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ABSTRACT

This publication is a compilation of the addresses and reports presented at the twenty-first annual meeting of the National Science Teachers Association (NSTA) held at Detroit, Michigan, in 1973. The materials were assembled from advance texts and abstracts presented by the program speakers and from on-the-spot reports from many of the panel sessions. The speeches delivered at the luncheon, banquet, and general sessions are presented in full. Complete reports and synopses are provided for the concurrent sessions of the Association for the Education of Teachers in Science, the Council for Elementary Science International, the National Science Supervisors Association, and for the NSTA concurrent panels and symposia. Abstracts of the NSTA-Sunoco science seminars and other papers contributed at group sessions during the conference are also included. (JR)

nsta twenty-first annual meeting

ADDRESSES AND REPORTS

Detroit, Michigan • March 30-April 3, 1973

NATIONAL SCIENCE TEACHERS ASSOCIATION
1201 Sixteenth St., N. W., Washington, D. C. 20036

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AETS — Association for the Education of Teachers in Science

CESI — Council for Elementary Science International

NAIEC — National Association for Industry-Education Cooperation

NSSA — National Science Supervisors Association

NSTA — National Science Teachers Association

SECTION PROGRAMS

AETS-NSSA ANNUAL LUNCHEON

STRIVING FOR SUBJECT MATTER THAT MATTERS

Kenneth W. Horn, Administrator of Environmental Education, Denver Public Schools, Denver, Colorado

I have been a science and biology teacher for nine years, a science supervisor for four years, and during the last five years I have worked in the field of environmental education. Although this in itself is not an uncommon experience, and provides me with no special set of credentials for today's discussion, it has given me a personal opportunity to have many varied and direct encounters in the spectrum of education.

These many varied teaching and administrative experiences, and my move from a basic academic curriculum to a relatively new area titled "Environmental Education," have given me some insight into the absolute stupidity of some of my own past teaching strategies. I have also gained some insight into and understanding of the incredible, inefficient, and antiquated educational machinery which turns out a large percentage of its products, students who are partially or totally "mistooled" or "poorly programmed," for a society in which they must function.

The one primary question, which I cannot fathom, is whether the many parts (people) are fouling the education machine or whether the basic machine structure (educational system and structure), is fouling the many parts, in order to cause so many of the machine's products to be poorly cast for their societal roles. I think everyone in this room who plays a part in the educational machine hopes he or she is part of the solution, rather than a part of the problem—but are we?

In some wilderness areas of this country there are still a few forests with dense stands of trees, so dense in fact that when the old trees die they cannot fall; they slowly decay where they stand. This is analogous to the state of the curriculum in our schools.

Our present curriculum is so crowded that any attempt to introduce new concepts or content, usually evokes anguished cries from all levels of education from teachers to the boards of education—"Impossible," "No room," or "Not enough money," or "Not enough time." But what is it that elicits these pitiful tear-jerking complaints? Do you hear such anguished cries concerning the teaching of the myriad facts of ancient histories and the early wars; the endless intricacies of irregular verbs; the mentally taxing endeavors of learning fundamental chemical processes involved in the Krebs Cycle; or the seemingly endless practice of learning mathematical computations for which there appear to be no application?—Rarely! The old giants just stand there on the hallowed ground they haved owned for so long; and if there is any hint that one academic species is taking up more room than another, or that a new species is making inroads, there usually arises screams of a territorial imperative not unlike those sounds of a coyote or a fox entering the henhouse

The usual pattern which emerges, if new concepts or course content can be convincingly sold at some educational level, is a grudging addition of a new elective course to be imparted to a few select students, or perhaps the addition of a unit or two into the existing disciplinary giants. This is usually accompanied by a statement from some administrative level that it must be done with little or no money. Perhaps there is an educational "law of rigor mortis" which says that academic giants have proved their value in the past; therefore, you get little or no support until you prove yourself to be better than they are. Yet none will tell you what proof will be accepted or believed. Above all, the message is, please leave undisturbed the basic academic monoliths!

Why are these academic giants so protected when more and more evidence indicates that they are not meeting the needs of today's students or preparing them for the world of tomorrow? The obvious truth is that the basic curriculum of our schools is crowded, and it is crowded because it continues to support a lot of deadwood, deadwood that has been standing for a long time. The obvious answer, and the best thing which could occur, is to go through and clear out all of the curricular deadwood. It may even be appropriate to apply the United States Forest Service concept of "clear cutting" to solve this problem, starting over again very selectively with a new set of criteria which would meet the needs of the youth of today and tomorrow. Whatever process is necessary, the curriculum must be updated to include what is important and to throw out that which is useless.

If I appear to be concerned about all this, I am. It is because through my past experiences I have had the opportunity to observe the unique process by which the old giants are being jealously guarded, and the inordinate struggle by individuals and groups to accomplish significant innovative change in education. The terrible frustration is that you are only one small part and unable to do anything about it. Again, is it the machine, the parts, or both?

At the same time, I have observed individual academic teachers and administrators with special vested interests in the various academic areas, establishing special trivia courses which fulfill their own scholarly ends, with little trouble. Perhaps there is another educational law which states that only through the standard academic areas can any significant change in education occur. Anything really new in content is treated as if it were some monster, some disease-carrying mutant to be totally feared and resisted, at all costs spare the giants.

It appears that educational methodology, at all levels, is fostering a common intellectual fallacy in this whole area, although there is probably a good rationale for it. We have all become victims of the knowledge explosion. Consider the growth in the following statistics: Twenty-five percent of all persons who ever lived are alive today; 90% of all scientists who ever lived are alive today; the amount of technical information available doubles every ten years; 50% of what we know about chemistry has been learned since 1950; approximately one-hundred-thousand journals, in 60 languages, are being published around the world. Scholarly research papers, equivalent to two complete sets of Encyclopaedia Britannica, are being published each week in biology, alone. And while the total available information continues to expand at an incredible rate, we must remember the equally staggering phenomena of present information which is being made obsolete by the new. But to date, as educators, we have found no effective means to get rid of the obsolete information. Therefore, we continue to accumulate

The reaction to this knowledge explosion in the field of education is to support and harbor the continual growth of specialization and departmentalization, subdividing our disciplines into smaller and smaller manageable units. Thus, students learn more and more about less and less. As educators, we have become so carried away with the pieces that we have completely overlooked the total view, or have assumed that students can somehow put all of these pieces of education together by themselves into a total world view which somehow prepares them for living in tomorrow's society.

It is tragic that the educational machine continues to concentrate on turning out students acquiring smaller and smaller pieces of information, which have greater and greater chances of being mistooled, so that students may never be able to form a complete picture out of the information, or they will have a partially completed picture of the world which has so many holes in it that the individual becomes a societal cripple. And all of this through no fault of his own. If the average student today emerges from our educational machine with a sense of how the world is held together, and his particular role in it, he does so in spite of us and only rarely because of us.

Up to this point I have been discussing what I generally perceive to be wrong in education. Because I have observed this phenomena, I am not ready to throw up my hands in disgust and quit. I think we must all work to solve these problems and strive to teach subject matter that matters.

Education is up against enormous problems, and it is being criticized on all fronts and from all levels of society. Finding the solutions cannot wait much longer. We must develop, in the next few years, the necessary skills and tools to make the fundamental changes in our present helter-skelter piecemeal approach to the solution of educational problems; particularly in the area of curriculum reform and educational management.

While the changes in our society are occurring at a phenomenally increasing rate, with all of the elements of "Future Shock," the education machine continues to plod along in its old rut, at its own rate, and appears to be almost oblivious to events occurring in the real world. Could it be that the old academic giants, and those who work for them are contributing to the rigor-mortis so prevalent in the educational system?

No previous generation of educators has had to contend with these rapid societal changes. No previous democratic society has ever learned to plan and carry out measures of the complexity and magnitude demanded in solving our critical education problems. Yet this generation must develop the technical and social mechanisms to save our planet and our youth of future generations.

Science educators are a very intelligent lot and as educators have been more favorable to change than educators in the other subject disciplines. I believe that science educators have provided more leadership in bringing about educational change than have those in other subject disciplines. You, as science educators, must assist in giving this generation of youth the necessary awareness, understanding, and values concerning their world. If you do not, who will? Passing the buck back and forth between the academic giants will not solve the problems.

I would like to give an example of the relevancy gap existing in education, and the total lack of competency in meeting the needs of our youth. It is a known fact that the work ethic in this country is being seriously questioned. We also see the national movement toward the four-day and in some rare places, the three-day work week for the labor force in this country. Everyone has read and heard about the fact that we have a recreation-oriented society. Yet more and more research by sociologists indicates that many, if not most people entering old age or experiencing the four-day week, are totally unprepared for their unaccustomed leisure time, and they do not have the background to carry out the individual lifetime leisure skills.

Now I ask you—what are most physical education departments doing for the masses of students, from kindergarten through grade twelve, in our schools today? Practically the entire program of physical education in our schools leans on team sports: football, basketball, baseball, and volleyball. What percentage of the time is devoted to teaching our youth individual lifetime leisure skills such as archery, golfing, hiking, snowshoeing, ski touring, outdoor camping? Each of you can answer that, it is so obvious, yet you see no radical program to adjust this area of curriculum to the critical needs of the students.

In defense of the physical education people, the reason for this lack of training in individual lifetime leisure skills is quite simple. In our schools, physical education is considered the school's dumping ground. It is quite difficult for a physical education teacher with 70 students at one time to carry on much of anything other than team sports. Also, team sports are cheap. You can throw a ball out to 40 kids and let them go at it. Team sports solve an administrative and economic problem, but, totally shortchange the majority of our youth. Are we ever going to think more about the needs of the kids than administrative and budgetary expediency.

The kids in our schools are extremely concerned about this, and I can assure you that if we do not take the responsibility for the needed changes, the youth of this country will make the changes for us. They will do it simply out of sheer desire and numbers, regardless of our likes and dislikes. Many of the academic giants are dying for lack of support at various academic levels, a direct result of the rejection by the youth of this country of the present curriculum offerings.

If all of these changes are imperative, what are the sciences doing to qualify youth to achieve the great societal tasks? And what relationship is there between our school science curriculum and what our kids are faced with? For too long too many science teachers have felt great urgency and need for all students to know all there is to know about the energy flow within the individual living cell, or the energy in a chemical molecule, or the energy stored in a condenser; without relating it to the everyday world. There is not a similar urgency to have students acquire the knowledge and the ability to save the nation's energy supply for future generations.

The overall problem is best stated by Ken Boulding economics professor of the University of Colorado, who says, The principal task of education in this day is to convey from one generation to the next a rich image of the total earth. That is, the idea of the earth as a total system. What formal education has to do is to produce people who are fit to be inhabitants of the planet. This has become an urgent necessity because for the first time in human history, we have reached the boundaries of our planet and found that it is a small one at that. This generation of young people have to be prepared to live in a very small and crowded spaceship. Otherwise they are going to have a terrible shock when they grow up and discover that we have taught them how to live in a world long gone.

I have also observed in my experiences, a horrible cop-out by many educators, that the government, and particularly the United States Office of Education, has all of the answers and all of the solutions for all of the problems of education. They may have the money, at least they did, but I certainly question whether they have the answers. I would like you to hear an excerpt from an article written by Dr. Hendrik Gideonse, Dean, School of Education, University of Cincinnati, "The Potential of Educational Futures," published by Charles Jones Publishing Company, 1972. (Previously Gideonse was Assistant Secretary in USOE.)

> Throughout government, the average tenure of an assistant secretary is less than twenty-three months. With each new man comes a new set of priorities, a profound desire to accomplish something significant, and a period of substantial upheaval. None of these circumstances are especially conducive to the kind of work which aims at the patient, systematic exploration of the linkages between policy options, the likely primary, secondary, and tertiary outcomes of these options, and the attention to consequences over long periods of time.
>
> Numerous critics of USOE see it as an agency staffed by the largest collection of incompetents ever assembled under the pretense of being a professional agency. But, in fact, OE behaves as if it either knows, or is in the position to know better than anyone else in the country, what the best solutions are for curing the educational woes of the nation. In short, its posture is basically elitist in character. Insofar as it is, the Office of Education simply does not hear messages that would require it to be something else other than a monopoly of policy power which it would like to see itself wielding. Finally, another reason why national education policies have been unaffected by the work supported by the Office of Education is quite simply that OE is not the place where educational policy is made in the Executive Branch. In fact, such policy is made in HEW and in the White House and, if not there, in the education panels of the Office of Science and Technology, or in the Office of Management and Budget. Policy development turns out to be far more often a matter of squeaky wheels, personalities, and sheer political opportunism, although on the margins it is possible for the application of logic and reason to have some effect. Although this must sound pretty dismal, it should. For that is the way policy development in the Office of Education now takes place.

The situation in the United States Office of Education, and probably education in general, is probably best summarized by the Petronius Principle—from Petronius Arbiter, ca. 60 A.D. in which he stated,

> We trained hard, but it seems every time we were beginning to form up into teams, we would be reorganized. I was to later learn in life that we tend to meet our new situations by reorganizing, and what a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency, and demoralization.

What is relevant curriculum? It is meaningful though not necessarily new. It is important to modern existence. It has adapted to the changing conditions of life, based on *timeliness*, not *timelessness*. It is more than just a collection of traditional activities. It is purposeful, or it is not an education. Our curriculum has simply not adapted to the changing conditions of our way of life. What is termed experimental or innovative is often just a new approach to the same old thing.

I would like to quote Dr. Noel McInnis from an article titled "Teaching More With Less" in which he states:

> Radical new ways of educating our youth for tomorrow would be, quite simply, to teach our discipline. Yet most of us do not teach our discipline. We teach what our discipline is about. We teach a volume of knowledge rather than the key to its usefulness, the how of it . . . survey courses in almost all disciplines are becoming increasingly impractical, because of their compulsive attempt to cover all, so-called relevant information. They could be made highly practical once again—or perhaps for the first time—if they were organized to convey the five or six most fundamental organizing and conceptual principles of the discipline and utilizing only the most immediately relevant information to bring the principles to life.

What must educators do generally, and in science specifically, to meet the needs of youth?

1. We must sacrifice some of the traditional chapters found in all subject disciplines, because they are not doing the job and replace them with effective information if we are to solve today's and tomorrow's problems in our society. Like the early western pioneers, we may have to throw out some of our cherished articles if we are to reach our destination.
2. We must directly relate our curriculum to the current problems in society and the world—environmental deterioration, career opportunities, population overgrowth, urbanization, central-city decay, racism, poverty, injustice, health care, alienation of our youth, drugs, crime, etc. The solution to any one of these requires an enormous amount of education and skillful effort. The problem is that they must all be worked on at the same time—the task is staggering!

   What is needed? Curricula which face the problem head on, rather than incidental treatment through an elective course for a few individuals or a one-week unit in a traditional course. If anything, these problems should be the core of our curriculum. And the way to make new curricula is to decide that which is most important, cut out the fluff, and then have the guts to implement the decisions.

3. Education must begin looking outside of itself for the answers. We must go straight to the lives of people—particularly to the youth in our society, to attain the needed curriculum changes. We can no longer afford to simply reshuffle the old curriculum and call it new—there really is nothing sacred about our present curriculum content—although some persons who have worked with it for a few years think there is. Curricula must be made for our youth—not the youth for our curricula.

I would like to close by quoting Dr. Paul DeHart Hurd's 1972 NSTA Convention address in which he said something that I think should be imprinted on the mind of every science teacher and repeated over and over.

> One of the most important issues to consider is how to bridge the various gaps that exist between science, society, technology, the individual, and the school curriculum. We require a new vision about the kind of world we can possibly achieve with the resources of science and what individuals prize most in their life. To achieve these broad purposes will require that science be taught with as much emphasis upon its application to human affairs as upon its theoretical structure and investigative approach. It is evident that science has become linked in various ways to nearly all aspects of human existence. No longer ought science be taught as a subject valued for itself, independent of the rest of society, governed by its own rules and directed entirely by its own policies.

I think he beautifully, but simply, summed up the problems which science must address itself to.

In regard to methodology of teaching, I would have to show my obvious biases and say that somehow we have forgotten that we learn best by tasting, touching, smelling, hearing, seeing, doing and (emotional feeling)—the more of these we can incorporate into the learning process, the more effective is the learning. The standard four-wall classroom generally emphasizes seeing and hearing. Although, fortunately, science educators and science curriculum emphasize doing, much of the doing is still vicarious learning. I think Environmental Studies in Boulder, Colorado, has said it best when it proposed that educators escape the classroom, and go outside into the real world. There is a fantastic wealth of natural and man-made materials just outside the classroom and around all schools, but we have for too long been conditioned to the idea that learning only takes place inside a classroom. In the early history of teaching, it was almost exclusively in the out-of-doors. Through time, it moved inside—maybe it's about time we reverse this trend and return outside so that children can optimize their learning through the use of all of their senses. I think we could all take a lesson from a bulletin I observed which said that one direct experience in the environment is worth 1,000 pictures.

In conclusion, I would like to recommend for your reading, if you have not already done so, the February 1973 issue of *The Science Teacher*. I was very pleased to find a number of excellent articles which were devoted to alternative types of science programs which could meet the critical needs of our youth.

AETS CONCURRENT SESSIONS

SESSION C

AN OVERVIEW OF BRITISH TEACHER CENTERS—A MODEL FOR AMERICAN EDUCATION?

Richard D. Konicek, Associate Professor of Education, University of Massachusetts, Amherst

On a U.S. Office of Education grant, Philip Woodruff, Assistant Superintendent, Westport, Connecticut, Public Schools, and I visited some thirty British Teacher Centers. These Centers ranged from groups of teachers and administrators without a building to very complex centers with budgets of as much as eight to ten thousand pounds. The primary goal of each of these Teacher Centers was to provide a place and some expertise in terms of consultants for teachers to share ideas about their teaching and to adapt curriculum to individual needs. Retreading or changing the teachers in the field was not a major goal of the Centers. Instead, their major thrust was that of extending the teacher's expertise concerning students and teaching environment to the point that he or she was allowed to make changes in curriculum to suit these individual needs. Since much of the British educational system is based upon trust from the administration down to the teachers, it is felt that this model was particularly appropriate for British schools.

There is some doubt as to the appropriateness of this model for American schools. Innovations in America too often suffer the harassment of too demanding evaluations, too insistent production expectations and schedules, and too high a performance level. A Teacher Center leader and a committee must have time to work out their working arrangements, develop their own priorities in response to local teacher needs, and prepare the programs they deem necessary. Since teachers now express almost unremitting skepticism about universities and colleges of education, about instant experts with instant workshops, about the circus of lectures, about the plethora of books condemning their present practices but offering little relief, about the government's program in rhetoric, about the ability of state department and federal department educational bureaucrats; another educational device to do something for teachers will scarcely meet with overwhelming enthusiasm—unless someone is prepared to give teachers opportunity and money and time. Then, something might happen. Here, it would seem the British model is most instructive.

Thus, the Teacher Center Movement in Britain attracts because it is visible evidence of the authorities' respect in caring for its teachers for their participation in their own growth and development. We may not want or need the kind of Teacher Center development the British have come to have, but we very much want and need, it would seem, some measure of official authority legitimizing and supporting the development of the means whereby teachers may find time, resources, professional assistance, and equipment and materials to help them grow personally and professionally *as they deem necessary*. The ultimate lesson of the British Teacher Center Movement may be that teachers, indeed, can be trusted to govern, direct, and implement programs of self and mutual growth and improvement

SESSION E

APPLICATIONS OF MODELING, FEEDBACK, REINFORCEMENT, AND PRACTICE IN SCIENCE TEACHER EDUCATION

John J. Koran, Jr., Chairman; and John T. Wilson, Graduate Assistant; Department of Science Education, University of Florida, Gainesville

There is a considerable body of theory, basic research and applied research in the area of using live, film-mediated, or written models for influencing teacher behavior. [1, 2] Similarly, feedback and practice variables have been explored and some generalizations about these variables have become possible in the training context. [3] This presentation deals with the practical applications of these findings to science teacher training. Examples of training, supervisory strategies, and criterion performance using specific teacher behaviors and concepts and processes of science are also provided.

