I hope more of you at the secondary level can answer that you do than can answer affirmatively at the college level.

I am constantly on the undesirable list of my colleagues in elementary science when I tell them they should spend their time with the three R's so that children can read and write intelligently when they enter secondary school. If they can do this, the secondary teacher can teach them all the science they will need. In like fashion, don't be concerned about preparing the student with specific factual information that will be repeated during the first year in college. Be concerned about getting the student involved with materials which will enable him to use his science in his immediate life. The student is not concerned if he doesn't see an immediate need for knowledge. The student wants to have something concrete that he can associate with. A student wants to feel that the information is directed specifically to him rather than to the class. I wish I could tell you we have such a program for you, but you will have to develop the program for yourself. You're not going to get it done in one day, or even in one year. Your first attempts will probably be disastrous, but don't quit. You'll probably want to climb the walls because of the amount of time and brain power required. I know the easy way out, the way the eight-to-four teacher operates, but this is not good teaching. We are attempting such a program at our lab school this year in biology. Seldom does a week go by that I don't want to throw in the towel, but we'll keep revising and improvising until we work out our particular problems.

SESSION B-2

SWINGING SOULFUL SCIENCE

Mattie S. Jefferson, Science Resource Teacher, Public Schools, Washington, D.C.

Of the language skills, the one that receives the most attention in inner city schools is reading. Teaching students to read is one of the major goals of many inner city schools. Teachers and administrators of inner city school systems constantly search for programs and methods that will motivate their students to read. Often the reading program that is to be taught from the course of study or textbook is not interesting to the students at all. At the same time, so much emphasis is placed on reading per se, that other language skills, such as writing, speaking, and listening get little attention. These skills are often overlooked as a means of motivating students to read materials written by others.

Science activities have often been suggested to inner city educators as a means of getting students to read. However, elementary teachers argue that there is very little time to deal with science activities in that so much time must be devoted to the teaching of reading and mathematics. Secondary teachers argue that they cannot teach science effectively because the students cannot read. If elementary teachers would assume some of the responsibility for teaching reading and other language skills then both sets of teachers would be contributing to the accomplishment of one of the major goals of the overall curriculum.

If science activities are to be used to develop the language skills of inner city students, the students must first be turned on to the science program. Too many teachers teaching in inner city schools use lectures, seatwork, silent reading, and answering questions from the book as their basic science activities. The science program for these students must extend beyond these activities. It should be one which is based on the students' environment, and allows ample opportunities for students to investigate and discover using equipment and materials. Programs such as SCIS, S-APA, ESS, ISCS, and IPS can be used successfully in many inner city schools.

In order to develop language skills through science activities, emphasis should be placed on utilizing the language skills that the students are capable of using. Most inner city students are capable in the area of oral communication. They are able to communicate in what is called their primary language. This language may be different from what is accepted as standard, but it can be understood with some effort on the part of the teacher. Effective science activities such as those in SCIS, S-APA, ESS, ISCS, and IPS can promote the use of this oral language in order to motivate students to write their own observations and reports based on their findings. Furthermore, success with these activities will encourage them to read science materials that are written by others in order to find additional information about a given activity.

The following is a list of some activities that promote language usage of inner city students:

1. Publishing a science newsletter,
2. Writing thank you letters to resource persons,
3. Planning and carrying out science assembly programs,
4. Preparing science projects for school and community exhibits,
5. Writing to different agencies for information,
6. Encouraging older students to work with younger students.

Many people erroneously believe that inner city students cannot or are not interested in learning. They may not learn in the way we want them to learn, but they can learn if they are taught by methods that are consistent with their expectations. It is very important that inner city students are provided with concrete experiences that will lead them to the development of effective language skills.

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SESSION B-3

SCIENCE IN SPECIAL EDUCATION

DEVELOPING SCIENCE CONCEPTS WITH SLOW LEARNING CHILDREN THROUGH ACTIVE GAMES

James H. Humphrey, Professor of Physical Education and Health, University of Maryland, College Park

Many of us in physical education can relate to the importance of science as far as our particular subject field is concerned. We are engaged in the human movement area of education and recognize that it would be difficult to visualize a physical education activity which is not concerned with science in some way. This is particularly true of physical science principles, since practically all voluntary body movements are based in some way upon one or more principles of physical science.

Some 2,300 years ago Plato expounded that "in teaching children, train them by a kind of game, and you will be able to see more clearly the natural bent of each." If one were given to rationalization it could be speculated that the content of my topic for this session might be what he had at least perhaps remotely in mind.

I like to describe active games as "active interactions of children in competitive and/or cooperative situations." Note that I am concerned with *active* rather than *passive* interaction. Thus, my particular philosophy centers around the idea that "when children learn they learn all over."

Without getting into an in-depth discussion of the various inherent facilitative factors compatible with child learning in the active game approach, I should mention that this medium of learning is backed up by objective research. While this research might well be considered much more exploratory than definitive, all of our studies in this area show that most children can develop academic skills and concepts very well through this medium. One of our findings is that this approach, while favorable for all children, appears to be more favorable for slow learning children. The obvious reason being that slower learning children will perhaps have more success with concrete kinds of learning experiences than those which are abstract. In other words, in the development of science concepts through the active game approach, the learning experience becomes a part of the child's physical reality.

Le me present four representative examples of how certain science learnings can be integrated with active games. Some fifty of these kinds of motor learning activities appear in the source:

Humphrey, James H., and Sullivan, Dorothy D. *Teaching Slow Learners Through Active Games*, Charles C Thomas, Publisher, Springfield, Illinois, 1970, pp. 145-182.

A book oriented specifically to this approach, entitled *Teaching Elementary School Science Through Motor Learning*, is currently in preparation and will soon go to press with the same publisher.

Each of the following examples contains a statement of the science concept, a description of the game, an application of the game for the particular purpose, and an evaluation of its effectiveness in a given situation.

Case 1:

Concept: Shadows are formed by the sun shining on various objects.

Activity: *Shadow Tag.* Players are dispersed over the playing area, with one person designated as "It." If "It" can step on or get into the shadow of another player, that player becomes "It." A player can keep from being tagged by getting into the shade or by moving in such a way that "It" finds it difficult to step on his shadow.

Application: During the social studies period the definition of a shadow was given. A discussion led the class to see how shadows are made as well as why they move. The class then went outside the room to the hardtop area where many kinds of shadows were observed. Since each child had a shadow it was decided to put them to use in playing the game.

Evaluation: The children saw how the sun causes shadows. By playing the game at different times during the day they also observed that the length of the shadow varied with the time of day. The activity proved very good for illustrating shadows.

Case 2:

Concept: Moving things slow down before they stop.

Activity: *Stop on a Dime.* A perpendicular line is drawn 50 feet from the starting line, with graduations or measurements drawn at one-foot intervals for ten feet beyond the line. Each child begins running when the signal "Go" is given. When he reaches the fifty-foot line, the signal "Stop" is given. The intervals past this line show how many feet it took him to stop after he heard the signal.

Evaluation: Each child was able to see that it takes time to stop. All realized that moving objects first slow down and then stop.

Case 3:

Concept: Things which are balanced have equal weights on either side of their central point.

Activity: *Rush and Tug.* This is a combative activity in which the class is divided into two groups with each group standing behind one of two parallel lines which are about 40 feet apart. In the middle of these two parallel lines a rope is laid perpendicular to them. A cloth is tied to the middle of the rope to designate both halves of the rope. On a signal, members of both groups rush to their half of the rope, pick it up and tug toward the group's end line. The group pulling the mid-point of the rope past its own end line in a specified amount of time is declared the winner. If at the end of the designated time the mid-point of the rope has not been pulled beyond one group's end line the group with the mid-point of the rope nearer to its end line is declared the winner.

Application: In performing this combative activity it was decided to have the group experiment with all kinds of combinations of teams such as boys versus boys, girls versus girls, boys versus girls, big ones against little ones, and mixed sizes and weights against the same.

Evaluation: This was a very stimulating experience for the group since it presented to them a genuine problem-solving situation in trying to get the exact combination of children for an equal balance of the two teams. When there was enough experimenting, two teams of equal proportions were assembled and it was found that it was most difficult for either to make any headway. They also discovered that an equal balance depended not only on the weight of their classmates but to a great extent upon their strength.

Case 4:

Concept: Electricity travels along a pathway and needs a complete circuit over which to travel.

Activity: *Straddle Ball Roll.* The children stand one behind the other in relay files with from 6 to 10 children in each file. All are in a stride position with feet far enough apart so that a ball can be rolled between the legs of the players. The first person in each file holds a rubber playground ball. At a signal the person at the front of each file starts the activity by attempting to roll the ball between the legs of all the players on his team. The team which gets the ball to the last member of its file first in the manner prescribed scores a point. The last player goes to the head of his file and this procedure is continued with a point scored each time for the team that gets the ball back to the last player first. After every player has had an opportunity to roll the ball back the team which has scored the most points is declared the winner.

Application: The first player at the head of each file became the electric switch which opened and shut the circuit. The ball was the electric current. As the ball rolled between the children's legs it moved right through if all the legs were properly lined-up. When a leg was not in the proper stride, the path of the ball was impeded and the ball rolled out. The game had to be stopped until the ball was recovered and the correction made in the position of the leg. The circuit had to be repaired (the child's leg) before the flow of electricity (the roll of the ball) could be resumed. A scorer kept track of the number of broken circuits each team had.

The team with the least number of broken circuits was the winner.

Evaluation: The children were quick to see and make the analogy themselves after seeing how the interference in the path of the ball sent it out of bounds and stopped the game. In similar fashion any blockage of an electric circuit would break the current and stop the flow of electricity. They gave this variation of the game a new name, "Keep the Circuit Closed."

An experiment with wired batteries and a bell was also used in connection with the development of this concept. Some children reported that they understood this better after they had played Straddle Ball Roll because they could actually "see" the electric current which in this case was the ball.

Although it is difficult to predict what the future holds for the active game learning medium, I feel assured that more serious attention is currently being paid to it. Discussions with leading neurophysiologists, learning theorists, child development specialists, and teachers, reveal a positive feeling toward the active game learning medium. And there is general agreement that the premise is sound from philosophical, physiological, and psychological standpoints.

Benjamin Thompson, Assistant Professor of Elementary Education, University of Wisconsin, Eau Claire

Traditionally curricula for EMH children has stressed "Persistent Life Problems" and this is almost universally construed to mean, in science, practical applications without background experience. The object of this initial activity was to instruct a class of Educable Mentally Handicapped (EMH) children in science emphasizing basic concepts. The topics, magnets and electricity, were selected because they are rich with opportunity for discovery of concepts. Experience with electricity and magnets can also be used to reach basic goals in teaching the EMH child.

The purposes of this study were:

1. To identify the ability of EMR children, ages 8-12, to demonstrate and state knowledge of basic concepts of magnetism and electricity, and
2. To identify where the study of magnetism and electricity can be used to provide special basic training required for EMR children.

Concepts emphasized include:

1. Magnets attract metals.
2. Magnets do not attract all metals.
3. Magnets do not attract non-metals.
4. Different magnets have different strength.
5. Different parts of a magnet have different strength.
6. Magnets can attract at a distance.
7. Magnets can attract other magnets.
8. Magnets can repel other magnets.
9. Each pole of a magnet is alike in some ways (look alike, attract metal).
10. Each pole of a magnet is different in one way.
11. Magnets can be used to tell directions.
12. We can make magnets with electricity.
13. Electricity can light a bulb.
14. Electricity comes from a battery.
15. Battery electricity is safe.
16. Electricity must have a path out of and into a battery.
17. Electricity comes out of this end ( ) of a battery, goes through a wire, and comes in this end (+).
18. Some things do not let electricity pass.
19. Metals let electricity pass.
20. Electricity can make heat.
21. Electricity can make things move (electromagnet and motor).
22. Electricity can be dangerous.

The children were visited each week by the author on Monday and Wednesday for one half hour. The science lesson was preceded by play time and followed by a library visit. During the lessons, one or two concepts were introduced. Seldom was information given to children verbally (electricity comes out of a battery). Almost all concepts were demonstrated (see what happens when I put this end of the wire here and the other end here), developed by questioning (what will happen if we turn the magnet hanging on the string? Will it always point toward Jerry's desk? See if you find out before I come on Wednesday), or developed by experimentation on the child's part (Here is a battery, bulb, and wire. See if you and your partner can make the bulb light). The children worked alone or in pairs--quite often they would crowd around an excited person who drew their attention. One or two students who could do a task were often asked to demonstrate for the class or help individuals.

The author had assistance from a student teacher with one child who, in the opinion of her teacher, was more trainable than educable.

Each child was provided with his own large plastic bucket in which all science materials were kept. The children were able to experiment with these materials during their free time when they could also play house, build with blocks, and do seat work. The room resembled a kindergarten classroom with tables, toys, a play kitchen, and movable chairs.

On occasion the teacher reinforced an idea, the directions--north, south, east, west; utilized an idea for writing skills; and had the children carry through on a language arts lesson associated with magnets. Beyond this the science lesson ended when the author departed.

In all, 18 visits had been made when this report was written. The previous year the author worked with the same children in the same manner on other topics. At the conclusion of the portion on magnetism, four children representing, in the teacher's judgment, the slowest, average (2 were chosen), and most advanced, were interviewed to record the extent of knowledge and skills acquired. The conclusions given were based on classroom observation and these interviews.

There are 11 children in the class, 6 girls and 5 boys. They range in age from 7-7 to 10-2 with the mean age being 8-11. Testing is not all current but IQ scores are as follows:

C.A.	I.Q.
9-7	Wechsler Primary Scale I.Q. 64
8-0	S.B. 71
8-5	S.B. 54
9-4	WISC 68
8-7	S.B. 73
7-7	WISC 65
8-7	S.B. 61
10-0	WISC 72
9-6	WISC 88
8-5	S.B. 61
9-11	WISC 68

In general, all but one child (EMR-trainable borderline) could state the concept worked with, in response to a question (What do magnets do? "They stick to iron." or "They stick to a nail."), and/or they could demonstrate the concept (How can we find out if a magnet will work through glass? -- the child might hold a magnet inside of a jar and try to stick a paper clip on the outside.)

Observation showed that children could often demonstrate concepts if they could not verbalize. Because there was little verbalization of concepts by the author except in summary, this result was not unexpected.

The two concepts with which children had problems and an example of those problems:*

1. **Magnets do not attract all metals.** The children could pick out metal objects a magnet would or wouldn't stick to, but only half responded correctly when asked "Will magnets stick to all metals?" some had trouble generalizing.

*Concepts beyond R had not been dealt with at the time of this writing. Some had trouble generalizing.

2. **Each pole of a magnet is different.** The children could demonstrate repulsion and attraction by experimentation when asked to show how many ways two magnets could work together but the labels, N and S pole, and stating the classic law of repulsion and attraction were not meaningful. Since both poles were equally good for picking up nails, the difference was too complex to assimilate.

Two examples where science activities were used to provide basic training:

1. At one point the children were asked to see how many paper clips their magnets could hold. They had several magnets in their bucket. One child could link paper clips together and he demonstrated the technique. First each child was given ten clips to work with. Both magnets could hold the clips up. Then they were given all they could use. Practice in fine motor and hand-eye coordination was provided. All were asked to count the ten clips in their first chain--then they added more until some had over thirty (The weaker magnet could not support more than 20 clips, the strong could). The use of number charts and board work correlated with and was reinforced by this activity. Counting a series of objects was more difficult in this case than just counting objects. Fingers had to be used to move the chain and mark the already counted clip as the child moved along.
2. Once the children knew that magnets attract through materials, they were shown how a paper clip could be attached to the bottom of a stand-up cut-out figure and the figure moved with a magnet. Their teacher instructed each child to make up a story and she typed it for them. Then paper figures and structures were constructed to represent individuals and places in the story. The children practiced their story by placing the objects on top of a cardboard box set on its side. Its opening was toward a child who reached inside, and moved the magnet underneath to make his figures move. Considerable coordination between hand and eye was required. Only one student needed to look under the box after three practice sessions. The characters went in and out of houses, walked together, ran and looked through windows as the author read the sentences slowly. Example of a story:

KEVIN: A MAN AND A BOY AND A HOUSE
The boy and the man go into the house and eat. And they wash dishes until they are done. Then they go outside and play. They go inside again and go to bed. They get up and they eat. Then they wash dishes. They go outside again. Then they go inside for a glass of water. They go outside again and they play. They go inside again. The end.

This unit led to a concept of direction rooted in a concrete experience. All but one child could use a compass to find directions and relate the words north, south, east, and west to an observable phenomena. The idea of direction, with additional reinforcement, will become much more than something the children are told and required to remember without extension to the environment. Magnetism is no longer approached as magic but as a natural property of some materials.

In addition, the new topic, electricity, will lead to an understanding of what electricity can do and why it must be respected.

The thesis of this author is that concrete experience in basic phenomena should result in more durable practical applications, more quickly grasped. In addition, this concrete experience should better equip the EMH person to cope with unanticipated life problems. The "Persistent Life Problems" approach as generally interpreted assumes EMH children differ from others in kind, not degree. No evidence of this was seen.

The exploratory activity outlined here leads the author to believe that practical applications should be based on concrete experiences with natural pehnomena. The children taking part in this activity did understand and apply the knowledge gained in this way. What they do with such knowledge in the future can not be stated, but if they do not have this knowledge, it is certain they cannot use it.

The main criticism "Persistent Life Problems" advocates have of this approach is that the time should be spent on practical aspects. The author feels there has been inadequate investigation to support this point of view.

SESSION B-7

SCIENCE AND HEART DISEASE

Virginia Newman, Teacher, Lines School, Barrington, Illinois

I don't think that the public even begins to appreciate the magnitude of the heart disease problem. It is, without a doubt, at "epidemic" proportions. "Epidemic" is a Greek word in origin; it means "something that has befallen the people." In a way, this is somewhat inaccurate. "Befallen the people" connotes a natural catastrophe, something unavoidable, an act of God, so to speak. But God really didn't get us in this jam. We did it ourselves.

It is a curious thing that it has taken us so long to begin to face this epidemic as we faced others in our history. This one is disproportionately severe. Sometimes statistics aren't too meaningful, but *anybody* can understand "over half." And over half of the deaths of this nation are due to this one family of diseases. Wouldn't it be acutely meaningful to you to consider that over half the people in this room will die of this disease?

Dr. Edward Williams, of California, said: "There is a matter that misleads a lot of people. Since many infectious diseases have fallen, there are those who take refuge in the statement: 'We're all living longer now anyway'. But we're *not* all living longer. The life expectancy of a baby has indeed been extended; but the life expectancy of forty-year-olds has not paralleled that gain." In other words, the continuing rise of degenerative diseases is busy wiping out the gains made by conquering infectious ones.

It's not "death" we're fighting; certainly that would be a losing battle. It is *premature* death that is so disturbing to us. It truly grieves me to contemplate the great ideas, the talents of which premature death has robbed us.

The world of medicine has long been worried about the extent of the heart disease situation. Then government became concerned and began to give money for research and study grants to determine what might be of help. Finally educators have been prodded into recognizing the gravity of the situation, and, quite logically, it is there.... in the world of education.... that the best remedy lies at this time.

We'd like to tell you about *one* way we're attempting to face this formidable challenge, a project which started small, about eight years ago on the west coast, under the direction of the national clearing house for smoking and health. Now, thousands of students have been through the program. But there's infinitely more to do.

We are now implementing virtually the same in-depth heart and circulatory system study unit in a number of schools in this area. It is based in the science curriculum. The sixth grade level was thoughtfully chosen for the unit; although I have seen it adapted, with success, to other grade levels. It is best to give it at a time when the students are old enough to comprehend the study and young enough not to have too deeply engrained detrimental life-style habits.

I treasure a letter I once received from the renowned Dr. Paul Dudley White. He emphatically maintained, "Children of this age are really much more able to advance in such deep study pursuits than the public gives them credit for." He definitely felt that the greatest gains in this battle were to be made by helping the young before it's too late.

The primary goal of the unit is: "To help the student gain a deep understanding of and an appreciation for the heart and circulatory system."

I defy anyone to give close attention and study to that marvelous organ, the heart, and to avoid developing a tremendous respect for it. When you truly understand and respect something, you're not so likely to abuse it. We've all known "car buffs" who lovingly tend their automobiles, carefully tuning the motor and polishing the exterior. These individuals know what abuse will do to their prizes, so take pains to avoid it. This can surely be related to learning about yourself, what makes *you* tick. One of the reasons this unit is approached with such enthusiasm, by teachers and students alike, is that learning about *yourself* is exciting.

The unit embraces the conceptual approach. It involves a detailed study of a whole idea (concept), using multi-facets, varied techniques, and an abundance of materials. Much of the material is obtainable through The Heart Association. With new ideas in this realm appearing so constantly, the teacher often learns along with the students.

The unit is only initially content-oriented, in order to give the students necessary basic understandings. Then they pursue, in varying depths and ways, different aspects... according to ability and interest. Sometimes students work in groups; sometimes individually.

The method avoids any moral judgments, any "thou shalt not." Finger-wagging, as we know, is a most ineffective teaching technique. Any resulting decisions must be made by the students themselves. It is our obligation to help young people learn about this matter. Then they make up their minds how they're going to use this knowledge, and take the options.

Many of us who have had the exciting experience of working with the unit have seen that it evokes growth of perceptions and changes at the behavioral levels... not only for students, but also for teachers and parents as well. Never have I seen parents follow a unit with more interest. Administrators gleefully tell us that it is "one of the best P.R. tools ever."

In the guidelines we have given to teachers in the fity or sixty area schools that have incorporated the unit, we stress that five general phases be followed in this sequence:

1. Awareness (of the heart and circulatory system as related to the entire body; and the extent of the heart disease problem)
2. Appreciation of the blood (studying its components and jobs)
3. Structure and function of the heart and circulatory system
4. Diseases involved (atherosclerosis, hypertension, smoking-related ones, obesity, strokes, etc.)
5. Prevention

Though the study is based in the science curriculum, it is essentially interdisciplinary. There are correlated activities in social studies, math, language arts, etc. Can you imagine a cinquain written about the sinoatrial node ("Pacemaker")? I've seen a great one! To keep the study from being too physiology-oriented or anatomy-bent, it's important to bring in other related aspects of interest.

Help students learn about the colorful superstitions that primitive men attached to blood and its uses. For example, using blood for fertilizing crops and drinking the blood of the animal whose characteristics one wished to acquire. "Bloody" superstitions have even persisted to relatively recent times. One instance was the curious custom of using the "sympathetic egg," where an egg was drained of its contents and filled with the blood of a healthy animal. The egg was then placed on the affected part of an ailing person (on the abdomen if he had a stomach ache, etc.). Supposedly, the "demons" causing discomfort would prefer the healthy blood within the egg and flee the patient. Another tale is about the origin of the barber pole. Are you familiar with that one? There are many.

Give some attention to the pioneers in the study of blood, heart research, and surgery. Help those who are interested to learn about Galen, Malpighi, and Harvey. Did you know that the author of one of the earliest theories about the circulation of blood, Servetus, was executed for stating his belief? It was considered heresy. Yet, he was subsequently proved to be correct.

Find out the amusing story behind timid Dr. Rene Laënnec's invention of the stethoscope. (He was loath to put his ear against the chest of buxom ladies, the only way to listen to the heart at that time.)

If math is especially to your liking, there are many possible activities in that area. How about problems relating the ratio between your heartbeat and that of an elephant, or a humming bird? And how about figuring out *why* that difference exists? Are you interested in the speed at which blood gushes over the aortic arch as opposed to its pace while passing through the capillaries? Or how about figuring the amount of blood the sturdy, dependable heart pumps in a day, a year, a lifetime?

Are you interested in how space travel affects the heart and blood? NASA has been watching this closely.

If you're more "project-inclined," help students learn to simulate a circulatory system using aquariums. Or let them build a "smoking machine" with a simple pump.

Have you ever viewed a heartbeat on an oscilloscope prior to the owner's smoking a cigarette and then again a few minutes afterward? The dramatic difference in rate is unforgettable. . . particularly to the one used in the demonstration. (Of course, students are *not* used as models.)

Study, if you can, the wee transparent shellfish, daphnia. While viewing via bioscope, students can give it stimulants and depressants. The immediate reaction of the heart can be watched through the little creature's transparent showcase.

Give them the opportunity to discover the simplicity of blood-typing (inexpensive blood-typing kits are available). Let them use and interpret a sphygmomanometer, the device for taking blood pressure.

The variety of activities and tangents you can "take off" on, triggered by the kids' interest, are numerous. Incidentally, this is certainly a beneficial byproduct for the teacher. How can such a unit ever get dull?

I would hope, if you were to undertake this program, that you might have the good fortune of the cooperation of community sources that we have encountered. Since hospitals are undertaking preventive education more and more, we've had the invitation of more than one hospital to help us. They not only demonstrate their coronary care facilities, but are a source of doctors and nurses willing to donate time and talent. They have given formal presentations and led informal discussions as well.

An additional treat this past year was a visit to our school by a nearby blood bank. They "laid out" a few of us on the faculty in the learning center and showed the students the ease of the blood-donation-storage operation. This helped to remove the stigma often attached to this action by the kids. (Of course, in the long run, this could be reciprocally advantageous to the blood bank.)

We find that the community, in general, is not only willing to help us, but even eager in many ways.

At first, a few years ago, we met with a degree of resistance on the part of some science teachers regarding the unit. . . and justifiably so. There was a time when even I bristled at the thought of adding one more thing to the already-burdened science curriculum. It is literally bulging with the likes of chemistry and geology units, etc. but I insist that the time has come when we *must establish priorities*. People aren't dying of *rocks*!

We hear the hue and cry for "relevance in the schools" from all quarters. It comes from students, parents, administrators, and teachers themselves. Can you think of more relevant subject matter than tackling this current plague? I say to you that you *can* readjust the time element of study units. You *can* shift some units to different grade levels, if necessary. You *can* make room for such a valuable educational contribution.

In whatever field we pursue, as teachers, it is our duty to provide the best possible educational program that will help students develop not only intellectually and socially, but also physically and emotionally. (Incidentally, in the prevention phase of the unit, good mental heath is given attention right along with physical aspects.)

In order to more nearly meet the lofty goals of our profession, we must stimulate and motivate the student to think clearly and effectively as he makes decisions. One of the prime aims of the heart unit is to help the student to realize his *own* responsibility to himself and others. We can help him learn about his "engine" (and we are remiss if we do not!) but it is he, alone, who is given the divine trust of caring for it.

SESSION B-11

FREE MATERIALS IN THE CLASSROOM

USE AND MISUSE OF INDUSTRY-SPONSORED MATERIALS

C.R. Duvall and Wayne Krepel, Indiana University, South Bend

A review of educational research reveals that free and inexpensive materials are used today to a much greater extent than in the past. The use of these materials by teachers is encouraged by the recognized experts in the field of education, despite certain inherent limitations implied by the fact that they are free. Studies conducted within the last quarter of a century showed that over 90 percent of the classroom teachers surveyed had used some form of sponsored materials. Studies of school policies and administrative procedures reveal that the use of these materials is permitted and often encouraged.

The producers of free materials are interested in their utilization by teachers. These studies, sponsored by the American Iron and Steel Institute, Washington, D.C. are evidence of the producers' interest in determining the strengths and weaknesses of the materials being sent into classrooms throughout the United States and utilized in the instructional programs of these schools.

To obtain the desired information a questionnaire was developed, accompanied by a cover letter which explained the purpose of the studies. Similar instruments were used in both studies, permitting comparisons and generalizations.

An analysis of the data relating to the two studies: *A Study of Teacher Opinions Concerning Selected Free Filmstrips Provided by the American Iron and Steel Institute to Schools Throughout the United States* (published August, 1972), and *A Study of Teacher Opinions and Evaluations Concerning Selected Free Printed Materials Provided by the American Iron and Steel Institute to Individuals Throughout the United States* (published September, 1973) is presented.[1]

[1]Materials for this presentation have been abstracted from two documents. Complete data may be obtained from:

DuVall, Charles R., et. al., "A Study of Teacher Opinions Concerning Selected Free Filmstrips Provided by the American Iron and Steel Institute to Schools Throughout the United States," *Research in Education*, 8:6 (June, 1973) p. 97 (ED 072 992).

DuVall, Charles R. et al., "A Study of Teacher Opinions and Evaluations Concerning Selected Free Printed Materials Provided by the American Iron and Steel Institute to Individuals Throughout the United States." *Research in Education* (in press--scheduled for February, 1974 release).

For both studies 1,200 questionnaires were mailed to randomly selected persons from mailing lists provided by the American Iron and Steel Institute. A similar percent of responses was obtained in each study (Filmstrips - 70 percent, and Printed Materials 68 percent). In the original studies, an adjustment for undeliverable queries was made. With this adjustment the percent of responses was Filmstrips 74 percent and Printed Materials 75 percent. Complete details are contained in the studies cited. In view of the relatively high rate of responses, generalizations were drawn to the populations sampled. Indeed, it is believed that the American Iron and Steel Institute materials are representative enough of free and inexpensive materials as a whole that tentative generalizations may be drawn to similar materials.

Examination of the data led to the conclusion that the respondents in the two studies are similar in nature. In no case did the percent of response within any school district category (rural, suburban, village, town, city, undesignated) vary more than 10 percent and in five of the six categories the difference was five percent or less.

The data dealing with level of training, as indicated by the educational background of the respondents, showed similar patterns between the two samples. While the educational backgrounds of the respondents appeared to be similar, the greatest divergences between the two samples were at the levels designated "Bachelors degree" and "Masters degree plus." In no case did the differences between groups within the sample exceed ten percent; therefore, the samples were considered to be similar.

When the responses were analyzed according to age ranges it was found that almost two of every three persons in both studies were 40 years of age or younger. However, examination of the data revealed that there was a somewhat larger difference in the percent of response between age ranges, particularly with respect to the younger groups designated 21-25 and 26-30. On the whole, the sample responding to "printed materials" tended to be appreciably younger than those who responded to the instrument assessing the filmstrips.

The following data are presented in an effort to analyze the effectiveness of the materials. These materials are examined from several different perspectives.

When the educational level of the respondents was used as the variable in the analysis, little difference was noted in the assessment of the two types of materials. The overall responses toward the materials tended to be highly positive and supportive of the efforts of the producers. Teachers with less than a bachelors degree tended to be more positive in the assessment of the worth of the filmstrips than the printed materials. Only about one percent of the teachers tended to rate these materials as "poor" or "having no value."

Examination of the same data, analyzed by relative size of the school district, showed a rather consistent positive opinion. Little discernible difference in the response pattern was noted.

It should be noted that a certain lack of clarity may have been introduced in the comparison between the two studies by the changing of descriptors used in the two questionnaires. The change was made from "outstanding-good-fair-poor" to "very effective-effective-somewhat effective-no value" to make the descriptors more definitive, and hence more meaningful. In the study dealing with printed materials the percent of teachers indicating that the materials were "somewhat effective" is higher than those teachers who indicated that the filmstrips were "fair." It is the opinion of the researchers that the change in descriptors was responsible for the variation in response pattern noted. It is also their opinion that the descriptors used in the second study dealing with printed materials were more definitive, even though this change evoked a somewhat lower relative rating.

One of the most frequently voiced concerns regarding free and inexpensive materials is the fact that their sponsorship may have an effect upon their use in the instructional program. Another inference sometimes made is that sponsorship has a negative connotation rarely positive. In order to ascertain the teachers' judgments of this assumption the question was posed.

When the overall response pattern was considered, approximately two-thirds of the respondents indicated that the fact that the materials were industry sponsored was either "unobtrusive" or had "no effect." Only one in 20 of the respondents indicated that industry sponsorship of these printed materials affected their usefulness. In the case of the filmstrips only one percent of the sample indicated intrusion.

Of prime concern to the producers of free and inexpensive materials is the use made and the evaluation of these materials by the users. Because of the differences between filmstrips and printed materials, the instruments used in obtaining the basic data for the studies were modifed and adapted to reflect these differences.

Teachers who use free filmstrips, in the opinion of the researchers, compare the free materials to commercially produced filmstrips and decide to use the best of the available instructional resources in their teaching. Respondents were asked to indicate assessment of the free filmstrips provided by the American Iron and Steel Institute as compared to commercially produced materials dealing with similar topics. Approximately 50 percent of them indicated that the free filmstrips provided were either "superior to most" or "better than most" of the commercially produced materials with which they were familiar. Another one-fourth of the respondents indicated that these materials were as "good as most" of the materials with which they were acquainted. Perhaps the most encouraging aspect of the results of this question was that only one percent of the respondents indicated that the filmstrips were in need of improvement. These data were analyzed by both the educational level of the respondents and the size of the school district in which the materials were used.

In the study dealing with printed materials an attempt was made to determine the reasons teachers had for requesting materials as well as the way in which they employed the materials after receipt from the sponsoring agency. Another unique feature of printed materials, when contrasted with filmstrips, is that they are consumable, whereas the filmstrips are intended to be retained and reused. This fact requires the producer to replenish and update the supply of printed materials at frequent intervals if the materials are to continue to be of value.

Teachers have many reasons for requesting printed materials from sponsors. Over half of the respondents replied that they were seeking curriculum materials. The second most frequently indicated reason was that they were building a resource file. Other reasons which occurred with some frequency were seeking "illustrative materials," and "materials which could be used with the entire class."

The instructional level at which these materials have been used is of concern to both the producer and the curriculum planner. In the case of the materials prepared by the American Iron and Steel Institute and their subsequent use, as reported by teachers, it is possible to make comparisons. Educators Progress Service (EPS), in its reference work entitled *Educators Guide to Free Science Materials, 14th Annual Edition, 1973,* has made specific suggestions to the teacher for appropriate levels of use.

The *EPS Guide* recommends that "The One-Leaf Book Story of Environment and Industry" be used "in grade 7 and up" and that two teachers guides are available, one for the science teacher and the other for the social studies teacher. An analysis of the data collected in the study indicates that fully 20 percent of the teachers who requested the booklet used it below the levels intended by the producer.

The pamphlet or cartoon (comic) booklet "Mark Steel Fights Pollution" description in the guide led the researchers to infer that elementary level usage is intended, however, no specific grade level recommendation was made. The results of the study indicate that over 50 percent of usage was made at the junior and senior high school levels.

When considered by guide recommendation, the pamphlet "Steel Science and Our Society" should be used in grades 5-8. Approximately one-half of the respondents indicated that they were using the materials at the suggested grade levels. However, over 10 percent of the respondents indicated primary use and an additional 13 percent indicated using it at the senior high school level.

Another interesting finding which emerged from this particular facet of the study was the extremely high use of the materials upon receipt. Only six percent of the respondents indicated that they did not use the materials after they had been received.

Examination of the data shows that the recipients used the printed materials in a variety of ways. Most frequently mentioned uses were as supplementary materials, pupil and teacher references, and as bulletin board materials.

The final analysis made concerns the respondents' intention to reuse the materials, if available. These data are of particular importance to the producers of free and inexpensive materials. Reuse infers a degree of satisfaction with the product. In this study, 60 percent of the respondents indicated they would reuse the pamphlets next year if they were available. Less than five percent indicated that they would not request these materials for future classroom use. The researchers interpret this response pattern as being highly supportive of the free instructional aids provided by the American Iron and Steel Institute.

Based upon these studies it is apparent that teachers do use free and inexpensive materials in the instructional programs of the schools of the United States. Teachers have indicated that the materials are (a) effective supplementary aids usually as good as, if not better than, commercially produced materials and (b) are likely to continue in use if provided by members of the business and industrial community.

Because of the widespread acceptance and use of these materials there is a basic responsibility, shared equally by users and producers, to insure that free and inexpensive materials are utilized in an instructionally appropriate manner. A high degree of responsibility is placed upon the producers to provide those materials which most nearly meet the instructional needs of the schools. Teachers have the responsibility to make proper use of these materials.

Producers of free and inexpensive materials should continue to more nearly define "curriculum content," that is, design them for more specific instructional use. This focusing of content may restrict the audience but it should give the materials a higher value for educational purposes.

Suggestions similar to those provided by the producers of the materials studied should be included with all free and inexpensive materials. Although the instructional guides and catalog descriptions did not result in appropriate utilization of filmstrips and printed materials in all cases, they were considered beneficial to the users. Therefore, producers are encouraged to provide, and in some cases more clearly define, these sources of aid to instructional planning. Indeed, producers may wish to suggest new and innovative uses for their materials, but they should provide at least minimum plans or guidelines.

Free and inexpensive materials are highly acceptable to teachers throughout the country. The producer's problem is not to gain acceptance, but to improve the product so that it more nearly meets the educational needs of the schools. Today, free materials are less "advertising materials" and are more nearly "instructional aids." Producers have the opportunity and responsibility to make these materials instructionally relevant.

Teachers should be selective in the choice of materials they use. The selection process should include a careful perusal of the various sources of information relating to the availability of free materials. Excellent examples of preliminary screening devices are the Educators Progress Service series of catalogs and the many references in current periodical literature. Teachers should screen materials upon receipt and make a decision concerning use in their program. The fact that materials are free does not mean they must be used.

It is suggested that other producers examine ways in which teachers utilize their materials. As additional data become available comparisons may be made and further generalizations drawn. This effort will contribute to a further understanding of the use (and possible misuse) of free and inexpensive learning materials in classrooms throughout the nation.

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FINDING AND SELECTING FREE EDUCATIONAL MATERIALS

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There has been no time in our history when there was greater need for industry to play a constructive role in the process of education and for education to use industrial contributions to make curriculum and classroom learning experiences meaningful, relevant, and interesting to the learner. It was interesting to note that one of the speakers at this conference last year stated that the task for business in the decade ahead is to explain the free enterprise system to the American public lest the American electorate dismantle the free enterprise system. One of the challenges to education in this decade is to humanize education, to help each person develop a positive attitude about himself, to help him to develop an understanding and appreciation for his fellow man and his fellow man's culture - in other words, help each child to become an individual capable of living in a pluralistic society. I have just returned from the twenty-ninth annual conference for the Association for Supervision and Curriculum Development and the entire conference was devoted to Creating Curricula for Human Futures, The World Our Children May Inherit, Education for Survival: Our Task, Educator's Survival Kit: Career Education and the Curriculum.

These are but a few of the topics which spell future educational shock to us complacent, mid-western school people whose past experience and living somewhat cloud the bifocals which look to the future. But look we must for we are presently dealing with the future in our schools.

For many years industry has produced material and made it available with little or no cost for educational purposes. This has, for the most part, been done as a method of advertising on the part of industry, however, it has proven to be a rich source of valuable curriculum material. One would find it difficult or impossible to name a discipline of instruction in the elementary or secondary school which could not be enhanced through the use of industry-sponsored or free material. Some minicourses can be built completely from available free materials.

The free materials are available but how does the average classroom teacher know what they are, where they are, and how to obtain them? To help the classroom teacher with this task, Educators Progress Service in Randolph, Wisconsin, has since 1936 made available eight different guides:

1. *Guide to Free Films*
2. *Guide to Free Filmstrips*
3. *Guide to Free Tapes, Scripts, and Transcriptions*
4. *Elementary Teachers Guide to Free Curriculum Materials*
5. *Guide to Free Science Materials*
6. *Guide to Free Social Studies Materials*
7. *Guide to Free Guidance Materials*
8. *Guide to Free Health, Physical Education and Recreation Materials*

Set of Cards, Educators Index of Free Materials

All of the guides are revised annually. This means that titles of material which producers have withdrawn are deleted in the revised guide and new titles are added and so identified. In the Elementary Teachers Guide alone there are 1,705 items listed.

As a further convenience to the busy teacher, the guides are title, subject, and source indexed. In other words, if one is familiar with some industry, he can readily note whether or not their material is listed, or, if one is planning a unit or topic, the subject index lists everything available.

The projected materials, videos, and transcriptions come free, but after use the majority of them need to be returned for further circulation. The printed material once received becomes the property of the teacher or school. Usually the teacher is privileged to keep such material.

Every teacher needs some file or storage space for the material he accumulates. Once the storage space becomes available it is well to establish a method of filing material. Personally I prefer the tabbed manila folder with an attached card bearing a brief description of the folder's contents.

The material in our guides has been evaluated for listing, but each user of material needs to evaluate in terms of validity, quality, and intended use. These are questions the classroom teacher could ask himself:

1. What was the basic purpose of the producer? Can you determine who the author was?
2. Does the material reflect some quality? Does it identify specific social, political, or economic viewpoints?
3. Where would the material best accommodate one's classwork? Is the material visual or factual? What is the grade level at which it is best comprehended?

Education is moving from the teaching-learning theory where the teacher was the "giver-of-knowledge" and the learner the passive-receiver to the process-oriented theory to the teacher as facilitator of learning. The teacher sets the stage, plans stategies and alternatives, and provides evaluative criteria while the learner uses his curiosity to explore, his imagination to fuse his findings, and his ideas and his creativity to construct ideas for himself or construct concrete evidence to share.

One can readily understand that in this kind of teaching-learning situation the idea of a textbook or even multiple-texts can't exist. There must be a limitless amount of material from which choices may be made and pupils must participate in the selection of learning materials. A unique contribution of the resource guide is that it allows the student to shop for material, either independently, or with the help of the teacher. In these days of scant budgets, free materials are a welcome asset to limited text and map supplies.

The process-oriented individualized learning program does not take place in a vacuum. Certainly the learner cannot help but gather factual knowledge as he interacts with others and with materials; however, it is to be hoped that he learns the necessary skills and develops a conceptual understanding of the content fields such as science or social studies. The use of industry-sponsored materials can play an important part in concept development. For example, in health one can find material to help little children learn simple health habits as well as material which helps one understand his body functions in adult life. This sets an example of spiral learning, the strengthening and broadening of concepts.

Earlier I alluded to the Educator's Survival Kit: Career Development and the Curriculum.

Here too, we can begin in early childhood to develop some simple concepts about work. Most kindergarten children know the school maintenance person or persons very well. We expand the work idea to recognizing different kinds of work, to knowing how different kinds of work are done, the material used in work, and ultimately to the learner having work experiences, both in school and out of school, and finally in job placement.

This is an exciting dimension of school today. Where could one find better resource material than from the industries, who are manufacturers themselves.

It would appear that this facet of education will yield some reciprocation from education to industry. I think for a long time we, in education, have ordered and used materials but seldom if ever furnished any appreciation or recognition. Maybe education has not communicated very well to any segment of society.

In the humanizing process of education, it becomes necessary to help learners develop a loyalty to their fellow men. Loyalty implies a faith in people, faith in a community of people, and faith in one's country. Faith is often viewed as something imaginary, but it must depend upon both the real and the imaginary. Faith is a behavior made possible when one can use his imagination combined with the learnings and create his own behavior. At this point the learner becomes the master of his behavior. This kind of behavior could have negative factors. If a person becomes self-satisfied and develops his own little world which he tends to protect and perpetuate, he loses sight of the big world. The excitement of learning must be developed so that people can have the motivation to adapt their own little worlds to the larger world and find satisfaction with their own behaviors in the larger pluralistic society.

Certainly the free materials available can help develop this faith in people and faith in one's country, the people who make the country.

In the course of projecting the uses of free materials, I have neglected to indicate that there are sources for exhibits, ideas for bulletin board displays, ideas to challenge the capable, and material for the slow learner.

SESSION C-1

SCIENCE FOR A NEW ELITE

CHEMTEC: A DECADE OF EXPERIENCE IN THE AMERICAN CHEMICAL SOCIETY

Kenneth Chapman, Assistant Head for Speical Projects, Education Department, American Chemical Society, Washington, D.C.

The phrase "New Elite" used in the title of this session calls for some reflections on pecking orders, job availability, salaries, advancement opportunities, and individual goals.

Does it not seem strange for us to talk about a "New Elite" in a democracy where all persons are considered equal and where the potential of 14 or 16 years of education is theoretically available to all? In an age of equality that is enforced by law as well as moral suasion, are we justified in raising a banner that says, "Join us and be better than the next person?" Following this philosophical train of thought may be intellectually stimulating and personally comforting, but it fails to provide for practical needs of today's society and many of the people who live in it.

To those who have worked with technical education within the framework of the American Chemical Society for the past ten years, the foregoing questions are far from academic. They are practical questions that have been debated in ACS Committees and even on the floor of ACS Council meetings where major policy changes are considered. These questions are important to educational policies within our discipline areas as well as for our society as a whole.

Please bear with me for a few moments while I outline some of the major discussion points of ACS considerations relative to technician education and the role of technicians in the scientific and educational organization we call the American Chemical Society.

A decade ago, an ACS committee went on record with the statement that chemistry portions of technician curricula should be fully transferable to chemistry programs designed to produce chemists and chemical engineers. The underlying concern was that students studying in chemical technology programs should not be hindered in any way from continuing study to become professionals.

Three years later, a second committee declared that the goals of technician education and the goals of the first two-years of a professional's program were sufficiently different that a two-year program could not produce a well prepared chemical technician while meeting all the needs of a student wanting to embark upon the third year of study in a program designed for a chemist. Instead, it declared that a distinct role existed in modern chemistry for technicians and that many individuals would be much better served by a curriculum specifically designed to build upon the conditions which led these individuals to consider technician careers in the first place. The committee stated that those wanting to continue to study to become chemists would be best served by courses that would serve as a bridge from technician to professional programs.

While one committee was tackling the educational problems of technicians, another ACS committee was struggling with the role of technicians in the Society. Membership requirements made it very difficult for technicians to obtain ACS membership; yet a significant number of technicians desired some services provided by ACS, particularly those that were educationally oriented. In eight years of work, this committee has not obtained input sufficient to show clearly whether ACS should redesign its membership requirements to admit technician or aid technicians in the formation of a sister society. Arguments for both courses of action come from both the professional and technician communities.

What has been clearly demonstrated is that chemical technicians are making major contributions to chemistry, that they have leadership and organizational expertise, and that they are much too important to the chemistry community to be shunted aside and ignored as in previous years. Without going into details, it is sufficient to say that chemical technicians are not only contributing to chemistry by doing the bench work in chemical laboratories, but they are contributing to the decisions which affect all those working within the field of chemistry on local, regional, and national levels.

The Chemical Technician Curriculum Project was developed to increase the professional participation of technicians in chemistry and to meet their educational needs. For this reason, the ChemTeC Project began its work with a curriculum concept in mind, with the design and production of instructional materials of secondary consideration.