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SESSION G

"FUTURING" ABOUT SCIENCE EDUCATION

Paul DeHart Hurd, Professor of Education Emeritus, Stanford University, Stanford, California

Accompanying the development of the new science curricula during the 1960s was a massive effort to retrain teachers to manage these innovative programs. In a 10-year period federal and private agencies spent nearly one billion dollars to improve the teaching of science. The payoff may be broadly described as disappointing and in turn has contributed to a loss of confidence in teacher education programs. Newly trained graduates today, for the most part, are no more competent to manage modern science courses than were teachers of 15 years ago

It seems to me that a major question is: What sort of changes will be necessary to establish a widespread feeling of legitimacy in science teacher education? The timing for this discussion could not be better. 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.

Recall some of the tremendous changes in American society that have occurred in the past decade—changes so great that their impact on people is being compared to the displacements that resulted from the introduction of agriculture some 5,000 years ago. Think about the major transformations in our economy, in life styles, in occupational demands, in our sense of values, in the influence of technology, and in social disorganization. One of the most significant changes has been in the character of the scientific enterprise: its dependence upon technology, its movement toward a moral science, and the questioning of its explanatory systems The surplus of scientists and science teachers, and the problems of overskill are no less important. A majority of the teacher-education programs of the 1970s are largely obsolete because they are designed to teach the science of the 1960s and there is little attention to on-going cultural changes and emerging science curricula. Hopefully the "new" teacher education in the sciences will be formulated by those now responsible for teacher education rather than by forces outside the profession.

What sort of teachers do we need for the future? It seems to me we should begin by rejecting students who wish to become teachers, but who are not really interested in a scholarly life, and who lack the essential personality qualities for working with young people. A teaching candidate who is not willing to spend, or doesn't see the importance of spending, at least 3% of his annual income on professional books, magazines, and activities throughout his entire career is not a person that we should encourage.

As educators of teachers we need to make some changes in our own thinking. Our most important task is to educate teaching candidates as *students of teaching*. It is not our task simply *to train student teachers*. We must think of teachers as something more than criterion-referenced mechanists and servants to computers, bound to prescriptions, and incapable of generating their own insights into problems of teaching.

The college's or university's responsibility for educating teachers should be primarily concentrated on the professional aspects of science teaching. This means developing an understanding of: the changing character of the scientific enterprise; the place of science in society; the nature of knowledge in the sciences; the learning of science-based knowledge; the philosophical basis of science education and the rationale for curriculum choices; the valuation of goals and similar topics. The intent of such a program is to develop a basis from which teachers are able to form hypotheses and make decisions about appropriate curriculum and instructional practices. We need teachers who have: a conviction of and a commitment to the worthiness of their subject specialty for general education, the ability to think and act within a frame of reference and to justify their actions, and the ability to recognize changes in society and to adapt to new conditions of living and human aspirations within the context of science and technology.

There is a popular notion that preservice education should provide beginning teachers with a few so-called "survival skills," and then turn them loose in schools; actually this is more a "kiss of death" than survival. We all know that the interactions of a classroom situation are never twice the same; to what extent then can we justify training in specific instructional skills? A greater effort is needed to help beginning teachers gain a personal sense of purpose and direction and a basis for intelligent action.

The development of the specific techniques a science teacher needs should be part of carefully designed inservice programs. Skills are best learned where they can be applied and against a background of knowledge and insight that makes them reasonable and generalizable.

We should make a greater effort to help teachers, who have acquired their knowledge of science within a discipline, to recognize that for the purposes of general education it must be taught outside the discipline. The precollege science teacher must recognize that his major responsibility is that of an interpreter of science and not that of a researcher.

In the near future I would like to see beginning teachers given experience as consumers of educational research, as well as prepared to participate or engage in classroom research on their own.

As teacher educators, we *must* put more pressure on the faculties of arts, sciences, and humanities to provide more appropriate courses for teachers. The greatest drag on teacher education today is the failure of liberal arts faculties to initiate courses suitable for interpreting the knowledge within their diverse disciplines for a wider audience than their fellow specialists. These faculties criticize teacher education and at the same time jealously guard the critical knowledge that would make general education in their field more effective.

We are entering a new era in American life and the professional education of teachers for this period must be conceived in terms unlike those of the past.

SESSION I

POINTERS ON OBTAINING FREE AND LOW-COST HARDWARE TO IMPLEMENT MATERIALS-CENTERED, INQUIRY-ORIENTED ELEMENTARY SCHOOL SCIENCE MODULES

Mitchell E. Batoff, Associate Professor of Science Education, Jersey City State College, Jersey City, New Jersey

A set of overhead transparencies highlights facets of the following topics.

1. Manipulative and investigative materials (hardware) are needed in *any* viable elementary school science program, *including* those which utilize the natural environment
2. Materials can be obtained at considerable savings, or dollars can be stretched to obtain more items for individual use by pupils by: purchasing in quantity, using the Yellow Pages; purchasing "seconds," rejects, or odd lots; not purchasing certain items that can be easily stockpiled free; purchasing directly from manufacturers, distributors, or importers; avoiding certain expensive sources of materials; purchasing from Government Surplus Outlets, taking advantage of special sales.
3. Other topics relevant to obtaining low-cost hardware: examination of products; catalogs; customs information and problems; plastics; "State prices;" letters, phone calls and legwork; directories; more.

   A forthcoming publication, Copyright Mitchell E. Batoff 1973, will elaborate on the various subtopics dealt with in this presentation.

CESI CONCURRENT SESSIONS

SESSION C-1

DOESN'T ACCURACY HELP IN DEVELOPING MEANINGFUL CONCEPTS?

Mario Iona, Professor of Physics, University of Denver, Denver, Colorado

The main theme of my talk is very simple: Science teaching should make sense

Let me elaborate on this statement in a number of slightly different ways which overlap quite a bit

1. Since the large amount of our thinking and, of course, most communicating is of a verbal nature, our language should be precise. It should be possible to attach meaning to the terms and statements so that concepts formed relate to experiences in the real world.
2. Many science concepts are sufficiently simple and closely related to everyday experiences that they can be acquired fully or at least in rudimentary form, if used correctly, without the need of formal definitions and drill. Thus, it is desirable to use these concepts correctly throughout the child's educational experience.
3. Since the intellectual development of the child seems to progress in stages, building consciously or unconsciously on previous experiences, educational experience should provide logically related and relatable material that allows meaningful integration with previous and future experiences; e.g., it should be correct and not contradictory.
4. Since science is an intellectual enterprise, we should provide the child with logically meaningful material about which thinking is possible; avoiding the need for memorizing unrelated facts. Logically meaningful material provides a basis for understanding and, therefore, intellectual enjoyment and satisfaction.

In the last few years at NSTA, at physics teacher meetings, and in various publications I have campaigned against what seem to me to be unnecessary errors and misleading statements in textbooks and journals which make it difficult for students to learn and teachers to teach. Although it seems obvious that faulty instructional material is an inadequate source for teaching, and a hindrance to concept formation, I don't find general agreement with this premise.

We are all familiar with the confusion created by textbook writers on such sophisticated terms as force, energy, etc. Statements such as "Force (is the) energy or power to do something" are misleading and there are countless examples of confusing mass and weight.

But even such straightforward concepts as "equal" are confused in science texts, supposedly in the interest of making it simpler. How does writing dissimilar expressions on the two sides of the equal sign simplify the meaning of equal?

2ft x 12 = 24in should read 2ft x 12in/ft = 24in.
$\frac{20}{60}$ x 100 = 33% should read 20/60 = 33% because % (percent) means 1/100 and 20/60 = 33/100. How can a child develop an understanding of the concept "per" or "percent" from such inconsistent equations?

Not long ago I visited a second-grade class where volume measures were being discussed. It was demonstrated that 4 quarts fit into a gallon and that ten 50cc measures fit into a 500ml measure. But the teacher called it 50cm, not cubic centimeters. She had omitted the cubit centimeter because for this class of slow learners once had to use a simplified vocabulary. However, as the slow learners would be especially subject to confusion between volume and length measure, extra precision was imperative.

Naturally, a term such as cubic centimeter makes no sense to the child the first time he hears it. But I believe he will gradually, if properly exposed, recognize a difference in the units used for the two different kinds of measurements. I do not know how common this example is, but it made me wonder whether teaching of this sort is the basis for Piaget's conclusions [1] that young children get very confused about the changes taking place when a ball of clay is rolled out into a sausage, or a liquid is poured from a wide container into a narrow cylinder. What is conserved: amount, volume, weight, etc.?

How can the child form a coherent picture of these situations if the information given is contradictory or meaningless? The pieces don't fit into the picture puzzle. The pieces have to fit together if they are to become part of the child's personal world, a time-consuming effort only accomplished by trial and error. Some of the examples quoted in linguistic and psychological studies seem to illustrate my point.

Some psychologists feel that language learning is perhaps different from other learning in that it is farther removed from imitations because each sentence is different, although it is formed on the basis of the same rules of grammar. Seemingly, applications of science learning also extend beyond imitation, and the gradual increase of specificity of science concepts is parallel to the trial and error phase psychologists report for language and grammar development.

A child does not suddenly acquire the correct form, but gradually realizes how it fits. One study [2] showed that children first indicate the past tense with "-ed" on weak verbs only, apparently mostly by imitation; the strong verbs remain unmodified except for common ones like "went." Perhaps, the child has not heard the "-ed" form often enough to imitate it, and is not yet aware of the correct form. Gradually he accepts the "-ed" as a rule and applies it to the strong verbs also, as for example "breaked." Only as a third step does he learn that the correct form is "broke." Could we not expect a similar development for the use of scientific concepts and terms if parents and, especially, teachers—who are the models to be imitated by the child, use the terms correctly and distinguish between mass and weight, lighter and less dense, speed and acceleration, etc. It is not necessary or likely that a child will comprehend the subtle differences immediately. However, he may recognize the different uses and gradually adopt them himself. We usually abandon baby talk early in a child's education and encourage his use of adult language, vocabulary, and grammar. Why not give him an equal chance in science concept formation and scientific language?

It is my contention that formal instruction conditions us to accept imperfectly developed concepts and to base our thinking on them.

I have found that even elementary science books discuss humidity. I am sure it is not detailed enough to be a rigorous study of the concepts, but rather a gradual introduction to the terminology. Humidity may not be a very common topic in your classes, and I suspect many of you have only a superficial acquaintance with the concept. You are probably familiar enough with weather reports to know that we express humidity in percent. Percent of what? I would like to hear your formulations and to attempt to arrive at some consensus. Such a heterogeneous group, not particularly familiar with this topic, may have difficulty establishing a definition acceptable to all or at least most. Any physicists in the group should avoid influencing the majority with a sophisticated answer. I would guess that the definition would be similar to "humidity is a percentage of the water that the air can hold at the given temperature." At least I have seen many similar statements in school books. By that definition, if you have a volume of $1m^3$ of air at outdoor temperature of, let us say, 5°C (41°F) which is almost foggy, you have 7g of water in it. That is called 100 percent humidity or saturation. If you had only 3.5g of water in $1m^3$ at the same temperature you would call it 50 percent. Similarly, the percent of humidity at a different temperature, let us say room temperature, of about 23°C (73°F), is based on a maximum moisture content of $21g/m^3$.

Now let us go to a mountain top, such as the location on top of Mt. Evans, where I am the manager of a high-altitude laboratory. The air pressure there is only 2/3 as great as at sea level. Therefore, in our $1m^3$ reference there will be only 2/3 as much air as there would be at sea level. Let us take our higher temperature where 100 percent humidity at sea level meant 21g of water. How much water will there be at saturation at the same temperature of 23°C? Will it still be $21g/m^3$? Does anyone care to explain or justify his or her answer? Who is for more? How many? Who is for less? Is there anyone for the same? Is there more room for water because there is less air? Is there less water because there is less air to hold it? Is there the same maximum amount of water since the air is really of no importance? You are all, I assume, trying to relate the question to previous information and experiences. It is my suspicion that most of you are on the wrong track. How many of you have more detailed experiences in this area? How many of you have heard of Dalton's Law of partial pressures? By having accepted the statement that saturation is the maximum amount of water vapor *air can hold* at a given temperature, you lost sight of the fundamental concept of a gas as being mostly empty space with tiny molecules bouncing around. The main feature of a gas is that the molecules are hardly affected by the others around them. Why should 1000g of air molecules be concerned with the 21g of water molecules? What does an air molecule do with a water molecule? — nothing! What do you mean by "hold?" The problem is the behavior of the water molecules. If there are too many or if they move slowly, as they do at lower temperature, they stick together and form water droplets. The behavior of the water molecules, thus, limits how many can be in a given volume at a given temperature in the gas phase. In describing 100 percent humidity or saturation, one is not concerned with the air in the same volume. One should more clearly state that at 23°C the maximum density is $21g/m^3$. This is a much more meaningful and less misleading statement. The maximum amount of water vapor depends *only* on the volume and temperature, and has *nothing* to do with any other gas present in the same volume.

This elaborate example was intended to convince you of two things.

1. You all had some background in this subject, primarily without formal study, and you had formed some concept of humidity. How did it come about?—from listening to weather reports, from misunderstanding phrases like "warm air can hold more moisture than cold air."
2. I chose this example because I was certain that most of you had misunderstood this concept. An innocent unnecessary qualification that "the air in a $1m^3$ box holds 21g of water vapor at 23°C" can confuse science teachers about the well-known behavior of gases. How disastrous it must be for children, who are at the stage of forming models and concepts. And, yet, so many confusing, ambiguous, and meaningless statements are found in most teaching materials.

If most of you formed an incorrect concept from a misleading statement, would one not expect that there is a good or better chance that correct concepts will be formed from correct statements? Students may develop correct concepts, in many cases, even without much training.

I think we turn the kids off by presenting them with meaningless, incorrect, misunderstandable jargon. Meaningful terminology can be much better assimilated into a complete picture puzzle.

If I interpret Piaget's example correctly, children will fit whatever is being said, or whatever they think is being said, into a, to them, reasonable and complete picture. It may be their fantasy world; they may misunderstand and arrange their picture to fit their understanding. Piaget reports [3] that a child, when asked to report on a fairy tale in which children were transformed into swans, retold the story by explaining that the children were dressed in white. The child will develop his world picture so that the pieces fit. If we say it correctly, there is that much more chance, but no assurance, that the coherent picture the children develop will be a logical one. If we are incorrect, it is likely that discouraging experiences will turn them off to science.

The acquisition of concepts is a very difficult process. Another example from Piaget, which his biographer interprets as children's peculiar disjointed way of thinking, attributes causal relations to unrelated events. Apparently children use incompletely developed concepts to develop causal relations. For example, the concept of "afternoon" has not been clearly developed [4] "I haven't had my nap so it isn't afternoon." Apparently due to the limited experience of associating afternoon with activities after the nap, the term "afternoon" was related to nap, not noon, which may still be a somewhat abstract and unfamiliar concept. Even in this daily experience the concept of afternoon was temporarily incorrectly developed. Are such inconsistencies unexpected when we give a child inconsistent material to form his concepts?

For example, such a common term as "rate" becomes impossible to understand if one uses science books as the guide. In one book for teacher training one finds "A rate involves the ratio of a change in the measurement of some quantity and the change in time" as if all rates were time rates such as speed, acceleration, fuel consumption in gallons/hr., etc. What about rates such as tax rates, fuel use measured in miles/gallon? Or the reciprocals of these: how many gallons/mile does an airplane consume; or car expense in cents/mile. In building a wall how many tiles/ft^2 are needed? A listing of science formulas distributed to high school students by the Air Force recruiting office uses the term "rate" in a very restricted sense, as speed only, by giving an equation for distance as "rate times time." How is one expected to interpret the following discussion found in an elementary school book "A decrease of weight of a rocket by a factor four when the distance from the earth center is doubled is described as being at the same rate." Other books use the term rate of speed, which does not make any sense. Can we hope that students will ever develop an understanding of the concept of rate?

On the other hand, one can find examples which might support the view that there is no need for consistent information because the children will not make any sense of it anyway. At least, one is tempted to throw up one's hands [illegible] when one sees the answers by nine-year- [illegible] following question of the nationwide test [illegible] National Assessment of Educational Progress [5]. "A pint of water at a temperature of 50°F is mixed with a pint of water at 70°F. The temperature of the water just after mixing will be about: 20°F, 50°F, **60°F**, 70°F, 120°F, & don't know)." The choices were (4%, 2%, 7%, 5%, 69%, 12%), respectively. I can't believe that the fact that almost 70 percent chose super warm water is due to a misunderstanding of the scientific content that a mixture of hot and cold water results in lukewarm water. Some basic explanation in concepts or relationships must be consistently misleading these children. Is there a poor association between a physical phenomenon (hotness) and its mathematical description?

Is there a lack of verbal communication, e.g., the children thought they were to combine numbers rather than water?

Is there a problem in test taking, such as "don't give it any thought but give the first answer that comes to your mind?"

Is there a correlation to the intellectual developmental stages described by Piaget, e.g., that nine-year-olds have no concept of certain, to us, obvious, relations?

The nine-year-olds' responses seem to indicate that the science experiences of these children have not led to the realization that one can think about scientific situations. Certainly, one would suppose that their general experiences have been sufficiently varied to conclude from experience that mixing hot and cold water leads to lukewarm water. Somehow, however, they seem incapable of relating this to a temperature scale, to numerical relations, where the in-between temperature between 50° and 70° is *about* 60°.

Can we expect sound relationships if we provide them with such meaningless numerical examples as the previous unit conversions or percent calculations? Or if they read in their science lesson such absurdities as one finds in a very popular 5th grade book that the thrust of the various stages of a multistage rocket are added to arrive at a total thrust?

We should provide the children with meaningful material and challenge them to think about it, to correlate their information, and to make it part of their individual worlds.

I believe we can learn quite a bit about concept formation from another example of Piaget's observations [6] A two-and-one-half-year-old girl who saw her baby sister for the first time in a bathing suit, pointed at the girl and asked "what is her name?" Her concept of her sister as "Lucienne" had been formed by certain associations—the baby and her dress together. Of course, later on her concept of what the name "Lucienne" meant became more refined and she realized that the essence of the concept "Lucienne" was the baby, and not the baby in her particular fully dressed appearance. Piaget's biographer interprets this episode as indicating that the girl failed to see the conservation of identity of her sister, and looked at her as two different persons in the two different appearances [illegible] e, it is more an illustration of the gradual form[illegible] of [illegible] verbal symbol or the concept that we call [illegible] a name. In science we use very refined terms that have a specific meaning when abstracted from their varying appearance. Continuous correct experience, more than formal misunderstood definitions, will clarify the concept.

The concept of mass, for example, seems to cause great difficulty. Is it because we confuse it with density, *i.e.*, in order to have the same amount of mass we need different volumes of different materials? Is it because we confuse it with weight, *i.e.*, we ask not what do we have but how much the earth pulls on it? But when we see how difficult it is for a child to form a concept of the entity that is called "Lucienne," how do we expect a child to form a concept such as mass when we use the term in such confusing ways? The AAAS [7] science program states, for example, that a nickel can be used as "a rough standard of *mass;* it *weighs* about 5g." Why not say it has a mass of 5g, when we discuss standards of mass? This introduces, at the same time as one is trying to clarify the concept of mass, a new concept of the earth's pull and then uses the unit defined for measurement of mass to measure weight. In discussion of the collision of balls where the typical concern is with the masses: one finds [8] "If two objects of different mass are moving with the same velocity, the heavier object will have the greater momentum" since momentum is m.v. Why not stick with the relevant property and call it "more massive" instead of heavier? Why say [9] that it is more difficult to stop a heavy moving car than a light one? The weight is of no consequence, but the concept of mass is important in this connection.