Much groundwork had been laid when the ChemTeC writing team first met in April 1970. However, the first order of business was to define and specify the qualifications and responsibilities of a chemical technician. Now, four years later, the definition lies within the body of texts of the ChemTeC curriculum, where the knowledge and skills expected of the technician are carefully stated. It is to be hoped that employers will recognize the capabilities of a trained technician and utilize these capabilities to full advantage. The supervisor who recognizes no distinction between the work of the technician and the professional chemist is likely to find both disgruntled. Each must be challenged according to ability, interests, and preparation.

Among the specific objectives set by the ChemTeC writing team were:

1. training students in the use of common laboratory techniques,
2. acquainting students with the language of chemistry,
3. teaching the basic chemical principles, and
4. teaching some descriptive chemistry as it is currently used.

Guidelines were developed for achieving these objectives. Borrowing directly from Dr. Robert L. Pecsok, Project Director:[1]

1. Keep the language simple and conversational.
2. Do not use so many words that what should be easy becomes difficult.
3. Adopt a phenomenological approach. Do, observe, interpret, and then explain the concepts, rather than do experiments to illustrate abstract ideas.
4. Give reasons behind the facts where appropriate.
5. Justify why a topic is important to the student.
6. Use experiments related to common experience where possible.
7. Keep the mathematics to elementary algebra, logarithms, and graphs.
8. Repeat concepts with a gradual increasing of sophistication and a broadening of significance.
9. Think in terms of questions the student should be able to answer.

Students using the ChemTeC approach bypass the usual introductions of classifying and describing kinds of energy, matter, etc. On the first day, the ChemTeC student is doing something very basic paper chromatography. A few months later he broadens his first day's work by using paper chromatography for separating ink components. He then extracts the separated substances, measures the absorption spectra, and learns the practical aspects of spectrophotometry, properties of light, and Beer's Law. This is the typical approach used throughout the ChemTeC program.

Mathematics in ChemTeC is oriented to use. Data is generated and to become meaningful, the student must organize it and do some mathematical manipulations.

Today the ChemTeC materials are available as a classroom tested and revised series of eight volumes plus a guidebook and teacher's manual. For traditional programs, these texts replace general chemistry, organic chemistry, analytical chemistry, physical chemistry, and laboratory texts. The lecture and laboratory is completely integrated. There is no artificial separation of the subdiscipline areas of chemistry. It must be emphasized that this is a laboratory-oriented program and the student must *do* chemistry, he cannot simply *read* chemistry.

[1] Pecsok, Robert L., "ChemTeC: An Innovative Approach to Chemistry," *Journal of Chemical Education* 50; P. 83, December 1973.

PHYSICS OF TECHNOLOGY MODULES—THE PRODUCT OF THE TECH PHYSICS PROJECT

Philip DiLavore, Project Coordinator, Tech Physics, Indiana State University, Terre Haute

The aim of the Tech Physics Project is to produce instructional materials for the teaching of introductory college physics in a "modular" form and with a laboratory-oriented approach. Each module comprises a relatively independent unit of instruction, and each is based upon a technological device or system. (Thus they are called the "Physics of Technology" modules.) The students' investigations are centered about the system and, in each module, only those physics topics which flow naturally from the study of the device are discussed. Ten to twelve modules will form a one-year course, but about twenty-five are being produced, so that the individual teachers can assemble sets of modules which are most appropriate for their students. Insofar as possible, the Project encourages individualized study.

The Physics of Technology modules are directed to those students who are in technician training or technology programs and who are taking a "technical physics" course. Thus far, the modules have been used widely by such students, but they have also had considerable use in other kinds of courses; e.g., those for liberal arts, pre-professional and even high school students. Even though the modules are based on technological devices, the aim is to teach basic physics concepts; the technology involved is used as a motivating device.

Unusual aspects of the Physics of Technology modules include the following:

1. Physics is taught by means of "real-world" devices.
2. The instructional units are three-week modules, which may be assembled from a much larger set than could be used in a whole year; the intention is that the teacher then can use those modules which are most appropriate for his students.
3. "Coverage" of topics in a traditional sense is not aimed for. Rather, it is intended that the students should explore the topics they do cover in more depth and give them a feel for the methods and topics of physics. However, most of the traditional topics are covered in some modules, and teachers may choose which topics they wish to include.
4. Generalizations into broad, physical principles follow from specific observations by the student of the particular principle in action in the device being studied.

This Project is funded through five separate grants from the National Science Foundation, one to the Project Coordinator and the other four to the Production Centers. The Project Directors at each of the Production Centers are: L.K. Akers and John F. Yegge at Oak Ridge Associated Universities, John McWane at Technical Education Research Centers, Bill G. Aldridge at Florissant Valley Community College, and C.R. Stannard and Bruce Marsh at The State University of New York at Binghamton.

Each of the four centers which are producing the Physics of Technology modules have been carrying on field tests. From the time the first draft is written, a module is tested in as many schools and with as many classes as possible, the results of these tests then provide information for the revision of the materials. In addition, some field testing emanating from the Project Coordinator's office has been carried on at other colleges, and feedback from these contributes to revision of the materials.

Presently the Project has under consideration by the National Science Foundation a proposal for more extended and coordinated field testing of the materials in a number of colleges. It is hoped that it will be possible to try out full-year courses based completely on the Physics of Technology modules at about ten colleges.

A list of Physics of Technology modules which are now available for preliminary classroom trials may be requested from the Production Centers listed above. The Physics of Technology modules will be published in final form in January 1976, by the McGraw-Hill Book Company. The accompanying apparatus is to be manufactured by Thornton Associates; some of which is now available.

SESSION C-3

SCIENCE IS IN THERE! CAN YOU FIND IT? IN WASHINGTON D.C.?

Mary B. Harbeck, Assistant Director, Department of Science, Public Schools, Washington, D.C.

Although science is a noun in the title of our presentation today we try to keep it a verb in the classrooms of the District of Columbia.

Let me set the stage for you. Twenty-five hundred classroom teachers, in one hundred and forty buildings are helping 77,000 children learn science. The largest building has about 1,500 students (K-6) and the smallest has an enrollment of 139. We have a corps of 75 science resource teachers to help in the task. Some of them are residents in a large building; about a third of them have two or more buildings assigned to them, and there are about twenty small buildings whose budgets will not stretch to cover special subject resource teachers.

This is, theoretically, a beautiful set-up. As is usually the case, the theory loses something in the translation into actual practice. We expected that classroom teachers would teach science as an integral part of the school day, with help from the science resource teacher. After the teacher's union obtained a requirement that classroom teachers have three planning periods per week principals found it hard to provide the planning periods in any way except to have science resource teachers teach children without the presence of the classroom teacher. The school-by-school budgeting system which we use makes it necessary that we negotiate with individual principals to include some expenditures for science equipment in the budget each year. The science department has no budget. The pressure from the central administration is on math and reading. Not all principals and teachers see the potential in inquiry-based science for developing and strengthening math and reading skills. Opportunities for massive inservice education for classroom teachers are hard to come by.

We have developed minimum performance objectives in grades K-6 and are in the second year of validation. Our philosophy emphasizes that the science program is to be both process and content oriented with the emphasis on process. It is based on the idea that all children should be successful in inquiring into natural phenomena in a free and "accepting" atmosphere. We are trying to get elementary science mandated for all children; probably this is really a bid for attracting increased attention to our program.

The minimum performance standards which we have set are highly compatible with ESS, SCIS, and AAAS. About 33 buildings including two open space buildings are using SCIS in the early grades. There are 20 buildings using the AAAS program. Here and there one finds an ESS unit or two in use. We have three buildings piloting the USMES, developed in Newtown, Massachusetts and one building using The Individualized Science program developed by the RBS lab in Philadelphia. The financing of these programs and the logistics of equipment distribution have never been adequate. Many of our buildings are using programs thought up and scrounged for by the science teacher who is there.

This, then, is a thumbnail sketch of the situation as it is. The resourcefulness and dedication of the science resource teacher keeps the program going, often surprisingly well.

How do inner-city children manage to "do" science instead of reading about it and talking about it? In just the same ways that suburban and rural children do. Inner-city children are at once just as alike and just as different from each other as groups of children in other locales.

In the schools where more traditional programs still prevail, children are memorizing the proper responses and feeding them back to the teacher in the expected fashion. Happily, in many schools we see that teachers who don't have SCIS and AAAS materials often have the philosophy of these programs. Children are observing ice and water in a jar instead of a beaker, sorting and classifying buttons brought from home, doing population counts in a gallon jar aquarium, building their own circuit boards (sometimes with telephone company wire), and computing the mechanical advantage of their own bicycles. They are maintaining mealworm colonies and studying animal behavior. The good readers do written and oral reports. The non-readers draw pictures and "show and tell." Some of them learn to spell ellipse and rectangle but get mixed up when reading was and saw.

Science has become a practical necessity for many of our schools with the advent of ecology and beautification projects. Children are learning to measure and map school sites. They are propagating geraniums to plant in window boxes this spring. They are using vaseline on cards to collect solid pollutants from the air. They are measuring the amount of trash produced in the classroom. Sixth grade students visit a National Park Service lightship on the Potomac and collect and test water samples for sediment and acidity. Many sixth grade students study a woodland and field habitat during a week of mountain camp life. They draw inferences from the data they collect on four nature trails. They compare and contrast the camp environment with their home environment.

The students in our bilingual schools sometimes get science experiences taught in Spanish. I have seen an armless child sort buttons in a SCIS lesson with her toes. . . . She had white socks on.

Our experience with the newer alphabet programs conforms to Walbesser's evaluation of AAAS the disadvantaged children do as well as those who are advantaged economically and socially. We find that children who have no personal possessions at home covet our magnets, magnifying lenses, and other small objects intensely. I wish I could get a carload to give away.

Inner-city children bounce and giggle in their seats, they have to learn to share, they often present sweeping hypotheses with little evidence to support them, they compete with each other, they beg for affection and acceptance from teachers, and they want to succeed. They deserve a better chance to learn than they sometimes get.

Our problems lie with the bureaucracy and financing problems present in large city systems, not with the children. Their cultural diversities make helping them to learn a richer experience for teachers. The learning of science processes and concepts is an avenue which can be used to improve communication skills and mutual understanding among all students as they investigate the environment which they all have in common.

SESSION C-4

SCIENCE TEACHING IN AN OPEN-SPACE HIGH SCHOOL

Maria Penny, Science Department Chairman, Wilde Lake High School, Columbia, Maryland

Wilde Lake High School is an open-space, individualized-progress high school belonging to the Trump Model School Program. The school philosophy is to provide a personalized, self-paced curriculum where each student is actively involved in setting goals and evaluating progress.

All science is taught in one large classroom with modern facilities. The staff also has access to auditoriums and conference rooms.

The program provides for four levels of abstraction in most of the sciences; offerings range from molecular biology and astronomy through biological and physical sciences for low-achievers.

The techniques used to individualize the different courses vary depending on the type of learner and the resources. Extensive use is made of UNIPACS, learning stations, flow charts, games, workbooks and small group discussions. Evaluation is both oral and written. Effort is made to hold informal, oral evaluation frequently to keep in close touch with student progress.

In the two and a half years of the program, the staff has begun to accumulate a variety of resources. However, much more effort is needed to develop materials on non-traditional topics and to meet the needs of exceptional students on either end of the ability spectrum.

SESSION C-5

MINERALS, ENERGY, AND THE ENVIRONMENT

THE NATURAL RESOURCE PROBLEM, A BLACK BOX TYPE OF APPROACH

John C. Griffiths, Professor, Department of Geosciences, Pennsylvania State University, University Park

The mineral industries is a subsystem of the total system comprising the life of homo sapiens on earth. Its structure is reviewed through illustrative examples.

The exploitation of mineral resources as part of this system is traced through time in terms of its changing dollar value. This may be looked upon as the output of a black box. The behavior of the black box may be modeled and, using the criteria of economic optimization, the outcome is, at best, suboptimal.

Implications of this behavioral pattern for future management and control of natural resources are examined.

MINERAL POSITION OF THE UNITED STATES–1974

John D. Morgan, Jr., Assistant Director, Mineral Position Analysis, Bureau of Mines, Department of the Interior, Washington, D.C.

The United States is the world's most productive nation and its citizens enjoy one of the highest material standards of living of any people in the world. Materials and energy are the lifeblood of any industrialized economy. Annually the United States uses over 4 billion tons of mineral materials and fuels, or 40,000 pounds per person. Domestic processed materials of mineral origin and energy are valued at more than $175 billion annually, and they are derived largely from domestic sources, supplemented by imports.

In recent years the superior productivity of the United States has also enabled it to give food and manufactured articles to many other less fortunate nations and peoples of the earth. What then is our concern with materials at this time? Seeing the burgeoning increases in our mineral demand: from 2 billion tons in 1950, to over 4 billion tons today, and a projected 11 billion tons by the year 2000 – we are getting questions concerning our ability to continue to increase production sufficiently for the future. Seeing the increasing deficits in our mineral balance of trade – $8 billions in 1973 – we are getting questions concerning our ability to pay for rising mineral imports. Seeing the manner in which mineral deposits developed abroad are being expropriated, nationalized, and otherwise preempted, we are getting questions concerning the degree to which our economy can rely upon foreign materials in the future.

The United States has but 6 percent of the world's population and 6 percent of the world's land area – the other 94 percent of the people on the other 94 percent of the land also want higher material standards of living, and they want to acquire rapidly more of the value added by manufacturing raw materials. While our economy has grown over the years, that of the world has increased even more, so that today we are finding ever increasing competition when it comes to acquiring needed raw materials, while at the same time we are finding strenuous competition in selling many manufactured articles in world markets. Two decades ago the United States produced about one-half of the world's steel, refined petroleum, and aluminum metal, but today, despite significantly increased domestic production, we produce only about one-fifth of the world's steel, one-fourth of the world's refined petroleum, and one-third of the world's aluminum metal. What is to be done to ensure mineral supplies for our economy into the future?

The natural resources of the United States are vast, but to be useful to man natural resources must be found, developed, and processed. The natural resources of any nation are related to its size, its geology, and its location on the earth. Only one nation – the Union of Soviet Socialist Republics – substantially exceeds the United States in land area, and only four other nations – the People's Republic of China, Canada, Brazil, and Australia – have land areas about the size of the United States. In addition to its land area the United States has extensive continental shelves and direct access to the seas and the seabeds of the world. The United States has almost every type of geologic formation within its borders. The climate of the largest part of the United States is temperate, and the United States also has areas with tropical and arctic climates.

As a consequence of its size, geology, and geography the United States has vast resources of: rocks and minerals, soils, subsurface fluids (including oil and gas), waters, and air. Our forebears believed that resource development could best be accomplished through private initiative, and they framed the early homstead and mining laws accordingly. The good farmlands and timberlands and the high-grade mineral deposits that outcropped on the surface naturally were the first to be acquired by private owners and developed. As time passed, future land and mineral development of necessity was rquired to operate on ever poorer lands and ever leaner mineral deposits. Fortunately, our national ingenuity, borrowing strongly from science and technology developed earlier abroad, and stimulated by laws which provided incentives recognizing the importance of the extractive industries, has enabled the nation to keep on developing natural resources, some of which are of declining quality.

To convert natural resources into useful materials technology must be continuously improved; the technology must be workable at reasonable prices; the processes must be compatible with environmental regulations and industrial health and safety standards; and the business must yield profits comparable with other economic activities. Mineral deposits generally are harder to find and assess than forests and other agricultural resources, because most mineral deposits are located out of sight below the earth's surface. The world's deepest mines have penetrated only to about two miles in a few places; its deepest wells only to about six miles in a few places; and current dredges operate in only a few hundred feet of water; yet it is nearly four thousand miles to the center of the earth.

Through the study of geological maps and the making of complex geophysical and geochemical measurements skilled geologists can, in some areas, infer what lies below the surface. Obviously, in areas where the rock strata are relatively uniform and cover many square miles, inferences as to what may be found below are better than in areas of very complex geology where heat, pressure, and earth movements have greatly deformed the rocks. Mineral deposits that have been found, adequately drilled to determine their content of valuable minerals, and that can be mined, processed, and converted into useful materials with known technology at reasonable prices are called "ores," and the quantitative content of the valuable minerals therein are called "reserves." (Example: the rocks of the earth's crust average 5 percent iron; the United States has vast resources of rocks containing more than 5 percent iron;

the iron ore reserves of the United States are 10,000,000,000 tons, which in turn contain 2,000,000,000 tons of recoverable iron metal, compared to U.S. steel production of 133,000,000 tons in 1972).

Agricultural materials are generally renewable in relatively short-time spans, in that some crops can be raised four or five times a year, annual cycles are common, and softwood trees can be raised on fifteen to twenty year cycles. Mineral deposits, however, normally are formed only over much longer periods of time - usually tens of millions or hundreds of millions of years. Consequently, the total supply of all minerals accessible to man in the earth's crust is, to all practical purposes, relatively fixed, and hence mineral materials are generally of greater concern to nations with heavy industry.

The naturally occurring elements are found in natural materials - some in animal materials, some in vegetable materials, and some in minerals. (Example: the element carbon is in the flesh and bones of men and beasts, in the cellulose, starch, sugars, etc., of plants, and in limestone, and other rocks, in coal and petroleum and natural gas). Consequently, for many elements, there are a wide variety of possible sources, but the technology for extracting the element from different sources varies greatly. On the contrary, for many other elements there are only a very limited number of sources, and this is particularly true of metals and minerals possessing unique properties of specialized application in modern technology. (Example: most high temperature metals). Other than in nuclear processes, elements are neither created nor destroyed - man's processing merely combines them in certain ways, recombines them, or reduces combinations into elemental form. Thus, the materials industries are engaged in extracting elements from natural materials, and/or combining or recombining them into forms more useful to man.

Nature itself is constantly engaged in vast processing activities, in which the "carbon-oxygen" and "nitrogen" and "hydrologic" cycles are major examples. For most purposes there are great interchangeabilities in materials. (For example: rubber can be made from: natural latex from rubber trees; carbon and hydrogen from alcohol, from grain, or from other agricultural materials; carbon and hydrogen from hydrocarbons from petroleum, natural gas, coal, etc.; and buildings can be constructed from: steel, aluminum, copper, glass, stone, slate, concrete, tile, wood, plastics, plywood, and many, many other materials.) However, in specialized technological applications in which a multiplicity of properties are required, (for example, a combination of strength, electrical conductivity, temperature resistance, corrosion resistance, and creep resistance) the available materials are much more limited.

Today, improvement of domestic productivity in the mining, minerals, metal, mineral reclamation, and energy industries requires accelerated development of new and improved technology and rapid introduction thereof into all stages including: exploration; mining, and petroleum and natural gas production; processing; use; and recovery and recycling. In all of the above, appropriate provision msut be made for the health and safety of workers and for environmental enhancement through: minimizing air, water, and land pollution; land restoration; and esthetic improvement.

The full resources of industry, government, and academia must be brought to bear on current major problems, including:

1. Discovery and assessment of resources presently untouched by our deepest mines and wells.
2. Development of safe and efficient coal mining systems to significantly increase underground extraction ratios from the present level of about one-half.
3. Development of improved petroleum recovery methods to significantly increase extraction ratios above the present level of about one-third.
4. Development of underground and surface mining methods to minimize degradation of the land surface, subsidence, and harm to surface and subsurface waters.
5. Development of clean solid, liquid, and gaseous fuels from coal, petroleum, and other energy materials.
6. Improvement of combustion processes to increase efficiency and to reduce emissions of fumes and particulates.
7. Improvement of electricity generation, transmission, and conversion methods.
8. Development of new energy sources including geothermal and solar.
9. Development of stronger, lighter, corrosion-resistant and temperature-resistant materials.
10. Improvement of recycling techniques to conserve natural materials and energy, and to promote environmental enhancement.
11. Stimulation of measures to conserve energy and materials in actual or potential short supply.

Over sixty years ago a great mining engineer, Herbert Hoover, concluded his "Principles of Mining" as follows: "To the engineer falls the work of creating from the dry bones of scientific fact the living body of industry. It is he whose intellect and direction bring to the world the comforts and necessities of daily need. . . . Engineering is the profession of creation and of construction, of stimulation of human effort and accomplishment." The needs of the present and the future make his words even more appropriate today.

Reference

1. "Mining and Minerals Policy - 1973, The Second Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970."

SESSION C-6

THE THREAT TO SCIENCE TEACHING

C. Noonjin Walker, Academic Vice-President and Associate Professor of Chemistry, Pensacola Junior College, Florida

For a half dozen years I was a member of the science faculty at a junior college, before that, a high school science teacher. I read science journals, attended science meetings, and talked with science teachers. I had a very good feeling about the future of science teaching.

Then my job changed. I read about science - but it was not written by science teachers. I attended meetings about science — but they were not conducted by science teachers. I talked about science teaching — but not with science teachers. Now, I do not have such good feeling about science teaching.

I see symptoms of science teaching being on the edge of a serious sickness. By sickness I do not mean to imply that science teaching is bad, or to be condemned, or that it should be "junked." I mean it is just as if I had said it has pneumonia. There is a germ, and our resistance is low. The germ has always been present but this particular strain is especially virulent and prevalent. Although science teaching got a special vaccination in 1957 that carried it healthily throughout the decade of the 60's, now, it is worn out. Our resistance is lowered. We have probably gone too far for a simple booster to work; what we need to do is re-vaccinate.

I see three symptoms and I want to share my observations, my diagnosis, and my prescription. These symptoms describe a threat — a threat to science teaching, a threat to laboratory instruction, and a threat to general education. The germ causing the problem is "money," or the lack of it.

Science instruction is expensive because of the need for materials and space, the low student-teacher ratio, and the long instructional hours. And, if science teaching in general is expensive then the science laboratory instruction is one of the primary reasons. Yet, we insist on the continuation of the science laboratory experience because it is essential, but to whom? And, for what purpose?

If we ask ourselves to list the objectives of the laboratory experience, what would we develop? Many are purely content objectives which can be accomplished more economically in the classroom or by demonstration. The documentation of this accomplishment is quite abundant.[3,1] In addition to the content objectives, however, there are the "process objectives" or "methods of science objectives" which can have a high degree of validity. Yet we are hard pressed to show where the instruction related to these objectives is in the laboratory experience. Again, research shows that although these "methods-types" of objectives are often articulated in the syllabus, seldom are they overtly taught and even less frequently is the accomplishment measured.[8] Yet, when articulated, taught, and measured, the accomplishment can be documented. Where is our science lab manual which lists the objectives to be accomplished for each experiment along with the measures so that both the teacher and the student know definitely what we are attempting to accomplish? Thus, our first line of resistance; clearly defined, measurable, non-content objectives, is lacking.

The public is looking for ways to decrease the expenditures for higher education. During the decade of the 60's, expenditures for higher education increased from $3.7 billion per year to $16.3 billion while the enrollment increased from 2.3 million to 5.7 million.[7] In this ten-year period we see enrollment in higher education increasing by 147 percent but the expenditures for higher education increasing by 340 percent. Obviously, one cannot expect the relationship to continue.

Blue ribbon committees have been established to make recommendations regarding the future of higher education. Regrettably, they propose amazingly similar solutions. The Carnegie Commission recommended that the four-year baccalaureate degree be reduced to three years. A savings of 10 to 15 percent in general expenses and a 30 percent decrease in capital outlay could be realized.[2] So enthusiastically has this been received that some legislatures have come within a breath of legislating the curriculum change. The Committee for Economic Development has recommended to the Congress that college tuition be increased until the student is paying 50 percent of the instructional costs — to be accomplished within five years. This will represent a 583 percent increase in university tuition; a 494 percent increase in the four-year college tuition and a 416 percent increase in junior college tuition.[6]

Another proposal goes one step further. Under a plan called, "full cost pricing,"[5] students will be charged tuition in proportion to the cost of the discipline based on the argument that "a student in humanities subsidizes the student in physics. This is inefficient and inequitable." A model developed on data at the University of Minnesota shows the costs of the Liberal Arts Program to be $1900 per year; education, $2800; and biological science, $3300. The statewide cost analysis of junior college instruction in Florida shows that the biological sciences are 15 percent more expensive than the social sciences and that physical science is 22 percent more expensive.

What will be the effect on student enrollment if full-cost pricing goes into effect? If student tuition reaches the projected 50 percent? Combine these factors with a "zero growth" population, and we have a definite leveling of enrollment with a commensurate leveling of operational funds. Let us examine briefly the impact on a science department with level enrollment and leveled funding.

Operational funds normally fall within two categories; salaries and supplies. If the total amount of money remains constant then these are the only two variables. If either variable changes the other must react. To increase salaries the money from supplies must decrease. But, we know that supplies continue to become more costly and hence less money will be available for salary. To continue operating with less money for salaries the number of faculty can remain constant and the average salary decrease or the salary can remain and the number of faculty decrease. Neither is a palatable proposal. One other alternative is available and that is to decrease the supply money by redefining laboratory instruction as an experience for the nonscience major only. Is this what we want? Not really, but our allegiance must be to the science major and, of course, our colleagues. We will say, with great regret, that science laboratory instruction is reserved for science majors. Is this the first washout in an erosion we later will not be able to check?

Aside from the tuition changes, a great deal of attention has been directed toward the "credentialing of previous knowledge" which is just a fancy way of saying "credit by exam." We know of the Advanced Placement Program, College Boards, and the College Level Examination Program (CLEP). These programs, especially the latter, have succeeded in redefining general education. Formerly, we referred to general education as those experiences (usually courses) which produced the well-rounded, critically thinking, enlightened citizen, who because of his breadth of knowledge could better understand his role in life and who consequently could perform in a more productive manner for himself and society. CLEP, for example, proposes that because a person has performed in society and has acquired a certain amount of specific knowledge that he should have this general education credentialed by the bestowal of college credit.

CLEP examinations are in two forms. One is a subject examination, such as in chemistry, algebra, american history, freshman english, etc. The other is the General Examination by which the student can earn a year of credit in each of five different areas; one of which is math and one of which is natural science. Eighty percent of the students taking the CLEP examination take the General. Are these exams popular? Judge for yourself. In 1970, approximately 6,000 students took the CLEP examination. In 1971, it increased to 21,000 and in 1972 to almost 62,000 [4]. And with regard to money, the examination program is the delight of the legislature and the tax-paying public. Sixty-two-thousand examinations could produce a million semester hours of credit even if only half of the people pass them. Translate the million hours to dollars saved and you have a sizable hunk of money. In Florida, in fall 1972, 3,000 hours of freshman english in the university system were earned through CLEP. Three thousand hours is a lot of teachers.

Do not misunderstand. I am not criticizing the examination programs, such as CLEP, although I personally do not think that only factual information should necessarily be the sole basis for awarding general education credit. But we must be honest, they are beating us at our own game. We in science have been awarding credit based on cognitive gain — a greater knowledge of fact. We have ignored the objectives that are more difficult to describe, to define, and to measure. We have eliminated science lab experience for the nonscience major because it was easier to do that than to figure out ways of increasing productivity — even though audio-tutorial labs are not limited by the academic discipline nor are labs which utilize programmed instruction incompatible with process objectives.

Once we have admitted that the laboratory experiences are no longer necessary for the nonscience major what will be the basis for saying that the lecture portion should remain necessary? In this era of "new vocationalism" and the new focus on practicality do we have such a vague and ill-defined justification of the science experience that we will be unable to defend it against an unsympathetic, scientifically disinterested attacker?

What is our defense when the new student asks the purpose of the requirement in science? "Why do I need this stuff? I could skip it and I would be out earning my living and contributing to society much sooner." Previously, the adults have interpreted this cry as simply that of one wishing to avoid hard work but today he acknowledges that the student may be right. If he can get out of school sooner, aren't we all better off? And now the public joins in the questioning. "What is the big deal to science? They have been studying it since the third grade." Thus, quite possibly the two allies can bring an end to what has been a tradition — a tradition that knowledge and an understanding of science are essential to the acculturation of man. And, this change can definitely happen because who speaks for general education? Naturally, the chemist speaks for the chemistry major and the biologist for the biology major — but who speaks for the nonscience major? Who speaks for general education?

I began by pointing to symptoms. The prognosis is that if left unattended they could lead to a severe sickness; one which could result in the demise of college science instruction as we know it today — a demise of kind and degree. My prescription is simple to express; it is less simple to accomplish. First we must define the unique objectives of our science instruction; we must overtly teach for the objectives; and, we must document by measurement the accomplishment. Lord Kelvin expressed this prescription very appropriately when he said, "When you can measure what you are speaking about, and express it in numbers, you know something about it, but when you cannot measure it your knowledge is of meager and unsatisfactory kind." And second, we must keep in mind the necessity of productivity; we must increase our capacity to accommodate the needs of more students yet stay within the parameters of fiscal limitation. We can individualize instruction; we can simulate one-to-one tutelege; we can create meaningful laboratory experiences for general education students that really turn them on; and we can implement self-paced, mediated science courses for the science major that will give him learning opportunities far beyond those of the last decade.

The threat to science education is real; but with this re-vaccination, its resistance can be reestablished. And, the vigor and vitality we have grown accustomed to expect will be insured.

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SESSION C-7

PHYSICAL ENVIRONMENT AND THE NATURAL SCIENCES

Lawrence J. Stephens, Assistant Professor of Chemistry, Elmira College, Elmira, New York

Findlay College has developed a required science course for nonmajors. While the course was developed to fit the needs and constraints at a particular college, an examination of our experiences may prove useful to others attempting to develop similar courses.

A better understanding of the role this course must play is probably furthered by first looking at the setting for the course. Findlay College is a small (900), church-related liberal arts college in northwestern Ohio. A rather small number of students come from the sponsoring denomination. Admission requirements are low.

In 1969 the College adopted a new calendar and a new academic program. The new calendar is the 3-3 plan in which a student takes three courses during each of three terms. For graduation a student must pass 35 out of 36 courses attempted. There are no credit hours and all courses count equally toward the 36. A student may exercise a credit/no credit grading option in up to six courses outside of his major. The 36 courses are theoretically to be divided into 1/3 for the major, 1/3 for electives, and 1/3 for the Liberal Studies Program.

The liberal studies program was also initiated in 1969 and was "designed to be responsive to the needs of students in a rapidly changing society and to new developments in the understanding of learning." The program consists of two parts. Six of the twelve courses which the student takes in the program are chosen from a bank of electives. Courses in the bank include traditional courses like general chemistry as well as courses developed specifically for nonmajors. The natural science division has developed current topics courses for nonmajors in chemistry, physics, and mathematics. There is a distribution requirement, as a result of which nonscience majors must take at least two science electives.

The other part of the liberal studies program consisted of six required courses. These courses covered: physical education, awareness and expression, humanities and fine arts, social science, physical environment, and a critical analysis of values. The lecture portion of the physical education course was dropped due to student and faculty dissatisfaction and the course now consists of three terms of physical activities.

The science course should be taken in the junior year, although many students take the course as seniors. The college science background of most nonmajors in the course is two courses or less and many students will have had no college-level science or math background. The student/faculty ratio is about 85 to 1.

Course objectives are similar to those usually given for courses of this type. That is, there is a greater emphasis on the methods of science and the role of science in society than on technical knowledge.

For the first two years the course was taught, the topic chosen to use as a vehicle in meeting the course objectives was oceanography. The class was taught by a 2-man team from biology and physics primarily using the lecture method. Audiovisuals were used extensively. Thirteen questions were distributed on the first day of class and it was announced that five of these would be on the final. A term paper on some topic related to oceanography was also required of each student.

In an attempt to increase student involvement, as well as to increase student faculty contact, a new format was used for the course during the 1971-72 school year. The course was divided into five two-week segments. During each segment one faculty member was in charge of a small group of approximately thirty students while the other faculty member taught the rest of the class. The topics for the small groups were: what is science?, computers, two segments on pollution analysis, and photography. The topics for the large groups were: water pollution, air pollution, population, photography, and environment and the oil industry. Students were permitted to pick one small group on a first-come, first-serve basis. Thus a student would be in the large group for eight weeks and the small group for 2 weeks, unless he decided to stay in the large group for the entire term.

The segment on computers was taught by the director of the college computer center. Executives from Marathon Oil Company, which has its headquarters in Findlay, taught the segment on the oil industry. This module covered the oil industry from exploration to marketing with an emphasis on the environmental aspects of the various areas of operation.

During the spring of 1972, an evaluation of the liberal studies (LS) program was carried out by a faculty committee. The committee attempted to determine the extent to which the goals of the program were being met and to ascertain student, faculty, and administration attitudes toward the program.

Student perception of having achieved the "awareness" goals of LS 5 were greater than in the other LS courses. Student responses indicated that the classes were well planned and that the outside readings were valuable. While there was some indication that the course was too difficult, students felt that they could get all the personal help they needed. There was some indication that the classes were seen as being rather impersonal and that memorization was stressed.

Changes for the 1972-73 school year were aimed at increasing student involvement by trying to look at science in terms of the individual. Thus we wanted students to look at science on a more personal level. Exclusive use of large lecture sessions did not seem conducive to this individualization of the material. Discussion sessions seemed to be a better format to achieve the goals of the course. Homemakers from the community who had science degrees were invited to be discussion leaders. In addition three students enrolled in a seminar in college were also discussion leaders. This permitted us to break the class down into groups of twenty without additional faculty load.

The two-week minicourse format was continued with some changes in the topics. The minicourses were:

1. Philosophy of Science. The approach was two pronged. A member of the English staff discussed science fiction and its relationship to science. The methods and role of science were also examined.
2. Photography. This segment was designed to help the student see photography (a) as a means of expressing himself, (b) as a means of viewing the environment, and (c) as both an art and a science.
3. Environment and the Oil Industry. The manager of the Environmental Control Division at Marathon Oil Company agreed to take charge of this segment. Experts discussed the environmental problems of the oil and transportation industries. Students discussed their role in the environmental problems associated with energy consumption.
4. Air Pollution. The causes and effects of major air pollutants were discussed both in general terms and as they related to the individuals in the class.
5. Science and the Quality of Life. This segment was an attempt to encourage students to look toward the future, what is meant by "quality of life?"

What effect will increased use of materials, energy, and technology have on future life?

Some of the advantages we have seen in using the discussion format include: increased student involvement in the course, increased student awareness of their role in science-related problems, decreased feeling that science is a collection of facts, and increased town-gown cooperation.

SESSION C-8

COMPUTER-ASSISTED INSTRUCTION

Bruce Arne Sherwood, Assistant Professor of Physics and Computer-Based Education, University of Illinois at Urbana

There are college science courses in chemistry, physics, computer science, and medicine which include an hour or two per week of computer-based education provided by the PLATO IV system. PLATO is used to tutor students, to simulate complex phenomena, to practice laboratory work, to help with lengthy calculations, etc. Extensive use is made of interactive graphics. The PLATO IV system is based at the University of Illinois, Urbana. Colleges and universities presently on the PLATO network include: University of Illinois, Chicago Circle; Kennedy-King and Wright City Colleges, Chicago; Parkland Community College (Champaign, Ill.); College of Dupage (Illinois); Purdue University, West Lafayette and Fort Wayne; Indiana University; Illinois State University; Northwestern University; University of Iowa; Iowa State University; Massachusetts Institute of Technology; and Stanford University.

SESSION C-9

DEVELOPMENT OF A NON-AUDIO AUDIO-TUTORIAL APPROACH TO THE TEACHING AND LEARNING OF ELEMENTARY COLLEGE PHYSICS

Bernard F. Schrautemeier, Professor of Physics, Meramec Community College, St. Louis, Missouri

During the summer of 1968 two members of the physics department of Meramec Community College in St. Louis working full time for six weeks each began to design a multi-media approach to replace the lecture method. We decided to rewrite the entire course and to use the audio-tutorial mode of instruction, which has been used successfully in various biology and chemistry courses at Meramec. The use of this method, of course, almost guaranteed the complete integration of lecture and laboratory. In retrospect, I believe we were quite optimistic and perhaps quite foolish in believing that with twelve man weeks of time we could even begin to accomplish what we had set out to do.

In any case, in the fall of 1968 we began to offer our multi-media course to a group of about thirty-five students. Since we believed that all of physics in some way or other involves the study of motion and of all of the factors influencing motion, and, since we believed that the students should be exposed as soon as possible to the general principles underlying all of physics we focused our attention on measurement and the conservation laws during the first semester of our two-semester, eight-semester-hour course (the second semester was taught via the traditional lecture-laboratory method). Measurement is obviously needed to detect motion and the conservation principles normally involve moving objects.

Now let me describe briefly the organization of the 1968 class. In the audio-tutorial instructional mode of instruction there are normally no formal lecture periods as such. We met the students as a group at the beginning of the week for an orientation session. Workbooks, lab books, and other materials needed for the coming week's work were usually distributed at this Monday meeting. After this orientation session the students were on their own until the latter part of the week Wednesday or Thursday, usually. The students were made entirely responsible for scheduling their own time in the audio-tutorial multi-media laboratory rooms during the course of the week where the real learning was to take place.

The audio-tutorial multi-media lab was open at certain specified hours during the week, usually the morning hours 8 through 12. We expected each student to spend six to ten hours per week in the laboratory. When the student came into the lab he sat down at a study carrel or a laboratory table where he found a self-contained tape recorder or a remote control unit connected to a central bank of tape recorders. The "taped program unit" to which the student listened formed the heart of the unit under study. It contained a set of instructions that guided him through the work of the week. Via the tape he was told to study certain sections of his text or some other printed materials, to do certain exercises and to answer certain questions in his lab manual, to view certain filmstrips or single-concept films, to perform certain experiments using the various pieces of apparatus that were found in the room, and so forth. The taped program unit was highly structured for some units while relatively open-ended for other units.

Experience with this instructional method at Meramec Community College in both biology and chemistry led us to believe that it was mandatory to divide the taped material into small segments, each usually less than 4 minutes in length. At the end of each of these segments the student was instructed to perform some given activity. Above all, the taped units did not appear to be recorded lectures.

Toward the end of the week, as mentioned above, the students met with the professor in small groups of ten or less. These sessions lasted from 30 minutes to an hour and student attendance was semi-obligatory. These sessions addressed themselves to the problems and difficulties that the students may have had in the course of the week. Students were asked to explain various things that they had done in the lab and in some instances assigned work was collected and discussed in these meetings. Many times these sessions turned into seminar type meetings and enabled students to see relationships which were not at all clear to them while they were going through the taped materials. These sessions, of course, could have degenerated into miniature lectures where the professor expounded at the podium for most of the 30-45 minutes. Needless to say, this was avoided. These sessions also served as a vital feedback mechanism and often provided clues which enabled the instructors to clarify the materials of the unit under discussion. A test on the week's work was

held on Friday. This test was non-repeatable because of the pressures of time.

At the end of this first trial semester it was found that there was considerable unhappiness on the part of the students. The instructors ascribed this to the crudity of the materials and the newness of the experimental technique. **During the summer of 1969 the materials** were extensively revised. Another trial was made during the fall of 1969 with a group of approximately 40 students. The general response was somewhat more favorable but the students were still rather displeased with the taped version of the course. The instructors again ascribed this to the crudity of the materials and thought that through another revision and an expansion of the materials to include an extensive list of behavioral objectives the course could be significantly improved.

The behavioral objectives were added and the course was again tried in the fall of 1970. The general student response at the end of this trial was somewhat more favorable than in the preceding two trials. The biggest objection centered around the taped materials.

In the fall of 1971 the course was offered for the fourth time using a different set of tape recorders than had been used in the previous three trials. Problems with these recorders the portable variety were so great that the instructors were forced to abandon the taped materials and to merely give the students a copy of the script from which the tapes were recorded. The students seemed to be much happier with this and performance in the course improved somewhat. Thus, the course began to use a "Non-Audio Audio-Tutorial" format.

In the fall of 1972 the course was again offered, this time to a group of about 40 students. No taped materials were used whatsoever and each week, the students were given a workbook, a script, a list of behavioral objectives and various data sheets on which some of the experimental work was to be recorded. The instructors continued to meet with the students for oral seminars but the number of students in each seminar was expanded to approximately twenty-five because of the pressure of time.

Essentially the same procedures were followed in the fall of 1973 with a group of 60 students.

Some of the lessons we have learned through the offering of this course are:

1. Students enjoy the flexibility offered by the course. They like to come into the lab at their own convenience and stay as long as they wish.
2. Students seem to enjoy the more integrated picture that they get through the approach that we are using. The students seem to benefit from the ability to do the lab exercises when they fit in with the material rather than when they fit in the traditionally structured laboratory schedule.
3. Perhaps somewhat surprisingly, the students seem to have a real dislike for taped materials in such a course as this. They overwhelmingly prefer printed materials.
4. The preparation and supervision of such a course forces the instructors to sit down and carefully formulate a set of objectives for their courses. From this listing of detailed course objectives we feel that many benefits and improvements are found to come about in the instruction offered to the students.
5. The student is generally introduced in a hands-on way to a wide variety of instructional materials that **he otherwise would only see from a distance. Many of the common demonstration experiments which are usually done by the professor in front of a large group of students are set up in the lab and are actually done by individual students. This seems to provide a better feel for the subject.**
6. **Such a technique as this can easily be modified to a complete Keller-type instructional plan for essentially any grade level. Pre-entry tests, pre-tests and post-tests (on as individualized a basis as is desired) can easily be incorporated into the system. In fact, in a sense, this course actually uses a modified** systems approach.
7. This approach requires less laboratory equipment than the traditional approach. One set of apparatus of good quality can in theory be made to serve a hundred students. It is no longer necessary to purchase lab equipment in multiples of 6, 9, 12, 18, 24 or more.

It's only fair to list the disadvantages of such an approach:

1. The preparation of the materials is a horrendously complicated job. Two to four weeks of work is needed to prepare a one-week unit of instruction this includes the initial preparation and one, two, and perhaps three revisions of the original materials. Since time means money this preparation is quite expensive. Also, this is not a job for those with relatively poor backgrounds in physics.
2. If this approach is to be used to its fullest extent it requires the employment of a lab assistant who will be on duty during all the times that the lab is open. Ideally, the lab assistant should have a Bachelors degree with at least a minor in physics. The lab assistant must also relate well to students. For small enrollments this expense is probably prohibitive. However, if a physics-physical science department can arrange to teach several of its courses along these lines, then this cost factor becomes less significant.
3. The audio-tutorial multi-media system is rather an exhausting experience for the instructors.

Is this mode of instruction better than the traditional modes of instruction? Based on our experience with several groups of students we seem to think so. However, we must admit that for the relatively small numbers of students that are enrolled in such courses in community colleges such an approach *probably* makes the technique prohibitively expensive. The grades that the students achieve seem to indicate that they are doing better under the new system than under the old system although exact comparisons are difficult.

SESSION C-11

CONTRACT LEARNING FOR CREATIVITY?

Elizabeth H. Simmons, Science Coordinator, Leflore County School District, Greenwood, Mississippi

Science programs have changed considerably over the past one hundred years. We take many channels to attempt to attain our goal, to educate children, but the basic objective is still to develop the child's awareness of his world and to develop his ability to communicate that awareness. Language is the basic vehicle with which a student assimilates science information, expresses his own generalizations, hypotheses, and abilities. Language is one of mankind's most powerful and useful tools; therefore, all teachers, especially elementary, should become more concerned with the development of communication skills.

Science students need to learn to read science, to write about science, and to speak about science. For the young student, reading in science may be quite different from reading literature. In some science texts the facts are dense, and students must be trained to find main ideas and grasp details. A student needs to be taught reading procedures which will help him identify and solve science concepts; he needs to be able to follow a set of directions to be able to carry out various science activities. With this awareness in teachers and students personalized instruction will be more effective.

Contracts are just what the word implies:

1. They represent a bargain and commitment between two sources of input; the teacher and the learner.
2. They provide for flexibility in content based on inputs from the teacher in regard to teaching strategies, skill development, and guidance.
3. They provide for flexibility in content, based on interest and aspiration relative to goal setting.
4. They provide flexibility variances in rates of learning.
5. Contracts are avenues for increasing students' responsibility and provide experiences in planning and establishing behavioral patterns.

The thrust of contracts is two fold progression in a curricular field and progression in assuming the characteristics of a mature, responsible person. The teacher gains a closer view of the child, and the child gains a better view of himself and his capabilities in working with contracts.

This approach has been employed in reading, math, science, English, and social studies, in grades 4-8 in the Leflore County School System.

Personal observation and conferences with teachers are as follows:

1. Some students worked with contracts well and found a greater opportunity to pursue individual interest and scientific skills, as well as to help strengthen their weaknesses.
2. Students who went forward with contract activities were always the students with average and above learning ability and usually in the middle social economic standing. It is felt that these students had more educational background in their earlier childhood development and were task-oriented.
3. It is believed that when students have been geared to task performances they perform better when working with such activities as personalized activity contracts.
4. It was observed that the students enjoy assisting other students who need help as long as it does not delay progress with their contract responsibilties.
5. Students perform on a competitive basis, attempting to complete one activity, be tested on achievement and move on to the next contract. This type of activity can become boring to the student who has completed his task and is given busy work to hold him until the rest of the class has completed them.

Students who were of low social economic levels performed at a slow pace, and some were not able to perform at all, causing a greater burden on teaching performance and responsibility. We feel that this low achievement was due to students' poor social background. They were not aware of what a task means because of the lack of parental orientation at home. Undernourishment and unidentified medical disorders also hindered students' progress.

In attempting to adjust to these problems, teachers, coordinators, and consultants attempted to draw up activities on the student's functioning level regardless of his achievement level. Other activities were planned to accompany contracts, such as making projects, (doing various things with the hands) various tours applicable to the activity being emphasized, collections and displays. These work very well with the children who cannot perform as readily as other students. However, there are many extra activities, other than the contract for the average performing student. From further teacher observations, it was concluded that:

1. The students who were successful in achieving were about 30 percent of the students in the Leflore County Schools.
2. It has been observed that contract learning can be successful and motivative with certain students and unsuccessful with others.
3. Learning contracts offer an opportunity to individualize without purchasing additional equipment or changing class schedules.
4. Learning contracts can be designed to suit the student's interest, needs, abilities, and goals.

Teaching by means of contract learning can be successful and produce creativity if it is implemented with teachers who are willing to pursue activities beyond normal class activities, work closely with students who need assistance, and plan daily and carefully for each student contract according to his progress and ability.