Of course, it is true that the information about the object can be obtained either from stating its mass or its weight because we usually compare weight at the same location where the object of greater mass weighs more. But what about the momentum of an object on the earth and on the moon? Will an object moving on the earth with the same speed as on the moon have more momentum? It is heavier!

Here is a selection of a few more similarily confusing statements from different sources to assure you that it seems to be a conspiracy to confuse the children, and probably some teachers, authors, and editors.

"It seems to be of interest to note the masses of some objects . . . Coming to some common inanimate objects, a motor car will have a mass of the order of 1000kg. A large passenger steamship may weigh 4×10^7 kg . . ." Why would one list a weight in a tabulation of masses?

How are students supposed to interpret the following statements if teachers are often not aware that the pound is originally defined as a mass unit, but that the weight of one pound is used as a force unit. "The unit of weight in this (English) system is the pound." Two pages later one learns "A kilogram weighs slightly more than a two-pound mass." Would it not have been less confusing to say that the kilogram weighs a little more than two pounds since the pound mass is undefined in this text.

After having stated that the gram is a mass unit, one finds: "For the present, we will define density as the *weight* of a sample divided by its volume. In metric units density is measured in grams per cubic centimeter . . ." At least the initial phrase indicates that this inconsistent definition may be refined later.

"This unit of heat (the calorie) is based on temperature measurement and a mass measurement . . British thermal units may be converted to calories by converting the weight and temperature to metric units." Why would anybody be concerned with weight in such a conversion problem? The Btu is properly defined in terms of the heat necessary to raise the temperature of one pound (mass) of water by one Fahrenheit degree.

In discussing Archimedes' Principle, one teacher's guide explains "This upward *force* is equal to the *mass* of the water displaced . . ."

In a recent NSTA Journal one finds "Measuring the apparent loss in mass of objects when they are under water." Would it not be better to speak of apparent loss of weight since one is concerned with the effect of a buoyant force?

If we use "weight" when we are concerned with the force, and "mass" when we are concerned with the object and its properties, the child would have a chance to first realize that there is a distinction, and maybe even succeed in finding out what it is. Much formal study becomes necessary in order to undo the damage done by using the terms indiscriminately. There may be no need to make the distinction at an early level, as the child will probably not appreciate the distinction. Is there any reason to confuse the terms?

Another item connected with language and thought is the appropriateness of scientific language over conventional English. Persons familiar with foreign languages often express the belief that certain ideas can be better expressed in the foreign language than in English. Would one not expect that the language of science has advantages in expressing scientific relations? Although mass and weight may ultimately give the same information, the emphasis and the relation to other properties is different. The general idea can be expressed crudely in many ways. The scientific way, however, conveys a more complete picture.

I do not want to imply that we can expect to develop scientists by assimilating these concepts without some school instruction. But remember that these examples are taken from instructional material where the authors attempted to clarify the concepts.

Is the learning of scientific concepts different from learning concepts in everyday life, which one acquires almost entirely by casual experience? It is true that the scientific concepts are not encountered as frequently as everyday concepts such as the name of one's sister. It may also be that the order of encounter is different. There may be a need for the everyday concept before the linguistic skills are developed to form the appropriate grammatical expression. The scientific concepts need clarification, probably, only after the vocabulary has been developed and applied, even if on' vaguely understood. I surmise, but unfortunately cannot prove, that the mechanism of concept formation and the development of a language in everyday life and in science are closely related.

On the other hand, I have found teachers who have concluded that the formation of concepts is so incomplete, if limited to verbal experiences, that students have to handle everything to form meaningful concepts. If time permits, I would like to do an experiment with you to illustrate, I hope, that everyday experiences can make a person ready for scientific concepts. Analogy is a powerful aid in acquiring an understanding of new and more abstract situations. I firmly believe in intellectual activity, logical relations, and derivations from analogy, *i.e.*, from models. I do not believe that everything has to be learned by discovery and experimentation. Some such experiences are necessary and very valuable; however, much can be learned by argument and thinking. An analytic approach will give much more general insight than an experiment. The child has to be ready for such an approach.

Piaget tells us about the various stages of intellectual development. Some of this readiness for an analytic approach seems to be age-associated, but mostly one deals with a succession of various stages. These stages are not reached in a vacuum. The child is constantly exposed to experiences which make him capable of reacting in certain intelligent ways to new situations and problems. To use my earlier analogy of a picture puzzle:
If the old experiences have led to fitting certain pieces into the picture, some pieces which one may have seen before will suddenly fit. The child has reached a new stage. This gradual completion of the picture, this becoming ready for a correct response to more complicated new situations is a gradual maturing and unconscious response to many experiences. That it is due to experiences is shown by Piaget [10] by establishing that blind and deaf children who lack certain experiences go through the same stages of intellectual development as non-handicapped children, but are a year or two behind. The influence of general experience on abstraction is illustrated by an example published in *Physics Today* [11] where drawings were reproduced which were to portray the way from home to school The 15-year-old-boy from the African bush drew a picture while the younger U.S. children drew maps. A U.S. child has more experiences of that kind. He sees maps at every service station and probably has to use them. No wonder he was ready earlier for such an abstraction. It is our obligation as teachers to provide the general, as well as the specific experiences, which provide the background for concept formation. Elementary teachers and authors should not expect the children to fully comprehend the meaning of the scientific concepts, however, the correct usage of the terms will go a long way in preparing the children for further development. Children imitate the teachers whom they respect, and the books which they consider authoritative, even if they do not fully understand them. Our examples have shown that children are quite willing and adept at modifying ***their*** personal concepts and grammatical rules to fit them into a new context. However, I am sure that there is reluctance and resentment if something which the child thinks has been taught in school has to be corrected later on.

The need for accurate and sensible language in teaching and teaching materials is evident. I would like to digress for a moment and discuss some of the reasons for the inaccurate material.

We have already mentioned the equivalence of baby talk—an attempt to adapt the terminology to what the author, and the editors, think is the level of the student. Seldom will an author defend a specific item on this basis. It is a general cover-up excuse. If the author really knows the subject well and has made a real effort, it would be possible in most cases to formulate more accurate statements which would be more meaningful. This excuse also assumes that the author knows what the level of the student's development is. It appears to me to be dangerously close to not making any attempt to further the students' development but to appease him with baby talk.

Incompetence or carelessness seem to be the major reasons for these inaccuracies. Closely related to the carelessness is what I would call contempt for the reader—"The reader would not understand anyhow" I have had that response from editors explicity. I suppose this contempt is implicit in the writing of authorities when they write for the lower level reader. These authorities also become careless because they assume that the context will tell the reader what is meant even if the wrong term is used, while the less competent reader *needs* the correct term to think correctly.

Even if the author is competent, it seems that the editors have the last word in writing school books and they often have no special competency. Publishers are in such a hurry that they usually do not take the time to have the manuscript critically reviewed. They are more concerned with having big names listed as consultants than with giving the manuscript to reviewers who would take the time to do a thorough job.

Sometimes statements are made, which I suppose neither the author nor the reader can understand, because they sound impressive, although they may be irrelevant or inapplicable. This is a form of "name dropping," little different from the previously mentioned incompetence.

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SESSION C-2

WHAT WE LIKE AND DO NOT LIKE ABOUT SCIENCE AND SCIENCE TEACHERS

Roger Van Bever, Supervisor of Elementary Science, Detroit Public Schools, Detroit, Michigan

Eight children from some elementary schools in Detroit were asked the following questions to determine the appreciated and unappreciated characteristics of science teachers and science in general.

1. What is the *funniest* thing that ever happened in the science room?
2. What do you *like most* about your science room?
3. What do you *like least* about your science room?
4. Do you like *science?* Tell why or why not.
5. What *field* in science do you *enjoy most?* Tell why.
6. What *field* of science do you *enjoy least?* Tell why.
7. What *ways of working* in the science room do you *enjoy most?* Tell why.
8. What *ways of working* in the science room do you *enjoy least?* Tell why.
9. Think about the *science teacher* you have *liked most*. Tell why you liked that teacher.
10. Think about the *science teacher* you have *liked least*. Tell why you did not like that teacher.

SESSION G-8

PRESCHOOL SCIENCE: EXPERIMENTS OR EXPERIENCES?

Ann C. Howe, Assistant Professor, Reading and Language Arts Center, Syracuse University, Syracuse, New York

The nursery school has traditionally been a place where children could have the opportunity for a variety of experiences, some of which were called science experiences. In the past few years, as a great number of preschool programs have come into being, and there has been more concern with the academic achievement of young children, science experiments planned for older children have been adapted and introduced into preschool programs. Chance experiences are too haphazard, and adapted experiments are often too difficult, but there are theoretical and experimental bases for suggesting two areas as appropriate and necessary for three- and four-year old children.

1. Activities to promote the growth of logical thinking. The work of Piaget, his co-workers, and followers indicates that children should have experience in observation, classification, seriation, and pattern recognition. Children need intelligent adult guidance in these activities as well as time and freedom to try things out on their own.

2. Experiences with things of the natural world. Such experiences help children to differentiate the self from the external world and enable them to give up animistic thinking and move toward a scientific worldview. The active participation of adults is a necessary part of this process.

Examples of ways to carry out these ideas with children, and slides of children in a preschool program are presented.

TEACHING SCIENCE EDUCATION IN FLORIDA'S NEW ELEMENTARY PROGRAMS

Lynn Oberlin Associate Professor of Science Education, University of Florida, Gainesville

How would you like to teach science education as a part of a teacher education program where:

1. Courses and regularly scheduled classes do not exist,
2. Letter grades such as A, B, C are not used,
3. Each student participates in field experience in the public school throughout his junior and senior year,
4. Students work at their own pace,
5. Students may complete requirements in different amounts of time,
6. Operational costs do not exceed those of the regular program,
7. Planning and decision-making is a cooperative decision between students and faculty.
8. Students are responsible for their own education.
9. The orientation of the program is humanistic, not behavioristic.

This program exists for elementary and early childhood education at the University of Florida. It began as an experimental program in 1969, based on 10 years of research by Arthur Combs and associates at the University of Florida, which involves findings of the nature of effective workers in the helping professions. These research findings are summarized in *Florida Studies in the Helping Professions*, published by the University of Florida Press in 1959. The underlying theories for the New Elementary Program are outlined by Dr. Combs in his book, *The Professional Education of Teachers. A Perceptual View of Teacher Education*, published by Allyn and Bacon in 1965. The program was based on four major assumptions. A person learns best when:

1. Learning is made personally meaningful and relevant,
2. Learning is adjusted to the rate and needs of the individual,
3. There is a great deal of self-direction,
4. There is a close relationship between theory and practice.

From the start the program was committed to a cost no greater than that of the regular program, as it had to operate within the regular budget.

From the helping relationship research, faculty experiences, perceptual humanistic psychology, and the four basic assumptions just stated, the program was organized around the following principles.

1. The self as instrument concept—To be effective, the teacher must use himself, his knowledge of children, and his knowledge of subject matter.
2. Student responsibility and self-direction—The student is responsible for his own education and has maximum opportunities for self-direction.
3. Maximum flexibility—Students with varying background and needs can adapt the program to such needs, and complete different programs of instruction at varying rates.
4. Close relationship of didactic instruction and practical experience—For learning to take place, students must see a relationship between what they are supposed to learn, and their need for the information in a practical setting. Participation in actual teaching begins early in the program, fol-

lowed by pursuit of learning which is relevart to them.

The New Elementary Program, known as NEP, which operated alongside the regular or traditional program, provided opportunities to observe and conduct research comparing the two programs. One of the studies involved the comparison of the teachers' evaluation of the training programs. The population consisted of teachers who had completed their first year of teaching. The same instrument was used for the NEP students and a control group selected from our regular program. The results clearly favor the NEP group. Significant at the five percent level was the area of competence to deal with teaching, and at the one percent level were the areas of program content, changes in values, self-initiation, field experiences, and skill and knowledge in helping others to develop. Another instrument, the Florida Rating Scale for First Year Teachers, was filled out by the principals of these same teachers. The results on all 14 items favored the NEP group. Only one item, which dealt with capacity to adjust with changing conditions, was significant at the five percent level. The one item significant at the one percent level was relationships with parents.

After observing and comparing NEP and the traditional program for over three years, the Department of Childhood Education decided to adopt the NEP as its official program and to phase out the traditional program. One of the strengths of the NEP was its size. The department decided to form five separate NEP groups rather than one huge program. Groups two, three, and four started in Fall 1972, January 1973, and March 1973, respectively. Because NEP, (New Elementary Program) became our regular program, we renamed it Childhood Education Program, CEP. In Fall 1973, five CEP groups will be operating in place of our traditional program. The material contained in this report, however, deals with only NEP groups one and two.

Seminar

The seminar is the heart of the program. When a student begins the program, he is assigned to a seminar with 29 other students, and he remains in the same seminar as long as he is in the program. Students also retain the same seminar leader. The seminar is divided into two groups of 15 students, with each group meeting with the seminar leader for two hours each week. Students in these groups get to know each other, and the faculty member very well, creating a personal humanistic experience. The seminar provides for guidance, counseling, and open discussion about educational practices and theory, and how they relate to the student as a person and as a professional, and serves as a support system for the student. Students in a seminar often rally around a fellow student, pitching in with a common effort, to help solve the student's problem.

Field Experience

Field experience is a very important part of this program. Students are continuously engaged in field experience during their upper division, junior, and senior college years which is designed to provide:

1. A wide variety of in-school and out-of-school experience;
2. Participation based on student need and readiness;
3. Increasing time in the classroom, and depth of responsibility at each level.

Five levels in the program provide for the above to happen:

1. Observation and tutoring—five hours per week;
2. Teacher Initiate—six hours per week;
3. Teacher Assistant—ten hours per week, five days per week;
4. Teacher Associate—a daily experience, ten hours per week;
5. Intensive Teaching—five weeks of full-time teaching in the final quarter.

Although the field experience component operates with no formal supervision by a college supervisor, we do have contact with the school. A University faculty member visits the classroom only when requested by the teacher, or teacher trainee.

Substantive Panel

The substantive panel is made up of faculty members who usually teach methods, curriculum, and foundation classes. The areas included are science, mathematics, social studies, reading, language arts, art, music, health, physical education, sociological foundations, psychological foundations, and curriculum. Before students can start working in any area, they must start orientation sessions. In each of the areas, students are required to complete a certain number of learning activities. In science, the number is six. Students are also required to do more than the minimum requirements in three of these areas.

Learning activities may be completed in a variety of ways. A student may work on his own, and submit evidence in the form of a written paper, or a conference with the substantive panel member that the activity has been completed. In some areas study groups are formed where students working on the same activity meet with the faculty member at a certain time. These are elective as to whether the student wishes to sign up; however, once a student signs up, he must attend. In science, many of the activities are completed in an open laboratory situation.

Evaluation

While letter grades are not given in the program, evaluation does take place. There is an entrance assessment at which time students' lower division, or junior college work is assessed. Deficiencies for entrance to the college of education are noted, and plans are made for the student to start work in the program. Approximately half way through the program, there is a diagnostic review and plan for the future. This takes place with the student, the student's seminar leader, and one or two membrs of the substantive panel. At this time, the student presents evidence of what he has completed, and of his plans for completing the rest of the work in a certain amount of time.

Continuous evaluation also takes place. In the seminar, evaluation of the student's progress is constantly taking place. In each of the substantive areas, every time a learning activity is completed, the student is given a learning activity slip. Not every activity attempted by a student is accepted by faculty members. The student's work must be well done. If not, it is handed back to him, or in a conference he is told that it is not acceptable. The reasons are given and he must take it back, rework it, and resubmit it. There is no failure but success is not automatic. Evaluation also takes place during field experiences. Some evaluation is in the public schools with the teacher and some evaluation of field experiences takes place in the seminar.

Before any student graduates, there is a final evaluation. This final evaluation takes place with the student, the students' seminar leader, and one or two members of the substantive panel. If the student has completed all requirements satisfactorily, he graduates and is certified to teach. The seminar leader writes a letter about each student, and it becomes a part of the student's permanent record. In writing this letter, the seminar leader utilizes material from each of the substantive panel members. This letter considers student strengths and weaknesses, our assessment of his ability to do graduate work and to assume a position in his chosen field.

The Science Education Component

Students in the New Elementary Program must complete six learning activities in science. The first four activities listed are required. Only the science orientation sessions require that a student be in a certain place at a certain time.

1. Attend Science Orientation Sessions and demonstrate competence in science content. (Science content module available)
   There are four 50-minute orientation sessions which the students are required to attend. These include a very close look at science learning activities which enable students to become completely familiar with what is expected of them, a pretest in science content, and a search for the answer to the question, "What is science and where does it fit in the elementary school?" The requirement to demonstrate competence in science content grew out of research which was conducted last year as to whether our New Elementary Program students were well-prepared, because they were not taught any basic science content as in our traditional science methods courses. Since both groups had to meet the same college of education entrance requirement of 15 term hours of content science courses, we administered a junior high school content test to our graduating seniors last spring in both the regular program, and the NEP. The results showed that the NEP students were about one and a half raw score points ahead of the students in our traditional program although there was no statistically significant difference. This part of the study looked good, but as we analyzed the data further, we found that none of the students in either program really knew very much science content. After further analyzing this and other data from science content tests given, it was decided that students would demonstrate competence in science content by obtaining a score on a standardized test at or above the 75 percentile for end-of-the-year ninth grade students. While this requirement may seem a little low, approximately half of our students that graduated last year did not meet it. The pre-test given as a part of orientation will meet this requirement for more than half of the students. The science content competence requirement must be completed before the student has successfully completed the science area.
2. Learn to use the Science Teacher Observation Rating Form (STORF) and demonstrate competence in observing two taped situations. As a member of a three-person team, observe (with the STORF) at least two science lessons being taught, and teach at least one lesson which is observed (with the STORF) by two team members.
   The STORF is an instrument being developed at the University of Florida to observe practices of elementary science teachers. An observer using the instrument records observations of teacher behavior, Behavior A and B, from three five-minute segments of the lesson. By observing traditional behavior (A) or experimental behavior (B) on tapes, students can begin to find out the kind of teacher they would like to be. By observing classmates and having classmates observe them, they can see whether they are doing the kinds of things their ideal teacher normally does. The items observed are the kinds of things that happen in most classrooms. We have never observed any teacher that entirely fits into one category, but the frequency and type of the acts help to characterize the teacher.
3. Learn about new programs in elementary school science (AAAS, ESS, SCIS). Examine and perform the activities for six units. This must include at least two of the programs.
4. Develop plans and materials, and use four of the following techniques in teaching science to children: (a) science center component, (b) counterintuitive (discrepant events), (c) pictorial riddles, (d) open-ended investigation, (e) inductive teaching.
   The actual teaching sessions for these techniques take place in the public schools. Much of the planning takes place at the university in the science laboratory or in my office.

The rest of the learning activities are *not* required, however, the student must complete at least six learning activities in all. The remaining activities are selected from the list or proposed by students.

5. Select and carry out two laboratory investigations in each of the following areas: (a) physical science, (b) life science, (c) earth science. (Three differe[illegible] sources are required.)
   The laboratory investigations must be appropriate for the level that the student is preparing to teach. Students are encouraged to use themselves as one of the sources required, and to design their own investigation. While not a requirement, students are encouraged to do these investigations with children in the public schools.
6. Present evidence that scientific information has been learned in two areas of physical science and two areas of biological science. Two sources of adult material must be used for each area. (Areas must be narrow in scope.)
   Students are asked to choose a very narrow area and explore it in depth. For example, the area of weather would be inappropriate. However, tornadoes might be an appropriate topic. Information for each topic must come from at least two sources of adult material, as distinguished from [illegible]mentary school materials and textbooks. [illegible] finished, the student may present the evidence in a conference; or in a short written review of the material, listing the sources used.
7. Demonstrate an understanding of the "Processes of Science." (Module available)
   The module is based on such processes as inferring, observing, hypothesizing, predicting, and classifying.
8. Plan and teach a science *UNIT* (several lessons) to children. The following must be provided for: Active involvement of children, differing achievement and ability levels of children, general student planning, student choices, student planned

inquiry, use of manipulative materials.
The teaching of this unit takes place in the public schools, generally near the end of the student's program, during intensive examinations or before.

9. Teach a *UNIT* (several lessons) of one of the new programs (AAAS, SCIS, ESS) to children. Learning activity three which requires that students learn about the new programs and do some of the activities with the materials from these programs is a prerequisite. Activity nine which takes place in the public schools, does require that area schools be well-equipped with materials from these programs. Aside from material shortages, this activity works well for many students. It usually takes place near the end of a student's program, during the intensive examinations or before.

10. Evaluate two state-adopted textbook series for use in the elementary school. For this requirement the student picks two of the four series and examines at least three levels such as grades two, three, and four of each of the two series. While a student may develop his own evaluation form, most prefer to use one which I have developed. The books are available in the library where students can check them out for short periods of time. Although I don't advocate a textbook program for science in elementary school, the book is apt to be the only thing in the science area that many teachers find provided by the school. This activity gives students a chance to look over the books and become familiar with them.

11. Propose other learning activities which will help the student to become a better elementary science teacher. The student can, and is encouraged to, suggest things relative to his needs from opportunities in his field experience. When there are things he wants to do, things he wants to learn, he will propose an activity and call it Number 11. Learning activity eleven may be repeated an indefinite number of times as long as each time is different.

The following statement is probably the most important one on the whole learning activity sheet. It comes at the bottom and is printed in capital letters. THE ABOVE ACTIVITIES MAY BE AMENDED OR CHANGED COMPLETELY THROUGH STUDENT-INSTRUCTOR AGREEMENT. Our students are told that if this program does not meet their needs, if it does not seem relevant, or if they are asked to do things that they have done before, they may join me in developing a more meaningful activity.

In the science area, there is nothing that any student is required to do at any specific time. Once the student signs up for orientation sessions, he is expected to attend those four meetings at the established time. All other activities in the area of science are handled in an open laboratory situation. Students are given the time when I will be in the lab and told they can come and work on any activity. They can ask me any questions regarding the science area. This is done to insure maximum flexibility for students—letting them work with things that concern them and are relevant to them at the time. Attendance varies greatly from as few as two or three to over 50 students in a small laboratory room.

Students are encouraged to spend several quarters working in the science area. Most students start science during their first or second quarter in the program. Some of the activities are very difficult for a student at this level to complete. Activities which require actual teaching in the public schools generally are not completed until the third quarter or later.

While grades such as A, B, C, are not given to any student in science education, I am demanding higher quality work than I did in the traditional program. If an activity is turned in that I feel is not up to standard, I return it to the student as unacceptable. Under the traditional program, I accepted it, and just put a lower grade on it.

With the traditional program students were pretty well boxed in to completing science education in a 10-week term. This limited the kinds of things we could ask students to do, and my effectiveness as an instructor because I was presenting material to a student in one quarter which he had no need for until two or three quarters later. Under the New Elementary Program, he can work on those things which seem relevant to him this quarter, postponing others until later. This system also provides him with a faculty member in each of the areas, including science education, that he may contact and work with at any time during the entire program instead of for one quarter only. Students can come in during their intensive examination with some problems in science education and ask for help.

This program is much stronger than our traditional program as it puts science education into a continuous format for students during their entire last two years in college, and lets them operate in a program of high standards demanding excellence before activities are accepted. While a student does not have to attend regular sessions, he does have to convince me with each activity that he has done it satisfactorily. He must complete all requirements in the science area satisfactorily before I will sign a completion slip for him, and write a paragraph evaluating him in the area of science education.

As the NEP experimental program becomes the regular program and new sections are organized, individual roles change. As of March 25, 1973 I am no longer working with science education in CEP I or CEP II. I am now the team leader for CEP IV, and will also work with science education in this team.

NSSA CONCURRENT SESSIONS

SESSION N-3

YEAR-ROUND SCHOOLS

Katherine Hertzka, Coordinator of Science, Atlanta Public Schools, Atlanta, Georgia

Since September 1968, the secondary schools of the City of Atlanta have operated on a four-quarter organization of the school year. Each quarter is approximately twelve weeks long. While all high schools are in operation for four quarters and a full tuition-free program is available to all students, no student is required to attend all four quarters, nor is he assigned to attend any three specific quarters and to take vacation during some specified fourth quarter. Thus, the Atlanta program, which I am about to discuss, is more accurately described as a four quarter program than as a year-round school.

Why did Atlanta elect to organize its school year into quarters, and into four quarters at that? Historically, there have been very few attempts at this type of organization. Only Newark, New Jersey, from 1912 to 1931, and Nashville, Tennessee, from 1924 to 1932, record any serious attempts by large systems to operate in the manner in which Atlanta has been operating for five years now. What ended both of these systems' ventures was the Depression. A four quarter organization is no money saver—it costs more in dollars and cents than a traditional nine-month school year. Economy is not the reason Atlanta moved into its present pattern of curricular organization.

Atlanta like other major cities in the United States, has changed dramatically in recent years. The heart of the city is no longer as it used to be—the domination of the agrarian society is not as strong as it once was, animal power has been replaced by machinery, and modern technology demands skills unheard of in previous years.

The structure and organization of education should be dictated by the pattern of living. The traditional patterns locked school buildings during certain months of the year. Traditionally, too, the school program was pretty much of single design, regardless of the size, shape, desires, aptitudes, and goals of the pupils. Courses were in sequential order—pupils passed or repeated before moving on. Pupils were grouped and scheduled rigidly by grades regardless of their learning abilities and potentials. The traditional patterns did not seem to be educationally meaningful.

What kind of education is needed in the 70s for the young people who will perform adult roles in the 21st century? What kind of organization, and what curriculum is dictated by a highly urbanized, technological life style? What specific implications do these questions pose for science education, and how, as science educators, do we go about answering the questions?

We were faced with finding an organizational structure which would carry the desired curriculum and fit the educational goals of the pupils. We have used the semester system, the "souped up" semester system, and we even examined the trimester. But we were still looking for an organizational structure which would permit more flexibility and individualization of instruction, one which would allow pupils to take one course, or two courses, or a combination of courses and activities, and which would make possible a wider selection of options. Finally, the idea came to us. We needed an organizational structure that would expand the school year and would permit the interchange of its various parts.

We of the Atlanta City Schools have had help and, hopefully, have given help in this reorganization. Representatives from the eight school systems in the metropolitan Atlanta area, in conjunction with the State Department of Education worked cooperatively to develop a plan. This group of school systems involved one-third of the total state school population. Curriculum developers, area superintendents, state department representatives, department chairmen, and other key instructional leaders met and studied to develop a plan.

The planners decided that the vehicle needed to carry the curriculum should have four interchangeable parts. The structure took shape, and finally, we agreed that the four-quarter plan was the vehicle we would use. But merely to "chop" the traditional courses into quarter blocks instead of semester blocks would not give the flexibility desired. So, each of the eight school systems, in varying degrees, organized and worked to develop an appropriate curriculum.

Atlanta's staff—composed of teachers, coordinators, subject area department heads, librarians, consultants, administrators, and others—examined the curriculum by subject areas. Each subject area committee exchanged ideas with similar committees in the other metropolitan school systems. Interdisciplinary groups (from each of the eight systems) worked together. Administrative committees were at work also, and collectively, they attempted to produce a nonsequential, nongraded individualized program.

The entire high school curriculum was rewritten. Curriculum revision in science for the four-quarter system involved moving from a narrow, limited sequential offering to a wide range of courses, flexible in sequence, more adaptable to individual needs, and with objectives stated in behavioral terms. The accomplishment of this task commenced in fall 1967, when the high school science department chairmen began a series of regular meetings, which continued through the school year 1967-68 for the purpose of examining the current science offerings, and determining the basis for a revision and reorganization of the science curriculum adapted to a four-quarter school year. The chairmen, the resource teachers, and coordinator met in the beginning as a committee of the whole to delineate the overall task, then later formed subcommittees for the separate areas of general physical science, general biological science, earth science, physics, chemistry, and advanced sciences.

Every science teacher became involved in the curriculum revision through departmental meetings in the individual schools. Chairmen reported to their departments and brought back to the general sessions the contributions of the teachers.

After much deliberation, examination of courses of study, a study of Robert Mager's *Preparing Instructional Objectives* and Bloom's *Taxonomy of Behavioral Objectives*, the various subcommittees drew up lists of student characteristics and behavioral objectives. Basic concepts in each discipline were identified and those which seemed to hang together were grouped in clusters and later arranged in courses. Using the guide for course development drawn up by the overall curriculum revision committee, which included, in addition to the above named factors, the administrative requirements for each course, the committees then determined the number and kinds of courses which needed to be in the curriculum. As a result, over fifty quarter courses were outlined, ranked, and sequenced.

Detailed teacher and resource guides have been developed for 33 of the 58 courses presently listed in our curriculum catalogue. This has been accomplished by committees of teachers, working with the coordinator and resource teachers and some consultative help. Almost all of the major writing and editing has been done during the summer quarters. Funds to pay teachers an honorarium were available through a grant for curriculum revision from HEW. Teachers were paid, either on an hourly basis, or by contract for work completed.

Because science curriculum committees had consistently revised the science curriculum over a period of years, and because science courses prepared in the 60s by national curriculum committees had largely replaced traditional courses beyond the eighth grade, it was determined to concentrate first on preparing courses for pupils entering high school, which they were doing then at the eighth grade level. (We are now reorganizing from a K-7-5 plan to a K-5-3-4 plan). During summer 1968, guides for the three quarters of Matter and Measurement, and one quarter of Matter and Energy for lower ability students were prepared in great detail, as was a guide for Matter and Measurement, a Mathematical Approach and Matter and Energy, a Mathematical Approach for students of average and above average ability. Individualization was attempted in student contract developed for both courses.

We were learning as we worked. Teachers on this writing committee had all increased their skills in institutes for IPS, IME, ESCP, and others. They were reluctant to cast aside the concept of the "story line" in IPS, for example, or the cyclical arrangement of the ESCP text for four nonsequential quarter courses labeled "Weather and Climate," "Earth in Space," "Changing Earth," and "Rocks and Minerals." As they worked this first summer, however, and as they have continued to use the guides in their teaching, evaluating as they teach, they have discovered that the majority of courses can be nonsequential. This means, of course, that we are finding that it is not always necessary to start at the beginning of the textbook and continue logically on through to the end. It means that various concepts can be organized in quarter length sessions, appropriately and properly.

In September of 1968, a student entering high school found that, in science, he could take one of the Matter and Measurement courses, either 101 or 111, or he might be scheduled in one of the earth science courses. In the following quarter he might move into 102 or 103 or he could be moved to the 112 or 113 level, if that level was best suited to his ability and interest. He could—and still can—leave this "sequence" and enter one of the earth science courses. Had he started in the earth sciences, he might continue, or he could move to the first Matter and Measurement course.

Customs and habits die hard, so we still have a listing of courses and a flow chart that looks very sequential and somewhat inflexible in what I would call the traditional courses. Matter and Measurement is really a course in general physical science; you see three quarters of general biology, three of chemistry, and three of physics, and at least one of those quarters is considered a prerequisite to the other two. Any youngster may take this more or less traditional program, taking a full year of a science for each of five years if he so desires, or if it meets his needs.

But no student has to do this. He has many options in his science program. First, he may elect to study in one subject area per year, taking a sequential approach to the discipline, and during the fourth quarter explore any one of the courses which have really been designed "from scratch," *i.e.*, without undue influence of some national curriculum studies. Each fourth quarter gives him a chance to enrich his learning experience—in Oceanography, Individual Research, Horticulture, Photography, or Microbiology, to name a few options—depending on what is offered. Secondly, he may elect any combination of quarter courses he chooses, providing he successfully completes 30 quarter hours of science. (Each course carries the same amount of credit as any other—one period per day for one quarter equals five quarter hours of credit; 15 quarter hours equals one Carnegie unit). The student could conceivably meet these requirements by taking Science and Society, Lab Skills for Aides, Horticulture, Astronomy, Photography, and Microbiology. No course in our whole curriculum is required except Health, Physical Education, and American History. Counseling by teachers, parents, guidance counsellor, and the realities of time, space, teacher ability, and scheduling requirements tend to keep students from having a program so fragmented that it could lead to frustration for the student instead of meeting his needs, interests, and abilities.

The greatest innovation that I see in the four-quarter or year-round school organization is that it has widened curriculum options for students. Before our reorganization and curriculum revision the student options in science were:

General Physical Science	1 year	8th grade
Earth Science	1 year	9th grade
General Biological Science	1 year	10th grade
Chemistry	1 year	11th or 12th grade
Physics	1 year	11th or 12th grade
Human Biology	1 year	11th or 12th grade

Students were required to complete one year of general physical science (earth science might be accepted instead), and one year of biological science to meet graduation requirements. Now he student has the option of some fifty-eight courses, of which he must complete only 6, as far as feasible of his own choosing. He also has both opportun y and time to explore or to study in depth in areas which are oriented toward his future in the 21st century.

In reorganizing our school calendar and revising our curriculum we have recognized that Atlanta's pupils come in different sizes and shapes. The old uniform curriculum design did not fit the majority of our pupils. The four-quarter plan provides wider option, and with proper counseling, better suits our pupils. With this realization, we have tried to design a science curriculum which would permit each pupil to select a program compatible with his individual needs, abilities, and goals.

SESSION N-4

TRENDS OF SCIENCE WRITING CONTESTS AND SCIENCE FAIRS—ADAPTING THEM FOR SURVIVAL

Leonard M. Krause, Science Department Chairman, Akiba Hebrew Academy, Merion Station, Pennsylvania

Concern has been expressed that fewer students are entering national and other science paper writing contests. The central questions to be answered are: "Can student programs survive; should they?" I take the position that we science educators *should* continue to stress the need for science outlets for non-science-prone as well as for science-prone students through local, regional, and national projects.

The traditional reasons given for providing these outlets to students include:

1. *Searching* for science talent among the student population
2. Providing *recognition* to students who enter, as well as to those who win
3. Enabling students to pursue science *out* of the classroom in some independent way.

I have always agreed with these reasons and support them. But, I hold that we needn't expect students only to perform intensive laboratory experiments, but should enable new patterns to emerge from the old. To illustrate, I will review some trends of paper writing contests and science fairs (as I have experienced them, and as I have perceived them indirectly through the literature) coupled with programs I have innovated.

"What motivated initial interest in many national science paper writing contests and in science fairs?"

1. I believe that Russia's Sputnik, launched about 16 years ago—when our present high school seniors were infants and this year's teacher college pre-service graduates were not yet in elementary school—was a major factor stimulating school districts to initiate massive science fairs. The school district in which I was reared changed its annual Flower and Hobby Show to a Science Fair. In 1958, in my third year of teaching, I initiated, through a science club organization, the first Science Fair of the district in which I was teaching. As did thousands of others, I jumped onto the bandwagon with those who felt we had deprived our children of rigorous science courses, and out-of-class science activities.
2. The impetus from Sputnik led to more than casual interest in science because numerous junior and senior high schools made participation in the local contests compulsory. Research courses were initiated in some high schools, entrance to which was possible only if students would agree to write and submit a paper to: Westinghouse Science Talent Search, the former Ford-FSA program, or the more recent Tomorrow's Scientists and Engineers program.
3. Numerous colleges opened their doors to talented students who worked with talented PhD's, and who consequently brought recognition to their local schools by winning blue ribbons, plaques, free trips, or other gifts. Some of these students were brilliant as was their research.
4. Generous higher education scholarships were made available to students in order to make it worth their while to enter a paper-writing contest.

"What has militated against continued high interest in science competitions?"

1. Generally, the aura of science and technological advancement has worn thin among the public. Even moon travel competes weakly with the preoccupation of the daily routine.
2. The national Government has reduced funding to a formerly well-established scientific establishment in Washington which has, in turn, reduced the prestige of the scientific elite in the public eye. Philip Abelson, editor of *Science*, the AAAS journal, calls it another sign of the administration's continuing policy of downgrading science.
3. Numerous contemporary science teachers who were part of the campus-revolt generation and who associate hard-core science and national *competitions* with "establishment" will not motivate students toward the local or national programs. Many teachers no longer assume that sponsoring a club should automatically be expected of them by their administration.
4. Tight money situations result in a diminution of massive financial support of national competitions, and *some* industries have concerns with some of the problems inherent in competitions discussed above. In brief, they want to avoid bad public relations. For example:
Several million students contributed to a backlash of resentment by industry and researchers through millions of their letters which requested· "Send me everything you have on atom smashers. Please hurry."
Judges of science fairs and other contests found themselves stymied with problems presented by projects done by parents or with PhD assistance, or with expensive equipment financed by well-to-do parents. Problems of this nature were generated at grass roots levels.
5. Students can now borrow money rather easily from state or national sources to attend college and needn't work for months, if not for years, polishing a paper which must be among the top 40 or top 10 to win the "big" prize money.

The second district I was associated with had a Science Fair—one time only. The science department thereafter voted unanimously in 1959 to discontinue that one-time local science fair. It had no such activity until 1969.

What did we do with interested science students during that decade? In 1958 I initiated a Science Research Club and in 1965 submitted an article to *The Science Teacher* magazine summarizing its activities. Let me read you the goals as stated in that article . . . .

> Goals of the Club: Objectives of the club are many including: satisfying science interests; developing an understanding of the meaning and significance of research; providing an opportunity to study areas not usually presented in class; and learning to approach problems in an organized way, such as recording data accurately, and presenting this information in a properly written and/or oral form. These and other goals arose from a strong desire on the part of the sponsor and research scientists to bring to able students a new dimension in science experiences. Research and its implications for twentieth century living were to be the cornerstones on which the structure of the club was to be built. Pure science and its natural concomitants would be set as the ideal goal.
> As thousands of science teachers know, students are often exposed only to the *history* of science and its *technological* aspects. Rarely do they receive the opportunity to pursue an independent line of inquiry in the classroom. The Science Research Club exists primarily to provide this opportunity.

We recognize now, that we *must* include history and practical applications to round out that puristic science approach.

> Monetary Grants: A lack of sufficient funds had prevented some students from delving deeply into their projects. This situation was alleviated when a request for a grant of money was submitted to an area industry by a member of the Senior Committee. The request was honored and, with monies received, several ultraviolet light sources could be purchased for students working in the field of bacteriology. Requests made to several other firms resulted in the club's receiving additional sums.
> Several industries in Philadelphia and its environs have contributed science equipment—

again, thanks to the efforts of the Advisory Committee Cameras, texts, analytical balances, and a pH meter are some of the gifts. A Warburg Respirometer donated by a Philadelphia pharmaceutical firm has been used by several senior members who are currently instructing sophomores in its use.

Students who were motivated to participate in the club selected it by choice and those who entered national contests did so voluntarily. Some even won! We did not need national competition motivation.

Now, some of us here today, I will assume, want to see a continuation of local, regional, and national science paperwriting competitions. I do, too, but with attention given to correcting abuses by improving local supervision and also with attention given (as stated in my introduction) to new patterns.

For example: Beginning in the Spring 1967, a new science youth program, "Eastern Pennsylvania FSA Science and Humanities Conferences" was initiated by me under the aegis of NSTA. Primarily, the conferences have provided youth an opportunity to discuss among themselves and with professionals, social problems that require the concerted attention of the scientist and humanist.