SESSION D-3

TEACHING COLLEGE CHEMISTRY

THE GENERAL CHEMISTRY EXAMINATION PROGRAM OF THE DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

Robert C. Brasted, Professor of Chemistry, University of Minnesota, Minneapolis

The format and plan for preparation of the General Chemistry Examination is reviewed in some detail. Among the changes contemplated were:

1. A modest change in format in which there would be a grouping of questions according to major areas studied. These areas (approximately nine) would correspond to general groupings of chapters found in the most commonly used textbooks. Thus, the teacher would have a better feeling after evaluating an examination as to the progress made in given areas of chemistry. A teacher could use the exam for an individual term, specifying that only certain items would be part of the examination or the entire examination could be administered at any time with areas of questioning being considered as

pretesting rather than posttesting. In the same vein, the examination could be used with greater confidence as an advanced standing examination. Many institutions administer the examination to form a basis for a decision as to whether a student should continue on to a course beyond the general chemistry area. A teacher might then establish certain criteria for qualifications as to whether a student should go back and review or satisfy his proficiency in certain areas. In order to arrive at reasonable categories as well as questions that would test these areas some ten or twelve years of examinations were evaluated. All questions in a given year were identified according to one of the nine areas established. The fraction of the total number of questions was then established according to these areas and the percent of the 1975 examination identified. For example, the number of questions related to periodicity, geometry of molecules as well as atomic architecture, appeared to be in the order of 18 percent. This percentage thus established the approximately 14 questions that appear in the 1975 examination on structure and geometry.

2. Another rather substantial change or addition to the 1975 examination is the incorporation of a laboratory input. The chairman of the examination for 1975 felt strongly that some input on a student's knowledge of the laboratory was possible to obtain even though technique itself could not be easily identified or evaluated by a paper and pencil examination. Professional help was sought for some questions and for another part of this area a unique "smorgasbord" or "bingo" type question was developed. Most educators in the chemical field will agree that a student being passed on by an advanced standing examination without some knowledge of his abilities in the laboratory could be thought of as marginal to poor pedagogy.

Some time is devoted to the discussion of the International Congress on Improvement of Education sponsored by IUPAC and UNESCO in Wroclaw, Poland, in September, 1973. The chairman of the Examination Committee, Ted Ashford, as well as the speaker were privileged to attend this Congress and participate in a panel devoted to the examination processes used by various countries represented at the Congress.

MINUS TEN AND COUNTING IN COLLEGE CHEMISTRY

Edward C. Fuller, Professor of Chemistry, Beloit College, Beloit, Wisconsin

In these days of smoggy air and smelly water, of chilly homes and frantic pursuit of that last gallon of gasoline, it is clear that the social problems which are growing out of applied chemistry and chemical technology will be ameliorated only by the development of more applications and new technologies. If one accepts this point of view, then we have an important job to do in preparing our chemistry majors to play an adventurous part in tomorrow's science and technology.

But this is not enough. The energy crunch and environmental pollution have driven home to us the realization that the most serious social problems generated by applied science and technology involve many disciplines. We must become multidisciplinary in our outlook and pay considerable attention to what we chemistry teachers can do to prepare students for careers in other sciences. The modern biologist must be well prepared in organic and biochemistry and be familiar with many concepts in physical chemistry. The modern geologist must be equally well prepared in analytical and inorganic chemistry and several aspects of physical chemistry. The engineer concerned with materials science must be familiar with many facets of organic, inorganic, and physical chemistry. The environmental scientist and the ecologist must be firmly grounded in many of the principles of our science. Even a physicist can learn something of value from chemistry!

But even if we do the right thing by these students who are embryonic scientists in disciplines other than chemistry we have a still more difficult obligation to promote scientific literacy among our students in the humanities and social sciences. They are ignorant of science, hostile to it, and suspicious of our efforts to enlighten them. It will take blood, sweat, and tears to make these students realize that science and technology are inescapable activities in our culture. We must be successful in this task if science is to flourish. The increasing complexities of scientific problems will demand ever more financial support for research if we are to solve them. The majority of our citizens are not scientists. We must convince them that generous governmental financing of scientific research is absolutely essential to the welfare of the body politic.

Well, how are we doing? In my opinion we have been doing a good job of preparing our students for careers as chemists but have made only middling progress in presenting chemistry as a vital part of preparation for practitioners in other sciences. We have taken the easy way out by assuming that what's good for the chemistry majors is good for other science majors, too. As a consequence, enrollments of students majoring in other sciences in our courses for chemistry majors have been minimal. Biologists, geologists, engineers, environmental scientists, ecologists, and physicists are taking only those chemistry courses which are required for their degrees. We ought to do better than that. We should be able to make chemistry interesting to them. Can't we get a few of them (especially the better students!) to take some chemistry that isn't required?

I think we need to offer more diverse instruction in analytical, organic, inorganic, and physical chemistry if we are to fulfill our obligations to scientists in other fields. Then we will have their support and understanding as we tackle problems with multidisciplinary facets. Chemistry will then become a more vital part of many scientific investigations. I believe that more effort spent on teaching scientists other than chemists is both enlightened self-interest and an investment in a good future for science as a whole.

And what about our efforts on behalf of students with a primary interest in the humanities and social sciences? Though we may have made fair progress in teaching chemistry to scientists who are not chemists, we have only scratched the surface in cultivating chemistry for nonscientists. We need lots of additional ploughing and harrowing if we are to grow a crop of citizens who respect, even if they do not fully understand, chemistry.

We ought to be teaching two or three times as many nonscience students as we are today. Within the last ten years we have made real progress in introducing humanists and social scientists to some bed-rock chemistry but is that enough? I think not. We must show our students how chemistry is applied for human benefit and how chemical technology can be developed to maximize these benefits and minimize undesirable side effects. We need more courses for nonscience students in applied chemistry—courses which deal more than superficially with human nutrition, chemistry and the fossil fuel crunch, chemical aspects of nuclear energy production, industrial uses of organic and inorganic chemistry, chemistry and food production, chemistry and medicine, chemistry and the economy, chemistry and cleaning up our environment.

It's easy to talk about what we ought to do. It's harder to do it!

NONREVOLUTIONARY CHEMISTRY: REVOLUTIONARY COURSES

Elizabeth S. Kean, Research and Teaching Assistant, Department of Chemistry, University of Wisconsin, Madison

Most of the students at the college level come out of an educational system in which "the grade" has assumed an extraordinary importance. I would like to describe here some efforts which have been made in Chemistry 107 at the University of Wisconsin-Madison, to encourage students to learn for their own purposes and to remove some of the more pernicious aspects of "the grade" upon their learning.

Chemistry 107 is the outgrowth of a highly successful honors course which had been offered at Madison for the past five years. Chemistry 107, like its predecessor, is intended to be taken by nonscience and nonengineering majors. It is a one semester, terminal course; however, arrangements have been made for students to enter the second semester of the traditional year-long freshman level course after completing Chemistry 107. This past semester a number of our students came from programs in liberal arts, but a significant portion came from business, pre-law, civil engineering, and agriculture. Most of these students enrolled in a chemistry course because they were required to complete a specific number of credits in natural science.

Such students offer both challenges and rewards. Because Chemistry 107 was not intended to serve as a foundation course for other work in science, we did not need to cover a syllabus which prepared students for advanced work. On the other hand, our students did not have the vocational motivation that often stimulates learning in the major area of study. Also, many of them came into the course with deficient math and science backgrounds.

The main goal of our course then was not vocational, but rather educational in the broadest sense. We hoped to help our students comprehend and interact in a more constructive way with the technological society in which they live. Such a goal required that students become actively involved in their education, and learn for their own purposes, and not merely for an academic grade. We arranged two aspects of the course to facilitate such learning: subject matter, and evaluation procedures.

The subject matter in the course was centered around three areas only: organic chemistry, biochemistry, and nuclear chemistry; the three areas of chemistry which have the greatest impact upon the lives of citizens. After general background material was developed in one of the areas, specific topics of interest could be discussed before moving to another area. Suggestions for these topics were solicited from students at the beginning of and throughout the course. The schedule was flexible enough so that topics of interest that arose during the semester could be included. Attending to subjects inherently interesting to students helped to motivate learning.

We attempted to relieve the insecurity and resultant concentration by students about evaluation procedures by establishing a contract grading system. Students were required to complete 7 of 8 problem sets and reports on 6 laboratory experiments for a grade of "C"; another half grade could be earned by completing the 8th problem set. The problem sets and lab reports could be resubmitted until they were satisfactory. A term paper of the student's choice could earn an additional half or whole grade. A multiple choice final exam could also be elected; satisfactory performance earned a half or whole letter grade. This procedure permitted students to decide for themselves what their level of involvement would be, and with the cooperation of the staff, work toward their goals.

However, even more important than what we did evaluate and grade was what we did not attempt to evaluate. Learning was taking place in this course on two levels, *factual*, dealing with measureable scientific skills, and *attitudes* and *appreciations*, which related the students to their environments. While we had some idea of how to evaluate scientific achievement, we had no idea how to measure, let alone make value judgments about, growth in attitudes and perceptions. Therefore, we did not attempt to do so. The students knew that much of what they did in the course was nongradable. Yet the majority of students did attend classes, did participate in class discussions, and involved themselves in the learning opportunities. Since external rewards and punishments, i.e., the grade, was removed as motivation for these activities, we believe that much of such action and the learning associated with it were self- or group-motivated.

At the end of the semester we requested that students fill out an extensive evaluation form considering the course goals, format, and accomplishments. The response in all areas was favorable.

SESSION D-5

PLANNING AND MANAGING A MINICOURSE

HOW TO PLAN AND MANAGE MINICOURSES

Joseph R. Barrow, Science Department Chairman, Nordonia Hills Junior High School, Northfield, Ohio

In a world when every moment brings new technological discoveries our secondary science curriculums are filled to bursting. A school year remains the same length. Yet, there is the persistent pressure to add additional material and topics to the existing, overcrowded curriculum. If one yields to this pressure, should the teacher's judgment replace all other methods in deciding on what should or should not be taught?

What criteria should be used to decide what topics should be replaced by more pertinent issues? It is our experience that the minicourse concept offers a logical alternative to these dilemmas.

A minicourse program topically presents items or areas of study in package form. These programs can either involve the total freedom of allowing all students to choose from the full variety of subject offerings or limit their choice by creating sequences and/or prerequisites.

It is our hope here to present an itemized process for creating your own minicourse program. To this purpose I shall present the mechanics of establishing such a program and my fellow speaker, Mr. Lakus, will present the philosophies and logic behind its construction.

When considering the minicourse concept, the first area of concern is the evaluation of existing curriculums. Where are the curriculum's present strengths and weaknesses? Sensitive, flexible teachers are best qualified to make analyses. However, the perspective of the administration and curriculum person(s) are valuable and helpful. Once organized this group might wish to create an itemized list. This list could have two or three columns and be used to examine the subtopics within the existing curriculum and separate them into subjects that should be dropped, kept, or be considered further. It is a shame that this process is not practiced yearly by every secondary, science department.

The student's viewpoint should be considered. One method for statistically considering a large cross-section of student opinions is the questionnaire. Such an instrument must allow for deletions, additions, and an "unrestrained" response. All educators are aware that such results must be pared down to get at the meaningful core.

Parents can also get involved; this is desirable both to gain information and future support. However, seeking it also requires the responsibility of feeding back progress reports, etc. to the public, this is good "P.R." and wise psychology. It is understandable that some educators avoid such meetings because they do not see them as helpful or constructive. However, through specific planning a decision-making meeting can be organized. Public support and involvement are the logical outcome of such a meeting of taxpayer and educator minds.

The first major decision to be made concerns the amount of time to be allocated to the minicourses. Should the minicourses be six or nine weeks in length? Are there other possible time lengths? The shortest possibility is probably the six-week minicourse; it offers the element of change six times each school year. The six-week unit also makes possible the greatest frequency or variety of topics a student can take. The six-week unit's disadvantage is the increased paper work required of the staff. This disadvantage is minimized when the length of time is increased to nine or twelve weeks, but at the same time the interesting, dynamic quality of changeover is decreasing. The length of time settled upon might be decided by some completely innocuous factor like the school's master schedule.

Once the length of time has been selected the topics to be taught must be "shaped" into this common denominator. It may be necessary to "marry" topics that are too short to be a separate minicourse by themselves (e.g. psychology and drugs, evolution and genetics, types of energy, etc.). On the other hand, some topics could be too large to fit into the length of time decided upon and might have to be divided (e.g. zoology = invertebrates and vertebrates). Keep in m[illegible] that there is no such thing as having too many cours[illegible] greater the number of minicourses the easier it [illegible] be to administer.

The writing or outlining of each minicourse is next. A good source of material is the science department staff itself. Brainstorming sessions can be held and/or each teacher can contribute written material to the writer(s) of the new curriculums. Personal materials such as pamphlets, bulletin board pictures, etc., can be centralized and categorized by the titles of each new minicourse. These "Care Packages" can then be used by the teacher, but can also be utilized by the writer of the curriculums and referred to in the final curriculum guide.

Also, don't forget to write for free and inexpensive curriculum material. The NSTA provides a list of curriculum materials and the addresses of the school systems offering them. Many of these guides list teaching ideas (gimmicks) and learning activities, both formal and informal, for the students. Special subject organizations such as the SPCA, The American Cancer Association, and The Sierra Club (to name a few) often eagerly supply free teaching materials. The best part about these sources is that their material is current; when written into the curriculum of the school it makes the program more meaningful and pertinent. The multitudinous bureaus and departments of the U.S. federal government should be contacted. One last area of help could come from the various professional organizations in which the department's staff holds membership.

The last point of concern of the curriculum writing is the style of the curriculum guide. It should reflect the desires of the staff. A good guide allows for voluminous teacher notation. Any lesson plan should be a combination of the teacher's personal thoughts and methods with the content set forth in the curriculum guide. What better way to encourage this than by allowing or designing for it to take place in the curriculum guide itself?

One great hurdle that must be overcome is the designing of the department's master schedule of the minicourses. This schedule shows what minicourses are being offered and in what sequence, it may or may not show which teachers are teaching each topic. Teacher choice and training should be considered. One method of achieving this last point is that of circulating a list of courses to be offered next year among the staff. They can then sign-up for their preference by some method that is agreed upon. Another method makes use of each teacher submitting a list of preferred courses and the designer can "wheel and deal." After the teachers make their choices the sequence of the minicourses must be determined. A check list of items that must be taken into account should be constantly kept in mind. First, seasonal subjects such as botany, weather, invertebrates, etc. should be scheduled to take advantage of the weather. Second, when two or more minicourses are designed to occur in sequence (e.g., invertebrates and vertebrates) the schedule should give them priority. Third, "touchy" topics like sex education or the theory of evolution that might require parental consent should not be scheduled more than once during a grading period. Fourth, departmental textbooks and equipment must be taken into account. Courses that would demand the simultaneous usage of a limited amount of equipment and texts must be avoided Lastly, team teaching might be desired or required. In any event, the team approach creates unique problems that vary with its specific nature.

Keep in mind that both seventh and eighth grade students could be mixed in the same class; this is usually not desirable though because of the interruptions (e.g., guidance) during the year. Also, each teacher has only one preparation per day – the same plan is used to teach seventh through ninth (the rationale behind this will be presented by Mr. Lakus). Ideally, the department schedule would have the planning period and lunch schedule together to augment communication, but this is usually impossible.

It is amazing how readily students adapt to this type of program. They love the change and excitement it presents. It is recommended that the first day of school in the fall be devoted to a combined, mass meeting of all classes. At this meeting the mechanics of the self-selection method can be explained; copies of the department's schedule of minicourses for that year can be distributed. A letter explaining the program can be sent via students to the parents urging them to get involved.

The second day of school brings the first sign-up. The time for the actual signing is short. As students sign up they can go directly to that class, and the regular process begins. All of the remaining sign-ups for the rest of the year can take place in each individual teacher's class. Since the office has "block assigned" X number of students, the class size can be balanced ahead of time by dividing the number of teachers available into X.

It should be apparent now that the first students to sign up will have full choice and the last ones will be limited. This can be compensated for by: (a) instituting the "*Primary Rule*: No class may be repeated unless no other possibility exists." (b) Rotate the sign-up sequence so that the last classes to fill up last time will be first the next time; in other words, rotate the sign-up sequence. To do this, careful track will have to be kept each time of the completion order for each class. (c) Enlarge the class size so that the greatest number of students can take a popular course. This isn't always desirable or possible, but it works every nicely when small classes exist.

It was mentioned before that the office "block assigns" the students into science. This statement would also indicate that the office would not have any record as to where a specific student is assigned in science. Therefore, it is wise to send a copy of the sign-up list to the administration or guidance office with another copy designated for the teacher.

Another good rule to institute is that of signing up absent students the day they return (if they missed the sign-up). One person should be in charge of the sign-up procedure and he should be sought out by the returning student. It goes without saying that this procedure should never be broken to allow a student to sign up before he leaves (e.g. family vacation, operations, etc.). Since a sign-up sequence is important it would not be fair to the other students to let anyone "skip ahead."

Interesting points of organization within the science department can now be designed around the minicourse topics. It was mentioned earlier in reference to the writing of the curriculums that "Care Packages" can be made for each course. In addition, files can be made containing transparencies, ditto masters, originals, etc. (one for each of the topics). If desired by the staff, a file can be created on each of the students; they would contain anything from report cards to returned consent forms.

Transferring from one class to another is not too complicated. It could be done in the following manner: the week before the changeover all classes sign up for a new course, but remain in the old one for the rest of that same week. On Monday of the new session the students would still report back to their "old" class and get a:

1. Report card (for their parents)
2. Grade record sheet (for the new teacher)

This grade record sheet would contain a list of all the courses the students took up to that time, it would show the sequence which they were taken in, and also show the grade he achieved. Additional information can also be placed on this grade record sheet. The student reports to his new teacher and hands him this sheet (or he doesn't get in). This whole changeover process can take place in three minutes time.

MINICOURSES: THE PROS AND CONS

John W. Lakus, Science Teacher, Nordonia Hills Junior High School, Northfield, Ohio

PROS

Minicourses are short, six- to nine-week topics that combine to form a total science curriculum. The use of these courses can be accepted gradually, as supplementary or enrichment material, or as a completely new program. However, changes in education do not come about easily, nor are they always justified. Crucial factors in deciding whether or not to adopt a minicourse program are: Will the change benefit the students and does it meet the goals of the educational system?

In a world where technology diminishes the humanity of each human it is a welcome change when a person is *treated as an individual*. The benefit is compounded when everyone involved is treated as someone special. Student-selected minicourses encourage individualization by allowing each student, perhaps under parental guidance, to mold himself based on his own potentials and objectives. Minicourses extend the freedom of choice in academic subject areas often allowed by high schools and colleges. They also add to what a creative instructor can do in individualization by using multiple techniques.

Flexibility is inherent in minicourses. Students select or delete areas from a particular curriculum depending on background or interest. The instructor can meet the students on their own interest or ability level. Also, outdated materials can be dropped and new, pertinent items added. No longer is a department religiously tied to a textbook that dictates subject materials. Fewer students will complain, "Why do I have to learn that, I'll never use it."

Built into the student's choice of a minicourse is a strong *motivational factor* contributing to his achievement. A choice of subjects not only gains the students interest but perhaps his enthusiasm as well. Very often a problem student is one that does not like being told what to do. A degree of academic freedom may reorient disinterested students. Furthermore, if a child's parents are informed of the program, their influence may reinforce the student at home.

Not only are students motivated by minicourses, but *teachers are motivated* as well. In a school with several science faculty members, a minicourse program can grant the teachers a preference of topics. Most teachers represent a wide spectrum of interests and training — a factor that can be used to advantage when the teacher can select from a menu of subtopics.

Improved use of the school's facilities is a financial implication of the minicourse program. Through thoughtful planning of the master schedule, the minicourses can be assigned to rooms that best suit the needs. For example, a school with limited facilities could schedule chemistry in a room with sinks, while a course like sex education could be held in a more conventional classroom. Botany should be given a room with a southern exposure and weather study could utilize easy access to the outdoors.

Efficient use of materials and supplies is another financial factor to be considered. No longer do all rooms need to be identical with identical textbooks. Subjects requiring the same equipment may be scheduled in sequence rather than simultaneously. Competition for materials can be greatly reduced since all teachers will not be doing the same unit at the same time as with traditional curricula.

Centralization of extemporaneous and supplementary materials facilitates their use by all involved. Since the instructors will generally be using different materials, miscellaneous teaching aids can be pooled. Supplies such as books, pamphlets, overhead transparencies, magazines, and various lab and teaching aids are shared. No longer do teachers hoard personal teaching collections but willingly lend them to other instructors since there is no simultaneous need.

The balancing of class sizes can be achieved within the minicourse program. The department schedules the students as a group and balances the class sizes to the best advantage. Teacher loads can be equalized, and groups may be large or small as best fits the program. Therefore, grouping is heterogeneous.

The minicourses are constant reminders of *short-range goals*. Science in the junior high is non sequential and the same course can be taught at various levels without affecting achievement. That is, success or failure in one topic does not forecast a similar result in the next. The student starts each new minicourse with a clean slate. He has a new topic and, perhaps a new teacher, and does not have to be the poorest student in the class all year.

Also, because of the topical nature of minicourses, grade failures need not be repeaters in the same course. New students, likewise, can avoid taking previously learned materials.

Teachers have only *one preparation per day* and can devote their full attention to doing that well. Since the teacher is likely to be instructing a class in a topic in which he has a personal interest, he will likely do a better job. It is too idealistic to believe that teachers are not bored by some subjects as are some students.

CONS

Like any other innovation the minicourse program does not solve all problems for all students. One must keep in mind that the minicourse program discussed here was designed to meet the needs of a particular junior high with special circumstances. The authors of this program realize that some schools have either the philosophy or facilities that could not lend itself to the undertaking of a minicourse curriculum. Nor are the authors unable to see the weaknesses of the program.

Probably, the most glaring fault of the program is the *loss of time* involved in the initiation and the process of its continuance. First of all there is explaining the sign-up procedure and the courses offered as well as the issuing and collecting of books and materials every six weeks. One person needs to be employed as a coordinator to be in charge of scheduling, communications, tracking students, room assignments, and perhaps curriculum responsibility.

Student selection of courses is an ideal that has been totally achieved in few, if any, educational institutions. *Students may be forced to repeat a course* that is offered more than once but by rotating the sign-up procedure this fault can be lessened.

Class periods must begin and end at the same time if a student is to have a full choice of all courses offered. Sometimes this is impossible due to the scheduling of other subject areas and a student may be limited in his choice of topics by his class schedule. This would also mean that an entire department would have identical schedules that could make extra curricular duty assignments difficult.

Human relationships can be hindered, or even be detrimental to the program. For example, long-term student-teacher relationships are difficult to establish if a student wants to follow a particular sequence of courses. Conversely, student to student relationships may become cliques that sign up for a particular course just to be together. Or students may sign up for a particular teacher who is weak in class control in order to have classroom freedom.

Overspecialization may occur at too young an age. A student may take only those subjects in a particular branch of science and neglect getting a well-rounded science education. It is possible for students to avoid the "hard" courses and receive only a part of the science background he would need for further study or to meet the requirements in high school or college. Care must be taken in designing minicourses to include certain basic concepts that are needed in all fields of science.

Some students are not capable of selecting courses that are pertinent to their goals in life. Youth often makes judgments that are emotional rather than rational. Care must be taken to counsel and direct students into courses that meet their needs even if these needs are not yet realized. Minicourses can be a prize that is too soon won.

SESSION D-6

PRESERVICE TRAINING FOR COLLEGE SCIENCE TEACHERS

Mildred W. Graham, Assistant Professor of Science Education, Georgia State University, Atlanta

There are intuitively good college science professors, born teachers. For most people, however, the transmittal of knowledge is not a natural talent. To improve instructional skills of the college science professor, these skills must be identified and taught. When, on the path to a doctorate in a specific science, can a candidate improve these skills?

For most graduate science students, there is only one phase of his graduate career where he can attain some teaching skill that is, as a teaching assistant in undergraduate courses and labs. Does he pick up his skill by observing his peers or senior faculty? This is a possibility but, at best, is happenstance. A planned program for the improvement of instruction must be implemented. This has been discovered by all the sciences in individual colleges and universities.

Each science department which tries to improve undergraduate instruction by improving teaching assistant competency has "reinvented the wheel." This panel has been charged to outline seminars and courses designed to improve skills such as questioning, evaluation, student-teacher interaction, etc. Questions discussed include: Who assumes the responsibility for such programs, science educators or science departments? When in the academic year should such courses be offered? Where are the materials to be used in these programs?

The realization must come to the science departments that training of teaching assistants is a viable means to improve undergraduate science courses and to help many graduate students attain goals of becoming "good" college science professors.

SESSION D-8

SCIENCE TEACHING ON "THE ROOF OF THE WORLD" AND "THE SPACESHIP EARTH"

USE OF THE SCIENCE MUSEUM AS A TEACHING RESOURCE

Harlan Falkin, Physical Science Supervisor, Pacific Science Center, Seattle, Washington

The popularity of Science Centers and Museums is growing throughout the country with attendance on the rise, and greater use of public and school programs available at these institutions. Many science museums have teacher-oriented programs that are designed to aid the teaching of science in the classroom.

Most science museums devote a major portion of time and money to the school and teacher programs. To accomplish the educational goals, a staff of professional certified educators develop, produce, and perform various activities as part of their jobs at the museum. These activities are usually the hands-on involvement type, permitting classes to actively participate by observing, hypothesizing, and testing their own ideas using equipment easily reproduced by the classroom teacher.

The services of a science center, or museum, help the teacher by complementing the regular school curriculum. Museum staff do lessons designed to introduce a concept the teacher will be expanding in the classroom. Lessons are designed to generate interest, not to do the teaching of the subject for the classroom teacher. Science center staff provide follow-up ideas and materials permitting the class teacher to mesh the interest generated at the museum with the classroom science program. Staff members are available to teachers for consultation regarding materials to introduce science subjects and suggestions for further classroom activities once a study of science is underway.

Many science centers and museums are chartered to "improve the public understanding and awareness of science." This is a broad mandate open to interpretation in a variety of ways. As a result, a myriad of programs are available within the same institution. At the Pacific Science Center we operate a laboratory-classroom program, perform live demonstrations, conduct classes for the general public on weekends, use puppet shows to entertain while illustrating science concepts, and perform auditorium programs from time to time. To improve these activities, science centers throughout the nation have formed the Association of Science and Technology Centers, an organization permitting museums with similar educational goals to compare programs, ideas, and experiences. Workshops for museum staff members are held periodically to discuss and observe many programs in operation at the member institutions.

A typical school program in Physical Science serving as an example of resources available to teachers at science museums is described. A class visiting the Pacific Science Center may have chosen to take part in a lesson introducing the concepts of observation, comparison, and identification, while learning the use of a scientific tool. The program they participate in begins with a cartoon story.

Materials for the lesson on Chromatography are easily reproduced, and directions for making them are included in a take-home pack given to the teacher following the lab experience. (Copies of the pack were available at the session.) We encourage teachers to use this pack and the suggestions included for expanding the lab experience once they return to their own classrooms. This type of program can be done at the science museum, or in the school classroom by museum staff. The recent gasoline problem has prompted many science museums to bring their programs out to the schools since bus fuel is at a premium in many school districts.

Another activity available to teachers is workshops. The Pacific Science Center offers: three-credit workshops in science and math activities for the elementary classroom. The courses include 30 hours instruction on presenting and preparing materials for 15 different units which are designed to motivate and captivate elementary classes. On completing the workshops, the teacher has kits for each of the activities ready to use with her or his class.

An additional program in teacher training is our Associate Teacher program. Teachers on leave from their districts spend one year at the Center developing and presenting lessons to a variety of classes, gaining the experience necessary to continue the programs when they return to their district. They go back to their school as a master teacher in science education ready to aid and improve the science instruction at the elementary level. Our Associate Teachers can earn their Masters degree while working at the Science Center.

Science museums serve one more function in the education community they provide experiences and equipment not available in schools. Advanced students might require the use of equipment which schools cannot afford such as electron microscopes and spectrophotometers. Special displays are available in the museums such as U.S. Atomic Energy Commission travelling exhibits which are made available to school groups by the host institution. Museums serve as community meeting places for visits by astronauts and active scientists. Here your students can talk with the people involved in science and exploration.

There is a lot going on at Science Center and Science Museums that can be helpful to teachers. I urge you to visit your museums, speak with the education staff, and make use of the available teaching resources.

SESSION D-10

TEACHER'S POINT OF VIEW–EDUCATIONAL USE OF ZOOS

Antoinette Seidelmann, Teacher, Chicago Public Schools, Chicago, Illinois

My part in this presentation is to give a teacher's point of view concerning the educational use of zoos. The following will be included in the discussion:

1. various classroom objectives,
2. making the zoo visit meaningful,
3. in-school activities involving zoo participation,
4. workshops for teachers at the zoo.

SESSION D-12

OUTDOOR BIOLOGY INSTRUCTIONAL STRATEGIES (OBIS): AN APPROACH TO COMMUNITY EDUCATION

Alan J. McCormack, Research Educator/OBIS Project Coordinator (on leave from University of British Columbia); and Herbert D. Thier, Co-Director of OBIS, Lawrence Hall of Science, University of California, Berkeley

Few poeple are unaware that a crisis exists between man and his environment. Clean water, fertile soil, and nourishing food no longer exist in unlimited supply. Man has carelessly clashed with the delicate balances and living networks of the ecosystem and provoked worldwide environmental maladies. Man can look only to himself to provide remedies.

The collision course between man and biological-physical realities has been repeatedly documented and is the subject of daily concern in the mass media.[5],[6],[9],[15] Yet, humans cling tenaciously to their "rights" to reproduce as they please, exploit the environment, and encourage uncontrolled economic growth.

Although environmental deterioration involves changes in natural, rather than man-made realms, it is clear that many environmental changes are caused by human action. And, it appears we live increasingly in a man-altered and man-managed environment. Even now, the most ubiquitous biotic communities are man-produced or man-influenced by planting, cutting, damming, building, and dumping.

Until recently, most of the environmental movement has been concerned with alerting the public that there *is* an environmental crisis. Now that the problem is widely recognized, it becomes increasingly important to ask: How can environmental problems be solved?

Solutions will not come quickly because we do not know enough about the fine structure of the environment to translate our concern into effective public policy. Even when some answers are known, it will take time to develop the public consciousness to support appropriate environmental management. Development of public environmental awareness may depend largely upon new, more extensive, and different, kinds of programs in environmental education. Programs designed as a supplement to standard school science curricula, though important and helpful, do not seem capable of meeting the challenge effectively enough or quickly enough. Public attitudes which allowed the development of our present difficulties provide strong evidence that past educational programs have met with little success in changing popular environmental beliefs and values. Most people have found it convenient to overlook changes like the following occurring since 1946:

1. A government-sponsored study found that "For the United States as a whole. . . the total nitrogen and phosphate discharged into surface waters by municipal sewage increased 260 percent and 500 percent respectively."[19]
2. Airborne lead has increased by about 500 percent.[17]
3. The bacterial count in New York Harbor has increased by as much as 890 percent.[11]
4. The increase in population of the United States has been more than 43 percent.[4]

Attitudes permitting man to select proper environmental alternatives will develop as a result of a deep understanding of ecological relationships. Like all living things on this planet, humans are part of an ecosystem a series of intermeshed, cyclical events linking the life processes of any single organism to the life processes of many others. Ecocystems can deteriorate, or even completely break down, when too heavily stressed by an overpopulation of one kind of organism, depleted of essential materials, or deprived of a minimal level of first-order food producers.

To help develop large scale and immediate approaches to dissemination of ecological ideas, the Outdoor Biology Instructional Strategies (OBIS) project is undergoing intensive development at the Lawrence Hall of Science, Berkeley, California.

Overview of the OBIS Project

OBIS is a National Science Foundation funded project concerned with promoting the understanding of ecological relationships by youngsters aged ten to fifteen. The main goal of OBIS is to design instructional strategies for learning experiences in outdoor biology that can be applied in diverse environments. OBIS activities focus on the environments where children *are*, using lawns, urban ponds and streams, and vacant lots as study areas.

Activities produced by OBIS introduce basic concepts of ecology in ways that are palatable and exciting for youngsters. Underlying all OBIS materials is the assumption that a basic understanding of ecosystems, populations, communities, food chains, and interactions of organisms with the environment is essential in making intelligent decisions about the environment. Techniques useful for the study of ecosystems are universally applicable wherever there is life, and are not limited to any specific environment or localized environmental problems. Thus, OBIS is based on a broader viewpoint than that of environmental groups which focus only on specific instances of pollution control or recycling.

OBIS activities are oriented toward community-sponsored youth organizations such as scouts, recreation center clubs, summer camps, and nature center groups.

The project is not primarily a school science curriculum, although many of the materials may be suited for use by school groups. School ecology clubs, "Saturday science" groups, school camps and other extracurricular school groups will also find OBIS materials useful.

OBIS departs from the common curriculum-development procedure of determining a single sequence of learning activities leading to specific concepts. Instead, the OBIS staff is identifying and trying out a variety of alternative strategies and techniques for environmental study. Assuming that no single learning pathway can be either interesting or applicable to all youngsters in all locales, OBIS plans flexible units involving multiple entrance and exit points. Physical sciences, social sciences, art, recreation, and psychology are being tapped as potential sources for interest-seducing "entrance activities" leading to the understanding of ecological problems.

A number of OBIS activities will be suitable for both large and small groups of young people, and many projects will be adaptable to completely individualized use. Printed materials being developed are intended for community-group leaders who may have little or no training in biology.

Examination of major funded educational improvement programs for the ten to fifteen year age group has revealed several other programs. Prominent among these are the National Environmental Education Development (NEED)[12] program of the National Parks Service, Environmental Units (EU)[14] of the National Wildlife Foundation, and Environmental Studies (ES)[1] of the American Geological Institute. Unlike OBIS, materials developed by these projects are designed primarily as school curricula. NEED is described as a "curriculum integrating process" by its developers.[13] EU materials provide a wide variety of interesting, independent units, but appear to lack a consistent framework of ecological ideas. ES aims primarily to promote student self-awareness.[1] OBIS represents an innovative departure from these projects in its community-group target population, basic concern with pervasive biological principles, stress on development of a *variety* of learning strategies, and emphasis on individualized instruction.

First Year of the OBIS Project

During the first project year (1972-73), two units focusing on specific environments, *The Lawn* and *The Pond*, have been under intensive development. These units have progressed to the stage of "trial" editions and are receiving extensive use by a variety of leaders in the San Francisco Bay Area.

The Lawn Unit

What is the dominant organism in the lawn community? What happens to the lawn community when the dominant organism's influence is removed?

To answer these and many other questions, OBIS goes "out-of-control." Try it! When you go home, get a couple of sticks and some string and fence off a few square feet of your lawn and let it go wild. No watering, no mowing, no fertilizer, no management. In the OBIS *Lawn Unit* this is dubbed the "out-of-control" area, and the kids use this area to monitor changes in the lawn community when man relinquishes his control. This is an important concept for young people to grasp: man's tremendous ability to influence and change the structure of communities. Liberate a section of your lawn community and watch it through the seasons. OBIS can't tell you *what* changes will occur, but OBIS can tell you changes *will* occur.

Perhaps you would rather try to solve the "Mystery of Weedman," another of *The Lawn Unit's* intriguing activities. Or, try your talent at estimating the population size of "bean bugs" on your own lawn. In completing either activity, you are likely to learn something about populations, distribution, and sampling techniques. You may even enjoy yourself!

The Pond Unit

Who ever said ponds have to be big to be good? OBIS *Pond Unit* participants construct their own "mini-ponds" and observe the drama of biological succession and change as the aquatic environment matures. Variables such as organic and/or inorganic fertilizers, light, and community composition can be altered or controlled to provide clear examples of the interdependent nature of ecological factors.

Larger pond sites (natural or man-made) are focal points for other activities. A variety of inexpensive and easily-constructed pieces of equipment have been designed to assist in the investigation of pond life. Pond bottom samplers, weed grapplers, plankton nets, and organism-observation containers are just a few of the observation aids that facilitate pond exploration. Also, a trial version of the OBIS *Pond Guide* has been developed to assist in easy general identification of aquatic organisms.

All *Pond Unit* activities encourage development of personalized individual projects by participants. Suggested "starter" activities may be done separately or in a variety of sequential patterns,

Field Trials

Trial-testing of *The Lawn* and *The Pond* involved 1500 youngsters ranging from nine to fourteen years of age. Groups included science classes, weekend community organization classes, summer day camp groups, and science clubs. Several procedures were employed in evaluating the trials, including:

Observations. The staff spent many hours in the field observing the OBIS units as taught by teachers and leaders. Observer reports, focusing on the participants' activity and understanding, were written and distributed to the staff for review.

Leader Feedback. Leaders and teachers received feedback forms to fill out and return to the OBIS office as each activity was completed. The teacher or leader could comment immediately as to youngsters' performance and interest in the activity. Personal meetings and telephone conversations with the leaders also provided feedback. Suggestions from leaders as to their personal adaptations of activities and additions to the basic unit structure proved especially valuable.

Student Feedback. Feedback forms were also given to participants so that they could express their feelings about a particular activity. Youngsters seemed to express their feelings best while involved in a particular experience. One OBIS staff member captured these feelings by systematically photographing the students participating in various activities.

Pretest-Posttest Comparisons. OBIS trial groups were given ecology concept pretests prior to involvement in OBIS activities. These data will be compared with the results of an equivalent form of the test given after completion of the activities. To provide an additional baseline for evaluating achievement, control groups have been given the same tests, without the benefit of the OBIS activities. The OBIS staff is currently analyzing the compiled data. When the results are complete, the activities will be revised to better meet the needs of the user group.

Activities Currently Under Development

Imagine this: Using paint and palette, you engage in a pleasurable outdoor activity that appears to be an art lesson. Twenty minutes later you find yourself discovering ideas about animal adaptations. Or, imagine participating in a group that is making photographs with simple materials. Soon you find yourself using the technique you have learned in piecing together the links of a food chain in a nearby vacant lot. Think of it ecology and art ecology and photography ecology and fun! Learning combined with pleasure just has to be popular with kids everywhere.

OBIS aims to please... and teach kids intellectually-solid ecological principles. Thus, OBIS staff members are presently involved in identifying all conceivable approaches and inventing new and unusual strategies. Present exploratory work includes sampling activities easily recognizable as ecology, physical science approaches, art-integrated projects, social studies orientations, scientific testing of superstitions about biological phenomena, and the invention of simple biohistory study techniques.

All OBIS materials are currently being designed according to a highly flexible format. Future OBIS "units" will be given final design "on-site" by group leaders and participants selecting from a variety of alternatives. Exemplary of the flexible quality of the proposed new approaches are the OBIS *Eco-Challenge Cards*. These provoke youngster's interest with an intriguing challenge or problem that can be solved in the outdoor environment using high-interest manipulative materials. Representative Eco-Challenges are "Invent-an-Animal," "Hi-Lo Hunt," and "Photogram Ecology." For each of these activities, participants can work individually or in groups, with or without an adult leader. Kids are first confronted with an engaging challenge, either via a printed card or cassette recording. For example:

> *Challenge:* Given a potato that has been painted white, make a model of an imaginary animal that is adapted to a particular habitat.
>
> *Challenge:* In a chosen study site, find the spots that are warmest and coldest, brightest and darkest, and wettest and driest.
>
> *Challenge:* Make a photogram showing at least three organisms that live in a specific habitat.

Information is then provided concerning needed materials and "The Action." "The Action" is a brief "how-to-do-it" description of a method for solving a given challenge. After attempting a solution of the challenge and considering some questions pointing up the relationship of the activity to ecological principles, the participant may choose one or more "Action Cards." Each of these presents a related, but different challenge, and leads to more activity.

The *Eco-Challenge Cards* can be used independently of each other, or in a variety of sequences to form cohesive learning units. These activities should be a valuable resource from which nature centers, camps, or other community groups can draw ideas and construct sequences particularly appropriate to their unique operational situations.

"Running Water" is another interest-area being investigated by an OBIS development team. Plans presently call for production of activities in a pattern similar to the *Lawn* and *Pond* units. In this family of units research techniques of practicing ecologists are modified for use with youngsters. These are then blended with supporting learning activities intended to help kids understand the populations, habitats, food chains, and community structures present within specific ecological sites. Early work with "Running Water" has resulted in a collection of proposed activities ranging from physical studies of water movement and man's influence on its flow, to biological studies of life zones common to streams.

What would happen to square meter plots of grassland exposed to varieties of drastic environmental pressures? To find out, one OBIS group is beating one plot with a board, while applying vinegar, baking soda, salt, insecticide, herbicide, and other materials to different plots. One plot is deprived of sunlight, while another has been converted to a "mini-swamp." This project is one of several being tested by seventh- and eighth-grade youngsters as part of "Physical Variables and Outdoor Biology," another of the newer themes for OBIS development. The "Physical Variables" team is also developing a series of inexpensive measuring instruments, including light meters, wind-speed meters, and temperature recorders.

Many school districts provide one-week camp experiences as an enrichment to fifth-, sixth-, or seventh-grade school programs. Also, thousands of children are involved each summer in day or residential camps at hundreds of camp sites throughout the nation. These programs have the potential to provide children with some awareness and appreciation of important ecological aspects of the out-of-doors. To assist school camp leaders who may have little knowledge of outdoor biology, OBIS is developing a series of materials designed for the camp milieu.

These materials are intended to provide as little or as much of an experience in outdoor biology as is desired by program leaders in particular camps. Individual activities can be selected for inclusion in existing camp nature programs, or groups of OBIS activities can be adapted to provide a major coordinated outdoor biology experience.

Future Plans

Change is the essence of nature. Man's hope for the future lies in the regulation of the environmental changes he induces. He is a partner with natural processes in the management of resources and biological and cultural wastes. The future depends on man's ability to develop an understanding of these processes and the wisdom to apply that understanding. OBIS plans to continue development of practical activities leading young people to these vital concepts. New staff is being recruited, and new directions are continually being sought. Hopefully, a significant number of OBIS activities will be available to the public in mid-1974, with many to follow over the next two-three years. The job is large, and time seems always frustratingly limited. We'll do the best we can.

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SESSION E-1

IMPROVING SCIENCE TEACHING THROUGH AWARENESS TECHNIQUES

AWARENESS TRAINING

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The introduction of a new and often very different science curriculum to an elementary, secondary, or college classroom can be compared to a newly forming social system. If teachers of such a program are "aware" of a particular set of social science concepts, they may be able to facilitate the learning which should take place in a modern science class. Ignorance of these concepts may actually result in teacher behavior which is counter productive to achieving the science curriculum goals.

Five social science concepts are most important to consider when introducing "a new science curriculum." Perhaps the best was to understand the implications of these social science concepts is to define them and compare what they would be in "traditional" and "modern" science classrooms.

1. *Goals* - The proposed objectives of the science curriculum, stated when possible in terms of what the successful learner should be able to do by the end of the instructional program.
2. *Norms* - A set of accepted and expected social behaviors common to a group whose members have social interaction together. The classroom climate.
3. *Roles* - The relationships between the members of a social group which make clear the part or character which each person assumes he has to play in that social system.
4. *Physical Arrangements* - The placement or positioning of the human and material resources used in the learning situation.
5. *Feedback Monitoring* - Periodic collection of information from the learners used to make inferences about the state of the social system and to modify the instructional program.

For example, the goals usually associated with traditional science require that the student learn a set of science content facts and demonstrate this learning by achieving a passing grade on a written test. On the other hand, "modern" science as typified by the discovery or inquiry alphabet programs (SCIS, S-APA, ESS, COPES, IPS, ISCS, BSCS, CHEM STUDY, CBA, HPP, ESCP, etc.) emphasizes student learning of some basic science process (problem solving) skills and science concepts, as well as some science content facts. This learning is to be demonstrated by performance in carrying out science experimentation, as well as on written examinations.

The difference in the stated goals of "traditional" and "modern" science programs would make one expect that different norms, roles, physical arrangements, and feedback monitoring methods should result in these two kinds of classrooms.

For example, some of the norms expected in traditional science classrooms are: quiet, students speak only when called upon by the teacher; students move about the room only upon direction of the teacher; interactions in general (questions, discussion, etc.) are normally between student and teacher, and seldom between student and student. In a "modern" science classroom the expected norms are: a moderate amount of noise, students speak to each other and have freedom of movement; and there are frequent interactions with other students as well as with the teacher.

In a "traditional" classroom the teacher's role is dispenser of knowledge, lecturer, and reward giver. The teacher talks and the students listen. The students' roles are those of passive learners gaining information from the teacher, and the textbook without too much thinking or questioning about what is being learned.

In the "modern" classroom the students role is to be an active investigator and learner; to gain information by experimentation and inquiry, as well as by reading; to constantly think and ask questions; to frequently interact with other students and the science materials. The teacher's role in the modern classroom is to facilitate inquiry, to ask questions which will promote thought. The rewards in "modern" science classrooms are supposed to come from satisfaction in solving problems as well as from the teacher.

Modern science programs are supposed to be student-centered and laboratory-centered. Traditional programs are usually teacher-centered. These would obviously call for different physical arrangements of students, teacher, and laboratory materials.

In order to assess how the students perceive the goals, norms, roles, and physical arrangements in any classroom the teacher needs some feedback monitoring system of collecting information from students.

When students are accustomed to traditional instruction in most subject areas, and when their previous science instruction has been in a traditional program, the introduction of one of the modern science programs is similar to what Miles[2] calls a Temporary System.

Anyone entering a temporary system needs answers to certain questions before productive work begins. The learner needs to know: "Why am I here?" "What is expected of me here?" "What is acceptable behavior here?" We can recognize these questions as asking about the goals, roles, and norms. Teachers must be clear on goals, roles, and norms and must consider how these will be affected by the physical arrangements in the classroom. Teachers need some method of collecting feedback data about their classrooms so that they can make instructional decisions.

[1]This paper is based upon a monograph "The Application of Temporary Systems Concepts to Effective Planning and Management of National Science Foundation Supported Educational Programs" being prepared under Grant GW-4508 made by the National Science Foundation to The Pennsylvania State University, Ogontz Campus, Abington, Pa. 19001.

[2]Miles M., "On Temporary Systems" in *Innovation in Education*, M. Miles editor, Teachers College Press, Columbia University, New York (1964).

USING CLASSROOM INTERACTION ANALYSIS SYSTEMS TO INCREASE INSTRUCTOR AWARENESS

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Classroom interaction is omnipresent and multifaceted. Many facets of interaction are present at any one instant of time. The major foci of classrooms tend to be teaching, instructional and learning processes, and activities. Teaching and learning are essentially interaction events, and learning is the result of interaction. The types and levels of interaction that take place in the classroom are as many and as varied as the differing personalities, socio-emotional climates, and overall ecosystems of these same classrooms. Interaction in the classroom may be one-to-one, group-to-group, one-to-group, group-to-one, etc. It may be verbal or nonverbal, planned or spontaneous, structured or haphazard, formal or informal, person-to-person, environment-to-person, etc. Classroom interaction is all these and more. Classroom interaction determines the classroom gestalt which is more than the sum of its individual entities.