During the second conference, held in April 1968, four major topics were discussed: (a) is there a scientific basis for claims of racial inequality? (b) medical ethics, (c) environmental instrusion, and (d) effects of crowding.

Students voluntarily submitted papers on one of these topics if they wished to chair a discussion group led by a practicing professional.

The conference attracted many students who would not ordinarily attend an exclusively science seminar. Approximately 30 students submitted papers to be eligible for the position of chairman, or interrogator of a professional speaker. Each year since 1967, four to seven local industries have given financial support to these youth meetings.

The new patterns mentioned in the beginning of this presentation include regional and national science youth activities of the type just described and club activities which make use of many local resources, including horticulture societies, garden clubs, museums, and club activities which associate science with social concern.

Having given the trends motivating interest and disinterest in national contests and two alternative patterns for a local science club, and a regional youth conference, I have the following recommendations or resolutions:

1. Let us stop trying to make professional scientists out of our secondary school kids by insisting only on laboratory investigation types of projects.
2. Let us broaden the base of science projects to include *ideas* for investigations, or *outlines* of experimental designs similar to the pattern set up for the skylab program last year.
3. Let us attempt to structure inter-county or regional youth conferences dealing with the social implications of science to permit dialogue among science students and practicing professionals, in a noncompetitive environment.
4. Let us reinstitute an annual national youth convention of science interested secondary school students to meet parallel with the NSSA and NSTA Conventions, enabling science educators, future scientists, and future science teachers to have dialogue.
5. Let us use the combined influence of the newly formed NSSA-NSTA youth committee to influence science supervisors to seek local industry to support local youth science functions and perhaps to sponsor youth to regional and/or national events.
6. Finally, let us use the *combined* influence of the NSTA sections to assure current sponsors of national science youth projects that these activities are indeed worthwhile and beneficial to America's youth, so that their present confidence in the ongoing programs will continue, regardless of the percentage of participation.

In closing, permit me to recount an episode in my professional career I've never forgotten. I spoke to an Exchange Club in the Philadelphia suburban area about my science club and about a project of a student who was taking a drop of blood occasionally from the ear of a rabbit. I was approached by a gentleman, who introduced himself as the director of the county SPCA! After questioning me about the nature and reason for the project he said bluntly, "I object to this project!" Having no tenure, I was worried, so I tried to assure the SPCA director that no harm was being done to the rabbit.

He replied, "Young man, I'm not worried about the rabbit, I'm worried about the ultimate psychological effect of this project on the boy." My feeling for the man and for the organization he represented was immediately overhauled. I submit that there is a message in this episode for supervisors of science.

NSTA GENERAL SESSIONS AND BANQUET

THE NECESSITY FOR A NEW THRUST IN EDUCATION TODAY

The Honorable Shirley Chisholm, Member, House of Representatives, Congress of the United States, Washington, D.C.

HENRY ADAMS once said of our profession: "A teacher affects eternity, he can never tell where his influence ends." I am inclined to agree. Our function as educators is to teach—to impart knowledge.

But what concept do we attempt to convey when using these words? To most of us "teaching"—the imparting of knowledge—has meant disseminating to our students the body of facts that mankind has accumulated. We have taken this definition and demanded that our education system evolve around it. Education is a world of excitement, dreams, and success; it is also a world of frustration, failure, and impossible problems. Education is charged with being irrelevant to the present and future needs of society and much of it is, but in our frenzied haste to become "relevant" we often detest all that was of the past and love all that smells of newness without analyzing in depth and without, in a sense, being objective about the situation.

I submit to you that before we, as educators, ask how we can better our capacity to educate we must first ask what is our function as educators. Before we look toward more and better legislation, before we talk about more money and better school buildings, we must ask ourselves the hard questions.

As I view the problem, we have stressed the intellectual aspects of education at the expense of the emotional. We have instructed our students in languages and numbers, but we have failed to educate them in self-respect, leadership, cooperation, and understanding. In a word, we have failed to help them—to allow them—to self-actualize, to come to know and respect themselves as human beings, as individuals with intrinsic value and worth.

Our primary function as educators must be to break from tradition when that tradition does not serve the present or retards the future; to reorient our school systems, not in terms of instruction in basic knowledge about the natural world, as we have done in the past, but in terms of imparting to our students and children a sense of self-respect, a sense of hope, a sense of belonging, a sense of power. Our primary function as educators must be to recognize that to educate is to "lead out."

Directly related to this, I believe, is the situation we are faced with in attempting to combat the problem of the drop-out in our educational system. When we begin to realize that the "inferiority myth," formerly advanced as the primary reason for the dropping out of the Black student, has been exploded; when we begin to realize that it is not merely lack of interest that causes a student to leave school; when we begin to realize that dropping out is not merely the inevitable result of a student's individual personality hang-ups; when we begin to realize all of this, perhaps then we can come to see that the problem is the sense of futility that the student experiences, often unconsciously.

Why should one remain in school until he becomes the recipient of a diploma, when it is apparent to him that he is in no way better prepared to cope with the outside—the real world? When he is in no way more capable of understanding himself? To the drop-out, an education in terms of present public schooling curriculum is irrelevant, that is, not meaningful to what he sees and understands of the world around him.

"Our primary function as educators must be to recognize that to educate is to 'lead out.' "

WE MUST demonstrate to all students that there is a very real reason for being in school and that real reason is to be taught, to be educated, to be *led out* of low income, high unemployment, poor health care, inadequate housing; to be *led out* of ghetto life.

But how can we do this? Projects begun after the child has become a student are remedial rather than preventive; they are an attempt to work within the prevailing organization of our schools, an organization which has itself resulted in failure.

Notwithstanding efforts which have been made, children who go to school in minority areas do not feel that they are treated equally, do not have the same chance of success academically, and are disadvantaged in finding good jobs in a society which increasingly insists on educational attainments for positions more and more of which require sophisticated skills. This in turn causes increasing numbers of such young people to conclude that effort to learn in school is a waste of time. In such an environment, even the best teachers face discouragement, a fact which contributes to the vicious cycle.

Learning today is often aimed at raising scores on standardized short-answer tests geared to knowledge of specific facts. Such tests are the easiest to grade, and they allow comparisons (invidious or otherwise) between students, teachers, and schools—in turn intensifying concentration of effort on teaching for the test rather than any other goal. Even teachers who abhor teaching by the criterion of a test rather than of the children are subjected to pressure to cover material which will be the subject of examinations on which the school may be rated. And the future of the children often depends on how they do on such examinations at every stage of their career. The result is that interest in exploring exciting questions in man's discovery about the world in and around him is often stifled. The search for understanding and the ability to deal with situations intelligently is slighted in favor of knowledge of routine standardized information and the ability to guess what the examiner wants you to answer.

In many schools, classes are large. Obstreperous pupils often monopolize teacher attention. Instruction is often by standardized methods (such as in the lower grades the "Look John, Look, John, See the Dog" type of readers). The individual child is thus deprived of the individual attention which he needs in developing his freshness of insight and his interest in learning "Why" and "How" as well as "What."

In much of education, the role of the student is strictly passive: to absorb information ladled out and then to prove he has absorbed it in order to get a grade or other sign of approval. The end result of this is often boredom and apathy or vehement revolt, expressed as young peo_' grow older in many kinds of defiance of what they believe is the behavior expected by others.

"In much of education, the role of the student is strictly passive."

Because of the salary scale of teachers compared with other professionals, the impact of overcrowded and overlarge classes, and pupil resistance due to lack of motivation, combined with pressure from above for results on tests, teachers lack the independence and status to work most effectively. This is compounded by community attitudes that teachers should "make the children learn" and that everybody knows as much as teachers do about education.

WHAT is needed is to realize that our education structure is too large, too insensitive, too out of touch with the problems unique to the various communities within each of our major cities to be able to deal with them effectively. We have lost sight of the fact that the community should have a voice in what goes on in the school. We have lost sight of the fact

"Our education structure is too large, too insensitive, too out of touch with the problems unique to the various communities."

that the community and the school should be inseparable. American culture is not a culture of homogeneous values. When we attempt to indoctrinate our entire population into a middle-class value system, a system that is not thrown open to all of us, when we attempt to reinforce through our school systems social values basic only to one segment of our population, when we attempt to do this, . can only result in a sense of frustration, hopelessness, and rage in those who have not had the benefit of the "system's" values in their preschool experiences. What we must do is to concentrate our thoughts upon the concept of community control.

Community control is not a panacea. I must preface my comments on it with that statement. But it is, as I view it, the most effective and immediate means of achieving our goals. We have all too often heard and made the cry that as teachers, our power is minimized by our principals; as principals, by our superintendents, as superintendents, by our school boards; as school boards, by our legislature. The cries are true, no doubt, and permit us some justification in viewing ourselves as being not totally at fault. But the time for rationalizing is well beyond us. The changes, if they are to be forthcoming, must be initiated by those of us who are on the inside, whose function it is to educate.

That you have come here today is an indication to me that you are, at the very least, interested, and concerned with what must be done. And what must be done is to free our teachers, our principals, our superintendents, and our school boards. Free them, emancipate them from the outdated restrictions that have inhibited meaningful progress in education; free them from the fear of having economic and social sanctions imposed against them by superiors who may or may not have the interests of the students and the community in mind; free them from the possibility of being passed over by department heads for attempting to strike out in innovative ways

We must force ourselves, as teachers, to question openly and honestly the goals, tactics, and values of principals and supervisors We must encourage ourselves to continually fight off the feeling of helplessness that has resulted from our present structural system We must encourage this because it is the only way I know to up-grade our quality as professionals.

Just as many of our students become drop-outs because our system has no relevant use for them, many highl_ competent teachers are lost to the edu cational world because that world does not permit them, in a word, to become "relevant." We must allow for variety, for experimentation, for innovation for individuality. We must allow for them, and seek to achieve them. We must not be so desirous of keeping within our ranks those who fit well within the educational world, those who are weak-minded and content to preserve the status quo, for by doing so we force out those who are concerned and capable and willing to try innovative ways. We force these teachers out because of their overwhelming sense of frustration

In effect, we must free ourselves from those whom we have served in the past—our professional superiors—and submit to those whom we should serve in the future—the community. As specialists, we should have been the first to appreciate the fact that we can no longer prepare curricula in a vacuum without consulting with the community.

THE RESULT of the curriculum production process looks like any other modern staple It is a bundle of planned meanings, a package of values, a commodity whose "balanced appeal" makes it marketable to a sufficiently large number to justify the cost of production Consumer-pupils are taught to make their desires conform to marketable values. Thus they are made to feel guilty if they do not behave according to the predictions of consumer research by getting the grades and certificates that will place them in the job category they have been led to expect.

In fact, healthy students often redouble their resistance to teaching as they find themselves more comprehensively manipulated. This resistance is due not to the authoritarian style of a public school or the seductive style of some free schools, but to the fundamental approach common to all schools—the idea that one person's judgment should determine what and when another person must learn.

Being so close to the young, we should have been the first to realize that in their preoccupation with long hair, "bizarre" music and clothing, that in their preoccupation with the use of drugs and their experimentation with sex, the young were attempting to show to us their sense of frustration with the world; and much of that young world is controlled by us; controlled by educators. We trouble ourselves over these preoccupations, yet we have never understood them. Never understood that, as individuals, our youth are in need of, hunger for, search for things which are immediate to them, things over which they feel they have control; vehicles by which they believe they can attain a sense of power. Their preoccupations are merely a negative reaction to the unhappiness, the senselessness, the hopelessness, they perceive in the world. But we must understand that these preoccupations become important, not for themselves, but only as a means of better coping with this world.

I do not wish to say that because the use of drugs can be attributed to an effect rather than a cause that the problem is any the less frightening. I do wish to say, though, that we should take that observation and begin to mark our direction in terms of it; that as educators, in the valid sense, we must accept the fact that our role, as educators, should be inseparable from the concept of the community; that our function is, and must be, directed toward alleviating economic, political, and social injustice. Indeed, what else can the purpose of education be?

THE LARGER problem is not nearly as much one of finance as it is of power and of wresting this power from the hands in which it presently lies and placing it where it belongs. Certainly, education is in need of increased funds, but no amount of funds will provide a more useful, meaningful education unless the effort is made at the local level.

Why do I advocate the use of community control? Perhaps the most immediate reason is that community control can provide us with the means of checking and balancing, at all levels.

Community control can be the vehicle by which school and community, now separate entities, become one; can be the vehicle by which teachers, now transmitters, become developers; can be the vehicle by which teachers, now advocates of the system, become advocates of the student; can be the vehicle by which parents, now spectators, become participants.

It permits members of the community to express an effective voice, not merely an ineffective opinion, concerning the goals of the schools which their children attend. It permits the community to hold principals and teachers accountable and forces the latter to become concerned with what the community feels its primary educational needs to be. Progress is rarely made where the views of those who are governed have no impact, where the men who guide and control our activities are not amenable to our sanctions. This is the situation that parents, students, teachers themselves, all those people that the term "community" embraces, find themselves in today. They have no voice in policy because those who should listen, those who are in charge of making policy, are too far removed from them, in terms of geography, ideology, and security, to worry about listening. And those who must listen, those who act as principals and superintendents, those who are themselves the subjects of power in the overall scheme, are too ineffective to achieve results.

"Community control can be the vehicle by which school and community, now separate entities, become one."

We must localize the structure of the school system and allow the administrator and teacher to be answerable, in a sense, to the immediate and pressing needs of the community they serve rather than to the far-removed desires of those who sit above them.

We must bring the educator closer to the problem and force him to put things in perspective, to consult with parents, to consult with students, to get a full view from all sides as to what needs to be done.

We must force the system to become aware of our needs and then force it to take them into account in setting its goals. In this way, then, education takes on a relevant meaning. The parent is able to meet with the teacher and the principal to discuss the specific problems of his child and of the environment in which the school exists.

We must not fear placing our trust in the community. We must not fear turning authority over to local boards, giving them some power to hire and fire and some power over curriculum and budgeting matters. We must not fear being held accountable. For within the concept of accountability lie the seeds for a part of the restructuring process; namely, that an educator's ability would be measured by, and dismissals, transfers, promotions, and pay raises would be based upon, performance and not merely seniority. Our system now protects the mediocre, not the qualified.

Today, when parents pressure a principal into transferring a poor or incompetent teacher, the transfer will most assuredly not take him into a "better" area. Often the move will be from one ghetto area to another. Rather than operating under a system whereby we will either produce results or be held responsible, we find ourselves cursed with civil service tenure rules which afford a way of life to the inept. I maintain that a system of accountability will protect our own personal interests as much as those of the community by weeding out those, be they few or many, who are either incapable or unwilling to undertake the responsibility of properly educating the young.

Community control is a way of providing the much-needed link between the school and the area's residents, whom it serves. By involving parents in this type of endeavor, it forces the curriculum to become relevant—relevant in terms of reflecting the cultures of the Black and Puerto Rican communities; relevant in terms of no longer being influenced by those who refuse to reach out to the community. Undoubtedly, this will mean that there will be a rise in the percentage of Black and Puerto Rican teachers, but it would be to raise a red flag to say that only such teachers would be permitted to teach within that community. What is required is an administrative and teaching staff that adequately reflects a cross-section of the particular community involved. By communities I mean all those who have a stake in the products of the school. Only in such a manner can we avoid the problem of lack of identification between teacher and students, between school and parent, and insure an emotional closeness between the two, a bond which is almost nonexistent in ghetto area schools as they now exist.

There are those who ask if community control will lay the concept of integration to its final resting place. I find I am most often approached on this issue by the very same people who fought against integration in the name of decentralization and the neighborhood concept. To me, it is but another red flag raised by these people who are now to be seen fighting against community control in the name of integration.

The question is not whether integration will die, but whether it was ever meant to live. For the integration of our day has been defined in terms of giving a white child a locker next to a Black child, busing 100 seven-year-olds from slum to suburb; hiring a Puerto Rican staff member to improve the public relations image of a school. To me, this concept was lifeless even before it took on its present form.

INTEGRATION, if it is to live, if it should live, must be seen not only in terms of race, but "in terms of culture, a coming together of different peoples in a social, esthetic, emotional, and philosophical manner, not in terms of a mechanical juxtaposition. It must be seen in terms of pluralism rather than assimilation; it must be based on a respect for differences rather than on a desire for amalgamation. It must be seen as a salad bowl rather than a melting pot." (Quote taken from NEA's Task Force on Urban Education: Schools of the Urban Crisis.)

If this is what people have in mind when they ask me about integration and community control, then my answer must be that the two are not only compatible, they are inseparable.

But regardless of the answer on this question of integration, the most crucial issue is still the quality of the education that we and our children are to receive. Community control seems to hold out a promise in this regard, a promise to bring education that needed step closer to being relevant to creating an environment that is truly democratic and rife with equal opportunity at all levels.

I have referred, quite often, to the word "relevancy." In some instances, no doubt, I have used it improperly. Rather than saying "irrelevant," I should have said "harmful." For it is harmful rather than irrelevant to instruct a child in the meaning of values, in the meaning of "good" while forgetting that the concept of "good" is based upon adult standards which are foreign to him. It is harmful rather than irrelevant to teach a child that in school he will remain docile and passive and obedient, harmful because when he is no longer in school he must forget these ideas and somehow learn to be creative and aggressive. It is harmful rather than irrelevant to raise a generation of what John Holt has referred to as "answer-producers," those who have the ability to "parrot" properly; harmful because their reward for so doing is merely to be led into lives of complacency and dullness. And as for those who are incapable of "producing answers," for them there is shame, fear, resentment, and rejection of others.

These, then, are, as George Dennison describes them in his essay "The First Street School" appearing in *New American Review #3*, "the most familiar waste products of our school system—complacency and rage."

Again, it is harmful rather than irrelevant to subject our children to compulsive processes, aversive processes, to attempt to force the child into unnatural surroundings and situations and then demand of him that he learn. "You must go to school." "You must sit." "You must remain silent." These are situations in which the student finds himself daily—confronted with a void of stimulation, an atmosphere totally lacking in the seeds of curiosity, an atmosphere that demands of the student that he force himself to memorize and thereby "learn."

As Marshall McLuhan has stated in "The Medium Is the Message," the young are merely confronted with "instruction in situations organized by means of classified information, in subjects which are unrelated and visually conceived in terms of blue-print. It is, in its most exposed form, a suppression of the natural direct experience of the young," a process which we utilize every minute while outside the classroom, to assimilate and digest. In these words we find the implicit demand that education must shift from "instruction" to "discovery," from "goal-orientation" to "role-orientation," an employment of total involvement dealing with human problems and situations, not

"The student brings to the classroom his entire person. Let us, then, educate the whole of it."

fragmented and specialized goals or jobs. "Education must shift from *structure* to *environment*."

In preparing my address to you, I gave considerable thought to including within it proposals dealing with specific curriculum changes, such as the introduction of sex education courses, courses on religion, and on education itself. I considered discussing the merits of employing in our educational approach newly advanced psychological concepts such as Skinner's concept of "arranging the contingencies of reinforcement." I could have discussed with you the idea of rearranging our teaching day, of shortening classroom time so as to permit home visits and individual work. I could have discussed what the federal government's role in our educational policies should be. I could have discussed these topics and many more, but I have chosen not to. My reason for so choosing is basic. It is based on the belief that what I have advanced here today requires our total concentration. It is based on the belief that we must first put our full efforts to the task of reversing direction, and only then, only after that has been brought about, can we afford ourselves the luxury of getting down to specifics. Institutions resist change; power concedes nothing. If we forget this we are lost.

If I may leave you with one thought; if I can implant within you one example, one reminder for all that I have tried to express here, let it be this: The student brings to the classroom his *entire* person. Let us, then, educate the whole of it. If we are really to affect eternity, let it be to our credit!