Social and educational psychologists and educators constantly emphasize the importance and effects of interaction in educational settings:

Sherif has noted that "To an important extent, the locus of change" - the fabled desired end of education -- "lies in the interactions of people with people."[34]

Guba and Getzels have pointed out, "Whatever the teacher may teach, it is obvious that the teaching is carried on in the context of an interpersonal setting. It is the factor which, more than any other, accounts for the critical importance of teacher personality in mediating the teaching-learning process."[19]

Gammage underlines the point, "The interaction of the teacher and the children is one of the most important aspects of the educative process and possibly one of the more neglected... the type and quality of the interaction will determine not only the effectiveness of the learning situation but the attitudes, interests and in part even the personality of the pupils."[16]

Reno emphasizes that "These daily encounters between student and teacher are impacts" which "occur at high speeds.... The collisions take place too rapidly for any computer to register, and the force they generate is always enormous.... and they become discernible when they accumulate."[32]

Despite the weight of evidence, classroom interaction dynamics are often not apparent to teachers, or they are misunderstood, garbled, misread or – worst of all – ignored. Why? First, there is often lack of awareness by the teachers of the impact and effects of classroom interactions. Even after awareness, there are other serious obstacles to be overcome. Interactions are there, but how are their patterns, subtleties, and nuances picked up? This can be as difficult and as frustrating as trying to discover the details of how one looks without a mirror or judging, truly and accurately, the qualities, timbre, and inflections of one's voice without utilizing tape recorder and audio tape.

With knowledge, awareness, effort, and observational practice the teacher may become a fair judge of interactions between and among students, their patterns, meanings – obvious and hidden – and affect. However, even with the best will and effort in the world, the teacher may still be relatively unaware of his interactional affect – both direct and indirect. A human is far too subjective an animal to be expected to make accurate and precise judgments regarding his or her effect on others. At best, the tactful human learns to control his verbal impact. He is still often totally oblivious to the nonverbal signals he may be radiating in all directions.

To assess our own interaction effects, we must either see ourselves as others do, or we must call on a third party to view and assess us. Even then, an objective assessment is difficult because of our own, or the other viewer's mental set. The situation can be greatly improved if there is not only a viewer who is striving for objectivity, but also a tool of proven objectivity and reliability for him to use. Systematic observation instruments can provide the latter.

Without the tool, the demands on the viewer and the relationship between the viewer and the viewed are colossal. Many of us have resented what purported to be an objective summary of our behaviors by a fairly sympathetic and personable supervisor. The thought of the resentment that might be engendered by a mere peer's observations, if they were anything but flattering, staggers the mind. Ned Flanders, himself, has noted that without a systematic observation scheme the "success" of having another observe our performance "may depend on how well he (the observer) can blend integrity and objectivity with compassion and empathy."[8]

Systematic observation schemes are tools. They are techniques which objectify evaluation of self by self or others. They are means to ensure that evaluation data are accurate and that they provide the type of feedback on which teaching and instructional judgments can be sensibly based.

Ober has described systematic observation as a "method of strategy-building and instructional improvement,"[26] a method of "organizing observed teaching acts in a manner which allows any trained person who follows stated procedures to observe, record, and analyze interactions with the assurance that others viewing the same situation would agree, to a great extent, with his recorded sequence of behaviors. . . ."[27]

Systematic observation provides communicable criteria for reliably observing and recording what transpires in a classroom. Systematic observation does not, nor does it purport to, place a value judgment of "right," "wrong," "good," "bad," etc. on what takes place. The assumption is that the teacher, knowing his intent and accurately apprised of the actual happenings that occurred in the classroom, can supply his own judgments and make decisions accordingly.

In order to qualify as useful, a systematic observation scheme should be: (a) descriptive; (b) objective; (c) easily mastered; (d) manageable by the classroom teacher, and applicable to the classroom for the desired end; and (e) capable of providing immediate feedback.

It must be descriptive because that is its whole reason for being – to describe certain aspects of what is taking place in the classroom. It must be objective; which means that its terms, definitions, criteria, check scales, etc. must be clear, precise and unambiguous, so that the same perception sets are communicated by them to all observers. The classroom teacher who is to use the scheme must be able to learn the definitions, symbols for recording, and techniques for interpretation quickly and easily in a matter of a few hours. If not, he will never become proficient and won't use the system. Though outside observers can and will sometimes be used by a teacher, if performance evaluation is to be fairly constant, the teacher will be doing much self-evaluation from audio or video tapes. Also, a particular system won't be used if it doesn't apply to classroom situations, or if it doesn't assess the particular classroom facets of interest to the teacher at a particular time. If the data provided by systematic observation are to be effectively utilized, they must be available immediately to the teacher, and their mode of interpretation must be simple and straightforward enough so that little time is involved in their translation to an intelligible format.

In order to meet conditions c, d, and, to a certain extent, e, above, a systematic observation scheme must, as Flanders has said, devote itself to "paucity of detail."[9] In other words, any single observation system can and should focus only on a narrow band of the total classroom spectrum. There are many variables within the classroom of interest and importance to the teaching-learning-instructional gestalt. It is impossible to consider all these variables in a single observation instrument.

Some interaction variables of particular interest are: verbal, non-verbal, cognitive, affective, role structure, and shift, etc. Most systematic observation schemes now widely-employed concentrate on only one of the above areas. A few combine two areas at a time. However, the more variables considered at one time, the more complex the system becomes, and the greater is the effort required to commit ground rules to memory and accurately transcribe observations. It is often better and easier to use several simple systematic observation forms than to try to use one very complicated one. Not only are techniques simpler, but the teacher can better concentrate on one aspect as needed instead of trying to "change the whole world in a day," or being overcome by the vast number of needed improvements.

Sometimes there is bemoaning of the somewhat imprecise nature of systematic observation schemes. This is to be expected in a culture conditioned to "hard" scientific data. However, when the relative youth of such systems is considered, the "state of the art" has really come a long way in a relatively short period of time.

Mention of objective observation and the need for it has occasionally appeared in the education literature from the turn of the century onward. However, systematic observation first appeared in the literature about 1935 with Wrightstone's study of selected New York schools using "Newer Practices."[28] Its application and development was slow until the late 40's when several pioneering observational systems – many aimed more at socio-emotional climate than any other aspect – appeared. These included work by Bales,[3] Medley and Mitzel,[21] and Whithall.[37] These systems stirred much interest and were quickly followed in the next two decades with development of different systems and their application in research and teacher education by Flanders,[10] Amidon,[1] Hough,[2] Ober,[29] Bellack,[5] Ryans,[33] Gallagher and Aschner,[14] Combs,[7] Galloway and French,[12] Good and Brophy,[17] and Smith and Meux,[35] to name a few.

There are two basic kinds of systematic observations: sign or category. Sign systems tend to be checklist-like in nature. They consist of lists of behaviors, and during a given period of time the observer checks the behaviors that occur. Each occurring behavior is checked only once, no matter how frequently it recurs. The OSCAR system, perfected by Medley and Mitzel,[22] is a fairly well known example of a sign system.

A category system provides specific classifications whose operational definitions, characteristics, and symbols must be learned by the observer. At regular intervals during the observation period, the observer determines the behavior category being exhibited and records the symbol for that category. The same or different symbols are recorded during each time-period depending on the behavior being exhibited. A category system gives a running account of behaviors and their changes and responses whereas the sign systems give information about whether specific behaviors did or did not occur. The Flanders system is a category system.

Generally, category systems are preferable when one aspect of behavior is being studied. They give a detailed, in-depth account of the occurrence of components of that aspect. Sign systems are preferable when several aspects are being studied, as for initial or periodic surveys or to check on teaching or instructional repertoires.

Classroom observation systems can be categorized further as: cognitive, affective, multi-aspect or multidimensional. Meux[24] classifies systems into one of these three categories based on the system's components -- the aspect(s) selected as the unit of analysis; attributes -- the characteristics, features, properties or qualities of the components; modes of conceptualization -- the ways of describing the attributes; and the kinds of relations -- the types of rules or laws uniting the system into a cohesive whole.

Cognitive systems are concerned with the type of intellectual activity occurring in the classroom, with the ways in which content is being presented and/or mastered. Systems developed by Smith et al.,[36] Bellack et al.,[6] Gallagher and Aschner,[15] Mork's VRBL System[25] and Ober's ETC system are cognitive in nature.[30]

Affective systems focus on the social and/or emotional climate of the classrooms and the behaviors constituting that climate. Flanders' system[11] and those developed by Hughes,[20] Whithall,[38] Galloway and French,[13] and Ober's RCS system[31] are affective in nature.

Multi-aspect systems focus on several classroom aspects -- emotional, sociometric, cognitive, etc. -- at the same time Bales' system[4] and that of Medley and Mitzel[23] are multi-aspect in nature.

The Flanders system has become by far the most familiar, widely-used, and copied of the systematic observation schedules used in American education today. First developed by Flanders and perfected and researched by Flanders, Amidon, and Hough, it is a system that is easy to learn, simple to record, and quick to analyze -- an altogether good method of "getting your feet wet" in interaction analysis. However, it is not the be-all and end-all as it is sometimes represented. It has shortcomings. Mainly, it focuses on a very narrow range of classroom behaviors, treats the class as a whole, and over-emphasizes the teacher. It is, with all that, an excellent beginning. It should not be, as it too often is: beginning, end, and all the in-between. Revisions by Flanders, Amidon, Galloway and French, Ober, and others have made better instruments that check a wider variety of behaviors, and they are easy to use if one is already familiar with the original Flanders scales.

Almost all of the systematic observation scales developed in the 40's, 50's, and 60's share one overriding shortcoming. They categorize student behaviors as though the whole class behaved, reacted, etc. in unison. Only very recently have Good and Brophy,[18] and some others begun to look at interaction scales that observe dyad interaction between the teacher and individual pupils. This is a good stride in the right direction because it should be apparent that in a thirty-pupil classroom, whenever the teacher interacts with the total classroom, there are really at least thirty separate interactions. Especially today, when so much emphasis is being placed on individualized approaches to learning, classroom interaction systems must attend to individual effects of and responses to group and mass communication.

This brief and parsimonious summary of systematic interaction observation scales is rather like viewing icing on a cake. It tells very little about the taste, composition, quality, etc. of the cake itself. That is only obtained by sticking in a finger, fork, or other utensil and bringing a sample to the mouth. In the same way, interaction observation systems take on meaning only when practiced, applied, and utilized for teacher decision-making. When so used, they prove to be valuable tools for extending teacher awareness in a most critical arena.

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SESSION E-5

THE HIGH SCHOOL SCIENCE PROGRAM: NEW DIRECTIONS FOR THE FUTURE

NOW AND THE FUTURE

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Those of us who are involved in instructional change are well aware that the present literature is filled with reform proposals. Many experts are calling for alternatives to structured learning.

In his new book *Learning for Tomorrow, The Role of the Future in Education*, Alvin Toffler of *Future Shock* fame pleads for educators to develop an image of tomorrow's society. He emphasizes the need for immediate change.

Today, in that vein, I would like to present to you two alternatives to institutionalized learning. Alternatives in which I have been involved. One presents a total change in the educational package dealing with the future. The other, in the immediate present, deals with a change in the method of presentation of science material.

First let me describe for you a movement that is presently emerging at the secondary level and might well be the wave of the future. It is based upon the acceptance by adults of the remarkable ability of children to learn and use materials far beyond our expectations and experience. The ultimate intent being that children will be better prepared for an effective role in an increasingly complex society if they are exposed to a more direct, real-problem-based approach to education than that which is allowed by traditional curricular topics or by the variety of curriculum reforms that overwhelmed us in the 60's.

From a conference held in Cambridge, Massachusetts, in 1967 came the statement that the objectives of science and mathematics education as a whole must be to increase the ability of individuals to make decisions, decisions which will affect their own lives in society. Decisions at the personal level, at the level of trade and politics, and at the level of science and technology. This objective demands that students learn the process of modeling a problem. It requires that they search out facts and concepts that may be adaptable to a given situation. It further requires that the student develop confidence in his method of facing real life situations.

To accomplish that objective, students would be given recognizable, real, and practical problems. The practicality of the "real world" problems would not only motivate the student, but also provide a criterion for judging the correctness of hypotheses and conclusions. Try it and see if it works. Furthermore, it was felt the solution to most real world problems would necessitate an interdisciplinary approach when their various aspects were examined.

The conference agreed that there would be difficulties. First, a better understanding of the problem solving process would be necessary, but the student's appreciation of this process would then motivate learning. To accomplish this we would have to break down the organizational obstacles that militate against introducing such an approach. It would be concerned not only with science but also with mathematics and the social sciences. It would be problem-oriented, rather than discipline-oriented. It would not be the Unified Science of Ohio State but an interdisciplinary high school curriculum. It would not be a supplement to courses, but the core material of a course from which will come socially responsible and competent adults.

The first steps for the accomplishment of this objective have been taken. In 1973 at Estes Park, Colorado, a two week conference was held on "The Role in the High School of Interdisciplinary Learning Through Investigation and Action on Real Problems." The report from that conference suggested that while attempting to cope with the "knowledge explosion" of recent decades there have been at least two unfortunate and unanticipated effects. First, the learning-by-doing process that characterized the adolescent years of earlier times has been virtually eliminated from education. We now learn by observing (reading, watching, listening). The second effect is a shift from education as a preparation for dealing with problems presented by the culture to education as a process of acquiring a prescribed body of knowledge.

The educational system has expanded quantitatively to provide the extra years of education required for this process. But in turn there has been a loss of appreciation by students of the value and power of learning causing intense disaffection among large numbers of today's students.

How then do we remedy this situation? How do we provide a curriculum that reestablishes the connection between school and society, between student concerns and the curriculum? How do we reintroduce learning by doing? How can we make our schools accept the fact that adolescents are remarkably competent people, but that they need the opportunity to assume active social roles?

How can we cause them to analyse and to take action on real problems, and to be held accountable for those actions?

These types of considerations suggest a problem-solving approach as a curricular vehicle for the integration of disciplines, school, society, and the lives of students. These problems must be real to students and relevant to them as individuals and as members of their society.

To argue that learning through problem-solving is educationally appropriate for adolescents in no way precludes or minimizes the importance of learning by other techniques. There are many kinds of learning that cannot be understood very well without some knowledge of the concepts and rationale of related parts of a discipline. For many students the most effective way to learn such concepts may be the relatively traditional one of exploring the discipline in a logically ordered sequence.

I'm sure we all recognize that this problem-solving approach can not be superimposed on presently existing systems that might be steeped in tradition, but rather, would call for a restructuring of our schools, and just as important, new programs for the preservice and inservice education of teachers.

The obstacles facing the introduction of this type of program in the present day comprehensive high school are formidable. State and college requirements, the tendency to look upon teachers as subject matter specialists rather than generalists, and the sheer size of most American high schools are formidable foes.

The introduction of this type of education will be an heroic feat if it is accomplished. I do feel, however, that it is the direction that science education might well take and that we should be aware of that possibility.

I would like to focus specifically on the present rather than looking, as I have for the past few minutes, to a possible plan for the future. Let me describe an instructional style that might provide for you, as it has for us, an alternative learning experience to conventional school programs.

We strongly feel that a student's educational experience can be brightened by a curriculum that stresses flexibility and freedom, but also demands of the student the personal responsibility to make the most of this freedom.

We have designed an independent study, self-paced, multi-level course in chemistry that offers students an alternative approach to education. One that we hope will have a positive psychological effect on student attitude both toward learning in general and science in particular.

The classes are heterogeneously grouped. We wanted to eliminate the "smart" and "dumb" labels that often accompany grouping. Moreoever, we feel that students who are continually told that they are not capable often accept this appellation and will not try. It was further hoped that by being placed with more able students outside of a structured classroom situation these students might be encouraged by the more able students. There are many other educational advantages for students in the program. For example, a student, after an extended illness, may pick up where his work was interrupted. Students do not waste class time by coming to class unprepared. Moreover, laboratory work is never performed without the student being prepared. We also encourage students to talk together during class because we feel that much learning occurs when students can freely discuss mutual concerns. There are also non-academic functions which might result from participation in this course. The student might find his potential for accepting responsibility. He will discover leadership potential. Inter-student competition lessens. Pacing is the responsibility of the student.

This program was not intended to make any changes in content from a traditionally taught course but to change the method of presentation. We feel that making the atmosphere less rigid and more enjoyable would entice students to more willingly accept the responsibility for their education.

Our high school is one of several schools in Massachusetts that has adopted an Open Campus procedure in which students in free time are not scheduled. The students are blocked into chemistry for ten, 40-minute periods a week. They are, however, only required to attend any six of those ten periods, but with open campus they may spend more than ten periods in chemistry. The chemistry laboratory is open to students in the program from eight o'clock to three o'clock every day with a teacher or a paraprofessional always available. Adjoining the laboratory are two classrooms, one for testing and one for studying. At any given time several activities, ranging from testing and laboratory experiments to small group discussions are usually going on.

Immediately after the student signs in, he is responsible for checking the bulletin board for any notices dealing with the course. The course outline is on a large chart on the wall and indicates the basic program order. On the blackboard is a further breakdown into the three levels of instruction we have established for the course: diploma credit, college credit, honors work. Also listed are any of the additional learning aids which have been prepared to supplement or replace the basic program material. There is a calendar with important dates and the weekly position of "Joe Average," the place where most students should be.

The course is lab-oriented and each student in the college preparatory program does a minimum of fifty hands-on labs during the year with materials placed in tote trays. Only one tray is necessary for each experiment since the students are all at various places in the course. There are many labs going on at the same time with students working as individuals or in small groups. The answers to all practice problems and labs are available to students so that they can determine their level of comprehension.

TV lectures by one of the instructors are used to supplement the reading to aid those students who have difficulty reading. Demonstrations are also done on tape. The student signs a request sheet for the particular lecture he would like and the time he desires to see it.

At one end of the laboratory is an octagonal carousel where demonstrations dealing with such topics as bonding, solubility, and electro-chemistry may be seen. These study areas may also be used to view film loops or filmstrips, overlays or other learning aids.

There are many options available to students who may desire to study alone or work in small groups. Not only has small group interaction been very significant but often a good student helps a slower student. We have retained the interest of students who formerly would drop out. In turn, a more able student can move ahead without being held back by a less able learner.

Since the teacher is no longer lecturing he is now available to work individually with students. We have all been in the position in the classroom where a student might have a question on a concept. If he is unable to have it answered immediately, he might then be lost for the remainder of the lesson. The opportunity is here to teach a student when he wants to learn. If a group has a problem a teacher can join in the discussion when members of the group want to learn. A teacher may also demonstrate various lab methods and techniques when the students *are* interested. We also have been fortunate in having a well qualified paraprofessional who can not only prepare solutions but many times is able to help a student.

Our testing program - composed of two parts, the self-tests and check-point tests is part of our school philosophy of freedom and responsibility. Self-tests are graded by the students themselves. They are distributed by Dr. Doolittle, a box on the counter. The student takes a test, grades it himself, and records the grade in a grade book. If he is not satisfied with his performance on the test, he can take another comparable test and we will accept the better of the two grades. The student then files the test in the "orange thing" as a permanent record. The check-point tests are given at the end of units of work. These are administered by the paraprofessional at the request of a student. In order to receive credit for the unit's work, the student must score within ten points of the average he received in his self-graded tests. He may take the unit test four times (we have four forms of the same test). We then take the average of the highest two. Instant evaluation of the self-tests affords the student a psychologically optimum opportunity to learn from mistakes.

How, finally, do our students receive grades. The grading method is made known to all students. The grade is totally cumulative. A student, therefore, is never behind the class. He is competing with himself. To calculate the grade we use a quality and quantity factor of 50 percent. The quality is determined by valuing the self-tests and check-point tests at 50 percent each. This average is multiplied by the quantity factor which is determined by the ratio of the number of programs completed by the student to a predetermined number of programs set by the level of achievement for which a student opts. This would be 40 programs for diploma dredit, 57 programs for college-prep credit and all programs (about 70) plus six extra labs for honors credit. Upon successful completion of a unit a student's average is calculated using a fractional part of the above requirements and a letter of performance is sent to the parents.

Beyond the basic programs we make available to all students small basic understanding programs dealing with such topics as mass spectroscopy, infrared spectroscopy, and x-ray crystallography. They study spectra and calculate various energy levels and must answer questions such as "What do the bright lines tell us about the theory of electron energies?"

They calculate the distance between carbon atoms in oleic acid now knowing the molecule is not a straight chain. They use pH meters. Many of the labs are taken from college texts. We are able to use the best labs from all available sources.

Another alternative feature of this program allows a student who does not complete the course in one year to return the following year and receive full credit. We also have students starting the course in their free time now for next year.

A further responsibility accepted by the students is their part in cleaning up the lab. Each student is assigned clean-up duty about three times a year.

Finally the standarized ACS-NSTA Chemistry Achievement Tests were given to all students who took chemistry under this approach and under the standard approach. No significant difference was found in the results. The results on the college board achievement test were not significantly different.

An attitudinal survey was conducted and most students indicated they were happy with the approach of this course.

Lest I mislead you in stating the level of attainment of our goals let me remind you as W. James Popham did in an article in *Educational Technology* of July 1973, "there are always developers who will attempt to accomplish goals which, at this point fall beyond the capabilities of current development expertise."

Take the case, for example, of an eastern regional laboratory staff member who during the bulk of his life had viewed with chagrin manifestations of antisemitism. Having served an apprenticeship period of two years in the product development activities at the lab, this developer set out to deal with the problem of antisemitism in an ingeniously straightforward fashion. He would simply make everyone Jewish! The developer clearly overestimated the potency of our current development technology."

Obviously I make no claims that we are that far along in our development. I do feel, however, that students not only have a good understanding of science and chemistry, but also in many cases a better understanding of themselves and what is meant by responsibility.

The system is designed to effectively handle small or large enrollments while retaining the humanistic qualities of a one-to-one student-teacher relationship.

This program has forced us to take a new and more intense scrutiny at the results of education. Our future lies with diagnosing learning problems, developing curricula, and creating and selecting media to assist us in the solution.

What then do we feel we have?

A place where the teacher is a director of learning! A place where students are encouraged to experiment and to record their experience in a meaningful way! A place where no two students might be on the same subject at the same time! A place where students and teachers are people! A place where people are listening to people! A school!

NEWTRITION NOW—A NEW SCIENCE PROGRAM IN THE CONTEXT OF AN URBAN COMMUNITY

Mary Hughes, Director, Newtrition Now Program, and Lecturer, School of Education, University of Pittsburgh, Pennsylvania and Leo E. Klopfer, Professor of Education, University of Pittsburgh, Pennsylvania

Testimonials abound about the shortcomings of high school science programs in meeting the needs of general education for today's youth, especially in urban areas. And science teachers are worried. The worry stems from the realization that the criticisms are all too true, that most of the content of high school science courses has little relevance to real contemporary problems, and that all too many students fail to see much value in learning science. The worry is aggravated by the fact that it is far easier to recognize what is wrong than to devise practicable alternatives that are better.

We've known for a long time that science programs designed for general education should appropriately focus on science content that is relevant to today's social problems and issues. We also know that most students will find the learning of science valuable only to the extent that what they learn is meaningful to themselves personally. When it comes to science teaching in urban areas, we are told that the content and strategies of instruction ought to be matched to the particular needs, wants, and expectations of the students in the community. And we are advised that it is a good idea to involve the community in some way in school programs. These good ideas and others are available to the educator who wishes to devise an alternative science program. The difficult part is putting the elements together in an operational way.

Newtrition Now represents one attempt to apply what we know about science instruction for general education to the operation of a science program in an urban community context. The program embodies a unique approach to life-science instruction for middle and high school students, for parents, and for the elderly in urban neighborhoods of Pittsburgh. It puts health, education, and consumer professionals in direct contact with students, and prepares those students to assist parents and the elderly in nutrition education. The program increases students' awareness of nutrition as a personal health and consumer concern by administering individual dental, physical fitness, diet, and nutrition tests, and through interactions with professionals from community health and consumer agencies.

The distinctive characteristics of the *Newtrition Now* program may be summarized as: (a) relevant and personalized science content, and (b) community involvement for science teachers and students.

Content of the Program

Nutrition is currently a much publicized health concern. Americans have become more "nutrition conscious" in recent years and are likely to associate good nutrition with good health. However, this exposure to general information about the importance of nutrition does not automatically make it relevant to the high school science student.

Effective instruction is more than telling or lecturing, demonstrating, assigning, and grading recitations, laboratory investigations, tests and papers on current nutrition information. If we want the students to acquire specific nutrition content, they must be able to perceive that this content is directly related to their personal growth and development. The instruction must be personalized. Personalization is achieved in the *Newtrition Now* program by including a sequence of concrete experiences that give each student measurements of his or her present nutrition and health status. These measurements become the basis of the instruction. Personalized instruction is in accord with two assumptions about learning stated by Postman and Weingartner:

1. Learning takes place best, not when it is conceived as a preparation for life, but when it occurs in the context of real daily life.
2. The best time to learn anything is when whatever is to be learned is immediately useful.[1]

[1]Postman, Neil and Charles Weingartner. *The Soft Revolution* Dell Publishing Co., Inc., New York, 1971, pp. 9-10.

The personalized instruction in *Newtrition Now* begins with the collecting of data on each student. Students are given four tests: Diet and Weight Assessment, Physical Fitness Test, Mouth Test with Dental Hygiene Rating, and Blood Test for Iron Content. These tests are administered by health professionals from the community.

Now the student has a personal evaluation of his or her test results. This evaluation introduces the student to the content of the curriculum of *Newtrition Now*. The relationships between the tests and the content are outlined below.

Test 1. ***Diet Interpretation with Weight and Height Ratings***
The student examines his own data and recognizes their relationship to the following nutrition content: adequate diets, dietary standards, nutritional status, kinds of nutrients, digestive system.

Test 2. ***Physical Fitness Test***
The student calculates his score on the Harvard Step Test, which is an index of circulatory-respiratory capacity. This introduces the following biological content: heart and exercise, circulation and respiration.

Test 3. ***Mouth Test and Dental Hygiene Rating***
The student's rating on the dental hygiene assessment introduces him or her to the unit's section on Health Concerns. The health concern specifically related to this test is the teenager's dental problems.

Test 4. ***Blood Test for Iron Content***
The student's iron content is measured by visiting nurses and compared to normal levels. This test introduces two serious nutritional problems that are discussed in the unit: obesity, adolescent pregnancy.

From the evaluation of the several test results, the student can assess his or her need for improving or maintaining present nutritional and health status. Hence, the student realizes that the content studied in the unit can be put to immediate personal use. In addition, the use of some of the unit's content is in itself reinforcing. If a person maintains a balance between calorie intake and calorie output, he or she practices good nutrition and its effects can be readily recognized in weight control and physical fitness. This personal payoff is important. Tackling the air pollution problem, by contrast, may have little personal payoff and requires collective efforts for improvement. If a person stops backyard burnings, there is not the same dramatic effect on air pollution as there is from practicing good nutrition.

As part of the *Newtrition Now* program, students visit their local supermarket, where food store representatives, nutritionists, and consumer protection representatives explain their concerns for wise and nutrition-conscious marketing. These sessions are taped. Students review these tapes in school and, during the final week of the program, discuss such issues as nutritional labeling, recommended daily allowances of nutrients, code-dating, and unit-pricing.

Instruction in the nutrition program differs from that found in most secondary science classrooms. Various learning strategies, grouping of students, external resources, and an individualized management system are all part of the process of personalizing instruction. The various learning strategies employed are:

1. Individual Lessons Students work independently on nutrition lessons. The pattern for these lessons is the Voit Unit, *Individualized Science* Program.[2] Students finish these lessons at their own rate, correct them, and arrange for remedial instruction if necessary.
2. Laboratory Work Exercises testing for the various nutrients in foods are performed. Students choose from several alternative investigations the number and kinds of chemical tests needed to consistently identify specific nutrients.
3. Interpretation of Personal Data In seminars, health professionals from the community interpret the results of the dental, diet, physical fitness and blood tests. In these small group sessions students are able to ask questions about health concerns that they might be afraid to ask in a large classroom.
4. Current nutrition films are used to introduce the four health tests and the related content.

To manage the program's various activities, *Newtrition Now* utilizes flexible groupings of students. Classes are initially divided into three groups: A, B, and C. A weekly Planning Sheet designates the sequence of movement to the various activities for each group, e.g., individual lessons, laboratory work, health test, film, or seminar. The Planning Sheet is also used by the student and teacher to chart individual progress through the nutrition program. Students who wish to repeat certain activities may exercise that option. Some students may initiate new activities. Through the use of grouping and the Planning Sheet, *Newtrition Now* classrooms display characteristics of individualized instruction.

Community Resources and Involvement

The second distinctive characteristic of the program is the use of community resources to enhance science instruction. Nutrition is not only an individual problem, it is a community concern. Because this is true, and because most community agencies have a commitment to community education, educational forces other than the school can be expected to help in an instructional program on nutrition. The health and consumer agencies in urban neighborhoods provide expertise that is invaluable to life-science instruction. The urban community with its neighborhood health center, community services center, and centralized shopping area provides many resources that can be coordinated. *Newtrition Now*, recognized as a supportive service to the school and community, provides the mechanism for health and consumer professionals to share their expertise with science teachers in a nutrition education program.

An important consideration for teachers in working with community professionals is the preparation of students for the participation of the "outsiders." Some assurance must also be given to these professionals that their contribution will have classroom follow-up. It is not an easy task to keep health and consumer professionals involved in programs with high school students. The mechanism that *Newtrition Now* initiated is that the high school provides a clinical setting for the training of health professionals in preventive medicine.

[2]This program was developed at the Learning Research and Development Center, University of Pittsburgh, and is published by Imperial International Learning, Kankakee, Illinois.

The schools of the health professions recognize education as preventive medicine. This places the responsibility on the high school teacher to provide feedback to the health professionals concerning the classroom reaction to their message. This symbiotic relationship between high school and health profession school strengthens the mechanism for continued involvement.

The community agencies contributing services, facilities, and/or personnel to *Newtrition Now* include: University of Pittsburgh, Graduate School of Public Health, School of Dental Medicine, School of Education; Pittsburgh Board of Public Education; Diocesan School Board of Pittsburgh; Allegheny County Health Department; Pittsburgh Dietetic Association, Advisory Committee; Shadyside Hospital, Dietetic Intern Program; Magee Women's Hospital; Children's Hospital; Neighborhood Health Centers; Pittsburgh Food Chains, H. J. Heinz, Co., and Giant Eagle Markets.

The *Newtrition Now* program is attempting to bridge the gap between community and classroom, first by bringing professionals in nutrition, health, and consumerism into the schoolroom, and then by taking the student-graduates back into the community to assist in the nutritional education of the elderly. Real community-school involvement necessitates this two-way traffic flow. Volunteer student graduates of the program take part in seminars to prepare for work instructing parents and the elderly. These seminars are conducted in senior citizen's lounges and cover topics such as meeting elderly people for the first time, explaining the program to them, exploring ways of being helpful to them, examining the physical facilities for program implementation, and dividing the work load. The program director and staff conduct these student sessions.

Upon completion of this training, *Newtrition Now* staff and their student helpers conduct the nutrition education program for adult and senior citizen groups. The components of the community program are essentially the same as the school program--dental health, physical fitness, diet and weight control, and food-buying. The instruction is geared to the health concerns of each group but the basic information remains the same. It is important that student volunteers are familiar with the basic content of the community programs. Students help as tutors, transportation aides, food aides, social service aides, and shoppers. The element of community service in *Newtrition Now* has been mutually acceptable to adolescents and senior citizens.

History and Prospects of the Program

Newtrition Now operates by invitation only, but any school or neighborhood recognizing a need for nutrition education is eligible. The pilot study began in the fall of 1972 at an urban high school in Pittsburgh. The study was done by the H. J. Heinz Company in conjunction with regional medical programs and the Diocese of Pittsburgh. With the demonstrated success of the high school program, *Newtrition Now* moved to the neighborhood parochial school, Senior Citizen's Lounge, and the YWCA and YMCA Outreach Programs. During the first year of operation 200 inner-city residents received the nutrition program. With the endorsement of the public and parochial schools the program has expanded to the north side of the city of Pittsburgh. This year the program has serviced over 300 students, 150 senior citizens and 80 adults.

The professional involvement from the University of Pittsburgh, city hospitals and County Health Department continues. It is proposed that *Newtrition Now* will become a clinical experience with accreditation for the training of health professionals from these contributing agencies.

Newtrition Now continues to expand as it continues to meet its stated objectives: first, to increase nutrition and consumer knowledge; second, to provide a program that makes health and consumer education interesting and pertinent to participants.

SESSION E-9

AN EVALUATION DESIGN OF THE JUNIOR HIGH SCHOOL SCIENCE PROGRAM

John E. Roller, Associate Science Supervisor, Tulsa Public Schools, Tulsa, Oklahoma

The program is designed as a self-paced, laboratory approach to science. The materials are organized in three levels which represent first, second, and third year science programs. Level I content covers concepts selected from all three of the major disciplines of science--life, earth, and physical. The laboratory emphasis is on energy. Level II content also covers concepts selected from all three major disciplines of science. The laboratory emphasis is on matter. Level III is much less structured than the first two levels. It affords students the opportunity to select minicourses or modules from the disciplines of life and earth science.

The program is not centered around any one instructional strategy, such as a textbook-lecture approach, but utilizes the media best suited for the student in a given situation. The laboratory material is a commercial program developed at Florida State University. This Intermediate Science Curriculum Study (ISCS) material emphasizes the processes of science. The enrichment component developed by the Science Department of the Tulsa Public Schools, at each level emphasizes the concepts of science.

The Level I and II materials have been used for three years and some of the eight modules at Level III are in use at Wilson.

Cleveland, Clinton, Foster, Lewis and Clark, and Skelly have been in the program for two years. Anderson, Bell, Gilcrease, Monroe, Nimitz, and Roosevelt have been in the program for one year. Carver, Hamilton, Madison, Thoreau, Whitney, and Wright are in the program for the first time this year. All project schools are now voluntarily committed to the junior high science program. Project schools have or will drop biology and have or will have some seventh grade students in the science program next year.

Project Objectives

1. To promote among students a positive attitude toward science.
2. To develop some of the science process skills such as: observing, measuring, classifying, predicting, inferring, formulating hypotheses, controlling variables, interpreting data, defining operationally.
3. To develop an understanding of some concepts selected from all three major disciplines of science life, earth, and physical.

Evaluation Procedures

Objective 1 will be evaluated by administering a questionnaire to samples of students in grades 7, 8, and 9 in each project school. The questionnaire, to be administered in February 1975, will be constructed by the Department of Instructional Research.

Objective 2 will be evaluated by on-site visits by Polk and Roller to all project schools. A written observation report will be submitted by March 1, 1975.

Objective 3 will be evaluated with a criterion-referenced instrument. This instrument, developed by a team of Tulsa Public School personnel, will be administered to samples of students in grades 7, 8, and 9 in each project school by April 1, 1975.

SESSION F-3

PROLONGED SIMULATION ENVIRONMENTS IN THE CLASSROOM[1]

Michael Babcock, Teaching Assistant, State University College of New York, Plattsburgh; and Sandra Latourelle, Teacher, Ausable Valley Central School, Clintonville, New York

We have known for many years that child-centered activities can be used to reinforce old skills and place new ones at the child's command. It has also been shown that single concept units can be taught with these types of activities. This paper describes a study in which we attempted to exploit such activities and concepts using long-term activities built around a limited amount of subject matter.

We termed this long-term activity "a simulated environment." (We chose this name because of the structuring of the activity.) Basically, the environment was designed as an information processing situation. Children in the seventh grade were presented with problems to solve, each problem being designed so as to encourage the learning of new skills and to reinforce previously learned skills. It was hoped that with these skills the children could then solve their assigned problems by processing the information that they had found.

We began our study in September 1972 at Ausable Valley Central Middle-High School (Clintonville, New York) with a seventh grade Life Science class. The class consisted of 28 students grouped in a heterogeneous manner. The class contained individuals from widely varied socioeconomic backgrounds.

We chose this class because of the students' lack of basic academic skills. Many read one to two levels below grade level. Most had never taken notes, used the library, or had to organize a plan of action. Because of their limited vocabulary, they could not readily communicate their ideas. Many of the children could not work in groups without loud verbal exchanges. We were hopeful that the learning environment we were setting up would alleviate these social and learning problems.

The planning of activities involved consideration of learning and behavioral problems. We felt that we could attack both types of problems by including both social and academic activities.

With what we hoped to accomplish, our objectives had to be different from those designed for an average class. Each objective not only had to help presenmaterial but also had to help that person overcome his or her special problem. There were eight objectives set for the program.

1. The material or information had to be easily retained.

   The learning of concepts has always been better when connected with a concrete action. To accomplish this, we designed most of our information processing and transferring steps as physical actions. Much information came from actual experiments carried out by the children. These experiments were designed, constructed, carried out, and evaluated by the students themselves. To transfer this information to others, they built models, drew maps, and performed illustrated experiments for their classmates.

2. The classroom environment had to help them see their own environment from an ecological point of view.

   This phase was accomplished through the tests and experiments that the students performed. When air or water was to be tested, each child would bring a sample to test. Under certain circumstances, the tests were done at home and the data reported. By making their homes, neighborhoods, and schools part of their environment, the children began to see that they were not isolated from the rest of the natural environment.

3. The classroom environment had to assist them in seeing what environmentally unsound practices can do to the environment.

   To illustrate the effects of environmentally unsound practices, groups of students set up terraria and aquaria. When the ecosystems had stabilized, the students would then introduce set quantities of toxins to observe the effects on the plant and animal life. The students were asked to consider how this poisoning could take place in their home town.

4. The classroom environment had to show them where the law could be used in the fight for ecological improvement.

   For this phase, a court system was initiated. Here, mock trials were staged with the students playing the parts of judge, jury, attorneys, ecologists, and corporations.

5. The classroom environment had to help them to discuss legislation concerning the environment intelligently.

   Through the simulation, we hoped to encourage the students to try to understand what the laws meant. To foster this understanding the court system (from objective #4) was used extensively. It was thought that the level of understanding achieved by the students would largely be due to their desire to participate in the activities. To participate, they had to understand what was going on.

6. The classroom environment had to help improve reading, spelling, and vocabulary.

   Working from the assumption that the low levels of reading, spelling, and vocabulary could be attributed to the existence of a conceptualization problem, we added a large number of high interest low reading level books to our library. These materials proved to be an asset for the students when they tackled more advanced reading material. Spelling and vocabulary were treated in the same manner. The new words were then made a part of the classroom vocabulary through selected activities.

7. The classroom environment had to foster library skills and good note-taking.

   In an effort to accelerate the eventual use of the library, we brought no reference material into the room. All background research was done in the library.

   When a child went to the library, he or she was shown by the librarian how to use the card catalog, the Readers Guide and other indices. After this introduction, he or she was expected to find his or her own material. For children who had difficulty, the process was repeated as many times as necessary. Under no circumstances did we or the librarian obtain any books or materials for a student.

   To encourage the skill of note-taking, we allowed a certain amount of frustration to build in the students as they tried to work with large amounts of uncondensed material. Eventually each would find that it was a necessity to take notes on what he read.

8. The classroom environment had to promote socialization.

   As stated before, most of the students found it difficult to work in small groups. To help them overcome this disability, we instituted a program of socialization. Small groups with common goals were allowed to form (i.e. environmental law, environmental chemistry, concerned citizens, etc.). For any of these groups to succeed at or accomplish anything, each person had to "pull his own weight." These goal-directed groups increased or decreased in size as interest waned and new goals were found.

All materials, equipment, and back-up setups that were used in this study can normally be found in any junior high or senior high school science classroom.

This study was carried out over a four to five week period. We felt that this amount of time would allow each student (progressing at his own rate) ample time to complete the available activities. Our grading system was based on various criteria:

1. The amount of information retained by the students.
2. The amount of work accomplished.
3. Growth in the social and personal domains.
4. Growth in creative thinking capacities, that is, given a problem to solve could they form a plan of action.

On the day the "game" began, the students were asked to assume roles. The groups became industralists, ecologists, professionals, and ordinary citizens. Tape-recorded instructions were given to each group to help set the mood.

After the introductions, the students were allowed to research their respective roles. They examined policies and philosophies of industries and municipalities. Each group was responsible for drawing and labeling its factory, utility, or park on a master town map. Once the map was completed (now it served as a game board), it was studied carefully by all groups so as to ascertain whether or not a particular factory or mill contributed to pollution in the village. If the ecologists felt a certain group was causing a pollution problem, they were required to go through proper court procedure to obtain redress:

1. Obtain a court order from the judge.
2. Serve a subpoena on the offending group.
3. Secure time on the court calendar.
4. Participate in the court action.

The jury was picked from citizens groups and the prosecution and the defense chose their legal representatives. The judge had been previously appointed by the class.

It was of interest that the first trial almost did not occur because of the lack of a Bible. Two of the "citizens" donated a handmade gavel. ("It adds class," they said.)

The ensuing trials were rather interesting. Some were lost due to lack of evidence (poor research). Some were won through hard fights and heated debate.

The outcomes of this project were many and varied. Some objectives were achieved while others were not or were only partially achieved. In relation to objectives posed, the results were as follows:

1. The material or information had to be easily retained.

   There was a decided increase in awareness of what was happening in the real world. Students brought in newspaper clippings, verbal contributions taken from television newscasts and personal experiences.

   An interesting outgrowth of the activities was the students' disregard of manufacturers' slogans and jingles and their subsequent demand for cold hard facts about a particular product or process.

   Early in the project, students would tend to solve pollution problems by demanding that an offending factory or facility be shut down. Soon faced with economic ruin, the students were forced to compromise and face what can best be termed economic reality. (You do not solve one problem by creating another.)

2. The classroom environment had to help them see their own environment from an ecological point of view.

   Students, as the term progressed, began to show more and more awareness of unsafe practices in their community, for example, commercial effluent treatment, indiscriminate landfill, and the need for environmental planning. The children used local television broadcasts and newspapers extensively in keeping track of development in their community.

3. The classroom environment had to assist them in seeing what environmentally unsound practices could do to the environment.

   The general classroom took on a new appearance. Pictures, news clippings, and magazine articles suddenly papered the cabinetry. All dealt with the results of ecologically unsound practices. At the beginning of each class session, many hands would go up to tell us about a situation recently discovered.

4. The classroom environment had to show them where the law could be used in the fight for ecological improvement.

5. The classroom environment had to help them to discuss legislation concerning the environment intelligently.

   Even we were astonished at the development of 30 budding Daniel Websters vying for a chance at the devil (pollution). Suddenly terms like writ, injunction, subpoena, briefs, and "objection sustained" were "household" words. Even the most shy and retiring student became involved in the drama that unfolded before us. Hearsay, common knowledge, and circumstantial evidence meant nothing. Every argument needed to be backed by fact.

6. The classroom environment must help improve reading, spelling, and vocabulary.

   Large numbers of entirely new words began to creep into the children's vocabulary. As time progressed, more and more attention was paid to spelling through such avenues as letters to local businesses, court briefs, and court subpoenae.

   They began to take pride in their literary accomplishments. Questions like "How do you write a business letter?" were asked of their English teachers. Other teachers, also questioned, began asking the students just what was going on in their science class. These teachers were rather surprised at the lengths to which the students went in their explanations.

7. The classroom environment had to foster library skills and good note-taking.

   Here we found that students had not progressed as far as we had hoped. Although not developed to their fullest potential, library skills and notetaking improved markedly if improvement is judged by the accumulation of materials by the students.

8. The classroom environment had to promote socialization.

   During the first couple of weeks in school, petty bickering made instruction difficult. With the institution of the simulated environment, the students now found that the bickering hurt only them. The accomplishment of tasks forced group cooperation and gradually this group interaction became a way of approaching most problems.

We have concluded from our study that a child-based, child-initiated learning situation guided by the teacher can produce results that outstrip a traditional classroom approach. We base this judgement on the fact that traditional (lecture) classrooms provide growth mainly in the academic domain. The simulated environment helps to develop a more well-rounded person by providing development not only in the academic domain but also in the personal and social domains.

We have conducted a similar study with a class of tenth grade students. The results suggest that the approach we have described will work well with any age group, economic bracket, or IQ. That the simulated environment approach to learning allows the child to progress at his or her own rate, undoubtedly contributes heavily to its apparent success. The student is also allowed to provide his or her own personal meaning for what he learns.

We believe that the simulated environment approach allows considerably better learning to take place in the classroom than does process instruction. Unlike process instruction or BSCS which provides the student with only one way of solving a problem, simulated environments, operating on the premise that we each see things differently, lays open all avenues for problem solving.

We believe that the most important part of the simulated environment approach is its ability to teach the student how to teach himself. We believe that the ability of a person to teach himself new concepts and to understand ideas previously foreign to him are essential to the development and maintenance of an educated citizenry. The simulated environment approach provides an effective way of achieving these goals.

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SESSION F-4

HUMANISM, CREATIVE THINKING, AND SUBJECT FUSION: BASES FOR SCIENCE ACTIVITIES K-12

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> We are at the end of a curriculum era in science teaching, the next period is already emerging with different goals, subject matter and instructional characteristics. . . . A majority of teacher education programs of the 1970's are largely obsolete because they are designed to teach the science of the 1960's and there is little attention to on-going cultural changes and emerging science curricula. [5]

It is evident from Paul DeHart Hurd's statement above, that "we are at the end of a curriculum era in science teaching." At the same time the elements of the new science programs are finding their way into the public schools, the inevitable swing of the educational pendulum has already started its counter swing as Professor Hurd said further, ". . . the next period is already emerging with different goals, subject matter and instructional characteristics." What trends are appearing in these three aspects of the next period?

Process + Content + ? = 70's Science Education

The 60's introduced programs emphasizing process and concepts. The 70's have introduced some additional elements. Some science educators observed that often the new science projects avoid direct relationships between man's life and conditions and the processes and concepts of scientific investigations. The influential and prestigious National Science Teachers Association also recognized this lack and revised its first position statement on curriculum development in science (1962), because as their introduction says:

> In view of the many changes that have occurred in the past decade and in recognition of the belief that curriculum development should be a continuing process, the NSTA Committee on Curriculum Studies, K-12 has reexamined the 1962 views on the science curriculum and produced the revised position comprising this document. [8]

Among the additional goals of science education as seen by the NSTA are:

"The scientifically literate person

uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and his environment

. . . .

recognizes the limitations as well as the usefulness of science and technology in advancing human welfare

understands the interrelationships between science technology, and other facets of society, including social and economic development

recognizes the human origin of science. . . .

. . . .

has adopted values similar to those that underlie science. . . ." [8]

The NSTA continues that "*science, because it is a human undertaking, cannot be value-free. Emphases on values and on the social aspects of science and technology must be integral parts of any curriculum.*" They see the major educational challenge of the next decade as a development of learning environments that prepare people to cope with a rapidly changing society. To do this, students will need to be alerted to these social aspects of science.

"perception of the cultural conditions within which science thrives

recognition of the need to view the scientific enterprise within broad perspectives of culture, society, and history

expectation that social and economic innovations may be necessary to improve man's condition

appreciation of the universality of scientific endeavors." [6]

The trends for Science Education for the 70's that can be gleaned from the above statements are:

1. Different Goals: greater emphasis upon science as human endeavor, society-oriented with value clarification skills.
2. Subject Matter: more relevance to children's lives and society's problems and broader integration of science with other curricular areas.
3. Instructional Modes: wider use of more flexible teaching techniques and individualization of instruction.

What are the implications of these trends for you as an elementary school teacher of science?

A More Humanistic Society-Oriented Approach to Teaching

Science education should capitalize upon societal issues and problems as the focus for its processes and content. The child can be helped to see that current controversies are interesting, relevant, and open-ended. Issues and problems by their very nature are unresolved. These unresolved issues may provide the relevance which invites real learner involvement; this is especially true for many of our "brighter" students or those we label "culturally deprived."

You will find the selection of issues relevant and controversial *to the student* is not difficult. Any alert, *listening* elementary teacher "tuned in" to the child's community can readily list many issues that have real meaning to her class. Search through such issues for broad appeal and importance to determine those with current social concern. Handling controversial topics is difficult, but we teachers must deal with them if we are to help develop "scientifically literate citizens." Consider these criteria when selecting issues for your science program:

1. Social relevance and controversial overtones.
2. Relevance to the student of the designated level or potential for such relevance.
3. **Lasting, recurring relevance.**
4. **Pertinence to several disciplines.**
5. Potential for direct student experience. [1]

Community media (especially TV) expose children to issues, problems and insights we used to think were too advanced for them to understand. Children's exposure to the following events and issues stir excitement, fear, bafflement, and anger around which the society-oriented science program might be built: adequate testing of the "Pill," cyclamates, etc.; racial conflicts; environmental waste, pollution, energy crises, etc.; overpopulation; drug, alcohol, tobacco and chemical control of man's mind; use of insecticides; space missions; heart transplants; poverty; war; disease; starvation.

Activities and projects can make science education relevant to human concerns and needs. It may take the simple form of caring for a classroom pet or aquarium, observing and comparing similarities in their environment, in water pollution and health, in food and growth, in overcrowding, life, and death. "Such activities create group pride and an appreciation of the relationship of life and growth to individual and group responsibility." [13] With your guidance, your children can be helped to broaden into *their* communities and its environmental and social problems.

One unique way children can be exposed to realistic views of their own communities and its social problems, is outlined in a new unit, "Kids, Cameras and Communities," [2] being developed by Educational Development Center (the ESS group) in Newton, Massachusetts. Children learn to insert film and take pictures with inexpensive "Instamatic-type" cameras. The unit contains specially designed dark bags which serve as portable darkrooms. Using these bags, children learn to prepare developing and printing solutions for developing film and making prints. The pictures received tell much about the community: garbage overflowing uncovered cans, "junkies" pushing dope on street corners, derelicts sleeping in doorways, rats scurrying across backyards, kids playing ball in the traffic congested streets.

A New York City program, "City Design and Urban Change," [3] shows also what can be done (even in inner-city areas) to tie together science and society through the study of pollution. This program was designed to awaken children to the importance of ecological problems in city planning. Pollution problems highlighted the interrelationships between man and his environment, which has special significance in studying urban ecology. Children were exposed to such ecological concepts as grouping systems, populations, food chains, and food webs, communities and ecosystems, interaction and interdependence. These concepts were related to needs children observed in housing, recreation, transportation, and other services needed for satisfactory living in their urban environment.

A fourth grade class doing a similar study identified these health problems in their community: littered streets, garbage collection, air pollution from incinerators, number of people who had not been vaccinated. The children (with the teacher's help) arrived at the conclusion that these conditions *could* be improved, *if* the community was alerted to the problems. Suggestions were made by children for circulating a petition to form a community council to see the governor. All of the discussion lead to a study of appropriate agencies and units of government necessary for converting science undertakings into constructive social action.

Belle Sharefkin of Brooklyn College presents this example to illustrate that the demand for *political* literacy in addition to *scientific* literacy in a technological society calls for a new alliance between science and social science:

> "One student teacher in a so-called slow fifth grade class in a ghetto area asked children to listen to a phonograph record dealing with crowding in the zoo. Visiting this class, I observed that the rhythm caught the initial interest of the children who then began to listen and comment. The children were surprisingly insightful and verbal in relating the problems stemming from overcrowding in the zoo to those of population density in their own neighborhood. They suggested that increase of crime, lack of sanitation, inadequate housing, and poor health services might be the end results of high population density, and then listed ways to investigate how community action might alleviate some of these problems." [14]

Although there are many things that teachers can do in this area, it is unlikely that *all* science teachers possess *all* the competencies necessary to deal adequately with *all* these social issues or with others dealing with interrelationships of science, technology, and mankind. Much help from administrators, college and community personnel, and professional organizations will have to be supplied. Perhaps new issues-oriented science programs or modification of existing ones will be written by the team-writing approach used in creating the current programs. "Any curriculum that would assist young people in an examination of their basic assumptions about society and its improvement must deal with values and social policies. Yet attention to values and social policies is now almost totally foreign to public schools." [7]

Science Education and Value Clarification

Public schools generally have avoided inclusion of value clarification skill development in their curricula, especially in science education. One reason is that Americans pride themselves on being individualistic and coming to one's own conclusions. (Provided of course the conclusions are fairly conventional). Perhaps there is fear we will teach *specific* values. Put another way, there may be concern that teachers will indoctrinate children with their own values.

Whatever the arguments, values issues *must* be part of the teaching of Science. It has not been done and it is no surprise that young people (in college, high school, and even junior high school) are particularly critical of established educational practice. A common charge is that education lacks relevance and does not address itself to real basic societal issues and controversies. Youth are not the only ones asking for the inclusion of issues and values in our schools. A Joint Commission of the Association of Classroom Teachers of the National Education Association and the American Association for School Administrators recommended that education break out the classroom walls and "project students into direct involvement in community activities." The Commission further urges that schools can provide "definite educational experiences which teach young people to develop viable value systems and standards for personal behavior." [9] Robert J. Havighurst, a member of the University of Chicago education staff since 1941, put it this way: "The two basic processes of education are knowing and *valuing*."

There are many ways of dealing with values and controversial issues in science *without* indoctrinating students with either our own values—or equally bad unquestioningally inculcating society's values. One excellent way has been advocated by Louis Raths, Merrill Harmin, and Sidney B. Simon in their book, *Values and Teaching*. [11] They suggest that any science subject matter can be examined on three levels: factual, conceptual, and valuational.

Fact Level

1. What is the earth's diameter?
2. At what temperature on a Fahrenheit scale will water boil?
3. Name the stages of development of the butterfly larva.

The above are examples of questions composed of facts and specifics. Most of their answers are difficult to remember, are rarely interesting to students, and are of little use in attempting to enlighten the students. Their encyclopedic nature renders them practically useless in transferring to other areas of learning.

Concept or Generalization Level

1. What causes the movements of air currents?
2. Apply the principle of Newton's action-reaction theory to a swimmer diving into a pool.
3. How are igneous, sedimentary, and metamorphic rocks formed?

Concept or generalization questions are considered to be strong and indicative of good teaching. They serve as a means of coalescing facts and specifics into a unified whole. Most teaching is constructed around a set of the most significant concepts related to the topic under consideration. An inherent weakness of concept type questions occurs when one assumes verbalization implies understanding. The strengths of concept or generalization questions far outweigh any weaknesses, but in this writer's view they are still limited.

Values Level

I will not attempt to entirely dismiss teaching at the fact and concept level. What is needed is a newer perspective on both. Regardless of how skillful teaching is conducted at the fact and concept level, science instruction will usually be limited to mere information giving. Science educators need to penetrate into the third level, that of teaching for value clarification. For example, you could ask:

1. What kind of person do you suppose would make a good scientist?
2. Have you ever wanted to invent something that would benefit mankind in some way?

The *values* level attempts to lead the student to a greater awareness of applying his knowledge to his own thoughts and feelings. Causal relationships suggest *why* centered questions. Value-clarifying questions are of the *you* centered type! They help the student to see how *his* life is related to the subject matter being studied. [15]

Have you ever wanted to try an experiment but decided not to because you thought it might make you look silly? Can you think of any inventors who people thought had strange, unworkable ideas, at least at first?

1. If you were in complete charge of how our atomic resources were used, how would you use them?
2. What are some of the things we need to assume for your experiment to work out that way?
3. What are some of the good things that resulted from

the development of . . .(add almost any invention or discovery)?

4. What are some of the alternate ways you can choose to gather data? Which of these do you use?
5. When do you think a person can predict the results of an experiment with reasonable accuracy?
6. Can you think of any way a person might be able to tell the difference between scientific evidence and mere hearsay or guesswork?
7. Can you give me some examples of scientific beliefs that people are in disagreement over today?
8. Try to think of any animals that have certain territories that they closely guard. Do you have any such territories?
9. Do you think enough emphasis is being placed upon the prevention of air pollution? Have you ever done anything about it?
10. How do you feel about using laboratory animals in such a way that might be unnecessarily cruel and injurious to them? Is this a personal preference or do you think that most people should feel the same way?
11. Have you ever done anything in your science classes that made you feel particularly satisfied or pleased?
12. If you could choose what to study in your science classes, what would be your first three choices?
13. How do you feel when the weatherman forecasts a sunny day and it rains? How do you think the weatherman feels?
14. Can you think of anything in history that people once believed in but have changed their minds about?

Often the teacher's dialogue with students consists of inculcating, indoctrinating, or moralizing. Utilization of value clarifying questions helps the student rely upon his own abilities to consider questions.

Try It–You'll Like It!

There isn't any magic formula for moving children's thinking from Levels I and II to Level III. The values level requires the facts and concepts levels, but also demands more information, insights, guided TV watching, magazine reading, personal experiences, art, literature, observation of human behavior, field trips. Try to structure *your* questions for Level III on a *you* format that involves the child where he lives. These questions aim at the student's values and life. They ask him to take a stand and often to *do* something. This is real relevance and not just intellectual gymnastics.

Remember: A teacher may start a values level study with *any* science topic. Sl ay begin with content and build toward values issues, or motivate subject matter study by opening with a value-oriented investigation. Different teachers are excited by different issues. Feel free to raise your own issues but note the suggestions and cautions:

1. Never insist upon one "right" answer for the issues level. This would defeat the purposes of encouraging students to search for their own values.
2. After students become familiar and comfortable dealing with *you* questions in confronting values issues, encourage *them* to start raising their own values issues.
3. The teacher should always declare where *she* stands on most values issues. Caution: try to do it in a quiet, dignified way, which does not require that students adopt your beliefs. Postpone telling the class until students have a chance to investigate on their own.
4. The teacher must have values of her own and state them –but with quiet dignity.

An outgrowth of a values issues approach to science usually is an action project. Look back over Levels I, II, III and speculate upon the action projects that would cap off the respective studies. Acting responsibly upon one's values is one of the highest forms of citizenship. Archibald McLeish put it this way: "The man who knows with his mind only, who will not commit himself beyond his wits, who will not feel the thing he thinks–that man has no freedom anywhere."

Integrating Science with Other Areas

If science is to be taught with a more humanistic, society-oriented, values clarifying approach, it will have to be integrated more with other areas of the elementary school curriculum. This is difficult because we teachers bring these "hang-ups" to the topic:

1. Subjects are what teachers know how to teach.
2. Teachers tend to teach as they were taught. When today's teachers were school children, it was usually obvious to them that courses in various subjects were intended, above all, to teach those subjects.
3. Today also, teachers and pupils both know that they will in practice be judged largely on the bases of subject-matter accomplishments. Pupils and classes are rated not by their ability to think or create, but by their accumulation of knowledge. [12]

How then can the separate subject approach be altered in elementary school science? One good way is to focus on the asking of questions which leads to the probing of relationships between "subjects," which in turn, "permits the development of a synoptic and frequently original view of knowledge instead of the traditional segmented view." [10] *Teachers* and *students* ask questions of interest to them. Let children start with questions in biology, such as "What conditions are needed for maintaining life in plants?" Before long, they will start asking questions in physics, chemistry, anthropology. Students will spend a great deal of time finding answers in many "subjects" for their questions, especially if not prodded to get back on *the* subject. Information is gathered from books, newspapers, people, the streets and neighborhood, TV, labs. A key element in preventing the question-asking, answer-finding, multi-subject approach from becoming a sterile and ritualizing activity, is to deal with issues and problems perceived by the *learner* as realistic and useful.

Marjorie Gardner [4] sees these trends in the interdisciplinary approaches to science teaching:

1. From discipline-based science to interdisciplinary science to fully integrated science.
2. From structured courses organized in scope and sequence fashion to interchangeable modules with multiple options and high degrees of flexibility and adaptivity to local, regional, or national situations.
3. From teacher preparation in specific disciplines to broadening teacher perspectives and teaching competencies through interdisciplinary science.

Need for More Flexible Teaching

Teachers will find their creativity and resourcefulness pushed to their limits to provide more flexibility in their science programs. More emphasis will obviously be placed on the individualization of instruction. Several of the funded science projects, especially ESS and SCIS, give much attention to materials and teaching–learning strategies that stress self-pacing and multi-level activities. Other new funded projects have been started to work on individualizing science education. Herbert Thier, Assistant Director of SCIS has two such programs. One is called, Adapting Science Materials for the Blind (ASMB) and the other is Individualizing Instruction, which is one of six interrelated research and development projects of the Advancement of Education in Science-Centered Programs (AESOP).

There is an increasing storehouse of material being produced for individualizing science instruction for all students, especially the "gifted" and "culturally deprived." Additional concern for individualizing instruction can be seen in the growing interest in "open education" here and abroad. Even the design of school buildings reflects a movement to greater flexibility in our ways of structuring learning environments for children. Schools with moveable walls and large areas which hold groups of 100-200 children are becoming more common. Also the multi-media approach used in science education reflects the concern with expanding learning opportunities for all children. Team teaching recognizes the unique contribution of the *teacher* and is finding its way into more elementary schools.

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Necessity may be the mother of invention, but creativity is the father. Without both, there will be no offspring.

What uses can you think of for a bar magnet? "Pick up iron filings or paper clips or use it to build an electric motor." Anything else? "Else? That's what a magnet is used for." Sorry, friend, you display all the symptoms of a common ailment: rigid, overly constrained, and convergent thinking. A psychologist might conclude you suffer from functional fixation.

"From what?" Look at it this way: if you weren't bound by your fixation, you would realize that a magnet could be used as a tack hammer, paperweight, ice crusher, or as a fastener to keep your shirt on. Or, try embedding them in gums to keep false teeth in place, making a magnetic-repulsion shock-preventing automobile bumper, magnetic shoes to climb steel buildings, or to help keep a railroad train properly on its tracks. Small magnets might be used as cuff links, and a multiitude of tinier ones would make ideal stay-in-place sand for a kindergarten's "magnetic sandbox." The magnetic sand would also be terrific for highway sanding operations during slippery weather. At the other extreme, a really huge magnet might be used as a dandy, no-fall ski slope.

In elementary science, creative thinking requires divergence in thinking. The thinker needs to imagine unique ways of looking at common objects, of developing uncommon uses for them, and of changing or transforming those objects in new ways. Objects, and ideas about objects, are synthesized in original ways. Flexibility and originality in idea production are the essence of creative thought.

Children are superbly qualified to generate ideas (the magnet uses described above were suggested by sixth graders). Unhampered by the adult's mental fixations and constraints imposed by longer experience, young thinkers aren't concerned about finding immediate "best" or "most logical" solutions to a problem. They like solutions that appeal to their sense of esthetics or humor, or maybe just a solution that's "groovy." Children haven't had time to be brainwashed by the usual pat ways-things-*should*-be-done, nor are they concerned with the businessman's continuing battle with cost, time, and materials. And, because they have unspoiled and flexible minds still fascinated with the wonders of simple things, they can be consummate creative inventors.

Already impressed with the highly imaginative devices and schemes invented by children in incidental classroom instances, I decided to develop a specific teaching procedure aimed at stimulating intermediate level children to devise and build inventions as part of their science program. We called it an "Invitation to Creative Thinking" and modeled it after a similarly named method which had been found useful in promoting creative (divergent productive) thinking by college students.[1]

"Invitations to Creative Thinking" are ordinarily developed in two stages. The first stage utilizes a

[1] McCormack, Alan J. "The Effects of Selected Teaching Methods on Creative Thinking, Self-Evaluation, and Achievement of Students Enrolled in an Elementary Science Education Methods Course." EdD Thesis, University of Northern Colorado.

teacher-designed sequence to focus attention and interest on an open-ended problem susceptible to unlimited creative solutions. The materials or experiences involved might include pictures, slides, films, humorous stories, or dramatic demonstrations. These are carefully selected to pique interest, remove threat, and—most of all—stimulate divergent, creative thought. The second stage requires a responsive and supportive environment blending three essentials: opportunity, materials, and encouragement. After stage one centers on a problem and inspires the children to draw upon inherent creative abilities, stage two must allow plenty of time for incubation of ideas and ample materials (lots of junk) for channeling thoughts into tangible products. It's a good idea to remove as many constraints (*unnecessary* classroom rules) as possible, and give lots of praise ("Gee, Albert, your Automatic Teacher-Aggravating Machine is great!")

Stage One: Focus and Stimulation

Rube Goldberg is remembered by the older generation for his cartoons of bizarre "inventions" which poke fun at the expanding technology of the twentieth century machine age. Goldberg's satires and ludicrous situations earned him vast popularity from 1916 to 1938 in the comic strips "Boob McNutt," "Lala Palooza," and "Foolish Questions." His most famous character was Professor Lucifer Gorgonzola Butts, the genius who demonstrated the inventions which eventually made "Rube Goldberg" a dictionary definition. Inventions like the "Self-Emptying Ash Tray of the Future" (love birds on a pivoting perch cause water from a sprinkling can to shrink a shirt which opens a drape unveiling a picture of a dog's master, encouraging the dog to wag his tail in an ash tray, flicking ashes and butts into an asbestos bag attached to a sky rocket which blasts off into space), the "Anti-Floor Walking Paraphernalia," and a "Simple Orange Squeezing Machine" were devices employing a wacky series of common, everyday items to demonstrate convincingly that the simplest task was impossibly difficult. Each of the contraptions used many mechanical steps, replacing the laws of physics with flights of fancy whenever necessary. Most of the inventions were horrendously ingenious, and all guaranteed the comic-strip reader a good laugh.

A collection of Goldberg cartoons is more than adequate as a motivating medium stimulating children to think about designing inventions. A series of slides depicting Rube Goldberg devices and a film showing a working model of a Goldberg-like contraption formed the first stage of an "Invitation to Creative Thinking" for children of grades five and six at the North Star Elementary School, North Vancouver, British Columbia. The Goldberg humor held great appeal for the children whose minds seemed almost to visibly incubate inventions of their own before the introductory lesson was halfway through. Goldberg's brand of fanciful thinking and inventing was exclaimed as "really neat" and "just what we always wanted to do!" Focus and stimulation? No problem. Let Rube Goldberg do it for you.

Stage Two: Opportunity, Materials and Encouragement

Any child who wished to design and build his own invention was *invited* to take a creativity kit and try it (remember this is an *invitation* to be creative, not a command). The creativity kits (packages of junk) quickly were commandeered, and the contents spread out at convenient spots on the classroom floor. A supply of kits had been put together earlier by the teacher, simply by stuffing cardboard, rubber bands, string, wood, paper clips, and other odds and ends into large manila envelopes. The children felt that these materials were good as a starting point, but didn't want to be limited only to the contents of the kits. All agreed anything could be added as long as it was legitimate junk which could be scrounged from somewhere without spending money for it.

The great innovators went to work. For two weeks, all science class time (and a lot of time outside school hours) was spent in the frustrating but intriguing process of blending ideas with materials in search of the great invention.

Admittedly, creativity cannot be taught, but children *can* learn to free themselves from mental blocks or constraints limiting the range of solutions to any problem. In conducting a creativity-inducing science activity, the teacher must make definite efforts to overcome these obstacles in his own thinking. Encouragement of divergence in the planning stages of a child's invention would be followed by stimulation and praise of oddball efforts in the invention's construction. (Keep in mind that the electric light bulb, "wireless," and flying machines were at first considered absurd and oddball.) Climbing over these mental blocks with children, and moving aside the usual anti-creative constraints ("It will never work; it's just not practical") can result in some amazing contraptions.

Fun and Games or Genuine Science?

The elementary science curriculum purist may feel the urge to raise certain questions regarding our Invention Workshops. What are the children learning? What specific concepts and skills are developed? Our answer: we maintain that children learn as much as they might from a more orthodox science activity and then some. Children still develop many of the same ideas about pulleys, gears, levers, etc., ordinarily included in a unit on "Simple Machines." But the ordinarily dull information concerning elementary mechanisms takes on full meaning when you're "figuring out" how to build an invention you are really excited about. And, if you are concerned about engaging children in the methods of science—the skills of observing, hypothesizing, measuring, predicting, and inferring—there's no need for worry. All of these are combined, and with this important "plus"—children are intimately involved as *creative* thinkers.

Granted, creativity as such cannot be taught; the matter is far too elusive and uniquely individual for that. However, it can be fun "thinking up" lots of ideas, playing with the oddball notion, and working hard grasping for a novel intuitive flash. The main goal, we feel, is that both teachers and pupils become sensitized to the existence, value, and sheer thrill of creative thought. Isn't that truly the essence of Science?

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SESSION F-5

SCIENCE IS NOT CONTENT! IF NOT, WHAT IS IT?

THE SCIENTIFIC PROCESS–CONTENT, INQUIRY PROCESS, AND VALUES

Jack L. Carter, Professor of Biology, Colorado College, Colorado Springs

I hope we are not beating a dead horse by the very nature of this session. When one says "Science Is Not Content! If Not, What Is It?" I get the old familiar feeling we should all give three cheers for inquiry and dismiss ourselves to the closest bar, well aware of the fact that all elementary, secondary, and college teachers teach science through the inquiry process.

This of course is not the truth. Those of us who spend considerable time in classrooms from kindergarten through college level see some teachers who understand the role of inquiry in science teaching and apply it in their teaching; but at the same time we observe many teachers who are devoting their entire science period to teaching the results or end products of the inquiry process. This is what I am assuming we are defining in this meeting as content. The corollary to this latter situation would mean students are leaving these content-centered classrooms with little or no appreciation of the most important process ever designed and utilized by the human mind. Teachers who do not involve their students in the inquiry process are robbing their students of the one activity that holds the greatest single hope for the future of this troubled planet.

At this point, and before I go one step further, let it be known to all within the sound of my voice that I strongly support the transmission of knowledge or content. The accumulation of new knowledge is what the inquiry process is all about. It would be even more hazardous if schools were to devote 12 years to elementary and secondary science education and the training of young minds and the students were to leave these schools with the impression that the inquiry process was nothing more than the way we have fun in science classrooms and laboratories. The relationship between the inquiry process and content must become a reality for every person.

The results of this inquiry process, call it knowledge or content, are having a tremendous impact on the matter and energy of this planet and now our knowledge is reaching far into space. The geometric increase in our knowledge bank is touching every piece of living protoplasm each day that it continues to live. Increased knowledge reaches into our sperm and egg cells before the fetus is even formed. This same new knowledge, resulting from the process called inquiry, touches every moment of our lives. The content of science is with us unto death. It is today determining how, when, where, and in the foreseeable future if, we will die.

But there is still another aspect of the scientific process that goes beyond content and the problem solving skills necessary to conduct investigations. There is an environment in which the best of scientific experimentation can go on, a setting that is conducive to the inquiry process. We might describe it as an environment in which the values of science or the affective behaviors of science predominate. When this environment and these values are present society can respect scientists and the new information they produce.

Basic to this setting for science are such ancient values as honesty and openness. The importance of sharing ideas and information must remain central themes of science. Trusting your colleagues and openly dissenting must continue to be treasured values of science. Respecting the freedom to search for new knowledge and to ask meaningful questions about any subject must be understood as basic obligations of science to society. The search for new knowledge demands that the atmosphere be one in which risk-taking and cooperation are encouraged. If these are the values or affective behaviors conducive to science, it is now possible to identify those values that are antiscientific, or those values that keep science from achieving its greatest potential?

Scientific experimentation cannot operate well through closure, in an environment of secrecy. Withholding data and telling half-truths limits the value of science to society. Competition in science may lead to short-term personal or financial gains, but in the long run all of society loses. Ownership of ideas and information invariably leads to dishonesty and loss of objectivity. The development and use of insecticides and herbicides for personal and corporate gains provides examples of where bad behaviors by scientists can lead a nation. The secrecy and closure within the oil refining and the automobile industries are two more recent examples of antiscientific technology at its very worst.

In describing what I consider to be antiscientific behaviors I am not saying that the history of science is free of those individuals who shrouded their work in secrecy and used dishonest tactics in order to be elected to the Royal Academy or receive the Nobel Prize. One only needs to read Robert K. Merton's convincing paper entitled "Behavior Patterns of Scientists" published in the *American Scientist* in 1969 or James Watson's *The Double Helix* to see the depths to which men of science will sink to achieve priority over others. But I would suggest that the dishonest, "Win at any cost," competitive science which characterized the attitude of James Watson or that prevail in many science departments of major universities that tell young professors to "publish or perish" and describe the interest of industry in scientific research are not representative of the scientific community I can or will support in my teaching of science. If there is one important lesson our trips into space and the energy shortages have brought to the attention of large segments of the world's population it is the concept of limits, limited resources and limited energy. We are being forced to cooperate rather than compete and I contend these two terms have opposite meanings, in spite of the way I see them misused by politicians, industrialists and, educators.

I as a teacher of science and teacher of teachers have a paradigm or model which I will call the scientific process. This process is composed of three parts, the content or knowledge of science, inquiry process or skills and cognitive behaviors of science, and finally but of vital importance the values or affective behaviors of science. It is my responsibility to convey this scientific process through what I teach and the methods I use to teach.

Respect for knowledge must be emphasized in my classes. World population, hunger, and nutritional problems must be dealt with in light of our present knowledge and the need for new information. Environmental issues, human sexuality, and drugs must be discussed in light of what is presently known and not known.

Involving students in the inquiry process can strengthen their trust in the content and knowledge found in their textbooks. As students participate in designing investigations, measuring, gathering data, interpreting data, and drawing conclusions from their experiences they can draw strength for their own lives. There is no greater lesson to be learned by students of any age than that they do have some control over their own destiny, if they will but learn to solve problems and make use of the information which is available to them.

And finally I must conduct my classroom in such a way that the values of science or affective behaviors of science I hope to exemplify are rewarded, and antiscientific behaviors are punished. Sharing ideas and information with your neighbor must improve your grade and secrecy or withholding information must lower your grade. Honest and open questioning and dissenting must be encouraged while closure is discouraged. The classroom and laboratory activities should be designed so that cooperation is identified with success, and competition results in failure. I do believe I have been able to do this in my teaching.

In a short period of time I have tried to describe the scientific process as I interpret it for my students and future teachers. If my paradigm or model is of value to me in teaching science methods courses, introductory botany courses, and advanced courses in botany it must also be useful to me outside the halls of ivy and in society at large. I have found this model useful not only in teaching but in dealing with my family and some parts of the community in which I live. As you might expect I have found the military community, some portions of the business world, and competitive athletics at odds with my views. But since I am only one teacher in a small liberal arts college I offer little threat to these entrepreneurs of another set of behaviors and lifestyle.

SESSION F-6

DIRECTIONS FOR SCIENCE TEACHER OBSERVATION RATING FORM (STORF)

Lynn Oberlin, Associate Professor of Science Education, University of Florida, Gainesville

This form was developed as an instrument to help observe teachers working with children in the area of science. Value judgements are not made as to good and bad practices but practices are looked at as being different. On the left hand side of the instrument is Behavior A and on the right hand side is Behavior B. Behavior A is experimental and Behavior B is traditional. No teacher fits entirely within Behavior A or entirely within Behavior B. The general behavior pattern is determined by the number of items checked under Behavior A compared with the number of items checked under Behavior B.

This instrument is used in teacher education to help prospective teachers look at different kinds of teacher behavior. In looking at different kinds of teacher behavior, the future teacher may begin to identify with a certain kind. He may find the kind of person he would like to be. At this stage, he can see in one column the things he would do much of the time and in the other column the things he would do much less frequently.

Room Observation

The room observation is made when the room is first entered. Some of the items are starred. A starred item is one that *must* be marked and it must be marked in only one column. For example, item Number 1, Behavior A, says "the room has a science corner or table." Under Behavior B it says "the room has no science corner or table." One or the other has to be true. Put a check in the total column in either Behavior A or Behavior B. One column must be marked but not both.

	BEHAVIOR A	BEHAVIOR B
Item 1	*1. Room has a science corner or table.	*1. Room has no science corner or table.

What is being asked is whether there is a place in the room where science things and materials are kept; and where children can work on science. It might be a corner or table; or it might be a shelf, counter, or other location.

Item 2	*2. Student-made or brought-in material is in evidence.	*2. There is little or no student-made or brought-in material.

This item refers to all kinds of materials. They do *not* have to be related to science. These materials must be evident from just looking around the room. If 0, 1, or 2 items are seen, it is interpreted as "little or no material" and recorded as Behavior B. If 3 or more items are seen it is recorded as Behavior A.

Item 3	3. Original art work of pupils displayed.	3. "Pattern" art work in evidence.

The third item is not starred. It may be ehecked in either column, both columns, or not checked at all. Original art work means things that children have drawn or created themselves. Pattern art work includes traced material, cut out patterns, and pictures already drawn which students color. Art work does *not* have to be related to science.

The *entire* Room Observation *section is* omitted when the teacher being observed is in someone else's room over which she has no control.

Teacher-Student Observation

Items 4 through 21 are timed. After the room observation is completed, observe what happens in the room for five minutes At the end of five minutes stop observing and spend two minutes recording what has been seen in column 1, items 4 through 21. Observe for another five minutes. After which, stop observing for two minutes and record the observations in column 2. Observe for another five minutes and then record these observations in column 3.

The starred items on Teacher-Student Observation are numbered 4, 5, 6, 7, and 8. Each of those items must be checked for each observation in either Behavior A or Behavior B; one or the other but not both. Items which are not starred may be checked in either column, both columns, or not checked at all.

Item 4

*4. Teacher brings other subject matter into lesson (mathematics, social studies, language arts, etc.)	*4. Teacher does not bring other subject matter areas into lesson.

Behavior A must be demonstrated by content matter from some area such as mathematics, social science, or language arts being included as a part of the lesson. It must be there for instructional purposes and not just used for punishment or class control. Behavior B is an absence of Behavior A.

Item 5

*5. Students can work at their own pace.	*5. All students proceed at same rate.

If the majority of students can work at their own pace it is Behavior A, if not, it is Behavior B.

Item 6

*6. Students share their experiences.	*6. No sharing of experiences evident.

Behavior A means that students are sharing experiences with each other and *not* just answering teacher initiated questions. The opportunity must exist for a majority of the class to participate, although it is not necessary for them to do so during the observation period. Anything less than what is mentioned above is considered Behavior B.

Item 7

*7. Students are active participants.	*7. Students listen only.

This item refers to the majority of the class.

Item 8

*8. Students have a chance to follow their own interests.	*8. Students have no chance to follow their own interests.

Score this item as to whether the majority of the class has a chance to follow their own interests.

Items 9-21

These items are *not* starred. For each observation period, both Behavior A and Behavior B may be checked, either may be checked, or neither may be checked. If *any* evidence of a described behavior is observed, it should be checked.

Item 9

9. Teacher engages in student activities.	9. Teacher refrains from involvement in student activities.

If the teacher engages in a student activity, Behavior A is checked. Behavior B is checked when there is a student activity in which the teacher does not become involved.

Item 10

10. Teacher has individuals doing different work.	10. Teacher has all students doing same assignment.

If the teacher has several individuals doing different work, Behavior A is checked. When most students are working on the same assignment Behavior B is checked. Both behaviors may be checked during the same five-minute period.

Item 11

11. Teacher asks open questions.	11. Teacher asks closed questions.

Open questions refer to questions which do not have just one correct answer. These are also called divergent type questions. Closed questions are questions which have just one correct answer. These are also called convergent type questions.

Item 12

12. Teacher asks questions not directly answerable from textbook.	12. Teacher asks questions which can be easily answered if student has studied the lesson.

This item has to be answered from evidence which is seen during the five-minute observation period. If the teacher asks a question and the student reads a statement directly from the textbook in answer to that question, obviously this is Behavior B. Behavior B also includes questions answered by facts which appear to have been learned by textbook reading. If the type of question the teacher asks cannot be answered with just textbook knowledge, it is Behavior A.

Item 13

13. Teacher questions misconceptions.	13. Teacher permits formation of misconceptions.

This cannot be observed unless some misconception comes about and is identified by the observer. Then, if the teacher questions the misconception in any way this is Behavior A. When the teacher permits the misconception to stand and lets the youngsters believe the information to be true, this is Behavior B.

Item 14

14. Teacher encourages guessing or hypothesizing.	14. Teacher expects students to know and *not* guess.

When the teacher encourages the student to try to answer a question by guessing or by trying to figure out the answer, this is Behavior A. Behavior B is exhibited when the teacher expects only *the* right answer to the question to be given and expects the student *not* to give an answer unless he is sure that it is correct.

Item 15

15. Teacher refrains from judging student's behavior or work.	15. Teacher passes judgment on student's behavior or work.

Judging a student's behavior or work refers to a teacher telling a student that his work is good, poor, he is a very good student, he is misbehaving, or has been very bad that day. A statement similar to these is evidence that a teacher is passing judgment on a student's work or behavior.

Item 16

16. Students read material from different sources.	16. Students are assigned to read from same book.

If students are seen to be reading from different sources during the five-minute observation time, this is Behavior A. If any time during the five-minute time students are assigned to read the same materials this is Behavior B. For Behavior B it is not necessary for the entire class to be assigned to read the same material but only for a majority of the students to be assigned the same material.

Item 17

17. Students' questions answered by other students.	17. Students' questions answered by teacher.

This is a matter of looking at each question asked, by a student, to see who is answering it. Both Behavior A and Behavior B are often exhibited within the same five-minute period.

Item 18

18. Students conduct experiments individually or in groups.	18. Teacher or student demonstrations for entire class to watch.

When students take an active part in an experiment, either individually or as a part of a group, it is Behavior A. If students are watching a teacher or another student do a demonstration, it is Behavior B.

Item 19

19. Students design their own experiments.	19. Students perform textbook experiments.

Behavior A is evidenced by the students designing their own experiments. Behavior B means that students perform experiments furnished to them in a textbook or some other source.

Item 20

20. Students' questions shape the direction the lesson takes.	20. Teacher determines direction of lesson.

What seems to determine the direction in which the lesson proceeds? If Behavior A is evident, students' questions have some effect on the direction that the lesson takes. As Behavior B is evident, student questions have no effect on the direction that the lesson takes and it continues onward in a predetermined direction. Both Behavior A and Behavior B may be evidenced within the same five-minute period.

Item 21

21. Teacher's nonverbal cues provide positive reinforcement for students.	21. Teacher's nonverbal cues provide negative reinforcement for students.

Nonverbal cues include everything except the spoken word. A smile, a pat on the back, a pleasing gesture, a frown, or a clenched fist are examples of nonverbal cues.

Scoring the STORF

The Science Teacher Observation Rating Form (STORF) is scored in the following way. Behaviors observed in the three observations are totaled in the right hand column for Behavior A and in the left hand column for Behavior B. As "Room Observation" takes place only once, each check scores as one. All 21 items are totaled and the amount recorded in the appropriate place at the bottom of the page. The score is obtained by adding 100 to the Behavior A column and then subtracting the Behavior B column from it. Score = 100 + A - B. Scores above 100 tend to indicate experimental behavior (A) and scores below 100 tend to indicate traditional behavior (B).

SESSION G-2

AN INTEGRATED APPROACH: THE YOUTH CONSERVATION CORPS

Howard Jennings, Director, Youth Conservation Corps Camp, Delaware Water Gap National Recreation Area, Keystone Junior College, La Plume, Pennsylvania

The Youth Conservation Corps is a program designed to fill four vital needs: (a) conservation work that is vitally needed to improve the quality of our public lands and waters; (b) gainful summer employment for the nation's youth; (c) the opportunity to interact with a social economic mix; and (d) the buildup of a reserve of environmentally aware young citizens, knowledgeable of their country's irreplaceable heritage of natural and historic resources, and their place in the ecological cycle.

The nature of the YCC Camp is such that the enrollees can sense the excitement of the Nation's newest National Recreation Area developing – The Delaware Water Gap National Recreation Area.

The YCC experiences at PEEC in 1973 centered around work projects, environmental education, and simply living together. A light show developed by the enrollees best illustrates the YCC'ers experiences during summer 73.

As Secretary of the Interior, Rogers Morton said in reference to the YCC program "It was a time of self-realization as they accepted responsible roles in shaping the environmental destiny of this great nation, and we are proud of this accomplishment."

SESSION G-3

BILINGUAL SCIENCE EDUCATION–PROJECT BEST

SCIENCE ASSESSMENT IN SPANISH

Mary Graeber, Visiting Professor of Education, Hunter College, City University of New York, New York City and Liza Martinez de Gómez, Bilingual Researcher, Bilingual Education Applied Research Unit, Brooklyn, New York City

During the 1972-73 session, the New York State Legislature authorized funds for the development of components of a statewide system of program evaluation. One of the most critical priorities was in the area of the measurement of the results of bilingual programs, where a broad choice of tests and measurements is not yet available. In addition to other bilingual projects measuring pupil acquisition of linguistic skills, the State Education Department has arranged with the Bilingual Education Applied Research Unit of Hunter College, New York City, to develop science test questions and answers for grades 1-3 in Spanish. These test items will be cross-referenced to related units in the New York State and City courses of study in early elementary science.

The Science Assessment in Spanish project involves a survey of teacher-made tests and the writing of new test items at different difficulty levels, as well as trial testing and review. To date the Bilingual Education Applied Research Unit has done the following:

Eighteen bilingual projects identified as having components of science instruction in Spanish have been contacted, informed of the project and their cooperation has been requested.

A needs assessment questionnaire was developed and sent to 150 teachers in the eighteen bilingual programs. Teachers were requested to forward any science test items which they had developed to this project.

The science consultants who have and will be working with the project are, Mary Graeber and Carmen Sanguinetti, Head, Curriculum Unit, Bilingual Office, Board of Education, N.Y.C.

Procedure

In order to ensure that the assessment instruments to be developed in Spanish were related to the curriculum being taught, the New York State and New York City Curriculum Guides were read and their "basic understandings" and curriculum objectives were abstracted and listed, as were those of:

1. the Cognitively Oriented Program in Elementary Science (COPES) developed by New York University,
2. the American Association for the Advancement of Science (AAAS),
3. Project ECOS developed by Northern Westchester and Putnam County BOCES # 1,
4. Science Curriculum Improvement Study (SCIS) funded by the National Science Foundation,
5. two commercial science kit and text series.

These basic concepts and science skills were categorized by grade and further divided into units according to the category system appended.

Sometimes an objective was listed in more than one unit - for example, when a skill (Measurement) as well as content (Properties of Matter) were involved. These overlapping objectives are indicated by an asterisk and will be cross referenced, so that if a teacher is teaching both units he will be alerted to the overlap.

After this process of synthesizing basic concepts, skills, and objectives from the programs cited above, the objectives were organized within each unit, and many were rewritten with these objectives in mind:

1. to list them in a logical sequence within the unit.
2. to write them in behavioral and experiential terms. The method of learning a skill was assumed to be as important as the knowledge gained. Therefore, the approach was that of students learning through their own observation, guided experimentation, discovery and generalization
3. to write the objectives clearly, concisely, accurately but avoid being unnecessarily technical. They are written for an elementary school teacher who is a generalist, not a science specialist.

Projections

Follow-up letters, including samples of the Science Learning Objectives, two units written in English and two units written in Spanish, will be sent to the Bilingual Project Directors and to the teachers. Teachers will again be requested for test items and asked if they would care to serve on the Teacher Review Panel. This panel of teachers will screen the test items to ensure that they are clearly written and appropriate for children of their grade level.

The objectives are now being translated into Spanish by George Obligado and Carlos Rivera since the feedback from the first mailing indicated that teachers requested objectives as well as test items. Most of the bilingual programs did not have science instructional objectives in English or Spanish, as the review of the proposals had also indicated. Project Directors had also suggested that more teachers would be teaching science in Spanish if they had such guidelines.

Test items to supplement those developed by teachers will be written in Spanish or translated from appropriate items already in the public domain (such as those of the COPES program developed with U.S.O.E. funding) by Liza Martinez de Gómez and Carlos Rivera of the Bilingual Education Applied Research Unit staff. The items will be reviewed by Dr. Sanguinetti for scientific accuracy and by the Teacher Review Panel for appropriateness to their students.

These test items, organized into mini test booklets by grade and unit, should be available by the end of March 1974. Teachers who are cooperating with the project can then select the mini test booklets for the units they have taught and pilot test the items in April.

The Bilingual Education Applied Research Unit's approach to evaluation is to match assessment with the curriculum which has actually been taught, rather than to use standardized achievement tests which may cover material which has not been covered in the classroom.

Content and skills which have been taught are assessed through the use of instructional objectives.

Instructional objectives have several advantages. In addition to being fair because they match the curriculum, they can also be used prescriptively. If an assessment is made at the beginning of the year, teachers then have a better idea of which skills and content their students have already learned, which skills need review, and which still have to be learned.

At the end of the year, another assessment is made by the teacher, and the students' growth can be seen. The next year's teacher will also have a better idea of what the students have already learned and which students are ready to move ahead and which need more review.

Guidelines for the individualization of the curriculum, which most teachers agree is the best system for students, are then available.

The evaluation is planned so that it will be as useful to the teachers and students as possible.

The Science Assessment in Spanish Project, directed by Marietta Saravia Shore, will then return the complete pool of test items to teachers for their use. Teachers will then be able to individually select test items which match the material in the science units they have taught to their students.

Teachers can also use the Unit test items at the beginning of the year, when they do not know the extent of their students' previous knowledge of science. In this way they can assess which areas students already know and which are still to be learned before developing their science curriculum.

The format of the test will include picture solutions so that young children who may not read, but who understand the science concepts, can have the test questions read to them and then indicate the picture which is the correct solution to the problem.

ABSTRACTS OF CONTRIBUTED PAPERS

GROUP A

COMPUTER-BASED EDUCATION

A-1 PROJECT C-BE (COMPUTER-BASED EDUCATION): ITS GOALS, SCOPE, AND FACILITIES

John J. Allan, III, Associate Professor of Mechanical Engineering and Co-principal Investigator; Joseph J. Lagowski, Co-principal Investigator; and Mark T. Muller, Project Coordinator; Project C-BE, University of Texas, Austin

This paper provides background on Project C-BE and how it is funded. The four goals of the Project – common concepts, evaluation, transferability, and implementation are presented and defined explicitly. In addition, the scope of the Project with respect to academic areas and modes of computer application is discussed in detail. The academic areas range from engineering, chemistry, physics, and math to psychology and linguistics. The modes of application include interactive graphics in design, tutorial, drill, simulation, and computer-generated, scored repeatable examinations. Slides featuring the existing facilities and their use accompany the paper.

A-2 PROJECT C-BE APPROACHES TO EVALUATION AND SOME PRELIMINARY FINDINGS

Sam J. Castleberry, Curriculum Coordinator, Project C-BE; H. Paul Kelley, Director, Measurement and Evaluation Center; Paul G. Liberty, Associate Director, Measurement and Evaluation Center; and Agnes Edwards, Associate Curriculum Coordinator, Project C-BE; University of Texas, Austin

Techniques used by all of the Project C-BE associate investigators to evaluate their individual projects and computer instructional modules are summarized. The presentation includes the methods used to validate the instructional modules, determine costs and cost effectiveness, and evaluate the overall effectiveness and impact of the course.

The overall evaluation of all the individual projects within Project C-BE is discussed with respect to noncognitive learner variables studied, common concepts and effects across projects, cost effectiveness, and the building of an implementation model. A brief summary and preliminary analysis of data collected conclude the paper.

A-3 CURRICULUM DESIGN FOR COMPUTER-BASED EDUCATION

George H. Culp, Curriculum Coordinator, Project CONDUIT; Sam J. Castleberry and Agnes Edwards, Project Coordinators, Project C-BE; University of Texas, Austin

General procedures for designing computer-based educational curriculum materials including course analysis; media/mode of presentation analysis; task analysis; behavioral objectives (cognitive and affective); modularization; synthesis; pilot testing, revision; course use; evaluation; revision; and documentation and dissemination are discussed. Specific examples and details of each step are given.

A-4 THE USE OF COMPUTER-BASED METHODS FOR TEACHING CHEMISTRY

Joseph J. Lagowski, Professor of Chemistry and Co-Principal Investigator; Sam J. Castleberry, Curriculum Coordinator; Project C-BE, and George H. Culp, Curriculum Coordinator, Project CONDUIT, University of Texas, Austin

A conventional general chemistry course which has been supplemented with computer programs effectively expands the capability of the instructor. Such programs can be classified broadly as tutorial/drill; examination; experiment simulation; and pre-skills. A detailed description of the course includes: the strategy for using the programs; results with respect to student achievement; costs; and benefits of the method.