Thomas Jefferson observed, "The earth belongs to the living generation." □

SPECIAL GENERAL SESSION

FOR SUCH A TIME AS THIS

Elaine W. Ledbetter, President of NSTA; Head of the Science Department, Pampa Senior High School, Pampa, Texas

THROUGH the years I have been disappointed that our national conventions have not afforded an opportunity for the membership to see and hear the president in any role other than as chairman of a session or as emcee at the banquet. I believe that the large number of teachers who attend the national convention have a right to hear the president speak to current issues. I also believe that the elected chief officer of any organization has an obligation to the membership to confide in them his experiences, his concerns, and his dreams for the future of that organization.

It was this rationale that prompted me to ask the program committee for a place on the program at this convention. This is not an ego trip for me. I have no illusions about being a great speaker. My request grew out of the fact that as a participating member of NSTA I knew what I have wanted from past presidents. As your president, I have attempted this year to give you what I myself have sought. A partial result of this attempt is this Special General Session.

One of my favorite Old Testament stories is that of Queen Esther. She was a Jew, although her husband, the King, did not know this. When the King issued a decree that all Jews in the kingdom were to be destroyed, Esther went to her Uncle Mordecai in deep distress. She was not willing to stand by and see her people destroyed, and yet neither was she willing at that time to risk her own life by revealing her true identity to the King. Mordecai advised her to go to the King, trusting in his great love for her, and to request that both she and her people be spared. Then Mordecai said to Esther, "Who knows but that you have come to the kingdom for such a time as this?"

Proper timing is a major condition for success in any endeavor. You golf players know this. If your timing is off you may as well put away your clubs until another day. Teachers know this, too. Do you ask your principal for released time to attend the NSTA Convention as he emerges from an unpleasant confrontation with an angry parent?

Proper timing is essential in planting seeds to produce successful crops; it is important in war and in winning peace; it is crucial when making career decisions. Upon many occasions I have heard people of prominence reflect on the reasons for their success only to conclude with the remark that they were simply in the right place at the right time.

The original ancestor of the National Science Teachers Association was the Department of Science Instruction of the National Education Association. This Department was established in Denver in 1895 at the annual NEA Convention, seventh oldest among more than 25 such NEA units. In 1940 the Department of Science Instruction became the American Council of Science Teachers. Then in 1944 the American Council of Science Teachers merged with the American Science Teachers Association, an affiliate of the American Association for the Advancement of Science. The result of this merger was the National Science Teachers Association. At its inception NSTA had some 2,000 members and subscribers; the annual budget was less than $10,000.

Robert H. Carleton became executive secretary of the Association during the fourth year of its existence. Today NSTA is the largest science teachers organization in the world devoted to the improvement of science education at *all* levels of instruction—elementary, secondary, and collegiate. We now have some 40,000 members and subscribers, and we operate on an annual budget of more than 1.25 million dollars. Much of the credit for our successful growth must be attributed to the creative leadership and the wise guidance of Dr. Carleton. There is little doubt but that he came to NSTA in 1948 for just such a time as that.

IN ORDER to place in proper context the remarks which I will make about the future of NSTA, let us look at the present status of science education in the United States. When the Board of School Trustees granted me a full year of sabbatical leave to fulfill my duties as your president, I began to think about how I might be of greatest service to the Association. Knowing that science education is in a state of turmoil and being aware of the fact that NSTA has not had a staff person who could devote full time to field work, I designed the IMPACT Program. IMPACT is an acronym which stands for Increasing Membership, Participation, Activity, Communication, and Trust. This was a multifaceted program, but basically one with two major goals. The first of these was to personalize NSTA for teachers who cannot or do not attend our meetings. It was my feeling that by meeting teachers in their own classrooms and by visiting with them informally about our common problems I might encourage them to become active, participating members of NSTA. My second major goal was to identify areas in which NSTA needs to strengthen its services to the membership and to the profession.

Since the end of last September I have traveled over 110,000 miles. I have been in more than 150 schools. public, private, and parochial. I have visited classes in more than 2,000 classrooms and have been on the campuses of nine community colleges or universities. On several occasions it has been my privilege to speak to seminar groups of preservice science teachers It is impossible for me to know how many new members this program has generated. However, I can assure you that the warm response to my visitation has been extremely rewarding. When teachers in remote areas come to me with tears in their eyes asking how the president of a national association could come to their small school, it is, indeed, a moving experience.

One cannot generalize about the quality of science teaching in this nation, because in every area one finds a gradation along the entire spectrum from superior to poor I have met enthusiastic teachers engaged in exciting programs who work in ancient classrooms that are almost totally lacking in facilities and that are unbelievably dreary. I have been both humbled and inspired by their dedication. I have met others whose teaching environment is a brand new, multimillion-dollar, open-space building where there is so little structure to the science program that total chaos is the result. One cannot generalize.

HAVING been in classrooms at the elementary, junior high, and senior high levels in 20 states, I perceive certain trends. There is a great deal of innovation in evidence throughout the nation. Innovation lies in three major areas: (1) the increasing use of educational technology, (2) administrative and instructional methods, and (3) the revision of subject-matter content.

I will not dwell on the increasing use of educational technology except to say that there is widespread use of tapes, both audio and video. Many schools have math and science resource centers where students can utilize such materials in audio-tutorial programs. Cassette tapes, overhead projectors, and various kinds of programmed learning materials are increasingly available to students. Computers are being used in certain schools, but the high cost of installing and maintaining such equipment is a limiting factor in their widespread use. In addition, relatively few teachers are trained in computer technology.

"It is inexcusable when young teachers emerge from teacher-training institutions with no knowledge of the new science curricula and with no skills for implementing them!"

By innovations in administrative and instructional methods I refer to such things as the open classrooms, alternative schools, implementation of the trimester or the four-quarter plan, the middle school, team teaching, and individualized instruction. These are producing more problems than the trend toward technological hardware In many cases administrators have assumed that teacher attitudes and teacher behavior would automatically change to fit the innovations. Such is not the case Many of these modifications require a drastic alteration in the role of the teacher. Not only do they require a change in teacher behavior, but often the teacher must undergo a change in his fundamental values. Such changes are not easy to achieve.

In the NSTA position statement on curriculum, "School Science Education for the 70s," we find these words:

> The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action.... Above all, the school must develop in the individual an ability to learn under his own initiative and an abiding interest in doing so. . . The major educational challenge of the next decade is to develop learning environments to prepare young people to cope with a society characterized by rapid change. To cope with and attempt to solve problems in a rapidly changing society, young people will need to develop science process skills and associated values to a greater extent than have similar groups in the past.

What constitutes such a learning environment? There are many factors, but I submit that the attitude of the teacher is the single most important component of the inquiry environment. I have observed many classrooms this year in which one or more of the so-called innovations were being tried. The only cases in which these were effective were in those classrooms where teacher behavior indicated a real commitment to the inquiry approach. It is understandable that teachers who have been practicing for a number of years need help in converting from their role as dispenser of information and as the source of all knowledge to the role of a facilitator of learning. But I think it is inexcusable when young teachers emerge from teacher-training institutions with no knowledge of the new science curricula and with no skills for implementing them! A few institutions have initiated creative pre-service programs that hold great promise for improving the teaching profession, but these are few and far between.

ONE of my major concerns is that innovations in administrative and instructional methods are being adopted without adequate preparation of that part of the staff whose responsibility it is to implement these innovations. Furthermore, when major changes are contemplated within the school, all interested parties must be brought in on the planning. Professional staff, students, parents, and the community must participate as fully as possible in preparing for such changes. Although the entire community may not be able to participate directly, at least it must be kept informed about what is being undertaken and the reasons for it.

Perhaps the most widespread innovation is individualization of instruction. Just what is the meaning of "individualized instruction"? Experienced and perceptive teachers have always been sensitive to the differences that exist among their students and have made certain adjustments in the curriculum to meet the needs of each individual. In an individualized learning environment there is usually a core program, but with many options that permit each student to select goals and rates of advancement that suit his own needs or desires. This is highly desirable and can be very effective in increasing student interest in science, but there are pitfalls which should be mentioned. The teacher who undertakes to create an individualized learning environment must, first of all, be totally committed to the approach. He must believe that students *can* assume responsibility for their own learning and progress, and he must believe this on the internalized, emotional level—not simply on the intellectual level. He must have the necessary software to carry out such a program. Several such programs are now on the market. If the teacher decides to develop his own software, then he should realize that this will require a considerable amount of time, effort, and some financial outlay. The support of the administration is of key importance. Furthermore, it is advisable to move into such an environment slowly, a little at a time, so that both the teacher and the students gain experience in how to handle the freedom which such a plan allows. NSTA has recently released a publication entitled "Individualized Science—Like It Is" that describes several individualized programs currently ongoing and closes with a chapter on how you can begin to individualize your own classes.

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"It is imperative that we develop criteria to bridge the disciplines in such a manner that all students who pass through our schools will emerge able to utilize the spirit of science in all relevant contexts."

SO MUCH for innovations in the administrative and instructional areas. The third trend which I mentioned in the beginning is toward the revision of subject-matter content. Many elementary schools are using the new programs that are activity-oriented individualized approaches to science. These are designed so that the child moves through a continuum from grades K-6 or 1-6. The emphasis is upon science processes.

At the junior high and senior high levels there are still relatively few programs on the market which are specifically designed to allow self-pacing, individualized learning. Particularly at the senior high level the emphasis in science courses is largely for the science-oriented, college-bound student. The continually decreasing enrollment in elective sciences indicates that we are not offering the kind of science that appeals to the majority of our students. I view this as an area of major concern, because if the young people who are in school today are to develop process skills and associated values that will prepare them to cope with a rapidly changing society, we must provide them with a science curriculum that makes this possible.

We need to continue to offer the kinds of science courses that can produce enough scientists to meet the requirements of our society, and it appears that we are doing this very well. However, it is imperative that we develop curricula to bridge the disciplines in such a manner that all students who pass through our schools will emerge able to utilize the spirit of science in all relevant contexts. If we are to produce a scientifically literate society, then we must enable adults to employ the methods of science in making rational decisions in their daily lives. For example, give students ample opportunity to evaluate current advertising claims in the same objective way by which they evaluate hypotheses formulated from experimentation.

What about values? The NSTA position paper says that students need to develop not only process skills, but also associated values. Values grow out of one's experiences. Therefore, it follows that we must provide the kinds of experience that will enable students to develop a sound value system. Let me suggest two examples of how this might be done. After biology students have studied genetics and understand the process of heredity, encourage them to read current literature on cloning humans. Provide time for them to discuss the possibilities for altering the future of mankind. Social, political, moral, and religious implications should be explored freely. Raise such questions as whether or not cloning research should be continued; who will make the decisions? what will be the mechanism for decision making in our society on such important issues? what values should guide those who make such decisions?

A similar procedure can be used in chemistry or physics classes with regard to the power crisis. Once students understand something about nuclear energy, ask them to do wide reading on the current controversy surrounding the construction of nuclear power plants. Encourage research on the reality of the power crisis; let students discuss the political, economic, and ethical aspects of these problems.

"Let students discuss the political, economic, and ethical aspects of today's problems."

We have a long way to go in providing a meaningful science curriculum for the young people who will soon be entering the 21st century. I urge each of us to assume responsibility in this endeavor.

I have dwelt at considerable length on the present status of science education in the United States and some of the concerns which I feel regarding it. In closing, let us look to the future. The theme of this convention is "Bridges to the 21st Century Through Science Education." What challenges face NSTA? What responsibility should our Association assume in determining the shape of the future?

There are four areas in which I should like to see NSTA exert strong and positive leadership:

1. *In opening lines of communication among all scientific and educational societies concerned with science education.* At present there are a myriad of such organizations operating at the state and national levels, each concerned with the promotion of its own discipline in its own way. If we are to attack the complex environmental and technological problems facing us in increasing numbers, then biologists, chemists, physicists, earth scientists, and others must begin to work together cooperatively. Since NSTA is the largest organization in existence devoted to the improvement of science education in the broadest sense at *all* levels of instruction, I feel it has an obligation to serve as the catalyst in securing the kind of cooperation among these groups that will result in the most effective utilization of our efforts, our resources, and our expertise.

2. *In cooperating in international scientific undertakings.* The earth has become too small for each nation to continue to attempt to solve global problems alone. For example, ecologists tell us that only by dealing with environmental education on a worldwide basis will be able to save our oceans and our atmosphere from destruction. On April 13-14 at the University of Maryland, approximately 40 delegates from different countries will convene to consider the formation of an international council of national science teaching societies with the ultimate goal of strengthening science education throughout the world. The immediate aim of the proposed council would be to facilitate the dissemination of information and ideas among the participating organizations and to their respective members. I believe that NSTA should become a member of this international council if it does form.[1]

3. *In providing more support for teachers.* NSTA has provided support for teachers by issuing a position statement on curriculum, by formulating the ASIST (Annual Self-Inventory for Science Teachers) document, and recently by taking a firm position on the inclusion of nonscience theories in science instruction. The nationwide study of exemplary facilities has produced a landmark publication on facilities and evolving patterns of secondary school science programs. It should serve teachers, school administrators, and architects for the next decade (Published by NSTA under the title *Facilities for Secondary School Science Teaching: Evolving Patterns in Facilities and Programs*). A committee is now completing work on interpreting the science results of the first National Assessment of Educational Progress. Another committee is currently developing an instrument for use in self-assessment of secondary school science programs. We visualize this instrument as having great potential for supporting teachers in areas where the accountability issue is raised. The issues committee has formulated plans for restructuring so that the Association may be able to react to vital issues in science education with greater immediacy than it has been able to do in the past. NSTA has an obligation to its members to provide the greatest possible support for teachers at all levels when issues arise involving science education.

4. *In providing permanent housing for the Association.* The Capital Fund Campaign to secure funds for a permanent building was begun at an unfortunate time. This is an example of how important timing can be to the success of a project. We began our drive for funds at the very time when

"NSTA has an obligation to its members to provide the greatest possible support for teachers at all levels when issues arise involving science education."

the national economy began to decline. As a result, the drive was discontinued. However, our dream is still alive, though dormant. The net amount of funds that remained after all bills were paid is $33,678.36. This money is in a Washington bank accumulating interest, and the Board of Directors voted at the 1972 summer meeting that no expenses are to be charged against the principal sum. When the time is right, let us resume our efforts to provide permanent housing.

Under the leadership of Robert Carleton, NSTA has achieved an enviable place among the scientific societies. An era in our history is ending. But it ends on the promise of an even more glorious tomorrow.

> There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune;
> Omitted, all the voyage of their life
> Is bound in shallows and in miseries.[2]

I believe that the tide of NSTA *is* at the flood. Our newly appointed executive director, Robert Silber, comes to us with impressive credentials. He has great potential for providing the leadership we need in the years ahead. Who knows but that he has come to NSTA for such a time as this?

Any association is only as strong as its members. You who are here today represent the best that we have. You have a special awareness of the problems we face. You possess your own unique talents for helping to solve these problems in your own places of responsibility. Let us accept the challenge of the 21st century and keep proud step with our destiny. Who knows but that each of us has come to our profession for just such a time as this? □

Shakespeare *Julius Caesar*, Act IV, scene 3

THE ROLE OF BUSINESS AND INDUSTRY—A VIEW FROM INSIDE

Burt C. Piatt, Executive Secretary, Committee on Educational Aid, E. I. Du Pont de Nemours & Company, Wilmington, Delaware

"The need for close and constructive cooperation between the business world and the educational establishment is greater than it has ever been."

IN discussing the role of business and industry in science education, I plan first to try to provide answers to three questions that are frequently raised when I get into a discussion with teachers or school administrators about relations between the schools and industry. Following that, I would like to talk briefly about the Du Pont Company's general interest in education, and specifically about an experiment in science education under way in the State of Delaware.

I offer the suggestions I am about to make with some hesitation, because giving advice is a risky business Darrell Royal, the football coach at the University of Texas, offers this explanation of his team's preference for running plays over the forward pass. "When you put the ball in the air," he says, "only three things can happen, and two of them are bad."

When anyone offers advice, one of three things is also likely to happen, and two of them are unpleasant. Your advice can be ignored, which is always a challenge to your ego Or your advice can be followed and prove disastrous. But those of us in the business community are encouraged to live by risk, and I hope that something I have to say will prove useful.

Certainly the need for close and constructive cooperation between the business world and the educational establishment is greater than it has ever been. There are quite literally dozens of ambassadorial committees working between the two groups today; some work quite effectively, others hold out more promise than performance. From the business side, we have the outstretched hands of the Education Activities Committee of the Manufacturing Chemists Association, which has established fairly effective liaison through its Awards program. From the academic side, we have such efforts as the NSTA Advisory Committee on Business-Industry Relations and the Industry-Education Councils of America established by the American Association for the Advancement of Science. Such groups will, we hope, continue to improve their effectiveness

Cooperation between industry and the schools frequently comes down, however, to the relationship between a specific company and a specific school system And it is with a view to providing a simple road map for such cooperation that I wish to consider the following questions:

1. Why should a major technical company be interested in science education at precollege levels?
2. How can a science teacher, coordinator, or supervisor identify the right person in the corporation for general communications and assistance?
3. How can business and industry assist science education?

NOW let us take up Question No. 1, "Why should a major technical company be interested in science education at precollege levels?"

The most obvious answer is that educated technical manpower is our life blood. Without the contributions of college graduates in technical fields, science-based industry simply could not exist The critical importance of the precollege experience is expressed very well by Doty and Zinberg in the December 1972 issue of the *American Scientist*

> Undergraduate education in science comes after a long and varied exposure to science and mathematics in primary and secondary school. The quality of this earlier encounter is probably the most decisive factor in determining the attitudes and motivations of students for further science study and in generating the sustained dedication that a career in science so often requires.

There is another reason why technical companies are interested in science education. Today we are facing a shortage of engineering graduates. It is becoming increasingly clear that the key point in the current fall-off in engineering enrollments lies at the high school level. Although a large proportion of our high school graduates go on to college, many who are sufficiently intelligent and curious to undertake an engineering education and to succeed in engineering careers do not matriculate with requisite high school credits. Others who do have the credits don't have the inclination. As a result, unfortunately, they sidestep career opportunities they might find most rewarding.

We believe that inspired secondary school teaching is one essential in correcting this imbalance. Another corrective is a better understanding on the part of guidance counselors of the importance of science and engineering in the modern world. A great deal is being written on this subject. A good recent article is the editorial by Dorothy Zinberg in the March 23, 1973 issue of *Science*.

The importance of science and engineering in our society has not lessened one bit despite the highly publicized cutbacks in space programs and in government funding of research programs,

"Without the contributions of college graduates in technical fields, science-based industry simply could not exist."

particularly in support of graduate research at the universities. The needs of science-based corporations like Du Pont continue to be great, and we do not see

"Modern corporations need a good general climate of public acceptance and understanding of their role in society."

at the moment enough capable young people coming through the educational process.

A somewhat less obvious answer to question one—that is, why should a technical company be interested in science education at the precollege level—is that modern corporations need a good general climate of public acceptance and understanding of their role in society. For one thing, it is essential that our national and local leaders have some degree of information about science, technology, and the economics of the industrial world. Congress is always well supplied with lawyers, but one looks long and hard to find a legislator with a degree in science. Legislation affecting regulatory practices might be more constructive if this were not the case. The broad voting population, furthermore, could express itself much more constructively if the citizens had a better basic understanding of science.

LET us proceed to Questio No. 2. "How can a science teacher, coordinator, or supervisor identify the right person in the corporation for general communications and assistance?"

Unfortunately, there is no simple answer to this question. Corporations are organized differently, and the responsibilities of managers often depend to a large degree on historical factors and individual interests. In most cases, the best initial approach is to write a general letter to the chief-executive officer of a corporation. You might express a desire to get acquainted with the general science activities of the company and ask for a chance to explain the science program of the school you represent. If the corporate headquarters are in your community, this approach should yield good results fairly promptly. If the headquarters are remote but there is a substantial plant or laboratory nearby, you should get good results although it may take more time to establish a satisfactory relationship. For other cases, I suggest limiting your efforts to leading corporations with a strong technical focus and established national programs that demonstrate an interest in education.

Now let's assume you have succeeded in identifying an individual with some interest in, and responsibility for, educational relations. Your first effort should be simply to get acquainted. Explore areas of mutual interest. Point out, if necessary, that the quality of science education may be important to the long-range interest of the corporation.

Keep in mind that most major technical corporations have fairly close relationships with science and engineering education at the college level and many provide some form of financial assistance. At the precollege level, however, be prepared to have the corporation manager point out that they contribute strongly to the tax base from which public schools are funded. Many companies consider that they discharge their financial obligation to the public schools adequately through taxes.

With a relationship established, we are now ready with the third question, that is, "How can business and industry assist science education?" I am going to talk first about broad aspects of this question and then about a subject I know best; namely, how the Du Pont Company assists science education.

A great many American businesses and industrial corporations are involved in a variety of ways with the public schools This involvement has been increasing to some extent in the last several years, stimulated in part by the intensification of concern about urban affairs and the strong interest in career education. In the case of science education, the assistance may take the form of:

1. Resource materials, such as films, career booklets, environmental brochures
2. General advice and assistance from professionally trained individuals
3. Loan of books and scientific equipment
4. Invitations to teachers and students to tour plants, laboratories, and offices
5. Summer jobs to provide stimulation toward scientific and engineering careers and acquaintanceship with industry
6. Financial assistance

Item 2, concerning help from professionally trained people, may contain some aspects that ordinarily would not occur to you. For example, most corporations have experts on computer programming, modern communications, transportation, environment matters, organizational structure, and personnel problems.

Do you need a physicist, for example, to take over a physics class while the teacher attends a scientific meeting? Perhaps you normally would look to a nearby college or university but you should also think about technical industry. An industrial physicist might bring your students a great deal of insight into how industrial research operates and how to prepare for careers in the physical sciences.

Also keep in mind that business and industry operate by defining goals and working toward their attainment. Normally there is an assessment procedure coupled with some feedback to correct weak activities Thus expertise on systems approaches to the attainment of goals exists in most large companies. There may be ways the educational community can benefit from this.

"Business and industry operate by defining goals and working toward their attainment."

I have placed financial assistance last on my list, because I really believe it often is of less importance to schools than other types of assistance Nonetheless, there are times when such assistance can help launch special programs. How then do you approach business and industry for financial aid?

I suggest you start out in a middle ground. If the request is very small, the corporation may not wish to take on all the red tape necessary to get approvals. On the other hand, if the amount requested is large, you may provoke a prolonged examination of all the reasons why it is appropriate at all for a corporation to supply any funds to public science education. So start at a modest figure. After the donor becomes better acquainted with your activities and finds them meritorious, he may agree to larger contributions later.

Keep asking yourself the question: "Why is it important for Corporation A to assist us in this particular purpose?" And when you do receive a contribution, be sure to inform the donor from time to time about the way the funds are being spent. When the money is exhausted, provide a complete account in writing of how the money was used and explain how this money truly contributed to the progress of the educational project

In developing a relationship with industry, keep in mind that it may not be too difficult to get a one-shot commitment from almost anyone. To sustain the relationship, however, work at it in order to continue the mutual interest in each other's affairs. Each party must feel benefited by the relationship If one feels "used," the relationship is bound to fail.

I would like to proceed now to Du Pont's interest in science education. Historically, the Du Pont Company was one of the pioneers in educational aid. Starting in 1918 with a modest commitment to graduate fellowships in science and engineering, the program has grown and expanded in scope Over the years, special emphasis to meet changing educational needs has been characteristic of Du Pont's aid-to-education programs. Each year's awards reflect the company's commitment to:

1 Help maintain U.S research and education in science and engineering at a peak of excellence and increase the qualifications of graduates in these fields;
2 Strengthen curricula and guidance at precollege levels;
3 Improve the educational and social environment in which the company operates.

This year's grants of $2,740,000 are principally earmarked for support of engineering and science research and teaching in 150 institutions. Continued and increased support for minority group education and improved science teaching methods and curricula for secondary schools are also included in the 1973 program.

The heart of the Du Pont program continues to be unrestricted grants of nearly $1 5 million, primarily to departments of biology, chemistry, engineering, and physics in public and private institutions, including liberal arts colleges. Adding $300,000 to support research by young faculty members, this category amounts to nearly $1 8 million.

The above figure also includes $62,500 for environmental studies in 11 major universities.

This year we announced a new program of graduate fellowships in science and engineering. This reflects the Company's concern about the rapid fall-off in federal support of graduate education in recent years and our belief that shortages of men and women with graduate degrees are inevitable in three or four years. We want to stimulate the brightest students to consider careers in these fields

"Shortages of men and women with graduate degrees are inevitable in three or four years."

For the reasons outlined previously, we also believe that the Du Pont Company's interests will be served by high quality teaching of science at precollege levels. Working with public schools nationwide would be overwhelming so we have chosen to place emphasis on the schools of the State of Delaware. This is natural for us because of the high concentration of professionally-trained employees in this area. Another factor, of course, is that our corporate headquarters are in Wilmington.

PERHAPS many of you here today have heard about the Delaware Model: A Systems Approach to Science Education, which we call Del Mod for short. The National Science Foundation has issued nationwide publicity on the program and an article on it appeared in last September's issue of *The Science Teacher*. Also, it was discussed at a symposium at the 1973 NSTA Convention in Detroit. I will summarize the origins of Del Mod and explain why the Du Pont Company is interested in supporting it.

Del Mod did not spring full blown from the minds of its originators. Rather it was based on exploratory programs testing out the idea that two or more institutions concerned with science education might work together closely to improve science teaching in the state. There has been a good record of communication and cooperation in scientific areas between the institutions of higher education in Delaware and the Department of Public Instruction, which is responsible for coordination of all teaching in the state. For example, many summer institutes, workshops, and extension division courses have been available to science teachers in Delaware.

On the financial side, there has been a good record also in the funding of special programs by our local tax-supported institutions, by the National Science Foundation, and by the Du Pont Company. In general, Du Pont's role has been twofold first, to provide funds quickly to get programs started, and second, to provide sustaining support for important aspects of programs that do not qualify for state or federal funding For example, during the early planning stages of Del Mod, it became apparent that base-line data would be essential in order to assess the extent to which science education was being changed. Du Pont contributed $20,000 to begin to collect such data a full year before Del Mod was completely organized and funded. In another example, the work of the field agents was greatly assisted by a grant from Du Pont to provide substitutes when regular science teachers attended workshops during school days. Funds for this purpose were simply not available from federal or state sources.

The origins of Del Mod itself go back about three years to when a small group, stimulated by the State Science Supervisor, decided that a new concerted program could reach all of the classrooms in Delaware where science is taught. A great deal of time was spent sounding out the possibilities of interest and support. This included all the public institutions of higher education of the state as well as the governor at that time, Russell Peterson. The National Science Foundation and the Du Pont Company were brought into the talks at an early stage and participated in shaping programs that would qualify for financial support.

Del Mod seeks, of course, to implant a process of continuing change and improvements in our schools. I am aware that there is a good deal of soul searching these days on this subject. There is a recent report of the Ford Foundation, "A Foundation Goes to School," that is a broad review of its comprehensive school improvement programs during 1960-70. The report candidly points to

"You the educators are the producers and we are the customer.

a great many failures and the lack of follow-up once outside funding has ceased. It also points out that the amount of money or the size of the program did not determine its success. One of the most important factors was the person in charge of daily operations.

There is an interesting account in the January *Saturday Review* (Education) by Benjamin DeMott, who has served as an educational consultant for the Office of Education. He also admits candidly that a high proportion of the massive educational experiments of the 1960s funded by the Office of Education failed to produce any meaningful change.

Will Del Mod do any better? Obviously, only time will tell and we are only in the second year. However, the experiences of Del Mod have taught us several things worth noting. First and foremost, a large endeavor of this type often results primarily from the efforts of a single individual who develops ideas about change and seeks to convince people and to obtain necessary funding. Second, there can be a pronounced catalytic effect of joint business-industry interest in science teaching that is extremely helpful in nurturing and furthering new activities. Finally, a great deal of excitement has been generated by Del Mod that I believe can be ascribed to the strong grass roots character of the program. I am optimistic enough to believe we'll see a permanent change as a result.

Of course, all of us hope that Del Mod will be successful not just for science teaching in the State of Delaware but also in establishing experience in cooperation that can be translated into new programs in many other states. It is hoped that what works in the Del Mod experiment—and perhaps some of what doesn't work quite so well—will be useful when other projects are put together, whether they closely follow the Del Mod blueprint or not.

If this proves to be the case, Du Pont will be most grateful that its contribution has shown a good return on its investment—not in dollars such as we look for when we invest in a new textile fiber —but in better informed and educated young people. As I noted earlier, in this respect you the educators are the producers and we are the customer. And we need the very best output you can supply. □

THE NEED TO LOOK AHEAD

J. Darrel Barnard, Professor of Science Education, New York University, New York City

"Nothing is more frustrating than to be denied the opportunity to participate in planning for the future."

A NUMBER of theories are used to account for human behavior and to serve as bases for making decisions regarding how behavior may be changed. Professor Louis Raths, a former colleague, was a convincing proponent of one such theory which I have found over many years of practice to be highly viable. He referred to it as the Needs Theory. According to the Needs Theory, all of us have common basic needs that must be met in whatever we undertake if our participation in that undertaking is to be effective, satisfying, and beneficial. One such need, as identified by Professor Raths, is the need to belong. If, in a group with which I am associated, such as NSTA, I obtain something of the feeling of belonging, then my effectiveness in the association will be enhanced. Another basic need is the need to be creative. If the activity in which I am supposed to participate, such as an NSTA committee, provides an opportunity for me to exercise my creative talents, meager as they may be, then both the work of the committee and I become the benefactors. Other basic needs that Professor Raths has identified include the need to understand, the need to achieve, and the need to be recognized as a person.

In considering the theme of this year's National Convention, "Bridges to the 21st Century Through Science Education," it occurred to me that to live completely another basic human need must be satisfied and that is: "The need to think ahead." The need to think ahead must be met if we are to be happy, reasonably well-adjusted, socially and politically effective persons from both a personal and professional perspective Nothing is more frustrating than to be denied the opportunity to participate in planning for the future when the results of that planning will have a direct effect upon you Nothing is more demanding than to become involved in the planning, especially when the course ahead is uncharted as is the case for the 21st century.

It is important that one other comment be made here regarding basic needs The satisfaction of any basic need is a reciprocal process The situation in which needs are to be met must be conducive, and the person involved must be actively responsive Regardless of the opportunities that situations provide, the individual must assume primary responsibility for dealing with them In fact, this is axiomatic in the satisfaction of one's basic needs The responsive part of the process must be self-activated and self-sustained One's needs cannot be satisfied solely through the efforts of others

Now I wish to comment briefly about "Bridges to the 21st Century Through Science Education" Here are some observations and projections which I consider to be highly pertinent to the theme of this convention

Classroom teachers are primarily responsible for whatever of significance has happened in science education in the past They also are responsible for whatever of significance is happening in science education presently They will be responsible for whatever of significance will happen in science education in the 21st century. In fact, science teachers are the "bridges to the 21st century." Their effectiveness will be determined by how well their basic needs, especially the need to think ahead, are met presently and will be met in the future.

"Classroom teachers are primarily responsible for whatever of significance has happened in science education in the past."

Very few of you will be on the firing-line New Year's Day of the year 2000, but what some of us have been doing over the past 30 years, and what many of you will be doing over the next 20 years, will determine not only the nature of the "bridges," but the directions in which they will be headed.

Over the past three decades NSTA has chalked up a commendable record of building foundations for better "bridges" into science education for the future. Many examples could be given. I should like to mention one that clearly demonstrates NSTA bridge-building at its best. It was the conference of scientists activated by the NSTA Curriculum Committee 10 years ago which resulted in the publication of a notable document entitled *Theory Into Action in Science Curriculum Development.*[1] If you have not read this document, I urge you to do so, and to give serious thought to what it has to say. From where I view science education for the next 30 years, *Theory Into Action* has much to say. A number of us consider its point of view with reference to science to be a promising one, and we have spent much of our time over the past seven years exploring it further through the COPES Project. We found the conceptual scheme approach, which it elaborates, to be not only feasible in designing an elementary science curriculum, but a functional frame of reference in learning science.[2] The conceptual scheme approach has also been found to be a manageable one in the preparation of teachers to teach elementary school science.[3] Some of you have no doubt found other NSTA activities that have served as foundations for your bridges.

NSTA cannot do more than build foundations whereby you and I can construct our bridges into the future. The future is really up to us.

Progress has been made in science education during the past 30 years because many of us willed it so. Many present members of NSTA are science teachers who will still be active in the science education business 30 years hence. Many of them are becoming restless about the future and are getting the itch to think ahead. That kind of itch is a wholesome symptom of the basic need to think ahead, and this need must be met if teachers are to feel really good about their work in the most demanding of all professions—science teaching.

With those of you who are thinking ahead, I would like to share some thoughts which I consider to be imperatives for the future in our business. If they are ignored in planning for the future in science education, the outcome of that planning will miss the mark, as much of the planning of the past has failed to score effective hits.

"Too often, we have come to think of schools, and our science classes, as places where only the intellectually competent should come to advance their literacy."

NOW let's examine Imperative No. 1. For a long time we have recognized the fact that there are individual differences among people in general and particularly among students in our classes. We have fretted about the wide range of reading abilities in our classes. We have practically given up in our efforts to work with those who appear to be completely alienated from intellectual activity. We have established levels of school citizenship, under the less obnoxious rubric of homogeneous grouping, and rationalized the practice in ways that degrade those who cannot adapt to superficial ways of learning to verbalize abstractions. Too often we have come to think of schools, and our science classes, as places where only the intellectually competent should come to advance their literacy. As we continue to operate with such a limited concept of schools, the less competent soon become displaced persons and their number in our schools increases year by year.

For the future, we *must* accept individual differences as indisputable facts of life and plan accordingly. Even though such realism is a most disconcerting base from which to launch bridges into the 21st century, the consequence of continuing to ignore them, or to deal with them in superficial ways, as we have in the past, will be disastrous. And we are rapidly approaching the brink of that disaster in many schools.

When we take a courageous look beneath the tarnished surface of individual differences, what we find is shockingly complex. Here are some of the disturbing findings.

Chess' research has shown that by the time children enter the science classes in the middle school, their modes of learning are as different as their faces.[4] Furthermore, during any one learning session members of the class are conditioned in a variety of different ways by the same cues to which they are exposed. It has also been shown that different children generally recognize purposes within a lesson that are quite different from those planned by the teacher. Furthermore, these same children work unyieldingly upon the accomplishment of their unique purposes, and only after they have accomplished them do they condescendingly accept in a passive manner the one proposed by the teacher. If one could view what is going on in the minds of each of 30 children, during what appears outwardly to be a well-conducted science class, it is quite probable that the scene would be a veritable battleground of indifference, confusion, cross-purposes, and condescension. There would undoubtedly be a variety of forays away from the main line of action as viewed by the teacher. Recognizing this condition, John Smith, a high school chemistry teacher, proposed the hypothesis that many students, by the time they get into high school or college, have learned the art of self-hypnosis and practice it effectively in their science classes. There is no question but that a classroom of students represents the most variable and complex phenomenon with which any human being is ever called upon to deal. And to think that there are those who contend that just any intelligent person can be a teacher!

It is imperative that future efforts to improve science teaching be conceived, from the beginning, as efforts to find ways in which all, especially the forgotten 50 percent in our schools, can be helped through their unique ways to become scientifically literate. We should turn our attention from curriculum development—we presently have a number of very fine curricula at all levels—to finding effective ways of reaching the nonreaders through science; to helping the alienated student experience the satisfaction that comes

[1] *Theory Into Action In Science Curriculum Development.* The National Science Teachers Association. Washington, D. C. 1964

[2] Shamos, Morris H., and J. Darrell Barnard. *A Pilot Project to Develop an Elementary Science Sequence.* U.S. Office of Education Project No. H-281. New York University, 1967

[3] Graeber, Mary. *A Comparison of Two Methods of Teaching an Elementary Science Methods Course.* Doctoral thesis. New York University, 1972.

[4] Chess, Edith G. *The Manner in Which Two Samples of Ninth-Grade General Science Students Analyze a Number of Selected Problems.* Doctoral thesis. New York University, 1955.

from being intellectually active in science; to providing permissive science programs that will accommodate a wide range of individual approaches to learning science; to making science available to bilingual children in ways that do not stigmatize; to reaching the blind and the deaf in ways that make more meaningful their dark and silent worlds. It is encouraging to note that a number of efforts have already been started in these directions, but ever so much more needs to be done if there is to be any substantial progress in science education at all during the next 30 years.

IMPERATIVE No. 2 is one that has been on the books for a long time. It has to do with the development of K-12 programs in science for our schools. The K-12 curriculum concept in science is still a tenable educational imperative although we have done relatively little to implement it. We have science programs for elementary schools, science programs for intermediate or middle schools, and science programs for high schools, but there is no articulated interrelationship between these programs that can possibly be considered a sequentially developmental science program from kindergarten through grade 12. To develop such programs in a number of school systems should have high priority as we think ahead to the 21st century.

K-12 programs cannot be accomplished by the development of still another elementary science program; nor other intermediate school science courses; nor by developing still other high school science courses. Such programs will come about only when local school systems recognize the need and become co-participants from the beginning in the massive efforts that will be required. A new breed of science teacher will be needed. He must be one who can operate with scientific and professional competence within the vertical dimension of the educational matrix rather than as a specialist in one of its horizontal dimensions.

To complicate the situation further, let's think more specifically about the middle-school layer of the three-layer cake we call the public schools. One of the artifacts of education in the 20th century has been the intermediate school, generally referred to as the junior high school. It came into being at the turn of the century and spread rapidly throughout the country. Proponents attributed noble purposes to its creation and established worthy goals for its existence. Unfortunately, over the years, it has become the unloved member of the K-12 family of public school grades. No one really claims it with fundamental professional attachment anymore, least of all its itinerant teachers. As I pointed out in an article written 15 years ago, the junior high school has become an educational no-man's-land.[5] The relative indifference to the intermediate or junior high school is indeed tragic, since the unique nature of its student body calls for an unusually enlightened and persistently compassionate treatment. It would appear that the challenge represented by the junior high school has been so frightening that it has been impossible to mobilize a major effort to deal with it properly.

"The junior high school has become an educational no-man's-land."

The advent of the junior high school resulted in the creation of two gaps in the inarticulate K-12 sequence where only one such gap existed before. Today, junior high school science teachers are faced with the almost insurmountable task of arching the gap from the elementary school to the junior high school and then arching the chasm between the junior high school and the senior high school. For the most part, their attempts at arching consist of futile efforts to deal with interfaces of discontinuous educational matters. To complete the K-12 hierarchy, young people must begin and complete school three different times during the 13-year period. Is this as it should be, particularly in science? Is it economically sound either from an educational or a fiscal point of view? Can the problem be solved? Within what administrative units should it be attempted, local, state, or national? Is it worth the great effort that it will take to accomplish?

Other administrative plans for dividing the K-12 sequence for the public schools have been proposed and are being practiced in some systems. None, in and of itself, will solve the problem of making science education an articulated development from kindergarten through grade 12. Only competent and committed teachers can accomplish this. It's a big order. However, I consider the implementation of K-12 science curricula to be an imperative for the 21st century.

"I consider the implementation of K-12 science curricula to be an imperative for the 21st century."

IN closing, I would like to speak briefly about Imperative No. 3. I shall introduce this imperative by telling you about two experiences that I have had which illustrate the need for doing something about it.