GROUP B

TEACHER EDUCATION (ELEMENTARY)

B-1 AN INTERDISCIPLINARY APPROACH TO THE PRESERVICE EDUCATION OF EARLY CHILDHOOD EDUCATION MAJORS

Leon L. Ukens, Science Education Group Coordinator, Towson State College, Towson, Maryland

As early childhood teachers are faced with numerous opportunities, either by plan or by accident, to relate various disciplines, an interdisciplinary approach to the preservice education of early childhood education majors has been developed at Towson State College. This approach utilizes a team of college faculty representing the areas of art, music, physical education, and science with specialists from the early childhood education department. The prevailing philosophy is to actively involve these preservice teachers in activities, projects, problems, etc., which simulate and challenge them on an adult level; as well as to help them keep in mind how these experiences could be utilized with young children. During scheduled weekly planning sessions the faculty team plans various multisensory learning experiences and concomitant approaches to be utilized with the college students. These experiences may involve meeting with the area specialists, working with children, working individually, or working in small groups. The experiences are coordinated in theme or approach.

Another block of time is then used by the early childhood education specialists to coordinate and evaluate these ongoing experiences with the college students. Suggested activities may then be "tried out" by the college students during their scheduled elementary classroom observation and participation time.

B-2 MODIFICATION OF CONCEPTS AND ATTITUDES HELD BY ELEMENTARY SCIENCE METHODS STUDENTS TOWARD SCIENCE AND THE SCIENTISTS

Henry G. Walding, Instructor, and Harold R. Hungerford, Associate Professor, Science Education,

Department of Elementary Education, Southern Illinois University, Carbondale

Interest in concepts of and attitudes toward science and the scientist is currently widespread. Notable research into facets of this topic has been completed by Beardslee and O'Dowd, Mead and Metraux, Jungwirth and others. Research findings, to date, indicate that both general populations and student populations hold concepts and attitudes which are largely inconsistent with the pedagogy of science itself.

Few studies have dealt with the modification of concepts and attitudes concerning science and the scientist. This study specifically deals with whether or not currently held misconceptions and erroneously derived attitudes can be modified (or changed) in a manner deemed appropriate by the investigator(s). It presents an empirical analysis of the modification of concepts and attitudes held by elementary science methods students at Southern Illinois University (N=120) during the 1972-73 school year. Data were gathered using an instrument designed by the junior author, which is structured to assess concepts and attitudes in a phenomenological mode.

Findings emphatically indicate that a carefully designed methods course for elementary school teachers can significantly alter the concepts and attitudes of preservice teachers in a direction deemed appropriate by the evaluators. Strategies involved include readings, discussion, and investigations into the philosophical foundations of science and science education.

This research appears to be of extreme importance as it indicates that the concepts and attitudes held toward science by teachers of science impinge directly on the conceptual and affective development of children. Given that teachers perceive science from a pedagogically sound perspective, concepts and attitudes developed by students under their direction should similarly be analogous to this same perspective. Herein lies a sound rationale for further research.

B-3 THE DEVELOPMENT OF AN INSTRUCTIONAL MODULE TO ASSIST PRESERVICE SCIENCE TEACHERS IN ACQUIRING QUESTIONING SKILLS AT VARIOUS COGNITIVE LEVELS

Theodore M. Johnson, Director of the Curriculum Materials Center, The Pennsylvania State University, University Park

Problem

The purpose of this study was to investigate the results of questioning-inquiring skills developed by preservice elementary science students utilizing an individualized questioning module. The questioning module was one of a series of modules under development which were designed to illustrate the need for and the techniques of questioning at various cognitive levels.

The Module

A systematic individualized questioning module was designed to provide the student with the opportunity to develop and refine questioning skills as part of his instructional behavior. Ultimately the module will enable students to organize their own programs of study. The skills of identification and classification, writing with proper phrasing, and proper use of questioning are built into criterion-referenced objectives. The skills are developed using a multi-media approach.

The student may achieve the various unit objectives by recycling until he reaches a prescribed criterion. It is assumed from other researchers that students placed in a formally styled and structured setting such as this module utilizes, may obtain these skills in less time than and in at least equal proficiency as others in less structured settings.

B-4 ASSESSING ATTITUDES AS AN ENTERING BEHAVIOR OF PRESERVICE ELEMENTARY TEACHERS IN SCIENCE

George P. Toth, Instructor, Curriculum and Instruction, The Pennsylvania State University, University Park

Problem

Studies on the effects of teacher attitudes toward science have revealed that a negative or neutral attitude toward science can influence the attitudes of children toward science and act as a detriment to effective science teaching [1], [4]. Although some work has been done to correlate the teacher's affective domain of learning with science knowledge, [3], [5] little has been done to identify the characteristics of the preservice elementary teacher's attitude toward science. This study was designed to find out how preservice elementary teachers value science as a school subject.

Method

Over a two-year period, two open-ended questions were given to 162 third-year education majors who had completed at least four undergraduate science courses and were enrolled in an elementary science methods course. Following a procedure used by Perrodin [2], responses for each question were interpreted as being "very positive," "positive," "neutral," "negative," or "very negative." Responses were also tabulated and categorized to identify the ten most frequently mentioned favorable and unfavorable comments.

Findings

More than 500 summarized responses showed that more than 60 percent of the student responses were in the "neutral" or "negative" attitude categories. Identification of the most frequently mentioned comments ranged from "I lack confidence to teach science," and "I have trouble understanding science," to "Biology has been my best science course," and "Science helps me understand my environment."

Discussion

If science methods course instructors accept Stollberg's [4] precept that "the teacher must be attracted to science" then it becomes obvious that methods must be employed to help develop the affective needs as well as the content, skills, and methodology of preservice teachers in our elementary science methods classes.

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B-5 COMPETENCY BASED PROGRAM FOR ELEMENTARY SCIENCE TEACHERS

Ronald W. Cleminson, Associate Professor of Education, Memphis State University, Memphis, Tennessee

Our second year of competency-based science teaching has brought an increased interest and several changes to our program. The competencies remain grouped into three sections for organization purposes, however, we have made many changes within this framework. The first section, *Inquiry-Process Skills* (A), has demonstrated that it provides an excellent background for inquiry teaching. We have integrated many of the processes, especially those that deal with formulating hypotheses. Also, we have made the competencies in this section more applicable for classroom use.

Section (B), *Instructional Skills*, was originally designed to provide prospective teachers with experiences necessary for developing teaching and classroom management skills. We found a need for more individualization than we had anticipated. Students and instructors were better able to identify specific needs and problems in small group and one-to-one settings. It was necessary to move away from the traditional one hour class period to blocks of time where students can work directly with instructors to solve specific instructional problems which they have confronted in their teaching.

The third section of competencies, *Research-Curriculum Knowledge* (C), requires students to read current articles and books for small group interaction and to develop a greater understanding of activity-centered curricula. Students and instructors preferred to have scheduled informal sessions where they had an opportunity to question what they had read and react to statements made by members of the discussion group. In addition, most students support continued use of Piagetian tasks in the module. Both students and instructors felt that the tasks provided students with an opportunity to interact with children on a one-to-one basis and, at the same time, provided an opportunity for students to observe the various stages of reasoning in children.

GROUP C

ENVIRONMENTAL EDUCATION

C-1 THE DEVELOPMENT AND FIELD TESTING OF AN ACTION-ORIENTED, PROBLEM-FOCUSED ENVIRONMENTAL EDUCATION UNIT

Patricia M. Sparks, Assistant Professor of Environmental Sciences, Glassboro State College, Glassboro, New Jersey

A majority of the environmental education programs developed in the past few years have been aimed at developing in students an awareness of environmental problems. Environmental quality will be achieved only when the young people in our school are actively involved in dealing with environmental problems in their community. As a step toward environmental quality this writer developed and field tested an action-oriented guidebook for teachers.

The guidebook contains thirty-six activities and four "designs for action" on solid waste, at three levels of sophistication: awareness, transitional, and operational problem-solving. The activities are based on a model which emphasizes open-ended questions that are structured to develop process skills.

As the basis for an 8-12 week unit dealing with solid waste the guidebook was field tested in two junior high schools, one urban and one rural. After teaching the unit, all five teachers involved in the study continued to deal with environmental concerns for the remaining five months of the school year. Teachers who tended to be traditional and content-oriented became less autocratic and more process-oriented as the unit progressed. This change in teacher bahavior paralleled an increase in student-initiated environmental problem studies.

Opinionaires given to the teachers and students involved in the study showed a high level of interest on the part of both. The student opinionaire reflected a desire for self-paced learning plans in which the student set his own criteria for success. Three of the five teachers in the study developed some form of independent learning program with their students after completing the solid waste unit. Currently, four of the five teachers are teaching environmental units which they designed on the basis of the solid waste model unit.

C-2 A BACKPACKING AND CAMPING PROGRAM FOR SECONDARY STUDENTS

Lee R. Ihlenfeldt, Physical Science-Physics Teacher, Memorial High School, Madison, Wisconsin

For the past four years, Memorial High School, Madison Public School System, has sponsored a Wilderness Studies Program in which students, teachers, and some parents took extended backpacking trips to Porcupine Mountain State Park in Upper Michigan and canoe trips on the Wisconsin and Flambeau rivers. The program began as weekend outings to supplement family camping. Classroom instruction gaged to include the novice camper, which is held after regular school hours, is open to students in all grades. Trips are planned by students; and highly qualified, experienced instructors check all details before joining the students on the trip.

Objectives of the program include:

1. Developing skills and attitudes which enable students to live comfortably and confidently in the out-of-doors without abusing the environment.
2. Providing students with an in-depth familiarity with the geological history and ecology of the only Pre-Cambrian volcano in the Midwest.
3. Introducing students to the lava flows and mountain formations of the Keweenawan Period.
4. Providing the experience of living and working in close cooperation with many individuals toward a common goal.

Classroom and field instruction encompasses map reading; compass orientation; menu planning; basic geological, rock, and mineral identification; astronomy; plant and animal identification; tool handling; campcraft; packing; outdoor cooking; first aid; water analysis; and fishing techniques.

Formal evaluation of the program has not been made, however, numerous and repeated requests of "When can we go again?" from anxious students indicate that the program is a success.

C-3 MIDDLE SCHOOL ENVIRONMENTAL EDUCATION – A MODEL FOR PRODUCING AN AUTONOMOUS LEARNER

Harold R. Hungerford, Science Education, Department of Elementary Education, Southern Illinois University, Carbondale, and Ralph A. Litherland, Science Supervisor, Carbondale Elementary District 95, Carbondale, Illinois

An effort in 1970 to create a learning environment at the middle school level that would result in autonomous learning experiences in environmental science met with a great deal of frustration. Large numbers of students at the middle school level could not "discover how to discover" processes that could effectively be used in investigating environmentally related topics.

An analysis of strategies available for investigating environmental problems plus an analysis of the character of environmentally related issues resulted in the development of a training hierarchy designed to assist students in functioning effectively as autonomous learners. This hierarchy is presently being implemented via a modular instructional model. Each module is designed to facilitate the acquisition of skills inherent in a prescribed portion of the training hierarchy. Objectives for each module are behaviorally stated and skill acquisition will be evaluated on the basis of students' performance as related to those objectives. Subsequent to the successful completion of the modular strategy, students will be placed in a bona fide individualized learning environment as autonomous learners in environmental education. A strategy for value clarification is built into the student's autonomous learning experience. The success of the training modules will ultimately be evaluated in terms of the results of independent investigation as well as the measurement of shifts in students' values.

This modular strategy was tested during the 1972-73 school year in Carbondale, Illinois. During the 1973-74 school year, a revised edition is being tested in a number of classrooms in New Jersey and Illinois.

C-4 CREATING QUALITY FIELD TRIPS FOR URBAN SCHOOL DISTRICTS

Robert E. King, Secondary Environmental Program Specialist, Public Schools, Topeka, Kansas

Eight modules, each providing 10 hours of instruction and a three-hour field trip, were developed for secondary students. Extensive cognitive and attitude testing was used in developing and revising each module. Teacher and pupil acceptance of the content and format is very high. Each module contains student papers, experiments, films, and extensive teacher suggestions. More than 1,000 students have evaluated most modules.

Outline summaries of the module and trip content, test results, and suggestions for developing similar material for other school districts are presented. Complete modules are displayed, and can be obtained free upon request.

The modules are:

1. **Forests and Man** – woodland habitats, their roles in nature, and man's effects on forest communities;
2. **Geology and Our Environment** - rocks and fossils of the Pennsylvanian Period, the forces that created them, and the role geology plays in determining the growth of cities;
3. **Life – Past, Present, and Future** the study of paleontology, evolution, biomes, and food webs, on man – his past and his future;
4. **Nutrition and the Growing Population** -- nutritional research, food processing and the selection of nutritional diets as a background for discussing the growing nutritional stress on the expanding human population.
5. **Electrical Production and Pollution Control** -- the production process for electricity, its environmental problems, and the growing energy crisis in the United States.
6. **Ecology-Geology Field Study** - a three-week summer school course in the geology and ecology of Kansas and the Rocky Mountains.
7. **Tire Production and Pollution Control** -- physical science properties utilized in producing tires and the environmental consequences of the product and the production process.
8. **Cellophane Production and Pollution Control** - the chemical processes utilized in producing cellophane, and controlling the attendant air and water pollution problems.

C-5 ENVIRONMENTAL EDUCATION AND THE DEL MOD SYSTEM IN THE ALEXIS I. DUPONT SCHOOL DISTRICT

Thomas S. Hounsell, Del Mod Field Agent, Department of Public Instruction, Dover, Delaware

The formal program in environmental education for the teachers of the Alexis I. duPont School District began three years ago in a developmental summer workshop. At this time, they developed an activity card system for environmental education as related to math, science, and social studies. Since that time we have continued the development and implementation of a K-12 multidisciplinary program in population environmental education. The last year of our work was supported by the U. S. Office of Environmental Education. We have incorporated several extended multidisciplinary camping experiences in our program in grades 3 thru 8. In addition we are presently adapting the Science Curriculum Improvement Study material to our program of environmental education K-4.

GROUP D

SPECIAL AREAS FOR CONSIDERATION

D-1 EDUCATIONAL OMBUDSMAN – SCIENCE AREA

James Gussett, Del Mod Field Agent, Department of Public Instruction, Dover, Delaware

A science field agent is directly analogous to an ombudsman. An ombudsman is, according to various dictionaries, encyclopedias, etc., "an official who investigates the complaints of citizens relating to decisions or action by governmental officials or agencies. The ombudsman cannot control other officials."

Altering the definition to be more compatible with education results in "a concerned educator who offers an outsider's viewpoint in regard to the concerns of teachers, relating to decisions or action by state employees or administration."

The Del Mod Science Agent is not an omnipotent person who solves everything with a magic wand. Field agents do not ride white horses (sanitation problems in hallways you know) or wear white hats. The field agent is not a cure-all. The science education ombudsman's efforts to assist are always done in the form of a suggestion with the understanding that the idea generated will become what the students interpret from the teacher.

D-2 THE FIELD AGENT AS A CHANGE AGENT

Dennis Reilly, Del Mod Field Agent, Department of Public Instruction, Dover, Delaware

A field agent describes the process which was used in causing changes in the elementary science curriculum (K-6) in a district of eight elementary schools. A coordinator supervises the district's total science program (K-12) which has a fairly well-defined science curriculum; using SAPA (Science A Process Approach), K-3, and district written units, 4-6 grades. With the concern about environmental (ecological) problems came the realization that the outdoors, as a learning laboratory, was being sadly neglected. Hence, the objective of a one-year part-time field agent was to modify the existing elementary curriculum in order to utilize the students' outdoor environment.

As a first step, existing school sites were surveyed to determine facilities available to each school. Committees, consisting of teachers at each grade level, representing each school were formed. Two to four half-day work sessions were set up on released time for each grade level. A presurvey indicated that teachers' competency in outdoor education was minimal; therefore, the sessions were divided into two parts.

1. The teachers participated in various activities which introduced them to the utility of outdoor facilities.
2. The teachers wrote resource units incorporating these activities into the curriculum, indicating level and lesson, as well as scope and sequence.

After resource units were printed, they were disseminated to the teachers during inservice time. The program included participation and explanation of the format.

This program resulted in the involvement of 34 percent of the district teachers constructively working together to upgrade their science curriculum. Their actual harvests were the creation of district-wide environmental education resource units for five of six grades. Various audiovisual instruments demonstrate incorporated lessons.

D-3 THE ROLE OF THE SCIENCE CONSULTANT IN THE DEL MOD SYSTEM

Audrey Conaway, Del Mod Consultant, Department of Public Instruction, Dover, Delaware

As project assistant to the research director I helped locate and identify the high school science teachers in each district. On the elementary level I conducted a survey of science programs, science equipment, and any additional science information by contacting the elementary principals and visiting with them.

As a field agent my activities were centered in the classroom working with the teacher on a one-to-one basis. The children were involved through demonstration teaching of SAPA and some environmental science units. I also assisted principals in choosing science programs, ordering and distributing equipment and taking inventories of SAPA materials.

D-4 THE ENVIRONMENTAL SEMESTER: AN ALTERNATIVE FOR TEACHER EDUCATION

Charles W. Mitchell, Associate Professor of Education, State University College of Arts and Science, Plattsburgh, New York

The Institute for Man and His Environment at the State University College, Plattsburgh, New York, offers a unique living/learning opportunity to study the man-environment ecosystem.

This program is one of several under the direction of the Institute and is entitled "Man and Environment." It consists of a residential semester devoted wholly to environmental analysis and research for 40-45 students. The site is the Miner Center Campus, a satellite campus located fifteen miles north of the main campus.

Man and Environment has developed as a cooperative venture between SUNY Plattsburgh and the William H. Miner Institute. The latter, an agency of a private philanthropic foundation, owns and operates the Miner Center Campus and provides substantial grant funding to the program. Man and Environment is divided into two curricular blocks, Introduction to Environmental Analysis (9 credits-8 weeks); and Environmental Research Project (6 credits-7 weeks).

During the research block, education majors are guided in the design and methodology of programs to translate environmental information into classroom experiences. They do this by working in the classrooms of a nearby school district under the supervision of the classroom teacher and their education professor who is a member of the Man and Environment staff.

Man and Environment offers a variety of activities and opportunities in addition to the regular curriculum. Periodically environmental specialists participate in seminars and symposia at Miner Center, often with guests from the college and community.

Extracurricular possibilities include hiking, back-packing and camping trips, downhill and cross country skiing, and horseback riding. Field trips include visits to urban Montreal, Canada, and various sites illustrating environmental concepts.

GROUP E

EVALUATIVE STUDIES

E-1 EVALUATION TECHNIQUES OF AN ON-SITE ELEMENTARY SCHOOL SCIENCE PROGRAM

H. Gene Christman, Assistant Professor of Education, The University of Akron, Akron, Ohio

The purpose of this study was to determine whether elementary education majors who were taking a professional course in the teaching of science differ from elementary education majors taking an "on-site" professional course in the teaching of science in, (a) the science content related to the elementary curriculum, and (b) their attitudes toward science.

The investigator selected students to serve as the experimental and control subjects. He then administered the pre- and post-tests to both groups with two testing instruments.

The experimental group consisted of 23 elementary education majors at The University of Akron who were experiencing an "on-site" elementary school science program. The science preparation for this junior group was the same as for the control group.

The control group consisted of 36 elementary education majors at The University of Akron who were experiencing the regular science methods course. The science preparation for this junior group was the same as for the experimental group.

Six hypotheses were evaluated during this investigation covering two controversial areas as reported in science education research literature. The six hypotheses concentrated on elementary science concepts normally taught in elementary school, and attitudes toward science.

E-2 STUDY OF ECOLOGICAL CONCEPTS OF FIVE-YEAR-OLD PUPILS

Mary N. Ayers, Associate Professor, Early Childhood Education, Tennessee Technological University, Cookeville

The purposes of this study were (a) to develop and evaluate materials in the content area of ecology for five-year-olds and (b) to compare two approaches to the presentation of ecological concepts to five-year-olds.

The subjects in the study were 26 males and 16 females selected from three kindergarten classes. The subjects were then divided into three groups. Each child was administered a pretest of 30 ecological terms.

After selected ecological concepts were measured in the pretest, ecology units designed by the investigators were presented to two groups of the children. Both groups received the same basic information utilizing the same objectives during the first half of each lesson. Each period of instruction was approximately forty minutes every day for six weeks. The reinforcement or second half of each presentation was different for the two groups.

Group A used reinforcement through a teacher-made workbook approach. Group B used reinforcement through experiments and audiovisual aids. Group C (1/3 of the children) received no instruction in ecology but was used as a control group in other phases of the study.

A post-test of ecological terms was administered. Concepts and the two approaches were measured. Other tests used for comparison purposes in the study included the Peabody Picture Vocabulary Test (PPVT) and the Metropolitan Readiness Tests (MRT), Form B.

Correlations were examined between the post-test scores on the ecology instrument and the test scores on the PPVT and the MRT. Comparisons of test scores on the ecology instrument between boys and girls were also examined.

Persons working with five-year-olds need to understand some of the ecological concepts that can be developed in the classroom. There is also a need for more information concerning appropriate materials and methods in presenting ecology to the young child.

E-3 CHILDREN'S ATTITUDES TOWARD SCIENCE

Jerry B. Ayers, Associate Professor, and Cynthia O. Price, Graduate Assistant, Tennessee Technological University, Cookeville

The attitudes that children have toward a subject can be a primary factor in designing a new curriculum and in preparing for positive changes in any school or school system. The major purpose of this study was to determine the attitudes of children toward science in grades four through eight (middle school grades) in an extremely culturally and economically deprived Appalachian school system.

All children in grades four through eight (N=544) in a rural deprived Appalachian school system in north central Tennessee were administered a 21-item questionnaire designed to assess their attitudes toward science and science instruction. The questionnaire was constructed by the investigators based on previous research on the measurement of attitudes toward science. Nine questions were of a projective nature, and 12 used a Likert-type attitude scale.

Results of the study indicated that there were few differences in the attitudes of males and females. An examination of the responses to individual questions by males and females indicated a similar response pattern. As with the results of previous studies, subjects in the lower grades appeared to have a more favorable attitude toward science than subjects in the upper grades. Moving through the grades older subjects had a more negative attitude and were more critical than younger subjects of such factors as textbooks, experiments in science, field trips, and the attitude of the teacher. In conclusion, the results of this study indicated that older subjects, just prior to entering high school, had a negative attitude toward science. For the subjects to become scientifically literate individuals, they must develop a more favorable attitude toward science. Results of this study have implications for curriculum development and teacher training in rural school systems.

GROUP F

DEL MOD: THE SYSTEMS APPROACH TO SCIENCE EDUCATION

F-1 DEL MOD – MEASURING SUCCESSES

Charlotte Purnell, State Director, Del Mod System, Department of Public Instruction, Dover, Delaware

The Del Mod System has completed its second year -- a year of expansion and innovation. Many of the innovations have been successful, others somewhat doubtful, and still others will not be attempted again.

Del Mod is a school-based system. It operates at the grassroots, or consumer level. Del Mod goes to the teachers and works with them as individuals on the problems they encounter in their own classroom or problems defined by their school groups. Measures or degrees of success may best be determined by assessing subjective judgments of the individuals conducting the projects, comments made by the field observers, or, perhaps most important, what the individuals think have happened to them. Often, success is enabling the teacher or school faculty to identify problems and to seek treatment to overcome them. Other times, success is judged by the person conducting the program whose criteria for his conclusions are the production of something specific, or in terms of teacher behavior in the present program as opposed to previously conducted programs.

Measures of success are also voluntary letters, phone calls, or conversations with principals, chief school officers, or supervisors. For someone who has been in the business of acting as am implementor of programs or as a change-agent, these are perhaps the most impressive. Unsolicited communications just do not happen unless there has been an observable behavioral change in teachers which is visible to an administrator.

Perhaps the most important indicator that something positive has happened, is that science enrollments in high school science classes are not dropping. It is also known that youngsters are expressing to their parents comments on what is happening; these comments in turn reach school board members and frequently Del Mod funds are matched, materials purchased, and teachers encouraged to try programs -- even in times of tight money.

F-2 DEL MOD DISSEMINATION: SPREAD THE WORD TO ALL

Thomas M. Baker, Del Mod/DPI Specialist, Department of Public Instruction, Dover, Delaware

Any project that involves a number of people is usually lacking one important entity, good communication. The role of the Del Mod dissemination specialist is to develop good communication lines and keep them open on a two, three, four, or more way basis.

In order to do this, several instruments have been and are being developed. The science teacher in Delaware is important, and these instruments are designed to meet his needs through inservice programs, newsletters, classroom visitations, development of objectives and guidelines, and news releases.

Within the Del Mod System, among its employees, the communication lines must also be kept open. The field agents, component coordinators, library technicians, and even secretaries are the arm of the dissemination specialist. Without assistance from these people Del Mod dissemination would be almost useless.

The communication and dissemina: n problem is a difficult one, but through diligent needs assessments and planning, this problem can be met and overcome.

F-3 DEL MOD – INVITATION TO ACTION

Catharine Y. Bonney, Supervisor of Science, Newark School District, Department of Public Instruction, Dover, Delaware

As an aftermath of an inservice workshop on the preparation and use of auto-tutorial programs in science education, a group of Newark teachers expressed a desire to produce some A-T packages of their own. Equally impressed with the potential of the A-T system for use in Delaware schools was Charlotte Purnell, then state supervisor of science, who later became director of the Del Mod Program. The invitation to action came in the form of Del Mod monies, supplemented by funds from the district's instructional budget, with the understanding that A-T packages produced would be duplicated and placed in the Del Mod Resource Centers throughout the state.

To date, approximately forty packages have been developed. The basic ingredients of an A-T system are: the cassette tape needed to interpret the topic, student activity sheets, instructions to the teacher, and an evaluation instrument. The teacher's guide specifies the laboratory material and equipment needed to perform the prescribed activities. Topics covered in the prepared A-T's fit into the areas of physics, chemistry, biology, earth science, mathematics, life science, health, or the physical sciences. These packages have been classified according to the library's Dewey Decimal System.

Another important facet of Newark's participation in the Del Mod Program was the attainment of services of a part-time field agent. This phase of the program was instrumental in opening lines of communication between science teachers throughout the district. Del Mod money was used to pay substitutes needed to free teachers for meetings during which classroom ideas were shared and common problems aired.

Finally, Del Mod's invitation to action made it possible for the district's supervisor of science to meet with other science leaders within the state during share-and-tell sessions open to project directors. This contact with other science educators was expanded to worldwide dimensions when the Newark supervisor represented Del Mod at the meeting of the International Confederation of Scientific Unions held at the University of Maryland in the Spring of 1973 and presented a paper entitled Del Mod: A Parallel to Science Teaching Centers.

F-4 GROUP PRESENTATION OF DEL MOD SYSTEM

Richard Cowan, Del Mod Field Agent, Department of Public Instruction, Dover, Delaware

Two items are crucial to good instruction: competence a thorough understanding of the subject, and confidence the ability to feel at ease with the material one is presenting. Teachers who desire to become more effective persons in the classroom will usually seek help with one item or the other.

The Del Mod field agent program provides the opportunity for an expert in his field to go into the classroom -- in a totally nonthreatening manner -- and help the teachers on their own turf. This is a feat most inservice programs cannot duplicate. It is the field agents' primary aim to help the teachers improve classroom performance.

Many people will agree that competence generates confidence. Hence, the emphasis for improving mathematics instruction has been on improving the teachers' competence. However, what happens if the efforts aimed at increasing the teachers' knowledge do not yield results, as so often is the case? The effort not only fails to increase the individuals' competence but in failing to learn the mathematics which was indicated as being necessary for improved instruction, the individuals lose confidence in themselves and as a result their classroom performance suffers.

Del Mod field agents are concerned with increased competence of the teachers with whom they are working. However, they feel that once the teachers gain confidence in what they are teaching, the teachers will be more receptive to programs which will improve their knowledge.

Edith Biggs, in her book "Freedom to Learn" describes a good classroom as one in which there is an "atmosphere which encourages resourcefulness, self-confidence, independence, patience and competence." It may be significant that competence is listed last. Del Mod field agents attempt to provide exactly the same atmosphere for the teachers with whom they are working.

F-5 INSERVICE EDUCATION AND THE DEL MOD FIELD AGENT

Barbara Logan, Del Mod Field Agent, Department of Public Instruction, Dover, Delaware

The call for radical educational reforms coming from all sectors of society points up the need for changes in inservice education. If teachers are to grow professionally, they need the time and the external resources that will enable them to clarify their perceptions, diagnose their own strengths and weaknesses, and assess their needs.

In the person of the field agent, Del Mod offers an external facilitator aiding teachers to master the skills identified by the teachers themselves, as important and needed. Through its release time inservice seminars, Del Mod strives to create the time needed for teachers to form new points of view, reach new understandings regarding the process of education, and acquire new skills.

With the psychological "boost" that comes from participation on a release time basis, the camaraderie that grows as teachers work together to solve common problems, and the continued support of the field agent, the teacher gains a confidence which reduces the anxiety of change. He begins to capitalize on his particular strengths, to develop a variety of teaching strategies and to adjust to the nuances of the learning situation.

GROUP G

ELEMENTARY SCHOOL SCIENCE

G-1 IMPLEMENTATION FOLLOWS NONRATIONAL RULES

Michael R. Cohen, Associate Professor of Education, Indiana University and Purdue University, Indianapolis

A National Science Foundation Cooperative -- College School Science program to assist Indianapolis in implementing its new elementary science program was conducted one year after the curriculum was adopted. The program was based on the available implementation research at that time. (The work at ERIE and the implementation work of Mary Budd Rowe). While the research was helpful in approximating difficulties, the speed of implementation within the Indianapolis system raised many nonrational problems not considered previously.

Knowledge of implementation procedures was not sufficient. When under stress it was easy to ignore guidelines. The level of conceptualization of ESS by the university personnel, the school administration, the publishing company, and the teachers raised many communication problems for implementation. The changing of teacher attitudes with regard to how children learn, messing about in science, and the importance of process education had a limited effect on their behavior.

The complexity of implementation results from a combination of rational and nonrational problems and considerations. Future implementation programs need an expansion of the conceptualizations and activities, such as human potential and value clarification, to insure their chances for success.

G-2 OVERNIGHT CHANGE: EXPERIENCES IN THE SCHOOLS

Gary E. Huffman, Science Supervisor, Indianapolis Public Schools, Indianapolis, Indiana

The decision to adopt the Elementary Science Study program (ESS) in place of a science textbook for the Indianapolis Public Schools was made in the spring of 1971. The implementation that September was the largest single adoption of such a program in the country, affecting 1,500 teachers and 48,000 children in grades 1-6.

The experiences of the schools in implementing this program during the next three years were based on continuous decision-making with incomplete data. The problems faced included: supplying more than 100 elementary schools with materials in a system geared to textbook distribution; evaluating for report cards without questions at the end of the chapter; providing time to "mess around" in science while pushing a "right to read" program; developing structures for an open-ended program; working with teachers who were not familiar with ESS activities or process education; overcoming feelings for low chances of success.

The solutions to overcoming or coping with these problems revolve around an understanding of, and an appreciation for: who makes curricular decisions; who carried out the decisions; and who is faced with the problems caused by the decisions.

G-3 RESPONSE WITH RELATION TO SMALLER SCHOOL DISTRICTS

H. Prentice Baptiste, Associate Professor of Curriculum and Instruction, University of Houston, Houston, Texas

The value of the experiences at Indianapolis depends upon their relationship with implementation projects in other school districts. The kinds of problems encountered in the implementation of ESS appear not to be related to the size of a school district. Only the magnitude of the problem is clearly related to the district's size. Implementation problems with teacher training, cost, an emerging philosophy of science education, reorganization, and evaluation will be faced by all school districts. This response which compares the similarities and differences between the Penn-Harris-Madison schools (a small rural-suburban school district) and the Indianapolis School district (a large urban school district) supports the above statements.

G-4 RESPONSE WITH RELATION TO STATEWIDE IMPLEMENTATION

Leonard Marks, Professor of Education, University of North Dakota, Grand Forks

For the past five years the University of North Dakota and numerous rural school districts have been engaged in a systematic effort to upgrade the overall quality of science education as part of a larger implementation effort of open-classroom teaching and learning practices. This response compares the similarities and differences between the Indianapolis implementation program and that of a number of small rural school districts.

GROUP H

INTERESTING APPROACHES

H-1 RESOURCE BANKING FOR THE IMPROVEMENT OF SCIENCE EDUCATION

Robert M. Jones, Research Associate for the Oklahoma Earth Sciences Educational Improvement System Project, The University of Oklahoma, Norman

During the design phase of the Oklahoma Earth Sciences Educational Improvement System Project (OESEISP), data were collected to aid in the development of instruments and techniques for assessing the needs of local school earth sciences instructional programs. An analysis of these data revealed that many of the expressed program and facility needs of local schools could be met with existing resources. This finding led to the pilot development of a classroom teacher-oriented earth sciences resource bank utilizing the General Information Processing System (GIPSY) at the University of Oklahoma Merrick Computing Center.

A survey of available catalogs and resource publications yielded an initial list of science discipline, topic, media, grade level, and user population descriptors. The resulting computerized file contains information on materials and services listed by 75 topics, 30 media, and 10 general discipline descriptors. In addition, based upon identified project needs, information useful in science education curriculum decision-making was obtained and entered in the file.

One unique feature of the pilot project is the use of inservice Oklahoma teachers as teaching resource evaluators. A rating system based upon the in-classroom usefulness of the media is utilized to assess the value of a particular entry. This results in only highly interesting and useable resources being retained in the bank.

The resource bank philosophy is independent of the hardware available or subject matter involved. Several communities in Oklahoma have developed instructional resource banks without utilizing sophisticated computer equipment. Information on the Ripley Elementary School learning center support system and the Mustang Middle School instructional materials center illustrate specific local utilizations of the philosophy.

H-2 THE TYPEWRITER AS LABORATORY INSTRUMENT: WHY NOT USE SCIENCE WRITING IN SCIENCE TEACHING?

Harry M. Schwalb, Editor, "Turtox News," Macmillan Science Co., Inc., Chicago, Illinois

All scientists are writers – of a sort. No experiment is complete without a written description of how it was conducted. Never before have so many professional papers been given or published; hence there has never been greater need for science writers to interpret them for today's readers. The biology class in senior high school and college is a logical place to introduce the writing of the science article. There would be several benefits:

1. It would teach science students the value – and pleasure – in interpreting their science activities in personal, informal, concrete, contemporary words.
2. It would simultaneously reinforce the value – and necessity – of the traditional *im*personal scientific report.
3. It would introduce talented students to the professional possibilities in science writing (now taught in a number of universities and schools of journalism).
4. It would demonstrate the remarkable precision of words as "tools" approaching the parts-per-billion sensitivity of optical-electronic instrumentation.
5. It would aid in the teaching of English, even though conducted in a non-grammar/syntax-oriented format.

The recent Anglo-American Seminar on the Teaching of English found that nothing in English is less effectively taught than writing. A major problem: the widespread assignment of irrelevant, fanciful, abstract, or over-literary subjects. The use of biology – the science of life – would provide an endless range of relevant subjects (example: what goes on inside the student when he dissects his first frog ... or when he sees his first scanning electron micrograph of radiolaria). Teachers would not grade these "papers" as English themes, and certainly not in the traditional isolation from students; they would mutually discuss the papers in groups, looking for scientific accuracy, freshness of language, and personal insights, incidentally enriching and stimulating the biology class.

H-3 USE OF SLIDES IN A HIGH SCHOOL PHYSIOLOGY CLASS HAVING MODULAR-TYPE SCHEDULING AND AN OPEN LABORATORY

Donald E. Mason, Teacher, Anatomy and Physiology, General William Mitchell High School, Colorado Springs, Colorado

It is important, in modular-type scheduling, to provide as much communication with the students as possible. Over a period of four years I have developed a series of 35mm slides that I use for prelab instructions, postlab review, testing, lecture presentations, etc. The presentation emphasizes the use of these 35mm slides in the educational process and summarizes different activities that take place in Mitchell High School's anatomy and physiology class.

H-4 MATRIX MADNESS: A METHOD OF CONTRIVING ALTERNATIVE SCIENCE INVESTIGATIONS FOR EVERYDAY THINGS

Larry E. Schafer, Assistant Professor of Science Teaching, Syracuse University, Syracuse, New York

Scene: A fourth grade classroom. Mr. Flibble, science supervisor or professor, and Mrs. Robb, classroom teacher, are standing before the class aquarium.

Mr. Flibble: "My, Mrs. Robb, what a beautifully immaculate aquarium you have. You must get a lot of science lessons out of that." (smiling, radiant)

Mrs. Robb: "Well, Mr. Flibble, we try. The children learn responsibility by taking turns feeding the fish and changing the filter. In addition, we talk about gills, how fish breathe underwater, and the function of aquatic plants. (Expressions of disappointment and concern begin to appear.) Frankly, Mr. Flibble, I am at a loss for new ideas. For the most part. our aquarium sits there and bubbles. What new investigations could we perform?"

Mr. Flibble: "Well, Mrs. Fobb, there is always the ... No, that's too advanced. Then you could ... No, you would need two tanks. I've got it! Gosh, I'm sorry that wouldn't work either. Oops! Mrs. Fobb, either your clock is 20 minutes fast or I am late for a meeting. Got to rush. See you next month. (Exit Mr. Flibble.)

Seemingly, a method of contriving science investigations for aquaria, lumps of clay, Halloween pumpkins, or any available material would be welcomed by the Mrs. Fobbs and Mr. Flibbles in our schools and universities.

Enter: The Matrix

Matrices (or grids) can be used to quickly identify the possible combinations for given sets of elements. Why not use, as the elements, variables associated with the investigation of available materials. Take, for example, the classroom aquarium. Environmental factors could be listed along one side of the matrix (see legend and the matrix) and fish behaviors along the other side.

Environmental Factors

A. Temperature of the water
B. Amount of space/fish
C. Amount of light reaching fish
D. Surface area available to air
E. Loudness of noise made near the tank

Fish Behaviors

1. Rate of gill movement
2. Depth of fish in tank
3. Frequency of direction change
4. Frequency of aggressive movements toward other fish

Environmental Factors

Fish Behavior	A	B	C	D	E
1				1-D	
2					
3					
4					

With 4 (down) x 5 (across) or 20 combinations, we have 20 investigations to consider. Combination, for example, 1-D would lead to the question: How is the rate of gill movement related to the amount of surface area available to air?

The methods of matrix construction are described with numerous examples of matrix use. The participants will acquire not only a large number of investigations that can be performed with available material but also a method of contriving more.

H-5 TOWARD SELF-DIRECTED LEARNING IN SCIENCE

Jack Hassard, Associate Professor, Georgia State University, Atlanta

This paper outlines an approach to self-directed learning, to support the approach from a psychological and learning theory rationale, and to identify examples in which the approach is being utilized.

Self-directed learning is a goal of education and to many educators may be the most important one. Because it is a goal and because teachers and learners vary in their style of learning, there are numerous variations in any approach to self-directed learning. Implied, however, in a self-directed learning model for education are the following assumptions about learning and teaching:

1. Every human has a natural potential for learning.
2. Learning can occur without the teacher being the dominant figure.
3. Learning that is important takes place when the subject matter is received by the learner as having relevance for his own purposes.
4. Independence, creativity, and self-reliance are facilitated when evaluation is intrinsic, rather than extrinsic.
5. Learnings which involve feelings as well as the intellect (affective and cognitive) are the most lasting and pervasive.
6. The teacher helps to elicit and clarify the purposes of the individuals in the class and to help implement those purposes as a motivational force to learning.
7. The teacher is responsible for providing a learning environment full of the widest range of resources for learning to help enhance the fulfillment of student goals.
8. The teacher accepts the intellectual content and emotional attitudes of his student...
9. The teacher takes the initiative in sharing himself with his class within the context as representing a personal sharing with his students.

The assumptions listed above guided the development of a special workshop with 29 teachers at Georgia State University during the summer of 1972. The philosophical and psychological foundation implicit in these assumptions created an atmosphere in the workshop that self-directed learning was a viable alternative for science teaching and could be put into practice. Examples of self-directed learning operating in an elementary class, a high school science class, and a college classroom are presented using a media presentation.

H-6 AN INTERESTING APPROACH

David Cohen, Visiting Professor in Science Education, University of Maryland, College Park, and Professor, School of Education, Macquairie University, New South Wales, Australia

No abstract submitted.

GROUP I

ENVIRONMENTAL EDUCATION

I-1 ENVIRONMENTAL EDUCATION IN THE ELEMENTARY SCHOOL

Glenn Clarkson, Elementary Environmental Education Program Specialist, Environmental Education Project, Public Schools, Topeka, Kansas

This presentation describes the curriculum units developed by the Topeka Environmental Education Project for intermediate grades. Each unit consists of instructional activities for use prior to and following an appropriate field trip. The following units are discussed:

1. **Knowing and Using Your Environment** contains topics on geology, plants and animals, rivers and reservoirs, nondestructive recreation.
2. **Environmental Fundamentals** provide the basic knowledge and skills necessary in order to make knowledgeable decisions regarding man's use of his environment including topics of Basic Needs of Life, Food Webs, Observational Skills, and Environmental Changes.
3. **Animals** supplements the animal unit included in the fifth-grade science text and utilizes the local zoo. Major emphasis is on animal adaptations, similarities, variations, man's influence on animal habitats, and animal distribution over the world.
4. **Plants** supplements the plant unit included in the fifth-grade science text and utilizes the local conservatory. Major emphasis is on plant adaptation, similarities, variations, man's utilization of plants, and plant distribution over the world.
5. **Water** emphasizes (a) the importance of water, (b) man's uses of water, and (c) how man aids natural purification through water and sewage treatment. A field trip through the waste water treatment plant and water treatment plant provides reinforcement.
6. **Energy and the Environment** illustrates how man's influence on the environment has been related to the amount of power a person can control. A field trip to the State Historical Society Museum is included.

I-2 CREATING QUALITY FIELD TRIPS FOR URBAN SCHOOL DISTRICTS

John Hirsch, Junior High School Science Teacher, Public Schools, Topeka, Kansas

Techniques for creating and implementing quality field trips on a large scale for urban school systems are presented. Data are based on three highly successful years for an environmental education project in Topeka, Kansas, public schools. Materials developed, teacher training techniques, field trip leadership problems and solutions, approaches for encouraging industry participation, and data indicating student and teacher response to the various trips are provided. Over 200 teachers, 25,000 students, industries, parks, zoos, and museums have been involved in the project.

I-3 A COMMUNITY ACTION MODEL TO REDUCE AQUATIC POLLUTION

Donald E. Maxwell, Project Director, K-12 Science Supervisor, and Bill Yost, Supervisor of Instructional Materials Center, Waterford School District, Pontiac, Michigan

This is a three-screen multi-media presentation of one community's efforts to solve an important immediate environmental problem while providing a basis for better informed citizenry for the future. The model exemplifies an action approach to environmental education. The program was made possible through an ESEA Title III grant. Its uniqueness lies in its three-pronged attack upon: (a) The immediate environmental problem, that of aquatic pollution; (b) the formation of a basic environmental education program; and (c) involvement of various community organizations.

I-4 INTERDISCIPLINARY STUDY AT JEFFERSON COUNTY'S OUTDOOR EDUCATION LABORATORY SCHOOL, EVERGREEN, COLORADO

Gordon L. Thies, Doctoral Intern, Department of Science Education, University of Northern Colorado, Greeley

Jefferson County Outdoor Laboratory School provides an innovative interdisciplinary curriculum at its Evergreen, Colorado, ranch. Current interdisciplinary aspects at the outdoor school include: meteorology, ecology, geology, pottery, dramatics, forestry, dancing, drawing, survival, outdoor cooking, camping, group dynamics, aquatic studies, music, backpacking, wildlife, astronomy, math, social studies, physical fitness, photography, mountaineering, crafts, writing, orientational--mapping and social skills.

Sixth-graders attend in groups of up to 200, accompanied for the week by their teachers, high school helpers, and curriculum specialists. The year-round staff consists of director, nurse-secretary, teacher-in-residence, maintenance staff, and cooks. The 550-acre site at 8,200 ft. on Mt. Evan's slopes has many facilities augmenting the interdisciplinary curriculum including five heated dormitories, a recreation-dining hall, an art-drama barn, an observatory, a main lodge with offices, a lounge and classrooms, tenting stations, marked trails, a museum-zoo, and the use of nearby U.S. Forest lands. The YMCA of the Rockies is used as an overflow camp.

Three weeks prior to arrival the outdoor education coordinator meets with school personnel and helps them plan topics to study, resources to use, and group scheduling. Modes of approach vary, but the assistance of a visiting geologist and forester as well as some fine arts teachers insures that every student explores integrating areas of outdoor learning in the cognitive, affective, and psychomotor domains. The teacher-in-residence and the director, with the help of interns, assist teachers in designing appropriate lessons to fit the natural environment, using teaching aids and multiple-talent approach. High school helpers contribute skills for teaching unique cross-discipline subjects to small groups and individuals. Classes are integrated with ongoing school activities through pre-camp fundamentals and post-camp follow-up studies. The outdoor program teaches *that best* which *can best* be taught in outdoor Colorado – a love of nature.

I-5 PHOTOGRAPHY AS A TEACHING TOOL FOR ENVIRONMENTAL SCIENCE

Donald C. Parker, Doctoral Student, Science Education, Syracuse University, Syracuse, New York

A simple method of increasing student interest and activity in environmental science is through the use of photography. Photography allows the student to actively investigate his immediate environment and record observations for classroom discussions.

Environmental science has gained much attention in curriculum development over the past few years. Many new texts, learning activities, and lab packages have been prepared to introduce students to the study of ecology. However, much of this material deals with general concepts which the teacher must adapt to the specific school locality. Depending on the teacher's subject background, availability of materials and resource personnel, this adjustment often results in less than successful transfer of intended objectives. In such cases, certain teaching tools are most useful in facilitating achievement of course concepts.

The use of photography requires a minimal amount of equipment, and operation is both easy and inexpensive (film and processing cost for 20 color slides – $3.50).

Photography has been used in my classroom, and materials produced by students and me are used to illustrate the following ways of using photography with the study of ecology:

1. recording the immediate environment for investigation of ecology concepts (succession, symbiosis, etc.);
2. recording different environments for ecological comparisons;
3. pre- and post-field trip discussions;
4. recording field trip observations;
5. pollution inventory of the community;
6. recording ecological changes with time (due to construction, seasons, etc.);
7. operation of the copy stand for producing slides from commercial materials.

GROUP J

TEACHER EDUCATION (INSERVICE)

J-1 INSPIRATION IS NOT ENOUGH FOR INSERVICE TEACHER PREPARATION: WORDS AND PICTURES

Mitchell E. Batoff, Associate Professor of Science Education, Jersey City State College, Jersey City, New Jersey

Inspiration and knowledge obtained in an inservice elementary school science course are necessary but insufficient to modify a teacher's style of teaching once he/she returns to the classroom after the course. In fact, many a course funded by the National Science Foundation (NSF) and other agencies has left teachers inspired and perhaps more knowledgeable but terribly, terribly frustrated. They often return to their classrooms at the end of the summer no more able to implement the grandiose ideas presented to them than before the course. Their teaching style remains about the same as before the course. Science is still taught predominantly as talk and chalk with little or no meaningful involvement on the part of the pupils; with little or no first-hand manipulative-investigative experiences for their pupils; with little or no "wet laboratory" situations.

This presentation offers no panacea but does show the efforts and results of a novel summer course offered in 1972 and 1973 by the Ontario Ministry of Education.

The authors believe that the participants' teaching style was modified, at least a little, as a result of the course, and particularly as a result of an element present (in this course) that is *truly* innovative and usually absent from similar inservice courses.

J-2 DESIGNING A MODEL FOR DEVELOPING LEARNING MATERIALS THAT PROVIDE ELEMENTARY TEACHERS WITH CONTENT BACKGROUND IN SCIENCE IN AN INSERVICE WORKSHOP FOI .T

Winston E. Cleland, DuPont Fellow, Del Mod, Department of Public Instruction, Dover, Delaware

One often hears teachers complain about irrelevant or inferior inservice programs which they are forced to attend each year. This paper discusses a model for designing inservice workshop materials that are relevant for teachers who are attempting to institute one of the new inquiry based elementary science programs (SAPA, SCIS, ESS, etc.) in their classrooms. The model is designed to provide the teachers with content background in an area of physical science while teaching them the process skills needed to successfully utilize new curricular materials with their children.

The model sets up four stages for development of a learning package suitable for inservice programs.

1. The new curricular materials that are being adopted by the teachers in the prospective workshop are reviewed.
2. Relevant content areas are delineated and a small coherent set of science concepts is chosen for inclusion in the workshop learning package.
3. The set of science concepts are behaviorized and broken into a manageable set of behavioral objectives that should serve as the vehicle for choosing appropriate workshop activities.
4. Workshop activities are chosen that relate to the set of content objectives and incorporate materials equipment, and if possible, that relate to actual exercises from the curriculum to be adopted.

The workshop exercises should be activity-centered with as little lecture as possible.

This paper describes how this model is used to develop a learning package in Newtonian Mechanics. The Newtonian Mechanics Module is behaviorized. The activities are laboratory-centered with the teachers using equipment and, in some cases, exercises, from the SAPA materials. Pre-tests and post-tests can be used to evaluate the participants or the module, or to diagnose learning difficulties. Field tests of the module and its evaluation are discussed.

Developing new approaches to the inservice training of science teachers is one part of a comprehensive plan to improve science instruction in the Delaware Public Schools being implemented by the Del Mod System.

J-3 WHY CAN'T TEACHERS UNDERSTAND SCIENCE PROCESSES?

Darrel W. Fyffe, Assistant Professor, Bowling Green State University, Bowling Green, Ohio

The notion of teaching the science processes and skills has been under discussion for a number of years. The *Science - A Process Approach* materials developed for elementary school use implement many of the best ideas in a process-oriented program. However, many teachers, even with time spent studying and using this approach still think of science teaching in terms of concepts.

The teacher's prior experience as a student and/or teacher has always taught that science dealt with concepts and ideas concerning the nature of our environment. Somehow we haven't communicated the notion of science as a method of inquiry. Some means must be developed to better accomplish this goal.

Another problem is that few, if any, other areas of study deal with the processes of that area of study. The content of each discipline is presented as the proper subject matter of study.

Lastly, few supplementary materials are available which use the language and goals of process development. We must devise or write more materials of this nature to reinforce the efforts of the teacher.

Some concrete examples of ways to solve the dilemma drawn from workshops and clinics conducted by the author are presented. Teachers must begin to better comprehend the processes of science before we can expect them to teach the processes.

J-4 THE EFFECTS OF AN INSERVICE EDUCATION PROGRAM IN SCIENCE ON THE STUDENTS OF PARTICIPATING TEACHERS

Joseph E. Pinkall, Science Education Specialist, ESU III-OSACS Science Center, Gretna, Nebraska

The purpose of this study was to determine the effects of the Omaha Suburban Area Council of Schools (OSACS) Science Center's inservice education programs in Elementary Science Study (ESS) and Process Science on the students of fifth- and sixth-grade teachers who participated in these programs.

The study was conducted during the 1972-73 school year using a Post-test-Only Control Group Design. (Campbell and Stanley, 1969) Randomization was used to insure the lack of initial bias between the experimental and control groups.

An experimental group of 150 fifth- and sixth-grade students taught by teachers who completed an OSACS Science Center inservice program in ESS or Process Science were compared with a control group of 150 fifth- and sixth-grade students taught by teachers who did not participate in these inservice education programs.

Comparisons between the experimental and control groups were made in three areas:

1. Knowledge of scientific processes based on Riley's *A Test of Science Inquiry Skills*,
2. Knowledge of scientific content based on the science section of the *Sequential Test of Educational Progress*, Series II, Form 4A, and
3. Attitude toward science based on the Metz *Science and Scientists Attitude Inventory*.

The analysis of data indicated that the experimental group scored significantly higher (at the .05 level) than the control group on all three of the evaluation instruments. Based upon the analysis of the data it was concluded that the OSACS Science Center's inservice education programs in ESS and Process Science had a positive effect upon the students of teachers who participated in these programs.

GROUP K

SPECIAL AREAS FOR CONSIDERATION

K-1 CAREER EXPLORATIONS IN SCIENCE AND ENGINEERING THROUGH A SUMMER YOUTH PROGRAM

Michael L. Agin, Assistant Professor of Science Education, Michigan Technological University, Houghton

This paper reports the development, implementation, and evaluation of a career exploration program. Slides illustrate some of the important aspects of this innovative program.

During the summer of 1973 the teacher education department of Michigan Technological University conducted an experimental career education program for secondary school students – grades 7-12. The basic objective of the program was to provide youth the opportunity to gain firsthand experience with careers in science and engineering. The students participated in one or two of 23 one- and two-week explorations of the Summer Youth Program (SYP), which included forestry, limnology, ecology, geology-mineralogy, field archeology, computer science, and several engineering-related explorations – civil, electrical, mechanical, and metallurgical.

Each student was given an excellent opportunity to study a career field of interest by participating in the activities pertinent to that field. The students in field archeology, for example, participated in the excavation of an abandoned copper mine site. These students were transported to the mine site each day, to work with university students and faculty at designated locations and plots. In addition to field work, the students did literary research to help identify the artifacts uncovered during their excavations.

The response to the program was extremely encouraging. Over 500 students (for about 650 student-weeks) participated in the program – the initial projection was 250 students and 400 student-weeks. In addition to the unexpectedly high enrollment, the students exhibited great enthusiasm for the career explorations by active participation and complimentary evaluations. A great majority of the students indicated a willingness to recommend next year's program to friends (about 92%).

The successful completion of SYP during the summer of 1973 has encouraged MTU to increase both the number and depth of the career explorations. Students will have an opportunity to study more fields of science and engineering, in more detail.

K-2 DO YOU HAVE AN OPEN CLASSROOM? A WAY OF FINDING OUT

John Barry Bath, Graduate Assistant, Syracuse University, Syracuse, New York, and Robert Vargo, Junior High School Teacher and Doctoral Candidate, Liverpool High School, Liverpool, New York

The Classroom Openness Scale (COS) has been devised to determine where a classroom is functioning as measured along a formal-informal continuum. Pertinent observations are made on pupil activities over a specific time period. In contrast to other instruments in the area of open-education, the COS is very objective with high intra-observer correlations. (.92-.98) The observational data can be analyzed by computer or more simply by classroom activity profiles.

The COS is useful for researchers, for teachers striving for openness, and for administrators who think that they have open classrooms within their school. The COS only classifies the classroom. It cannot evaluate. No value judgments are made as to teacher quality.

Data show some of the uses of the COS. Attempts are made to show the differences between the profiles of formal versus informal classrooms. Profiles of typical elementary classrooms are compared to secondary school and college classroom profiles. Comparisons are also made between and among subject areas.

K-3 MINICOURSE DEVELOPMENT AT JAMES MADISON MEMORIAL HIGH SCHOOL 1968-74

LeRoy Lee, Science Department Chairman, James Madison Memorial High School, Madison, Wisconsin

James Madison Memorial High School initiated a program of short courses for students in 1968. These four- to nine-week courses, later to be called minicourses, were offered to supplement existing science courses and were taken by students during their unscheduled time.

The formative years of the short course program presented the staff with the problems most such minicourses face, i.e., lack of teacher-student identification, difficulty in providing courses to meet the needs of a variety of students, scheduling, community involvement, and evaluation. Since the program was supplemental rather than the sole science program, many of the problems were easily resolved and the experimental period provided time to develop and to evaluate the program carefully.

Based on a three-year study time a limited number of minicourses were introduced within the existing Biology II course. Students could select one of three choices for the last nine weeks, each of which were considered to carry Biology II credit. The 1972-73 school year expanded the program to provide the Biology II students with at least four minicourse selections during three six-week periods in the second semester. Success of the program was indicated by verbal and written evaluation and more dramatically by a 60 percent increase in enrollment.

With the opening of the 1973-74 school year, JMM initiated a minicourse program involving approximately six hundred Biology I and Biology II students as well as interdisciplinary minicourses in earth science, physics, chemistry, math, and art.

When minicourses were offered one major new problem JMM faced was assuring that all biology students would have some common background upon graduation. This was solved by the formation of a 12-week core program that consists of those behavioral objectives identified by the staff as being important to all high school graduates. All students enrolled in biology must complete this core program before advancing into minicourses. This also provides students with a base teacher who functions as their advisor throughout the year and reduces the problem of teacher-student identification.

Scheduling and record keeping, always a problem, were alleviated by the development of easily administered and scored surveys, and a key-sort retrieval card system for all students.

Evaluation is an ongoing process with students providing feedback at the end of each six-week minicourse. End-of-year evaluations provide information, keyed to year in school and approximate grade point average, about course management, course structure, interest generated by the course, and overall student-teacher interaction.

K-4 MAD-MITCH MANIA

Donald E. Mason, Physiology Instructor, and John M. Akey, Science Chairman and Planetarium Director, Mitchell High School, Colorado Springs, Colorado

With the present trend of students questioning the need and relevance of science, the science department of Mitchell High School in Colorado Springs, Colorado, has developed a slide-tape presentation explaining our science curriculum. The presentation was primarily developed for the ninth-grade students of the junior high schools feeding students into Mitchell. It can also be used with counselors of these junior highs and Mitchell to assist them in placing students into the science curriculum or used with adult groups including parents, PTA's, etc.

This presentation is a dichotomous saga of the Mad Scientist versus Mitch Scientist. The Mad Scientist depicts the person who feels science is a trial-and-error, do-your-own-thing approach to solving man's problems. Mitch Scientist takes a more systematic approach to science by examining all the possibilities available to him through the science program at Mitchell.

The purpose of this presentation is to explain how one science department has attempted to improve communication with students and adults.

K-5 INCREASING THE PARTICIPATION OF WOMEN IN SCIENCE CAREERS

Walter Scott Smith, Associate Dean of Women and Lecturer in Science Education, University of Kansas, Lawrence

Women represent less than 10 percent of all engineers, doctors, chemists, geologists, and other science-related professionals. Despite the publicity focused on the women's movement, women are not increasingly entering science professions. This disproportionately low representation of women in scientific careers constitutes an underutilization of talents to which education, and particularly the science teaching profession, should address itself.

Women are not entering science careers partly because of discrimination, but more so because they have not attempted to obtain the training necessary for entry into professional careers. In order to increase the number of women seeking professional training, science teachers in all grades should take affirmative action directed at changing the aspirations of women.

Because of a lack of role models, women view science careers as "not me." Young women are not encouraged toward science careers and often do not study subjects prerequisite to collegiate science majors. Thus, although women may become aware of their opportunities, they feel they do not possess sufficient knowledge to pursue their options. Finally, young women are presented with the problem, real or imagined, of the incompatability of marriage, family, and science careers.

As we institute "hands on" elementary science curricula, women should be encouraged to manipulate, tinker, and do all the mechanical operations which are often reserved for males. Women students, particularly in the middle grades, should be saturated through all instructional modes with role models of women scientists. More secondary school women should be encouraged into math and science courses. In preparing young women (and men) to face the career/marriage/family dilemma, they should be apprised of their life style alternatives which include remaining single, delaying marriage and/or family until after the completion of career preparation and entry, or pursuing a career through job sharing or part-time employment.

GROUP L

SCIENCE AND HUMANISM

L-1 INTERFACING SCIENTISTS AND HUMANISTS IN AN INTERCOLLEGE COURSE

Katherine M. Jones, Associate Professor of Physical Science, University of Tulsa, Tulsa, Oklahoma

"Toward One World" might be the theme of the course Science, Technology, and Society at the University of Tulsa.

One World of People and One World of Knowledge. The "One World of People" is composed of the scientists engineers whose orientation is toward quantitative and specialized aspects of the world, and their nonscience oriented corrollaries. to humanists, whose aptitudes and training lead to different interests and activities. The course aims to broaden the view of the science/engineering students and to develop in them an awareness of the far-reaching effects of their work and of society's capability to compel or constrain its implementation. For the humanists, the aim is for a greater awareness of the undeveloped capabilities of technology and a more realistic attitude concerning the limitations and the "scientific fix." The course is concerned with the often inadequate and insufficient communication between the technologists and humanists and also with the too common depreciation by each of the other's thinking. The "One World of Knowledge" is concerned with the nature, seriousness, and urgency of the complex environmental and social problems challenging man today. It involves an appreciation of both costs and benefits of alternative solutions to the problems. It is related to their feasibility, the moral philosophy regarding their impact, and with human behavior which determines whether they will be implemented or repressed. Most important, it is aimed at fostering positive, humane attitudes toward the end that the earth may support a civilization in a rich ecosystem for a geologically long period of time.

L-2 HUMANE EDUCATION: AN OLD CONCEPT WITH A NEW NATIONAL EMPHASIS

Stuart R. Westerlund, Professor of Education, The University of Tulsa, Tulsa, Oklahoma

From the days of the so-called "three R's" our educational system has become a dynamic process, geared toward producing better citizens as well as providing an adequate education in the many academic areas. It is recognized that young minds of elementary and high school students provide rich fertile soil where ideas and attitudes – good or bad – take quick root and grow to enrich or impoverish the total adult personality. Influences and factors that will contribute to character development and to a balanced and mature personality are now recognized as fundamental in the education of children.

A significant area of educational programming, powerful in its potential effects upon the ultimate character of the child, has been largely ignored or neglected. With few exceptions, very little is being done in American classrooms insofar as humane education is concerned, due in part to the lack of appropriate humane education instructional materials.

Convinced of the need to integrate humane education into school curricula, The Humane Society of the United States – in 1964 – commissioned The George Washington University to conduct a study to determine the importance and feasibility of considering the development and implementation of such a program. The study left little doubt about the need for, and feasibility of, developing and implementing humane education programs in the nation's schools.

The Humane Society of the United States and the University of Tulsa recently entered into a cooperative effort aimed at implementing the recommendations made in The George Washington University Study. This undertaking is known as The Humane Education Development and Evaluation Project (HEDEP). HEDEP represents the beginning of a concerted effort to introduce the fundamental concept of humaneness into already existing school curricula.

L-3 EVOLUTION OF A HUMANE EARTH SCIENCE COURSE

Florence M. Boring, Earth Science Teacher, Millard Lefler Junior High School, Lincoln, Nebraska

With the realization that students learn best when they discover things for themselves rather than by being told or by reading from a textbook, teachers became aware that they had permission for change. With the emergence of today's typical nonconforming and often nonperforming student, teachers are realizing that they have a mandate for change. They and their classrooms *must* change in order to survive.

A teacher's typical lesson plans have progressed at least from the textbook-oriented (so many pages per day) to the concept-oriented (so many behavioral objectives per week). Many teachers, discontented with the lack of relevance and the resulting lack of response, have reached the point of developing materials which students can use at their own rate of speed. This has solved some problems and created others. It has worked well with students who already have some ability toward self-direction coupled with the imagination to see some relevance in the materials they are using, or at least with a willingness to conform to expectations. This certainly does not include all students.

Fortunately there is no one way to learn, and even within the same science class there are no specific learning experiences that all students *must* have. Some very fine programs have been developed for earth science which allow a student to progress at his own rate. Some make the additional provision of permitting students to decide for themselves at least a part of what they will learn and what methods they will employ. In my earth science class I am using materials, methods, and experiments from a number of these programs to organize a curriculum where students progress at their own rate, choose from an increasing number of options, and fulfill a science requirement by making their own selections from nine-week minicourses.

GROUP M

LEARNING AND COGNITIVE DEVELOPMENT

M-1 AN INQUIRY INTO THE PHENOMENON OF UNDERSTANDING ABSTRACT CONCEPTS WITH APPLICATION TO CLASSROOM INSTRUCTION

Nasrine Adibe, Associate Professor, Graduate School of Education, Long Island University, Greenvale, New York

Since Reisman first described the learning problems of the disadvantaged child as an inability to deal with abstract concepts, the terms "abstraction" and "abstract concepts" have come into prominence in educational circles. Yet a satisfactory definition of the terms and research findings on the topic, and guidelines to facilitate the tacit understanding of such concepts are not available to teachers.

This paper reports on a study that has explored the phenomenon of understanding abstract concepts, and has attempted to formulate a workable definition of abstract concepts; to delineate the mental processes involved in abstraction; to develop criteria for assessing the congruency of abstract concepts with learning cognitive level; to create instruments to evaluate understanding by learners; to identify, select, and develop strategies that can be used by science teachers to facilitate the understanding of such concepts.

Findings of this exploratory study are relevant to educational planning, structuring and sequencing subject matter in the curriculum, and assessing learning outcomes and procedures used in science instruction.

It is hoped that this inquiry and its findings and exploration of many of the variables that influence meaningful learning in science will generate significant questions for further research.

M-2 CONCEPTUAL COGNITIVE SCIENCE EDUCATION THROUGH READINESS EXPERIENCE FOCUSED ELEMENTARY PROGRAMS

Dorothy Alfke, Associate Professor of Science Education, The Pennsylvania State University, University Park

The writer believes that a most critical aspect of conceptual learning in science, termed by the old-fashioned rubric as *readiness experiences*, is grossly neglected. Although the idea of readiness is incorporated into the national elementary science programs, users of the programs do not seem to be aware of its importance.

Elementary school years, particularly primary, are a time for rich, exploratory, childlike investigation. Learning outcomes of such investigations should be determined by what children can observe and communicate in their own way. A constructive spirit of the tentativeness of interpretations and explanations should pervade, with the use of planned experiences which lead children to re-examine ideas as they encounter new evidence. Children should not be forced to make big leaps from one or two narrow experiences to broad sophisticated generalizations. Rather, elementary science should provide some of the bits and pieces which will equip them with a meaningful experiential background for junior and senior high school where learning can become integrated into sound broad concepts.

Examples of the readiness idea are abundant. A primary child readily learns to respond, "on cue," with the phrase "air pressure." But place most students, even juniors in a teacher education curriculum, in a situation involving interpretation or application of conceptual understanding of air pressure and the weakness of the foundation is discouragingly apparent. A rich background of meaningful experiences related to air pushing, balanced and unbalanced air mass forces, and, in fact, related to the reality of air itself, is essential to dealing with the complex idea of air pressure. The elementary program can and should provide such experiences (probably without the imposition of the term itself before fifth grade).

Readiness experience focused elementary science is in harmony with the work of such men as Piaget, Bruner, and Bloom.

M-3 PIAGETIAN CONSERVATION ACTIVITIES: SOME QUESTIONS

Cecilia E. Grob, Third Grade Teacher, Airport Elementary School, Berkeley, Missouri

This paper describes an investigation concerned with children's acquisition of Piaget's conservation concepts, also presenting several questions related to conservation activities in the elementary classroom.

The investigation was implemented to determine the effects of conservation activities on children's acquisition of Piaget's conservation concepts. One hundred twenty eight seven- to nine-year-old children in four classrooms were given a pre-evaluation measure of conservation ability. The experimental group of children then completed a set of 42 self-directed conservation activities over a five-month period during the 1972-1973 school year. All the children in the study were given a post-evaluation measure of conservation ability. No significant differences in mean conservation scores were found between the experimental and control groups. Several variables were tested for interaction effects on the children's conservation ability. Age was found to interact with group status to affect conservation scores. Achievement scores and I.Q. scores were found to be significantly related to the children's conservation scores on the post-evaluation measure. Sex, race, and socioeconomic status were not found to be significant factors relating to conservation scores. Further research was recommended in order to study the effects of conservation activities on children's conservation ability and on other education-related variables.

Several questions were raised from analysis of the investigation results. The questions were related to: the effectiveness of conservation activities included in an elementary classroom; the timing of conservation experiences; the effectiveness of the measure of conservation ability developed for the investigation; the role of several education-related variables in conservation acquisition; and, the relevance of the total classroom situation to children's conservation acquisition. The purpose of this presentation is to generate additional questions related to needed research on application of Piaget's theory to the elementary classroom.

M-4 THE ROLE OF PIAGET'S EQUILIBRIUM MODEL IN SCIENCE EDUCATION

Edward Labinowich, Assistant Professor of Education, California State University at Northridge

Recent writings in education have resulted in increasing reference to Piaget's theory of cognitive development as a basis for discovery learning and as a cognitive justification for an open classroom environment. Although considerable evidence has been gathered to confirm the existence of sequential stages of children's thinking, there is a general absence of evidence for his equilibration (assimilation-accommodation) model for learning. This paper clarifies Piaget's equilibration model through relating the works of Berlyne, Festinger, Charleston, and others to Piaget's model.

GROUP N

COLLEGE SCIENCE TEACHING

N-1 ROLE OF HISTORY OF SCIENCE IN SCIENCE COURSES

Sheldon J. Kopperl, Coordinator, History of Science Program, College Landing, Allendale, Michigan

No abstract submitted.

N-2 TEACHING SCIENCE FROM A PHILOSOPHICAL BASIS

Leo Schubert, Chairman of Chemistry Department, The American University, Washington, D.C.

Courses in science, and surely chemistry, tend to be oriented to scientific concepts and facts. We generally ignore a consistent educational approach in teaching the material. What is perhaps a more subtle problem is that we are unaware of the philosophical basis upon which science is constructed. The teaching of science is part of the educational spectrum and these considerations must not be ignored. Specific examples such as existentialism, and the major educational theories are discussed.

N-3 RELEVANCY AND THE NON-SCIENCE MAJOR

Mary E. Lynch, Assistant Professor of Biology, Manhattan College, Bronx, New York

Biology – the science of life – as applied to the living world and mankind is of value to the nonmajor. It is the interdisciplinary nature of biology that is to be stressed if biology is to have relevancy.

Depending on subject area requirements within the school, a biology course can be adapted to a variety of student needs and interests. The course must have a solid foundation in the fundamentals of biology – cell theory, systems, cell chemistry, interactions within the biosphere, the role of man in nature. Relevancy must have a firm basis in the principles of biology.

There are many ways to achieve relevancy. Active participation by the student is the key. Seminar sessions dealing with topics of present and future interest for mankind are a means of achieving relevancy. Technology assessment can be introduced as a process, as a technique for studying societal needs, and as a means for evaluating alternatives to present and future problems. Students can be given the opportunity of relating biology to real-world situations.

In addition, field trips are of value if they are not stereotyped and repetitious. Media usage by students adds interests, provokes student imagination, and allows individual expression through media other than print. Film, slides, tapes, video, free-hand art – all can be used on field trips. Students can explore animal behavior, animal coloration, or any biological theme. Urban ecology problems can be expressed through communications media. Students are encouraged to become involved in biology. They must see, do, and think. They must be encouraged to express themselves in a variety of ways.

In short, relevancy is achieved by relating biology to life and to the future of mankind.

M-5 PIAGETIAN TASK ANALYSIS – A PRACTICAL MEANS OF ASSESSING INTELLECTUAL DEVELOPMENT IN HIGH SCHOOL AND COLLEGE BIOLOGY COURSES?

Floyd H. Nordland, Assistant Professor, Biological Sciences, Purdue University, Lafayette, Indiana

Piaget's theory of intellectual development has received considerable attention and has been recently used as a basis for the development of elementary science materials such as the Science Curriculum Improvement

Study. It is generally assumed that once a student has advanced beyond 14-15 years of age that he has arrived at the stage of formal operations. Therefore, most high school science curricula and all university curricular materials are developed on the assumption that the students being taught are fully capable of thought processes characterized by the stage of formal operations.

Recently the work of Renner, Karplus, and others has questioned this assumption. Renner, et al. have administered five Piagetian tasks designed to determine the stage of intellectual development of a student population. By assigning numbers to these tasks it has been possible to characterize what proportion of a class is fully formal, transitional, or concrete. Once this is established it has been possible to compare mean scores as a way of assessing the increase in intellectual development associated with inquiry teaching as compared to more conventional instruction.

Another form of analysis is to assess course assignments in terms of appropriateness as related to Piagetian task analysis. If 50 percent of a group is designated as being formal, then an assignment requiring formal thought processes should be completed satisfactorily by 50 percent of the group.

This paper reports on a battery of tasks appropriate for high school and college students; results of Piagetian task analysis of selected populations representing middle school, high school, and college students; and an analysis of course assignments in relation to Piagetian testing.

N-4 STRATEGIES FOR SCIENTIFIC LITERACY IN UNDERGRADUATE EDUCATION

Joy S. Lindbeck, Associate Professor, College of Education, University of Akron, Akron, Ohio

Most college and university undergraduate programs require a core of science courses as a basis for scientific literacy for nonscience and nonengineering majors. The undergraduate science requirement at a Midwestern urban university is frequently met by scheduling three of the following televised natural science courses: biology, geology, physics, and chemistry. To determine the effectiveness of the program and to explore reactions to alternative programs, the senior seminar students in the spring quarter and in both summer sessions of 1972 were surveyed by questionnaire. Of 312 questionnaires returned, 201 (the total sample) indicated that one or more natural science courses had been taken.

The most frequently scheduled natural science course was biology, followed by geology, physics, and chemistry. Except for biology, the frequency pattern for natural science course selection was in contrast to that of high school.

The student level of understanding of scientific developments reported via newspapers, TV, and magazines in the field of the natural science course completed was rated. Forty percent of the respondents indicated improved understanding in their respective fields after completing biology and geology, and 20 percent indicated improved understanding in physics and chemistry. Interest developed by natural science courses encouraged from 6 percent of the biology students to choose a second biology course to 2 percent of the chemistry students to choose a second chemistry course. A higher percentage of respondents indicated that they would have taken another science, schedules permitting, ranging from 30 percent in biology to 13 percent in physics.

The most frequently suggested improvements included live lecture with smaller sections, lab programs and/or field trips, small discussion groups and more demonstrations. The presentation of a unified, three-quarter science course should be explored as an alternative program in view of the 31 percent "yes" response and the 28 percent "uncertain" response on this suggestion. A multiplicity of options to complete the undergraduate science requirement should be incorporated to meet the varying preferences as indicated by the 34 percent response to televised natural science, the 41 percent response to courses in the science department, and the 25 percent response combination of both, if students could reschedule the science requirements.

N-5 ENVIRONMENTAL MAZE: A MODEL FOR ACADEMIC CHANGE

William B. McIlwaine, Professor, Millersville State College, Millersville, Pennsylvania

Educational literature contains scores of statements reflecting dissatisfaction and disenchantment with higher education. College programs with their self-contained inertia resist fundamental changes, long-standing programs are rarely eliminated, the student as an individual learner is ignored, and educational goals are rarely questioned.

As a result, many students find their introduction to college a frustrating experience. They come with dimly perceived goals. They search in vain for meaningful personal associations with instructors, who represent the "rich and rewarding" intellectual promise of college life. They settle quickly into a routine of unrelated courses, often repetitive of content and no more vigorous and innovative than in recently departed high school. Soon their gloom deepens and they search outside the classroom for a meaningful college experience; meanwhile the faculty charge them with "copping out."

Disturbed by this aura, a pilot program was developed which can serve as a model for academic change.

We offered a thematic program for freshmen based on the relevant theme of *the environment*, and comprised of especially developed integrated, and interrelated courses which provided experiential learning. The program was all encompassing in terms of achieving goals of affective and cognitive development. It was a total semester's academic experience molded quite differently from the standard freshman program. Scheduling was a function of program design and development, not the college-wide master plan in the traditional pattern.

Results exceeded all expectations. Businesses and government agencies provided competent resource personnel. Varieties of field experiences stimulated the freshmen to dialogue and action not evoked from their predecessors. Faculty participated in each other's classes, and debated issues freely with colleagues and students. Problem-oriented assignments allowed the individual student to exhibit his level of competency for evaluation. Student reaction was overwhelmingly favorable, determined by evaluative interviews and instruments developed and administered by a non-participating colleague (Director of Educational Research).

GROUP O

SCIENCE FOR THE UNINVOLVED

O-1 SCIENCE FOR THE UNINVOLVED: A SELF-PACED, INDIVIDUALIZED, INSERVICE TRAINING PACKAGE FOR IIS TEACHERS

LaMoine L. Motz, Director of Science Education, Oakland Schools, Pontiac, Michigan

With the implementation of any new, activity-centered program in science, a certain amount of inservice time is needed for the teacher to become aware of the philosophy of the program, the materials, and the instructional strategies and techniques necessary for an effective and enjoyable experience in teaching the program.

The question is often asked, "Does a teacher need special training to teach IIS?" This question can be answered by posing two simple questions: (a) Would you drive a car without first learning about the new controls? (b) Would you involve students in a project without first giving them the necessary orientation?

A self-paced, individualized, teacher implementation inservice package for IIS teachers has been designed. Most science teachers have a general background for teaching the traditional college-oriented courses, but few, if any, have had any instruction in how to teach the uninvolved students. Although the unique teacher can always teach the IIS program from instruction in the Teacher's Manual, it is highly recommended that the teachers using or planning to use the IIS program participate in some kind of an inservice development program. The purposes of this training program are to assist teachers in acquiring:

1. an understanding of the rationale and philosophy of IIS;
2. an understanding of and experience in the teaching style and strategy of IIS;
3. an understanding of how IIS is to be used in the classroom to motivate the educationally uninvolved student, and in developing empathy for the needs of the student;
4. a better orientation to the content, process, social relevance, and personal relevance of IIS.

O-2 INVOLVING THE UNINVOLVED

Anna A. Neal, Coordinator of Science, Fayette County Public Schools, Department of Instructional Services, Lexington, Kentucky

Administrators who prefer to spend most of their time in the office playing up to their bosses, perusing research, and sending out volumes of reading material to teachers and principals can expect little or no change in teacher attitudes toward student involvement in the learning process. If we expect teachers to be concerned, understanding, enthusiastic, and loving in the classroom, then we must exhibit these same characteristics with teachers. We must get to know them as individuals and let them know us. If we expect principals to be understanding and to reinforce teachers, then we must use these qualities with them. If we expect those who establish budget priorities to uphold the role of science in the total curriculum, then we must be aware and considerate of all other curriculum areas.

We can begin by fertilizing the seeds of discontent. These seeds are not difficult to find. Teachers will discuss openly their problems with the "dumb-bunnies" in their classes. Sympathize, offer help, discuss with these people possible alternatives to what they are now doing in the classroom and then determine together the kinds of materials that would add zest to the program. Finally, identify those teachers who have responded positively and provide them with the needed materials. These teachers sell the program to their peers. Enthusiasm is contagious. If the same steps outlined above are followed in working with principals, implementation of the program can be assured.

A model for implementation has been developed in Fayette County Public Schools, Lexington, Kentucky. It is working. Teacher attitudes are changing and students are being "turned on" by their activity-oriented science classes.

O-3 WINNERS AND LOSERS

Gerald Skoog, Associate Professor of Curriculum and Instruction, Texas Tech University, Lubbock

American schools traditionally have served as tools of selection to separate the "winners" from the "losers." A hidden curriculum based on WASP values plus endless achievement tests and teacher-made examinations have been the chief mechanisms of selection and elimination. Those with the desired competencies became the "winners" while those lacking in the competencies were labeled the "losers."

Today, this model of education is outmoded and must be replaced. In a society that demands universal education, a system geared to eliminate many is obsolete.

Traditionally, academic achievement has been linked with economic output. Economic output has been correlated with success. However, Jencks in *Inequality* concludes that cognitive skill and educational attainment explain very little of the variation in men's income. He speculates that "luck has at least as much effect as competency on income," and competency in most cases seems "to depend more on personality than on technical skills."

While the validity of Jencks' argument is being debated, youth continue to reject academic achievement and materialistic gains as indicators of success in school and life. Many youth in our society today agree with James and Jongeward in *Born to Win* who differentiate between "winners" and "losers" on the basis of authenticity rather than achievement. To them a winner is not "one who beats the other guy by winning over him and making him lose" but one "who responds authentically by being credible, trustworthy, responsive, and genuine." Thus the shift is to accepting a person on the basis of his "interiority" rather than as a representative of some category of completer of some task.

The classification model of education must be replaced by an affirmative model where personal development is stressed and authenticity nurtured. Despite much opposition by the omnipotent and omnivorous programmers, much research and philosophical support exist to validate such a model.

O-4 ENRICHMENT ACTIVITIES FOR IIS

Lynda Ann Smith, Science Teacher; and General Science Instructors, Thornwood High School, South Holland, Illinois

A 15-minute slide/tape narration shows enrichment activities for IIS at Thornwood High School. The presentation includes descriptions of:

1. The use of bulletin boards as an addition to the learning experience;
2. The decoration of the learning environment as a booster to student self concepts and as a means of emphasizing good working habits;
3. A supplemental text of activities for IIS, compiled by school staff, and designed to provide additional materials for over-achievers and additional drill materials for the entire class;
4. Guidelines for making use of "student-aids" in laboratory set-ups and stock-room coordination including qualifications, duties, and responsibilities.

GROUP P

SIMULATION GAMES IN SCIENCE EDUCATION (K-12)

P-1 SIMULATION GAMES AS A LEARNING ALTERNATIVE: TOWARD AN ACTIVE LEARNING ENVIRONMENT

John A. Masla, Associate Dean, College of Education, Ohio University, Athens

Traditionally, students at the elementary and secondary levels have for the most part been engaged in passive learning environments – one in which the learner assimilates knowledge as a result of being given information verbally or through the reading process. In science education, we have attempted to become more "action-oriented" through the laboratory or demonstration approach, through inquiry, and through problem-solving.

Simulation games represent a technique for learning which offers the student total and active involvement. Involvement takes place with a variety of realia, stimulus, and motivational competition. Learning takes place as a result of the process of gaming rather than as a result of listening, preparing for a test, memorizing, and other forms of passivity. Simulation games take advantage of having fun while learning, a concept which has been noticeably absent from the traditional classroom.

There is no real doubt as to the relevance of simulation games to today's classrooms. Simulation games provide a multivaried conceptual approach to learning, utilizing several learning principles such as reinforcement, feedback, exposition, and practical application. Simulation games, provide the student with:

1. Practice – by performing "on the job" tasks during the simulation game;
2. Self pacing – time limitations are varied with the interests of the learner;
3. Assessment – built in as part of the game, provides student with self-evaluation;
4. Monitoring – opportunity for instructor to serve as observer and facilitator;
5. Peer instruction – students learn from each other through the content and process of the game; and
6. Remediation – games are replayed, reinforcement is continuous.

P-2 GUIDELINES FOR THE CREATIOι OF HOME AND SCHOOL GAMES FOR SCIENCE

Lester C. Mills, Professor of Education, Ohio University, Athens

The inventor of games and toys for use in schools may easily lose sight of the user's point of view. The educational goals and objectives which are of deep concern to the developer may obscure the game and play aspects of the activity. Several such criteria are presented for those interested in developing educational games and toys in science.

P-3 MANUFACTURING, MARKETING AND PROMOTING EDUCATIONAL GAMES

Robert E. Cooley, President, Union Printing Company, Athens, Ohio

No abstract submitted.

P-4 REVIEW OF CURRENT SCIENCE SIMULATION GAMES

Jerry D. Wilson, Department of Physics, Ohio University, Athens

A large group of game buffs has developed in our society. As a mini-national pastime, games are played by people of all ages. Educators and teachers, particularly those of science who are always alert for new teaching methods have begun to capitalize on this means of communication in an effort to make learning a more pleasant experience, even fun. Although the effectiveness may be debated, educational games do introduce and make familiar, topics which might otherwise be avoided completely.

Within the last few years several scientific simulation games have been marketed and several others described in literature. Some of these are described and their teaching effectiveness examined.

GROUP Q

COLLEGE SCIENCE TEACHING

Q-1 IMPROVING PROCESS SKILL COMPETENCY AMONG COLLEGE NONSCIENCE MAJORS BY USING SCIENCE – A PROCESS APPROACH MATERIALS

Mary M. Pohlmann, Graduate Fellow, Department of Secondary Education, and A. J. Pappelis, Professor, Department of Botany, Southern Illinois University, Carbondale

"Interdisciplinary Science – A Process Approach" is an 11-week, 4-quarter-hour course developed at Southern Illinois University, Carbondale, intended for undergraduate nonscience majors. The purpose of this course is to develop the basic and integrative science process skills required for scientific inquiry common to all areas of human endeavor as well as within the realm of the scientific disciplines. This course is based on the AAAS (American Association for the Advancement of Science) K-6 science curriculum, *Science-A Process Approach*. One section of this course has been offered for each of the past three quarters with a total of 60 students having now completed the course. At the outset of the course, the students were pretested to determine their entry level competency in science process skills. A 96-item instrument, *The Test of Science Processes*, developed by Robert S. Tannenbaum at Teachers College, Columbia University, was used for this pretest. The test is composed of eight subtests designed to measure eight different science process skills: observing, comparing, classifying, quantifying, measuring, experimenting, inferring, and predicting. This same test was administered as a post-test upon completion of the course. A groups-by-trials analysis of variance was used to determine whether there were significant gains between pre-test and post-test. Significant gains were indicated in total test score for all three quarters in which the course was offered ($F = 20.65$, d.f. 1,57, $p < 0.001$). Specifically, increases were greatest on the subtests of measuring ($F = 15.86$, d.f. 1,57, $p < 0.001$), classifying ($F = 5.56$, d.f. 1,57, $p < 0.01$), inferring ($F = 4.74$, d.f. 1,57, $p < 0.05$), and experimenting ($F = 3.84$, d.f. 1,57, $p < 0.05$).

Q-2 TECHNOLOGY – PEOPLE – ENVIRONMENT: AN ACTIVITY-CENTERED INTERDISCIPLINARY PROGRAM FOR THE ACADEMICALLY UNSUCCESSFUL

Thomas T. Liao, Associate Director, Engineering Concepts Curriculum Project, College of Engineering, State University of New York, Stony Brook

"The Man-Made World" (TMMW) course, developed by the Engineering Concepts Curriculum Project (ECCP), is intended for average college bound high school students who are not choosing careers in science or engineering. Unfortunately, many high school students have not had the academic success of the above-mentioned students, who in general are good at learning via written materials. Non-academic students typically are students who are poor readers with little mathematical ability.

Many teachers of TMMW feel that all high school students should be given the opportunity of learning about the characteristics, capabilities, limitations, and impact of modern technology. The fact that students have poor reading and mathematical skills does not necessarily prevent them from developing technological literacy. The basic philosophy of the activities approach to TMMW is that academically unsuccessful students can develop an understanding of the many dimensions of modern technology; provided that they are involved in activities which are fun and do not depend heavily on the written word and abstract mathematics.

Two of the more important educational priorities in this age of rapid social and technological change are:

1. Development of strategies for making it possible for disadvantaged and unmotivated students to succeed at learning;
2. Development of a technologically literate public, members of which understand the nature, characteristics, and limitations as well as capabilities of modern technology and how this rapidly changing technology impacts on their lives.

With the previously stated priorities in mind, this activities approach to The Man-Made World has been organized as a series of minicourses for secondary schools. These minicourses can be taught independently of each other, or organized into a complete course.

The following sequence is recommended when the minicourses are organized into a complete course.

Introductory Activities

1. Technology ↔ People
2. Human User ↔ Technology – Job
3. Technology ↔ Society
4. Technology ↔ Environment
5. Quality of Life
6. Man as a Consumer
7. Communication Man ↔ Man ↔ Machine ↔ Machine
8. Thinking? Machines

Q-3 HUMAN GENETICS AND SOCIETAL PROBLEMS

Pauline Gratz, Professor of Human Ecology, Duke University Medical Center, Durham, North Carolina

Recent achievements in modern genetics threaten or promise to give man the ability to modify or control his own genetic future according to his own design. Such forecasts as the preselection of a child's sex, sperm banks, harboring the sperm of prominent persons, cloning (replication of individuals), and transduction (incorporation of foreign DNA into the host chromosome) raise profound ethical questions.

Through attendance at a AAAS-NSF Chattaqua course in 1972-73 under the direction of Peter Volpe of Tulane, a questionnaire was drafted to ascertain the attitudes of students enrolled in a human ecology course offered in the school of nursing. The questionnaire attempted to determine attitudes pertaining to the social and ethical dilemmas created by genetic advances. The questionnaire was drafted during the November session in 1972 and tested for validity and reliability in February 1973. During the second meeting with Volpe the questionnaire was revised.

The revised questionnaire will serve as a focal point for a second study under a Duke Regular Grant which will explore changes in attitudes before and after a thorough exploration of the theoretical and practical possibilities of genetic engineering.

A course in human genetics and societal problems will be offered this fall. Appreciable attention will be given in the course to the current state of research on birth defects, biochemical disorders, the human chromosome complement, and malformations resulting from mishaps in the chromosomes. Topics such as the detection of heterozygous carriers of genetic disorders, genetic counseling, prenatal diagnosis of genetic defects by amniocentesis, and therapeutic abortion will claim high priority.

Students will be requested to respond to the questionnaire prior to learning the content and immediately after the content has been learned. It is hoped that the study will provide data to indicate that students have recognized that the problems of life and living require an integration of knowledge before "decision making" can be achieved.

Q-4 THE ROLE OF FUTURES RESEARCH IN PRE-COLLEGE SCIENCE EDUCATION

Christopher J. Dede, Assistant Professor, School of Education, University of Massachusetts, Amherst

As science educators increasingly emphasize "science for citizens," the methodologies and findings of futures research will become important in precollege science instruction. In learning the strengths and weaknesses of technology-projecting tools such as the cross-impact matrix, the Delphi, and FAR, students can better evaluate the validity of current warnings on the drug crisis, the population explosion, ecological catastrophes, and so on. Moreover, much of the individual powerlessness within our society students feel can be alleviated by involving them in making their own forecasts of how science will evolve in the next 30 years, and how these evolutions can be shaped by citizens. Finally, by examining the major schools of thought in futures research, science educators can assess the scope and sequence of science/society materials that will need to be included in pre-college curricula in the next several decades.

This presentation focuses on the major alternative forecasts which have been made for the United States in the year 2000, with particular emphasis on the interactions among science, technology, and society contained in these forecasts. Using these projections as background:

1. Classroom process techniques which can be used to involve students in the future of science are elucidated,
2. Teaching strategies which help students understand how technology projections are made are discussed, and
3. Current trends towards a science/society focus in pre-packaged science curricula are evaluated.

GROUP R

AREAS FOR SPECIAL CONSIDERATION

R-1 AN ADAPTATION OF A SCIENTIFIC WORK FOR CLASSROOM USE

Robert E. Lewis, Science Teacher, Springer Junior High School, Dover, Delaware

The object of this project was to adapt for use in the junior high school earth science classes in the State of Delaware, the technical manual, "The Geology of Delaware's Coastal Environments," by John C. Kraft, Chairman, Department of Geology, University of Delaware.

After a survey of the needs of earth science teachers in Delaware, Ruth Cornell stated that Delaware teachers needed lessons that could be presented to students dealing with Delaware geology. Kraft's manual was chosen as a means to provide this material.

Twelve lessons were developed from the manual. The material was organized to be taught either as a two-week unit or as distinct lessons presented in conjunction with the regular earth science curriculum. Lessons emphasize student involvement in an investigative approach.

Upon completion of the teachers' manual, a twenty-hour, ten-week course was developed. The first hour of each class was devoted to background material concerning the subject area. The second hour the teachers participated in the various activities designed for the students. Graduate students of the University of Delaware were selected to present the background material to the teachers. Each graduate person presented material in their own field of research. The presentations were taped.

Self-tutorial lessons were developed from the tapes and audiovisual materials used during the presentations. The tutorial lessons are available in the Del-Mod Resource Centers to teachers preparing to use the materials developed for the project.

R-2 PROTOCOL FOR A SCIENCE INSTRUMENTATION RESOURCE CENTER

Ledi Lantis, Del Mod Component Coordinator, Department of Public Instruction, Dover, Delaware

For years science teachers and chief school officers in Delaware expressed concern that science classroom equipment was gathering dust for lack of repair. As such repairs tend to be costly, time consuming, or both, it has often been simpler to reorder equipment than to repair it. Because such resources have been standing in dark or hidden places laboratory oriented programs have been crippled or have been continued at a greater cost than necessary.

Responding to statewide concern, Charlotte H. Purnell, Director of the Del Mod System, instituted a survey to determine the extent of the problem. It was so great that she was able to convince the State's council of college presidents of the need for action. A private Delaware foundation agreed to fund a science instrument repair center at the Stanton Campus of Delaware Technical and Community College. The paper covers ways and means which the center is able to provide public and private schools with service for only the cost of the parts. It outlines the special occupations program under which a small number of students intern to provide needed repairs while learning instrumentation and the repair of AV hardware.

While it is too early to assess the full impact of the program, planners do anticipate that the taxpayer will be saved money through elimination of duplicate purchases or costly repairs; pupils will benefit from laboratory oriented classes which will function because required equipment is available.

R-3 SCIENCE/MATH RESOURCE CENTER: WHAT MAKES IT GO?

Ellie Sloan, Technician, Science/Math Resource Center, Dover, Delaware

Because the baseline data from which the Del Mod System evolved indicated that teachers, especially in the middle schools, needed help with resources and teaching ideas, resource centers in each of the three counties were set up to meet these needs. The paper outlines the services of the Del Tech location which differs somewhat from the others.

Among its features are a one-page newsletter, idea files, community resource lists, and its functioning as a focal point for the field agent and science education technician programs.

This paper also gives examples of the impact of the resource center on the science and math education community through examples of teacher enthusiasm and increased effectiveness in the classroom from science/math resource center exposure.

R-4 THE FUNCTION OF THE DUPONT FELLOW

Peter M. Shannon, Del Mod Field Agent, Dover, Delaware

Based on the success of the field agent program, the DuPont Fellow has been established to release a mathematics and a science teacher for one year from their district to act as field agents. They are assigned to specific districts and perform on-the-job training with aid for classroom teachers. This program gives the released teacher an opportunity to develop leadership, become more aware of programs in other districts, and try out some new ideas. The Del Mod System is able to provide a resource person to the schools who can have rapport with the teachers and serve as a field agent. The districts would benefit from the input of the DuPont Fellow, and when the Fellow returns to his regular assignment at the end of his field agent year, the district gains a person cognizant of many mathematics programs and ideas and is capable of carrying out inservice programs in the home district.

This program provides the leadership to improve the mathematics competencies of Delaware mathematics teachers and to offer inservice training on evolving mathematics programs, materials, and techniques.

R-5 SCIENCE EDUCATION TECHNOLOGY: A FACET OF THE DEL MOD SYSTEM

Mary Stein, Director, Science Education Technician Program, Department of Public Instruction, Dover, Delaware

Some science teachers in Delaware are feeling the exhilaration of implementing a hands-on science program with the assistance of a trained technician handling the non-teaching tasks. Technicians were trained in rationale, philosophy, design, and implementation in a pilot program originating at Delaware Technical and Community College. Much attention is directed to the advantages of the pilot program for teachers and students, teacher-pupil attitudinal changes, and acceptance of the technicians in the school system, as well as the problems still facing this program. An outline of the actual presentation follows.

Science Education Technology: A Facet of the Del Mod System

I. What is a Science Education Technician?
   A. Rationale
      1. Community College Philosophy
      2. Hands-on Internship
   B. Design
      1. Advisory Committee
      2. Curriculum Committee

II. Successes of Science Education Technician
   A. Acceptance
      1. School Administration Acceptance of Interns
      2. Teacher Acceptance of this New Assistance
      3. Advantages to Schools and Students
   B. Teacher Attitudinal Changes
   C. New Career Model for Delaware Students
   D. Student Attitudinal Changes
   E. Economics Wrought by Science Education Technician
      1. Savings
      2. Costs
      3. Return on Science Education Investment

III. Problems of Science Education Technician

GROUP S

SPECIAL AREAS FOR CONSIDERATION (K-12)

S-1 FACTS OR FANCY: WE TEACH WHAT WE HAVE LEARNED

Mario Iona, Professor of Physics, Department of Physics and Astronomy, University of Denver, Denver, Colorado

From the frequent occurrence of the same erroneous concepts in elementary science textbooks it appears that there is a well-established body of erroneous information being propagated from generation to generation. This illustrates (a) the limited understanding many science book writers have, (b) the uncritical way in which the material is treated, and (c) the possibility that people learn from the material from which they study. Wouldn't teaching efforts be more successful if meaningful material were presented? The fact that many traditional errors can be found in instructional material does not preclude the possibility for imaginative writers to introduce new errors. It is unbelievable how successful they are. Examples of a variety of traditional and novel errors are discussed and audience response is sampled.

S-2 SCIENCE AND THE ARTS – MYTH AND IMAGINATION IN THE SCIENCE CLASS

Joseph C. Ciparick, Science Teacher, Manhasset Junior High School, Manhasset, New York

There is a greater need today to show the importance of insight and creative imagination in science, especially when relating true science to religion and the arts. Creative imagination is used in these fields to explain the mystery of reality. When the imagined myth or art form becomes real and an end in itself, dogma takes over. Instead of science, art, and religion, sharing their creative insights, they are often set against each other.

Students should be encouraged to use their imaginations more in science and to develop a sympathetic appreciation of the various interpretations of reality offered by different cultures at different times. They should also see the pitfalls of dogmatism, and preserve a healthy scepticism toward hypotheses and theories.

S-3 SCIENCE AND SOCIETY: A SUMMARY OF EFFECTIVE TEACHING METHODS FOR THE SECONDARY TEACHER

David J. Kuhn, Science Coordinator, K-12, Public Schools of the Tarrytowns, North Tarrytown, New York

This report deals with a survey of effective, practical teaching methods for secondary teachers interested in introducing courses or units concerned with the relationship of science and society. The theoretic basics and the practical application of several pedagogical approaches are introduced. The methods discussed and illustrated include: value clarification exercises, simulation activities; the use of fantasy trips and debate; laboratory exercises and demonstrations; attitudinal surveys, and techniques for the critical review and analysis of articles and advertising in the public press and other media.

A major trend in science teaching for the 70's is an increased emphasis on the social implications of science. A pursuit of relevance is evident in all of us. The media are filled with popular concerns about pollution, overpopulation, drugs, mental health, the neurobiology of the learning process, genetic engineering, and the like. It can be argued that social problems rest, in part, on basic scientific concepts: one cannot understand pollution without a knowledge of fundamental concepts in ecology; overpopulation without a knowledge of population dynamics; or drug action without some background in human physiology. Clearly, we must bridge the gap between societal issues and science concepts.

Teachers cannot be realistically expected to meet this challenge unless they are equipped with a variety of appropriate pedagogical tools. The techniques suggested may be a partial "answer" to this difficulty.

S-4 POTENTIAL SAFETY SYMBOLS APPLICABLE TO THE SCIENCE CLASSROOM AND LABORATORY

Gerald C. Llewellyn, Assistant Professor of Biology Secondary Education, Virginia Commonwealth University, Richmond

In an effort to emphasize safety in the science classroom, a series of symbols have been developed, and preliminary tests for their effectiveness are currently being made. It is our opinion that symbols depicting the concept better portray the idea than written warnings alone, or non-conceptually related symbols.

Some of the basic shapes found on highway signs and some of the proposals for symbols on Canadian products appear to be a familiar starting point. For example, the severity of the danger in our symbols can be related to the geometric shape surrounding the central drawing. A red triangle represents "caution;" a diamond indicates "warning;" an octagon indicates "danger;" a circle with a 45° slash represents "Do Not;" a slash alone represents "No;" and a square represents "Required Use" of a particular safety device such as glasses or gloves. These shapes can enclose a skull and crossbones, indicating a poison, or a flame, indicating combustion. A bony hand in a beaker represents a corrosive material; a blue light bulb indicates UV (ultraviolet) light. The series also includes an exploding flask and a flask with escaping vapors. To encourage the use of safety glasses and gloves these objects are shown in sketches surrounded by a red square. In addition, a two-headed serpent and the silhouette of an inverted animal infer biohazards.

It is hoped that after further refinements the above proposed symbols and warning shapes could be tested in mass in the classroom in an effort to increase communication and reduce injuries.

S-5 AN OPEN SYSTEM FOR PREPARING ISCS TEACHERS (WHAT HAPPENS IF YOU TRUST TEACHERS?)

Ted Mills, Professor, Oklahoma State University, Stillwater

This presentation is an instructional design which encourages individualized, self-paced activities from which participants are free to choose. How teachers react, what can be accomplished, and the instructional design's potential to effect change in the public school classroom are discussed.

GROUP T

INTERESTING APPROACHES

T-1 ASTRONOMY AND A LUNAR SKYLAB

Kenneth C. Wardwell, Science Technician, Research Professors Institute, Cohoes, New York

A lunar skylab could be a desirable follow-up to the Earth Orbiting Skylab. As details of design and launch would be similar to the EOS, a lunar skylab could provide a source for astronomical observations of the moon rather than the earth. Studying astronomy from the moon's surface would not be necessary.

During the months the lunar skylab would be aloft, as a satellite of the moon, it could serve as living quarters for astronauts, astronomers, and geologists studying our galaxy. Besides mapping the moon's surface, the team of astronomers could observe the planets and their retrograde motion to a background of distant stars and constellations. The sun's size could be verified when the moon was new and, also, full. The inferior planets could be plotted at eastern and western quadrature to the (moon's) skylab position at first and third quarter phases. The data relayed to earth could be computed, and observations resolved and compared to the data of superior planets and their retrograde motion. By observing sunspots and the sun's corona to the sun's polar axis of rotation, the lunar skylab astronomers could determine the sun's orbital motion within the earth's orbit around the sun. Observation each month for meteor showers could determine the radiant point from which each shower originates (some lasting for several days).

Future observers aboard the lunar skylab could also observe Mercury transits, Halley's comet, and the Venus transits of the next century (2004 and 2012). Each year there are three eclipses or more and the lunar skylab could gather important data at lunar and solar eclipses. Photographing the corona of the sun from skylab during each eclipse could be compared to earth photographs done at the same instant of time to compare the effects of earth's refracting atmosphere. Discovery of the sun's orbital diameter could be a prime factor in elevating astronomy to its rightful place as a "pure science."

T-2 A SYSTEM APPROACH TO SCIENCE EDUCATION IMPROVEMENT IN OKLAHOMA

Edward Stoever and Robert Jones, Professors, University of Oklahoma, Norman

No abstract submitted.

T-3 MOTIVATIONAL SCIENCE QUIZZES

Gordon J. Senoff, Assistant Professor of Education, Brandon University, Brandon, Manitoba, Canada

Quizzes can function to stimulate interest in outdoor education, creativity, critical thinking, concept teaching, the process approach, and in an interdisciplinary emphasis.

Typical outdoor quizzes are: Nature Did It First; What Am I; Do You Have a Bird Brain; A Can Full of Worms; and Nature, Fact or Fiction. Some illustrative items are: Only male mosquitoes bite. (T,F) [1]; A blueberry is red when it is green. (T,F) [2]; A porcupine is born with quills. (T,F) [3].

The standardized Remote Associates Test on creativity can be used as a model for writing a Science Associates Exercise. In this exercise you are presented with three words and asked to find a fourth word which is related to all three. For example, nine, night, nap, ____ [4]. In a poetic Who Am I quiz the pupil may be asked to write his own stanza describing an animal or plant.

Critical thinking can be encouraged with the use of Planetary Baseball, Contradictions, and analogies such as: DOE:VIXEN. SOW: ____ (drake, buck, mare, capon). [5]

Concept teaching can be enhanced by Pictorial Science Misnomers, All in the Family, Family Tree, and Order in Class. An exercise on misnomers could be presented in multiple-choice form, for instance, Which of the following is a GRASS? (pepper grass, couch grass). [6]

Misnomers could also be engaged in teaching the process of classifying. The process of observing may be promoted by the use of Bird Silhouettes, Who Goes There? (animal tracks), Optical illusions, and the Photographic Mind.

The interdisciplinary area may be represented by the following examples:

Home Economics – Corned Beef is beef and ____. [7]
Mathematics – A bakers' dozen consists of (12, 13) items. [8]
English – Pluralize: goose, mongoose. [9]
Geography – The (Atlantic, Pacific) end of the Panama Canal is the farthest east. [10]

Answers: 1. F; 2. T; 3. T; 4. cat; 5. mare; 6. 6; 7. brine; 8. 13; 9. geese, mongoose; 10. Pacific.

T-4 DEVELOPMENT AND EVALUATION OF A COMPUTER SUPPLEMENTED SECONDARY SCIENCE CURRICULUM

Daniel A. Myers, Physics Teacher, Computer Education Specialist, Wasson High School, Colorado Springs, Colorado

I attempted to develop and test materials for use in a computer-oriented physics course. The materials were designed to help individualize instruction and free the teacher for more contact time with the students. The effect of these materials on the student's cognitive progress and his outlook toward physics was studied by means of various testing devices.

All students in the 1972-1973 physics class took part in the work. The effect on their cognitive progress was studied by comparing test scores for this year against last year (1971-1972). Both tests and testing conditions were as nearly identical as possible. A pre- and post-attitudinal test was administered to check the effect of the program in the affective domain.

It was found that the overall feeling generated by the program was positive, probably due in large part, to increased freedom of the teacher for more individual student contact. There also seemed to be a vastly improved ability to retain and, more importantly, transfer concepts to other areas and levels.

T-5 A CONTRACT UNIT ON PLANTS

Frances Weiss, Life Science Teacher, Warren Junior High School, Newton, Massachusetts

This contract unit was developed in order to provide for individual needs in heterogeneously grouped eighth-grade classes. Due to the broad range of abilities in such classes, it is difficult to use the more conventional "lockstep" approach.

The contract consists of required assignments and a variety of optional investigations. Activities in the contract include: reading, using question sheets, planning and carrying out a controlled experiment, using a taxonomic key, dealing with plant structure through six or more laboratory activities, working with a microscope, growing bacterial cultures, and viewing filmstrips. The variety of activities allows nonverbal students to select an almost totally experimental and audiovisual contract. At the same time, students who like reading and writing more than experimentation can choose the major portion of their contract work from those categories.

Students enjoy selecting their own assignments and working at their own rate. The motivational value of the contract is clearly illustrated by the fact that the vast majority of students elect to work for an "A" or "B" contract and nearly all of them complete the requirements for the mark selected.

GROUP U

CURRICULUM DEVELOPMENT (7-12)

U-1 A DESIGN FOR CURRICULUM INNOVATION (7-12)

T. Ray Jackson, Secondary Curriculum Coordinator, North Olmsted Senior High School, North Olmsted, Ohio

This presentation deals with the development of the needs assessment phase and the techniques used in the establishment of the problem areas to be tackled within the science department of the North Olmsted City Schools. It was found that staff involvement throughout the project is essential if the result is to develop into a viable curriculum program. This involvement can result in the development of a team approach to the teaching of science.

U-2 A DESIGN FOR CURRICULUM INNOVATION (7-12)

Irene Szaniszlo, Chemistry Teacher, North Olmsted Senior High School, North Olmsted, Ohio

The wide selection of courses that have been developed within the science department of the North Olmsted City Schools on a nine-week, semester, or yearly basis, depending upon circumstance, is briefly discussed. These offerings provide a sequence of learning more appropriate to student needs and interests than previous offerings. Courses utilize a variety of modes of learning. Problems relating to choices of learning alternatives, alternative grading procedures, and the selection of materials are examined.

U-3 A DESIGN FOR CURRICULUM INNOVATION (7-12)

Ken Frazier, Physics Teacher, North Olmsted Senior High School, North Olmsted, Ohio

An overview of the teaching staff, the scheduling of classes, and the teaching load as it pertained to curriculum innovations within the science department of the North Olmsted City Schools is presented.

GROUP V

EVALUATIVE STUDIES

V-1 ASSESSMENT OF THE SCIENCE PROCESSES FOR STUDENTS AT THE END OF MIDDLE AND/OR JUNIOR HIGH SCHOOL

John F. Reiher, State Supervisor of Science and Environmental Education and Del Mod/DPI Component Coordinator, Department of Public Instruction, Dover, Delaware

A program entitled Delaware Educational Accountability System, developed by the Delaware Department of Public Instruction, went into operation in January 1971. A set of goals for education in Delaware's schools with input from the general public, students, teachers, and administrators were evolved and finally adopted by the State Board of Education. Then, a series of objectives for the areas of natural science, mathematics, reading, and language arts were constructed with a team of teachers representing each of the content areas. Upon completion of general objectives for each content area, and with cooperation from the Educational Testing Service, a series of tests were developed. The test series represented a step closer to the goal of developing a statewide testing program, at the end of the first, fourth, and eighth grades.

As the test items were consistent with the statewide natural science objectives for the fourth and eighth grades, the test was administered in spring 1973 to all fourth and eighth graders. The preliminary results show good scores in student achievement for natural science. The contention of this writer is that due to the nature of the test constructed we are measuring science content based on the student's ability to read. If an instrument could be designed to measure the same basic objectives, but to focus on the student's audio and visual senses the student's achievement measure would be a more reliable assessment of his knowledge of the natural science processes.

Objectives are:

1. To develop an audiovisual test of the natural science processes for students completing the eighth grade in Delaware's junior high and/or middle schools by using the statewide objective for natural science,
2. To implement the use of this test instrument in a randomly selected junior high and/or middle school from across the state in five to seven schools, and
3. To evaluate the results of the new test instrument as compared to the present instrument being used for eighth graders in the state.

V-2 TRANSFER AND RETENTION OF THE SCIENCE PROCESSES OF OBSERVATION AND COMPARISON IN JUNIOR HIGH SCHOOL STUDENTS

Audrey N. Tomera, Assistant Professor, Science Education, Department of Elementary Education, Southern Illinois University, Carbondale

Scientific processes have value as components of critical thinking. The question of the length of retention of two basic science processes and the ability of students to transfer said skills are addressed in this presentation.

A special methodology for teaching the skills of observation and comparison was used with a sample of 172 participating seventh and eighth graders. Students were instructed using three-dimensional science objects, either deciduous winter twigs or microscopic algae. Samples were randomly assigned to two- or four-week training groups, review or no review-treatments, and the instructional vehicles.

Instrumentation for measuring achievement were the *Scientific Observation and Comparison Skill Test-Twig or Algae Forms.* These tests have been validated as well as positively researched for test-retest reliability; interscorer reliability, and alternate form reliability.

Students were administered a pre- and post-test to measure transfer ability. Delayed post-tests (on the training vehicle) were given at three-month, five-month, and one-year intervals to ascertain the degree of retention of observation and comparison.

Transfer data were analyzed using the multilinear regression approach. Retention data were treated descriptively using the mean percent of retention from post- to delayed post-testing.

Results of the study indicated that observation and comparison skills are phenomenally retained over all three time periods. There was no significant difference obtained between samples receiving and not receiving the review treatment. No significant difference was obtained between samples receiving two and four weeks of instruction.

Significant transfer of observation occurred in both two and four week training groups, regardless of which vehicle was used for training or for measurement of transfer. Significant transfer of comparison occurred in the two-week training groups.

In summary, the results indicate that junior high school students can be taught the skills of observation and comparison in a relatively short period of time. The methodology used to achieve this can insure phenomenally high degrees of retention over three-month, five-month, and one-year delay periods, as well as securing positive lateral transfer.

V-3 THE MEASUREMENT OF THE ACQUISITION AND TRANSFER ABILITIES OF JUNIOR HIGH SCHOOL STUDENTS IN PERFORMING THE SCIENTIFIC PROCESS OF CLASSIFICATION

Henry G. Walding, Instructor, Science Education, Department of Elementary Education, Southern Illinois University, Carbondale

Numerous researchers (Gagné, Livermore, Schwab, and others) have espoused the need for training in the processes of science rather than science content per se. Similarly, many of these individuals have stipulated that these processes of science do have transferability to other areas of the curriculum and everyday life. Certainly this assumption is in agreement with one of the broad goals of general education: that what is learned must have applicability beyond the context in which it is learned. This assumption also appears to be of extreme importance to the discipline of science; both in terms of developing a scientifically literate society and in training individuals in skills which will transfer from one science content to another.

There have been a sparse number of research studies which have dealt with measuring the acquisition and transferability of the processes of science. Junior high school students (N=170) were selected for the research population. This study presents an empirical analysis dealing primarily with two basic questions:

1. Can junior high school students significantly improve their scientific classification abilities as a consequence of instruction?
2. Can these same students subsequently classify unfamiliar scientific objects to a significant degree when compared to a control group who have had no scientific classification training?

Although teaching for transfer of learning may well be a viable pedagogical and research practice, teaching for transfer was not a part of the strategy used in this research.

Results of this research do present an extremely strong case that students can indeed learn how to classify scientific objects and subsequently transfer what they have learned to another set of unfamiliar scientific objects from a different context without having specific training for transfer.

V-4 TEACHER SELF-EVALUATION IN PHYSICS AND CHEMISTRY

Mahlon Wissink, Science Department Chairman, Mayo High School, Rochester, Minnesota

The original organization plan that was undertaken in the physics courses at Mayo High School involved five areas of evaluation.

1. National tests and norms for students,
2. Appraisal from fellow teachers and/or administrators,
3. Small group conferences with students,
4. A questionnaire to be answered anonymously by all students,
5. A TV tape of lectures for self-evaluation.

Item 1 was based on physics tests written by the textbook authors, designed to compare student achievement with a national test sampling. Some analysis of the type of student in each course as to ability and interest was necessitated. Due to lack of time this was done only for Project Physics tests and should have included more students.

For Item 2, evaluation from fellow teachers involved in the physics department on a team teaching approach, was *not* done on a class "visitation" approach, but with an evaluation instrument agreed upon by teachers involved. It was necessary to design the instrument for evaluation.

Item 3 involved conferences with small groups of students (5-10 per group) covering anyone interested. Planning as to the type of questions appropriate for student response and cooperation of our teaching teams to free students for such conferences was required. Discussions were carried out by the teacher himself or by his colleague to determine student opinion when the teacher being evaluated was not present.

Item 4 allowed students to fill out a form anonymously. A form was designed in cooperation with the other teachers so that personal biases would be somewhat minimized.

For Item 5 video tape was used during class sessions involving teacher lecture and demonstration. Videotaping was done for personal improvement and was a somewhat unnatural situation as there was a temptation to prepare especially for the lecture being taped. It was useful, however. Another problem in our approach to teaching was that lecturing does not play a major role, however, it is still present and should be evaluated by all of the methods discussed. A form was provided for tape evaluation.

GROUP W

APPROACHES TO INDIVIDUALIZATION

W-1 REACHING THE SLOW LEARNER WITH CAREFULLY STRUCTURED AUDIO-TUTORIAL LEARNING EXPERIENCES

Dennis M. Afton, Science Teacher, Oil City Junior High School, Oil City, Pennsylvania, and Michael Szabo, Associate Professor of Science Education, The Pennsylvania State University, University Park

This study describes a self-paced audio-tutorial (A-T) science program for slow learners. How would low-ability students react to a science program which is self-paced, provides increased contact with manipulative materials, circumvents reading problems, and delegates responsibility for self direction? The literature was reviewed to validate the author's observations of slow learners and to identify instructional techniques useful with them.

A series of self-paced science modules to cover six weeks of instruction was developed. A multi-media, A-T approach which features instructional objectives, frequent diagnostic feedback, and manipulative laboratories was selected. Twelve eighth-graders, low on IQ and reading scores, completed the units with minimal teacher instruction. Thirty-eight students were exposed to the same subject in a traditional (i.e., group-paced with lecture and demonstration as the dominant mode) learning environment.

Quizzes, exams, grades, and course attitude questionnaires provided the data. The A-T group felt they learned more and that more courses should be offered in this format. Grades confirmed feelings; the A-T group earned higher grades than the traditional group. Their grades dropped, however, to the level of the traditional group when they reverted back to traditional instruction.

Students wrote that they enjoyed the freedom and the trust placed in them. The comment that the materials were suitable and did not rely on reading was also mentioned frequently. Although some missed the classroom interaction, they would choose A-T again as the preferred mode.

There was less absenteeism in the A-T group although the A-T approach reduced problems of administering make-up work. Some students subsequently developed their own high quality A-T learning packets which were added to the course.

With proper planning and execution, individualized instructional materials can be developed to educate the slow learner; hopefully each student can be educated to his or her maximum capacity.

W-2 INDIVIDUALIZING INSTRUCTION IN BIOLOGY AT THE SECONDARY LEVEL

Joseph A. Chambers, Biology Teacher at the Secondary Level, Affton Senior High School, St. Louis, Missouri

In an effort to update our biology program, meet the needs of our students, and to utilize best the time and talents of our teachers, we instigated an individualized program at Affton Senior High in October 1972. Our method of individualizing is through the use of learning packets to teach the various areas in biology. The packets include a brief introduction of the subject to be learned; the objectives to be reached; and the activities, both required and optional, necessary to reach the objectives.

Since all test questions are based on the knowledge and behavioral objectives, the student can take the tests with confidence providing he understands the objectives. The individual student works at his own rate in performing each required activity which includes readings, dissections, experiments, visual aids, and audio cassettes. While each student completes the activities in his particular packet, the teacher is available to help the student with individual problems.

Our observations indicate that it is somewhat difficult to make the transition from a traditional approach in other classes to individualization in biology. However, once the students accept the responsibility, they appreciate the opportunity to learn at their own pace.

W-3 AUDIO-TUTORIAL BIOLOGY – AN INDIVIDUALIZED APPROACH AT JAMES MADISON MEMORIAL HIGH SCHOOL, MADISON, WISCONSIN

James Hein, Biology Teacher, James Madison Memorial High School, Madison, Wisconsin

The individualization of high school biology has taken many different forms, the A-T approach being one of the more popular. The audio-tutorial biology laboratory at Madison Memorial High School was designed, implemented, and operated by this author. Tapes (cassette), 35mm slides, and program materials have been developed by the author, and a large library of filmloops and printed reference materials contribute to the overall program opportunities for students to learn on an individualized basis. The utilization of instructional objectives and objective-based examinations are reinforced through retest opportunities for each student. The philosophy of the laboratory emphasizes continuing student-teacher interaction, doing away with the "mechanical" trap that some A-T programs have fallen into.

The most recent development of the A-T program at Madison Memorial High School has been in connection with the minicourse philosophy undertaken by the biology teachers at Memorial. Prior to this development, the author taught approximately 150 students per year exclusively through the A-T Program. The minicourse opportunity is allowing students to select various minicourses in biology after the completion of a twelve-week core program in some of the basic fundamentals of biology. Many of the minicourses are being offered through the A-T Laboratory – thus more students will have an opportunity to learn biology through the use of an audio-tutorial program that has proven itself to be quite successful.

W-4 A FANTASTIC WAY TO INDIVIDUALIZE SCIENCE IN THE ELEMENTARY SCHOOL

John D. Hunt, Assistant Professor of Science Education, University of Northern Colorado, Greeley

Individualized instruction is not a new concept; it has been practiced for years, usually involving discussions, student-centered activities, and teacher demonstrations. Dwight Allen advocates that individualized instruction should encompass large group, small group, and independent study. This type of instruction was used in an undergraduate elementary science teaching course at Baylor University and is being used at the University of Northern Colorado.

The course was structured according to Robert Glazer's teaching model of four components. The first component, instructional objectives, was stated for each activity in a behavioral mode. Second, the students entering behavior was determined by means of a pre-test at the beginning of the course. The third component, concerning instructional procedures, was process and content-oriented and semi-structured in an inquiry mode. Small group discussions with the instructor present were used as a culminating activity. The last component of Glazer's model involved assessing the students' performance which was achieved by administering a post-test of the paper-pencil type, to each student. Both the pre-test and post-test were identical. The student who met the criteria of 75 percent at the end of the course received an "A" for the course.

To lead to the expected criteria, the instructor spent his energy building up the self-image of all students by reinforcing every activity with praise. No deadlines were imposed.

An important phase of this modular-centered course was the development by the undergraduate student of a multi-media auto-tutorial system with reinforcement and feedback. Research conducted by the instructor substantiates cognitively that behavior can be modified at the 0.01 level of significance for the student with a low IQ as well as one with a high IQ.

Several positive student responses to this course are: increased student interaction with instructor; increased student responsibility for his own learning; the objectives for each activity were stated; the end of the course was seen; and if questions, for certain sections, were answered correctly the student was exempt from activities in class in which 75 percent competency was shown.

W-5 INDIVIDUALIZATION OF PHYSICS FOR INCREASED ENROLLMENT THROUGH MODERN INSTRUCTIONAL TECHNIQUES

Leslie A. King, Physics Teacher, Boyerton Area High School, Boyerton, Pennsylvania, and Michael Szabo, Associate Professor of Science Education, The Pennsylvania State University, University Park

Physics curricula designed to accommodate different student interests or modes of learning never touch students who opt not to study physics. This paper describes a project developed to increase exposure to high school physics.

Local problems attacked by this project were: lack of student interest in physics, inadequate serving of needs or interests of the majority of physics students, and physics teaching with no provisions for accountability of student learning. The solution involved a carefully balanced integration of modern curriculum materials and several of the best known teaching strategies known today. A curriculum which lends itself to individual differences was selected; Project Physics. Behaviorally stated instructional objectives (io) were developed to communicate course expectations and to stimulate self-directed learning.

All students undertake a basic core of ios to assure adequate learning of basic concepts of physics. Beyond these core objectives, each student selects optional ios and appropriate learning activities to correspond with his or her interests and goals. Specific interests, abilities, and goals of each student are assessed through a series of tests at the beginning of the year.

A mastery learning model is used with the core and optional objectives because it is deemed more important to help students arrive at demonstrable levels of physics understanding than to find out who scores higher on a physics examination. Frequent performance level testing is used since progress is regulated by mastery of prerequisite concepts.

Seniors who had completed physics are utilized to help manage the project as student aides. They serve as lab assistants and instructors, clerical recorders, and remedial instructors.

Questionnaire evaluation indicates that student confidence and satisfaction with the course are high. Physics enrollment increased 14 percent after the first year and another 15 percent after the second year of the program. Average scores on standardized physics tests are equivalent to national norms.

This project represents a realistic step that may be taken toward providing more effective physics programs at the high school level.

GROUP X

ENVIRONMENTAL EDUCATION

X-1 THE POLITICS OF ENVIRONMENTAL EDUCATION: SOME INSIGHTS FROM VERMONT

Russell M. Agne, Associate Professor of Education, University of Vermont, Burlington

Vermont is one of the leading states in the United States in taking legislative action on environmental concerns. Questions might be raised however concerning its environmental education effort. This paper chronicles the history of environmental education planning in Vermont during the last several years, and offers suggestions for those considering statewide environmental education planning.

A conference held in May 1973 brought together representatives of the public schools, government (state and federal) agencies, colleges and universities, and a variety of private environmental groups. A great deal of useful information about the politics of environmental education was derived from this working session. Judgments were made which formed the basis for directing future efforts such as a Governor's Conference on Environmental Education held in October 1973.

X-2 BACKPACKING IN THE SCIENCE CURRICULUM

Stanley O. Martin, Secondary Science Supervisor, Topeka Public Schools, Topeka, Kansas

For the past three summers, the Topeka Public Schools has offered its high school students an opportunity to study ecology and geology in a field-study setting. The purpose of this field-study course is to provide students an opportunity to acquire an understanding and appreciation of their natural environment through outdoor experiences with ecology, geology, and camping. The major features of this course are several weekend outings which serve as training sessions, and a 16-day field trip through Kansas, Colorado, Wyoming, and Nebraska in late July. Pre-field-trip activities emphasize basic ecological and geological field study techniques as well as the learning of camping skills. Hiking and backpacking play an important role in bringing the student into a close relationship with his natural environment.

A slide presentation shows the importance of this type of science course offering in today's science curriculum. Detailed planning and curricular materials used in this course are available.

X-3 AN INNOVATIVE ENVIRONMENTAL SCIENCE EDUCATION PROGRAM FOR SECONDARY SCHOOL SCIENCE TEACHERS

Harold J. McKenna, Assistant Professor, The City College of New York, New York

An innovative master's degree program which was problem focused (each course in the program develops content around specific environmental problems); interdisciplinary (concepts from both the natural and social sciences are integrated into each course);

intradisciplinary (content, teaching methods, and action involvement are incorporated into each course). All courses in the program have the title ESE (Environmental Science Education) and are offered on a sliding credit scale, whereby students select the number of credits they wish (one to three).

Using a course in human ecology as a working model of the program, instruments were developed to determine the extent of:

1. Student involvement in various activities (such as committee participation, club formation, journal reading) could be determined as a result of having taken the course;
2. Student use of seven identified teaching methods (such as discussion, oral report, parable, and problem-solving) could be observed;
3. Acquisition of basic concepts in environmental science education could be determined.

The results of the evaluation are as follows:

1. Nine activities were identified as having a marked increase as a result of students having taken the course in human ecology. Of the nine activities, four – attending meetings in environmental education on a regular basis, reading environmental science journals and books, taking personal action on the community level, and developing new courses, clubs, and curricula at the secondary school level – showed the greatest increase of involvement by students.
2. Five of the teaching methods – discussion, problem-solving, case study, oral report, and audiovisual – were used by 45 percent or more of the nine teachers observed.
3. Twenty-five of the 42 basic environmental science concepts developed in the course were used by 33 percent or more of the nine teachers observed.

In summary, this study demonstrates that teachers of science at the secondary level can: use major concepts from an environmental science education course, incorporate methodology developed in the course into their own teaching at the secondary level, and become actively involved in community activities as a result of special training.

X-4 OUR NATIONAL PARKS – AN INTERESTING STUDY

Robert M. Schumacher, Teacher and Science Chairman, Yorkville Community Unit No. 115, Circle Center School, Yorkville, Illinois

This presentation describes an eighth-grade earth science unit which demonstrates how the geology, the geography, and the meteorology of our national parks combine to make an environment for a unique set of living things -- the plants and animals in the parks. The study of our national parks is a means of integrating all of the sciences -- the earth sciences, the life sciences, and the physical sciences - and seeing how they complement each other. Students are challenged to use all of their language arts skills as they are exposed to the ecology and conservation of our natural resources in real situations.

The unit is appropriate as a minicourse, an individual assignment, or a group study. Students or committees participate in a research project after obtaining sufficient guidance to ferret out information from library, park service, and other sources. Research projects culminate in the preparation and presentation of an oral and a written report, delivered to the class with the confidence of an expert. Each student prepares a variety of visual aids which include maps, graphs, charts, drawings, models, and pictures. Many students find a certain feature of the park very interesting and do further research on this topic.

Students enjoy studying our national parks, and learning how to use their leisure time and to appreciate our country's untamed wilderness areas.

X-5 MARINE SCIENCE: FIELD TRIPS FROM NEBRASKA TO THE GULF OF MEXICO

Gary Brown and Jack Head, Science Education Specialists, ESU 3-OSACS Science Center, Gretna, Nebraska

Twice each year, 16 Nebraska high school students travel with the ESU 3-OSACS Science Center staff to the Gulf of Mexico, where they visit the University of Texas Marine Science Institute at Port Aransas. The group camps enroute and then resides at the dorm facilities while visiting the Marine Institute. Included in the week's activities on the Gulf Coast are: the study of plant and animal life, collection methods, tides, currents, navigation, food webs, and research in marine science. Many of these activities are conducted aboard the Marine Institute's research vessels.

As many as two hundred and fifty living marine specimens have been returned to Nebraska during a single Gulf Coast trip. The school of each participating student is then provided with a saltwater aquarium and several specimens. The remaining specimens are kept on display in the live room at the Science Center.

GROUP Y

CHEMISTRY (SECONDARY)

Y-1 THE IMPACT OF AMERICAN CHEMISTRY PROGRAMS ON SCIENCE CURRICULUM WORK IN NIGERIA

Sam 'Tunde Bajah, Lecturer, Department of Education, University of Ibadan, Ibadan, Nigeria

Science education in Nigeria has had phenomenal growth during the last five years. The Science Teachers Association of Nigeria (STAN), aided by funding organizations such as the Ford Foundation through CESAC (Comparative Education Study and Adaptation Centre), the British Council, West African Examinations Council (WAEC), the State and Federal Ministries of Education, developed within this period (1968-1972) a number of curricular materials in biology, chemistry and physics. The primary focus seems to be in the production of science books. There is no doubt that the impetus for this innovative work in science education in Nigeria has been catalysed by trends in other parts of the world - America, Scotland, and the United Kingdom. This paper focuses on the influence of the American programs on curriculum in Nigeria.

Curriculum planning in Nigeria, as in many other advanced countries involves at least two very different kinds of processes. First, there are political and legal considerations. Controlling agencies such as the Ministries of Education and the West African Examinations Council set forth guidelines which sometimes take on the character of law. Second, curriculum planning is a substantive enterprise in that it has certain perennial foci of intellectual attention, commonly identified as considerations of ends and means. While it may be unrealistic to expect packaged programs which can simply be adopted as complete units in a developing country, it is clear that well-developed programs can often be implemented by a teacher or school system with relatively slight modification to fit the particular local circumstances.

Y-2 CHEMICAL ANALYSIS – A HIGH SCHOOL MINICOURSE

Jon R. Thompson, Chemistry Teacher, General William Mitchell High School, Colorado Springs, Colorado

To increase relevancy in science courses and expose previous chemistry students to specialized topics our chemistry course at Mitchell High School includes minicourses. As chemical analysis is a very large and important portion of the chemical industry which is often only touched upon in most high school chemistry courses, one specialized minicourse is devoted to exploring types of analysis.

The eight-week minicourse schedules students to meet in a structured class once or twice each week. During these meetings they are taught the basic theories behind certain methods of analysis. Articles and reprints of such journals as *Scientific American* and *Chemistry* are utilized to explain topics related to analysis.

Students are required to do six experiments on the following topics: ion exchange, column chromatography, visible spectrophotometry, nephelometry, infrared spectrophotometry, ultraviolet spectrophotometry, nuclear magnetic resonance, gravimetric analysis, volumetric analysis (titration). Another two experiments are chosen from several available and performed during student unstructured time (open laboratory: Mitchell is on modular scheduling).

All students:

1. Do an unknown on the IR Spectrophotometer as part of a field trip to the University of Colorado Organic Laboratory.
2. Build their own simple gas chromatograph and do an unknown with it.
3. Complete an analysis using ion exchange prior to a field trip to Holly Sugar Research Laboratory where ion exchange technique is used.
4. Complete an analysis using the visible spectrophotometer prior to visiting a local science facility (Kaman Sciences Corporation) that has an atomic absorption spectrometer.

Other correlated field trips and experiments are also included.

Students learn the basics in the laboratory and see or study it firsthand just a few days later in the real industrial laboratory. Course participants indicate that they have seen chemistry in action for the first time and realize more fully the need to study certain laws and theories.

Y-3 CHEMISTRY PERFORMANCE EVALUATION: A NEW TECHNIQUE

William M. Frase, Chemistry Teacher, Fairview High School, Fairview Park, Ohio

The chemistry curriculum, like that of the other sciences, has changed from an emphasis on rote memorization and text orientation to the "discovery approach" which has a greater emphasis on laboratory experiences.

There has been little, if any, change in evaluation techniques to meet the needs of this new curriculum. Time honored pencil-paper types of evaluation, which in most cases have no relevance to what the student learns in the laboratory, are still being used. For several years, I have used a method of evaluation called a laboratory practical which meets the needs of the new curriculum and carries a high validity in the measurement of student comprehension and student application of learning skills.

Practicals are not new to the biological sciences; where they have come to mean tests in which students move from station to station at specific time intervals, identifying preserved specimens or objects under microscopes. However, the ramifications of this method for chemistry as well as other laboratory sciences are many. Instead of using mere identifications, the imaginative instructor can measure laboratory skills and evaluate learning at different levels of comprehension.

As an example, stations might include such basic skills as weighing, measuring, running chemical tests on the comprehension and application levels, deciding the proper apparatus to synthesize an organic compound, or interpreting an infrared spectrophotometer reading on the analysis or synthesis levels.

Presented are: procedures of implementation; the pros and cons of this technique; a statistical analysis and validity data pertaining to this method's viability as an evaluative tool not only to chemistry but to all the laboratory sciences.

Y-4 MODULAR APPROACH TO NINTH GRADE CHEMISTRY AND PHYSICS

Gary E. Dunkleberger and Ruth W. Smith, Science Teachers, Alexis I. duPont High School, Dover, Delaware

In an attempt to promote a greater retention of concepts in the area of introductory chemistry and physics, Alexis I. duPont High School has implemented a modular approach to laboratory activities. Modularization has occurred by structuring the lab phase of the freshman chemistry-physics course into small self-contained units relating to seminar discussions. Students utilize a computer-assisted testing format to self-pace through laboratory activities with an option to return to difficult segments. Evaluation of student progress is made by randomly generated criterion-referenced test items associated with specific objectives for that particular laboratory module. At the conclusion of each quiz, individual students receive a series of computer-generated remedial commands for each concept found to be deficient. After completing the remedial activities, students have the option to receive a requiz on the same concepts.

This project was funded by Del Mod in its developmental stages. It is an example of the projects possible with joint efforts between local districts, organizations such as Del Mod, and the Delaware State Department of Public Instruction.

Y-5 AN EXPERIMENT IN SOLID STATE CHEMISTRY: THE CRYSTALLOGRAPHIC MICROSTRUCTURE OF ZINC

John Bycoskie, Department Chairman and Chemistry Teacher, Downingtown Area Schools, Downingtown, Pennsylvania

Solids differ from fluids or gases in that the atoms or molecules of which solids are composed are in a lower energy state than they are when in the liquid or gas form. The randomness of location and the motion and energy of the components within a solid are of low degree. The components tend to be arranged in a structure which shows long range regularity, and their motions and energy consist primarily of vibrations about fixed points in this regular structure.

An orderly arrangement of particles as described which extends far enough in three dimensions through the material is considered a crystal or grain. An array of crystals of various orientations is typical of a solid material such as zinc. Within any particular crystal of zinc all of the atoms of zinc are arranged with one particular orientation and pattern.

Adjoining crystal sides in three dimensions constitute a crystal or grain boundary which may be revealed by proper physical and chemical means. Ordinarily a material (in this case zinc) is smoothly polished and then chemically attached or etched for a relatively short period of time with an appropriate etchant. The atoms of zinc in the vicinity of the crystal boundaries will dissolve more rapidly than other atoms within the crystal because of higher energy considerations and will leave a line (or crystal boundary) which can be seen with a microscope or even with the naked eye. Zinc is unique in the laboratory for two reasons: unusual equipment or materials are not required, and the hexagonal close-packed structure can easily be seen.

Y-6 HOW SCIENCE TEACHERS CAN HELP THEIR STUDENTS BETTER UNDERSTAND THE MATHEMATICAL EXPRESSION OF CHEMICAL CONCEPTS

Susan Abramowitz, Doctoral Candidate, School of Education, Stanford University, Stanford, California

Chemistry teachers often complain of the difficulty their students have in handling scientific concepts that are expressed mathematically. Some of the methods that teachers use to help their students understand problems involving stoichiometric and gas law relations are the "factor-label" method of dimensional analysis, reasoning from knowledge of the physical relations involved, and rote learning of formulae. The underlying assumption in this paper is that these problems are difficult because they demand an understanding of proportionality.

Knowledge about how children acquire an understanding of proportionality has been generated primarily by developmental psychologists, such as Piaget and Robert Karplus. Teachers, however, have ample opportunity to investigate this problem. When existing teaching techniques are not successful, teachers are expected to try out new ones, and "subjects" for these trials are readily available.

Suggestions that classroom teachers themselves might use to help their students understand proportionality and work with related chemical concepts are given. These suggestions include a series of activities involving measurement and the mole concept drawn, in part, from the author's experience in teaching to chemistry classes in Washington, D.C. She noted substantial improvement in her students' ability to handle chemistry problems involving proportionality by the end of the year in which she used these activities.

GROUP Z

MEASUREMENT AND THE METRIC SYSTEM

Z-1 PRINCIPLES OF PRECISION

Mary Ellen Quinn, Chairman of the Division of Natural Science and Mathematics, Immaculata College of Washington, Washington, D.C.

The demand, "Be more precise!" is one frequently heard in science classrooms. Although students seldom ask the meaning of such a request, they will most often respond with a simple repetition of an observation or of a complete experiment. Other students may make more careful measurements, reporting experimental results with an accuracy of three decimal places instead of the original two. A philosophical analysis of the term "precise" as it is used in the natural sciences provided the basis for constructing a set of principles of precision set forth in this paper.

This report relates the development of a set of principles of precision to be used in measuring the quality of hypotheses elicited during an experiment in teaching hypothesis formation to sixth-grade children. However, not only can the principles be used to ascertain the precision of hypotheses; they also permit a determination of the precision of other inquiry skills, such as, observing, classifying, inferring, and predicting. Since the principles of precision apply also to various inquiry skills, they are applicable to the different areas of science including biology, chemistry, physics, and earth science.

Z-2 GOING METRIC IN THE ELEMENTARY SCHOOL: SOME HAPPY IMPLICATIONS

Linda Jones, Assistant Professor of Education, Department of Elementary Education, California State University, Northridge

The most formidable obstacle to going metric in elementary schools is the apprehension it arouses in teachers. It is only natural to fear the unknown, but once teachers recognize the simplicity and usefulness of the metric system through pleasant firsthand experiences the unknown will recede and they will be ready to tackle the more realistic problems of implementation.

The advantages of going metric are greater than the obvious one of simplifying computation. Among the shifts and changes will be more and better instruction in measurement and place value and less emphasis on common fractions. The value of firsthand experiences with real objects in measurement will be recognized and, it is hoped, applied in other areas of the curriculum as well. Science activities offer the most practical context for learning to "think metric." As the state departments of education turn attention to the implementation of metric instruction, many opportunities to improve science instruction should result.

The above considerations will come into view gradually and may not be apparent during the first year or two of metric instruction. What is bound to be a problem at first is the acquisition of suitable, inexpensive materials. Although commercial suppliers are beginning to offer some metric materials now, there will probably be a lag between supply and demand during the early phases of changeover. Teacher- and pupil-constructed materials will be very important. The learning potential in the process of such construction should become apparent during the lag period and, it is hoped, will be included as a regular part of the curriculum even when commercial supply becomes adequate. Several construction ideas and techniques are discussed.

Z-3 ELEMENTARY SCHOOL GRADE LEVELS APPROPRIATE FOR TEACHING THE METRIC SYSTEM

Theodore John Bargmann, Science Coordinator, Lincolnwood Schools, Lincolnwood, Illinois

Whereas gradual changeover to the metric system in this country now seems almost certain, there is a need to investigate how and when metric measurement should be taught in school programs. The study reported here is concerned with identification of elementary school grade levels appropriate for teaching certain skills and understandings of the metric system. The study also revealed some difficulties which elementary school teachers may encounter in teaching the metric system.

A teaching unit emphasizing student discovery was developed and then taught by the research to a sample of 201 children in grades three through six. Using analysis of covariance, pupil achievement in learning the metric system was compared for the four grade levels on fourteen criteria. In consideration of the results of this analysis and of achievement levels on various tests used, the following guidelines were formulated to indicate those grade levels at which different aspects of the metric system may be taught:

1. At grade three, or possibly even before, the following may be taught: (a) understanding the meaning and approximate sizes of various metric units of length, liquid volume, and weight; (b) ability to measure length, liquid volume, and weight using whole numbers; (c) understanding the organization of the metric system by multiples of tens; and (d) ability to perform simple conversions between metric units using whole numbers.
2. At grade four, the phases of the metric system given in number 1 and also the determination of area and cubic volume may be taught.
3. At grade five, the phases of the metric system given in number 1 and number 2 and also the following may be taught: (a) ability to measure length, liquid volume, and weight using decimals; and (b) ability to perform conversions between metric units using decimals.
4. At grade six, the phases of the metric system given in number 1, number 2, and number 3 may be taught.