When I became a member of the teaching staff of the Department of Science Education at New York University, one of my major responsibilities was to supervise student teachers who were doing their practice teaching in the New York City schools. In the beginning, the New York City science teachers to whom my student teachers had been assigned resented me very much. Their resentment was based upon a feeling that even though I was a college professor, I was not competent to supervise student teachers since I had not been a science teacher in the New York City schools. Although I had a fairly good track record from Colorado, to them I was more naive than the students about how you teach science in New York City. The more the teachers demonstrated their resentment, the more critical I became of what I observed happening in their classes. Fortunately, we eventually were able to develop a productive working relationship. This was brought about primarily through cooperative planning and management of informal seminars for student teachers in which it became evident that our respective competencies complemented each other.

On another occasion, I was invited by the superintendent of schools in Great

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[5] Barnard, J Darrell. "The Case for the Three-Year Program in General Science" *Current Science and Aviation*, April 27-May 1, 1959

Neck, New York, to serve as a consultant for his science teachers. At my first meeting with the teachers, the secondary school curriculum coordinator introduced me as a professor of science education from New York University, and explained that I was to be available as a consultant to help them improve their science programs. She had hardly completed her introductory remarks when a chemistry teacher stood up and shouted. "Who in the hell asked Barnard to be our consultant? What does he know about science teaching in Great Neck? We're doing all right, we don't need any help from a college professor such as he!" Again it was a struggle to develop a working relationship with these teachers In fact, I doubt that I ever brought as much to them during the semester we were together as they brought to me.

I can cite many instances in which student teachers have been told by the science teacher to whom they have been assigned to forget all of that "idealistic stuff" they were taught in their methods courses at the college, because it just doesn't work. And you know, a lot of it doesn't. It would seem that the longer one serves as a college professor the more scholarly he may become in science education, but the farther he becomes removed from the clinical problems of the classroom; and it is in the science classroom that everything of any consequence in science education must happen. Greater efforts must be made to bring educational theory and classroom practice into a more functional relationship.

FOR some time now there has been talk about schools and colleges sharing responsibility for the education of science teachers. The rationale for such a cooperative arrangement is sound. On the one hand, schools should know what it takes to be a good science teacher; schools should know the conditions under which science teachers must work; schools should be expected to provide the practice experience for prospective teachers; and schools will become the employers of those who complete our teacher training programs. On the other hand, colleges should maintain scholarly pursuit of ideas and conduct research regarding such matters as the goals of science teaching, what should be taught, the nature of learning processes in science, how they should be managed, ways in which individuals, both children and teachers, differ, and methods of providing for such differences; colleges should plan programs of study to produce intellectually competent teachers; and colleges should have a variety of resources that can be used to provide service to teachers beyond those usually available in the schools. The third imperative for the 21st century is to bring about a coequal sharing of responsibility for the professional education of science teachers. Both institutions, the college and the public school, have critical functions to perform. Plans for integrating these functions in effective programs should be developed wherever future science teachers are being educated.

The direction in which some bridges in science education should be headed is toward a genuine partnership of schools and colleges in which planning for the professional education of science teachers, implementing the plans, and evaluating their outcomes, are shared on a 50-50 basis with each making maximum use of its resources in the education of quality science teachers. The development of designs by which this will happen should have top priority among the tasks ahead for both the AETS and NSSA sections of NSTA

As you or your group yield to your need to think ahead, direct it beyond tomorrow, toward the year 2000 in science education Begin by asking what should be the directions in which bridges in science education should be leading In review, may I suggest that you consider one or more of the following:

1. The search for more effective methods and the commitment of greater efforts in providing for the individual differences among those young people who, we hope, will be taking science in the 21st century

2. The infusion of vitality into the teaching of science by career teachers in those grades that separate the elementary school from the secondary school

3. The development of integrated professional programs for prospective science teachers in which schools and colleges share equally the responsibility. □

NSTA ANNUAL BANQUET

THE CORTICAL CONNECTION

Ralph E. Lapp, Director, Quadri-Science, Inc. Washington, D.C.

THIS convention theme—"Bridges to the 21st Century Through Science Education"—can be abbreviated as "The Cortical Connection." I have been spending much of my time projecting into the next century; and, as I see it, the United States must seek new frontiers if it is to maintain its status in the world. Since we are a bounded nation with fixed territorial limits, our heady pioneer spirit of the past must seek new outlets. To a large measure we have exhausted or are rapidly depleting our premium resources such as fossil fuels. We must, therefore, maximize our brain power—hence my phrase "The Cortical Connection."

To the rest of the world the United States must appear as an immense industrial machine spewing forth the products of mass production in seemingly endless quantities. All of this has been possible because of the happy combination of bountiful natural resources, an enterprising spirit, and inventive talent. But two fundamental inputs for our industrial economy must be maintained if it is to flourish in the future.

One is a plentiful supply of power to keep the wheels turning, and the other is an invigoration of our research and development activity to serve the needs of the future. These twin powers—of fuel and of brains—happily interlock in that it is possible for science and technology to unlock the doors to new fuels so that the nation extends its energy frontiers.

The first waves of the energy crises are beginning to lap at the shores of the United States These are but ripples on the surface of an oncoming sea of crises. Americans are bewildered by the appearance of fuel shortages. We have taken for granted an abundant supply of oil and natural gas. Most of us are unwilling to believe that proved reserves of these premium fuels peaked five years ago and that we are now operating on the downslope of the supply curves. The situation is aggravated by the fact that as supply from domestic sources tapers off, demand continues to soar Basically we are dealing with what you will all recognize as a classic differential equation representing inflow to and outflow from a liquid con-

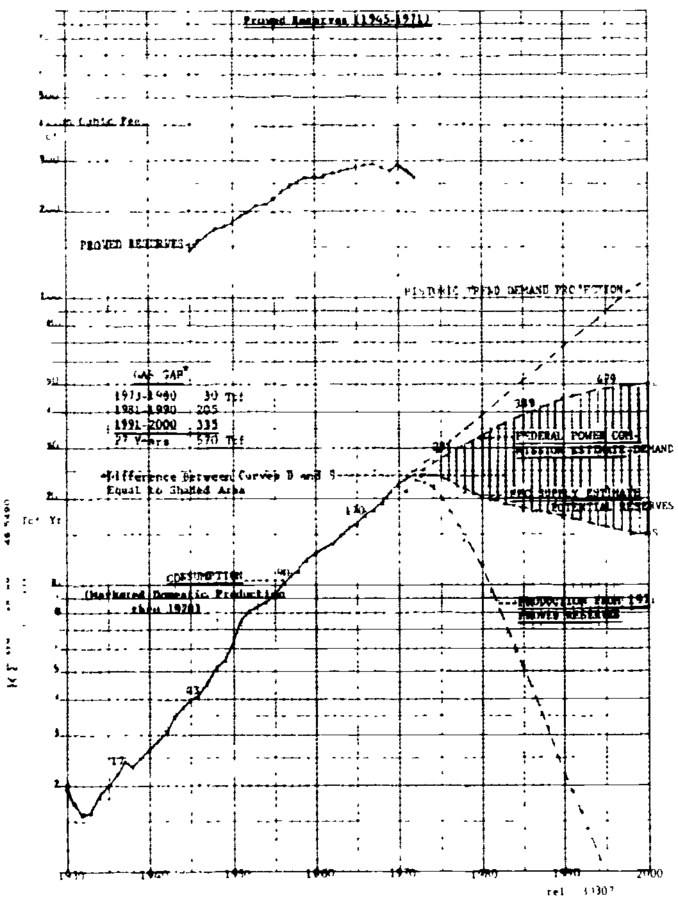

Figure 1. U.S. natural gas demand and supply (1930-2000).

tainer. In this case the inflow of new oil and natural gas constitutes a decreasing supply from potential reserves, and the outflow represents escape of liquid from a widening orifice. Result· The level of available liquid in the resource barrel drops and the gap between supply and demand increases.

Since natural gas and oil represent about three-fourths of the fuels burned in this country—an understandable fact because pipes make it easy and cheap to produce, transmit, and distribute the fuels —we must reckon with the future supply of these premium fossil fuels.

FIRST, let us look at the natural gas situation. The historical pattern of consumption of this resource is illustrated in Figure 1. Note that on a semilogarithmic chart the straight-line nature of the curve shows the exponential growth of this fuel. Prediction of demand for this clean energy source can be justified as a straight-line extrapolation—exceeding an annual burn-up of 110 trillion cubic feet (Tcf) by the year 2000. More realistically, patterned after available resources, government estimates project a 50 Tcf/year "demand," but even thi scaled-down figure would mean producing more than 1,000 Tcf in the next 27 years. Our present proved reserves are only a fourth of this volume, and new addition. to reserves are projected by the National Petroleum Council at about 10 Tcf per year for the next decade.

The most exploitable gas reservoirs have been tapped and now the more difficult to reach and hence more costly sources must be used. These come under the heading of potential reserves and fall into three categories:

Probable . . . unproved but thought to exist in known fields	218 Tcf
Possible . . . in new field discoveries	326
Speculative . . . in formations not previously productive, such as offshore N.E. Atlantic Coast	307
Total Potential =	851 Tcf

To this total we might add some 300 Tcf of gas locked in tight geologic formations that require fracturing, or "nuclear stimulation," and also a measure of public acceptance of slight radiation risk associated with radioactive hydrogen in the gas. All in all perhaps 700 Tcf of gas in addition to the present proved reserve is within reach, especially if higher prices are allowed. The production of somewhat more than 1,000 Tcf of natural gas over the next 27 years cannot be met with these reserves since at century's end the annual production of 50 Tcf would require a *proved* reserve of more than 500 Tcf, this is because a reserve to production ratio of 10.1 must be maintained for the sake of conservation.

This means, then, that even on the scaled-down rates of demand there will be a huge gas gap With luck we may be able to provide half of the year 2000 demand of 50 Tcf from natural gas wells in the United States or offshore. There are three possible ways to meet this gas demand:

1. *Imports* Gas may be imported from Canada through a pipeline or transmitted from Alaskan fields, assuming that the oil with which this gas is associated, is produced. Alternatively, gas may be imported from other continents in liquefied form (−258°F) as LNG. It is highly unlikely that such imports could fill the projected gas gap. Such sources must be looked upon as supplemental high-cost alternatives coming to U.S. city gates at three times or possibly four times the present pipeline prices.
2. *Fuel or energy switches* For some applications. as in home heating, oil may be substituted for gas but this is hardly an attractive option if oil is scarce. Alternatively, heat can be provided by electric energy. However, if a central station burns fossil fuel to produce this electricity then the comparative efficiencies of on-site combustion and wired-in power involve a twofold greater burn-up of fossil fuel I think it is appropriate to label such electric heating a Carnot crime
3. *Synthetics*. Given the existence of a gas-pumping system and a dependence on this fuel for industrial and domestic heating, it makes sense to seek synthetic substitutes for natural gas; i e , SPG synthetic pipeline gas The nation, fortunately, has immense reserves of coal that can be converted to gas provided that the technology is pursued aggressively and measures are taken to protect the environment.

On balance, I believe that the best option is for the United States to launch a determined technological program aimed at economic and environmentally acceptable substitutes for natural gas. The coal gasification process must be looked

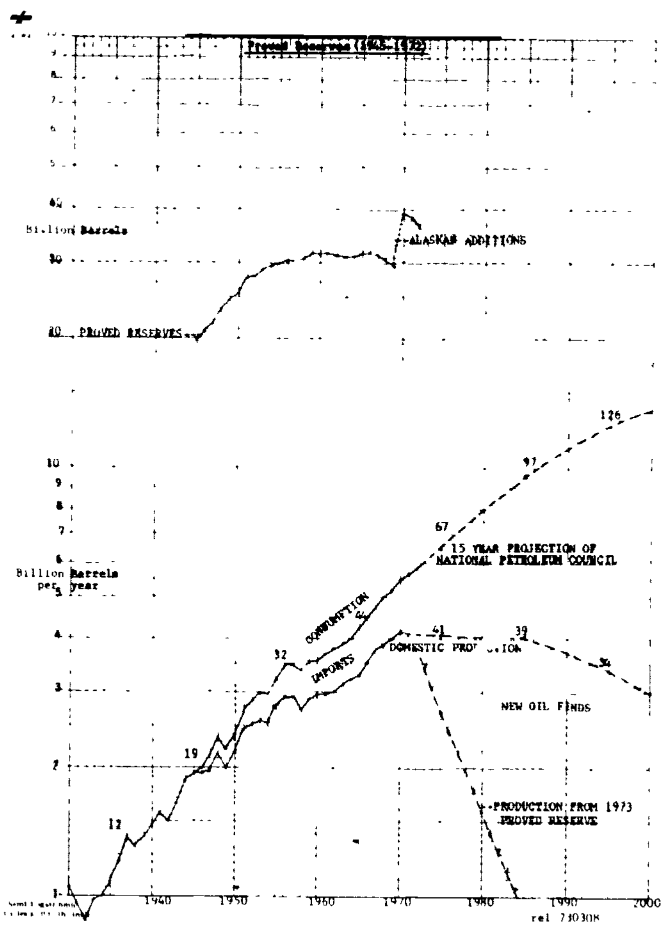

Figure 2. U.S. oil demand and supply (1930-2000).

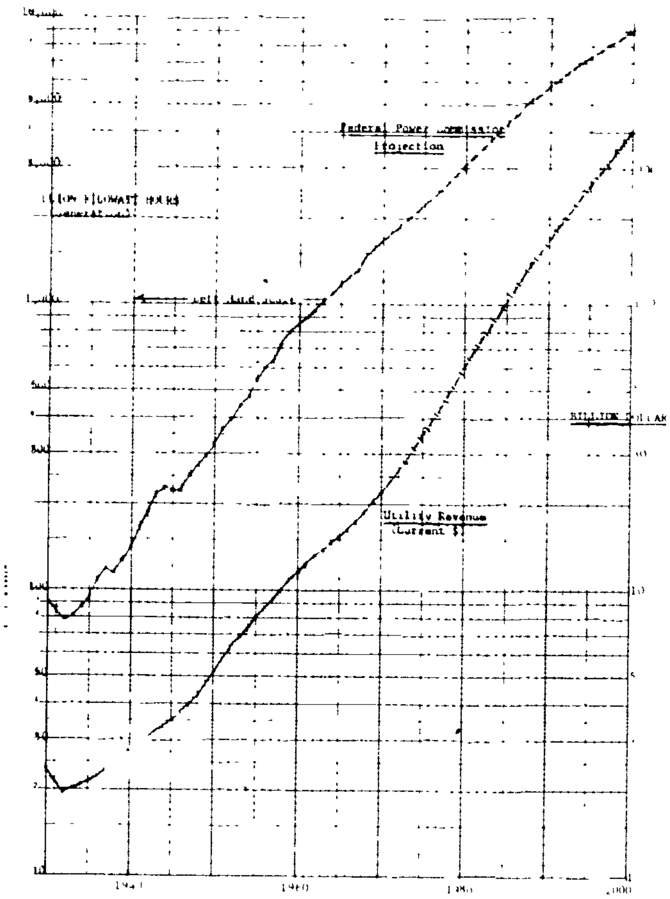

Figure 3. U.S. electric energy (1930-2000)

upon not only as a way of filling the gas gap but also of allowing utilities to burn high sulfur coal. Illinois, for example, has large reserves of 3 to 4 percent sulfur coal—far above the 0.7 percent EPA limit—and this forbidden fuel could become available as a boilerfeed source if coal gasification is successful. To supply half of the U.S. year 2000 demand for gas would require converting to gas about twice as much coal as is presently mined. Such conversion would require building some 275 plants at a cost of close to $100 billion.

THE situation with respect to oil is even more critical to the long-term U.S. economy than I have indicated for natural gas. We are now consuming about 6 billion barrels per year and almost all energy projections indicate more than 12 billion barrel (Bb) consumption by the year 2000. Figure 2 shows a projection that illustrates a bending over of the demand curve. Decade by decade, total use of petroleum is indicated as increasing more than tenfold over a span of 70 years. National Petroleum Council estimates of U.S. supply (Lower 48 plus Alaska and offshore) are given for the 1985 time span, and I have plotted a declining production to the year 2000. The difference between total demand (272 Bb) for the 1973-2000 period and supply from domestic sources (102 Bb) is 170 Bb. The uppermost curve in Figure 1 illustrates the historic pattern of proved reserves, accentuated by a recent increase reflected in the Alaskan finds.

The world's most abundant oil reserves are to be found in the Persian Gulf where proved reserves of 345 Bb are conservatively estimated to exist. However the U.S. importation of this oil is a much-nettled affair, involving as it does a considerable flow of U.S. dollars and a dependence on energy supply that can be interdicted by price barriers, changes in export policy, availability of ocean tankerage, and pollution associated with this transport and its off-shore terminals. My own conclusion is that oil imports do not constitute an acceptable means of filling the U.S. oil gap.

Since oil is the dominant energy source in the U.S. economy, there is little hope of relief in energy switching. Moreover, our mobility depends on the internal combustion engine, the hydrocarbon fuel for which is the pacing factor in oil demand. The automobile is so much an integral part of the American economy and life style that it cannot be tampered with unless one accepts the risks of political and economic consequences. In the long run we will have to find new solutions to the oncoming mobility crisis, represented by gasoline shortages, but right now there are no practical options for alternative means of transportation.

One can, of course, invent ways to conserve gasoline—such as telling Detroit to limit horsepower to the Volkswagen class. Shrinking the 400 hp (500 cubic inch displacement) engines down to a small fraction of their size would mean severe reductions in weight-performance and consequently in the price of the model. The Volkswagenization of the U.S. automobile industry would be an extreme political act. It would involve dislocation of this sector of the economy and almost all other sections would feel the impact. Recent political trends have in fact been in the opposite direction so far as gas consumption is concerned. Decreased compression ratios and add-on pollution controls have meant cars that give fewer miles per gallon and consequently increased national gasoline consumption.

It will be noted that the curve of consumption in Figure 2 corresponds to a doubling time of about 18 years, or an annual growth rate of 4 percent for the 1970-85 period. Thereafter it is assumed that this rate will slow to half of its current rate, reflecting in part a saturation in motor fuel consumption. Thus the projections in this illustration do not assume unlimited growth.

If energy switches and imports are restricted, then America's choice is singular—to synthesize motor fuel from solid fossil resources, namely coal or oil-shale. Given the projection made in Figure 2 and the 3 billion barrel annual domestic production, there will be a requirement for about 7 billion barrels of synthetic oil (here one assumes imports equal U.S. domestic production). The creation of a domestic industry capable of such fuel synthesis is one of great magnitude for which there is little evidence in prospect.

The conclusion is inescapable that the United States is allowing itself to drift into the future with inadequate planning for the synthesis of premium gaseous and liquid fuels from solid fossil resources. Carbon-based fuels are projected to supply energy equivalent to about 140 quintillion (10^{18}) BTU in the year 2000. Since one ton of coal has the heat equivalent of 25 million BTU, this means that a year 2000 fossil fuel requirement equal to 5.6 billion tons of coal will be targeted for that year. If much of this energy is coal-derived and converted to synthetic fuel, then the total coal mined will be in the range of 6 billion tons; this assumes that about 60 quadrillion BTUs are supplied from oil and natural gas. Such a mining demand can only be met with an order of magnitude increase in strip-mining and clearly this poses grave environmental risks.

YET the total of 140 quadrillion BTUs for the nation's energy burn-up in the year 2000 is by no means the projected total. In addition, it is projected that over 50 quadrillion BTUs will come from nuclear fuels. The nature of nuclear energy release is such that it is confined to the core or firebox of a nuclear reactor and must be used for the generation of electricity.

If 100 percent of the atoms in a pound of uranium could be split in a reactor core, then energy equal to heat released by combustion of 2.5 million pounds of coal would become available. However, only 0.7 percent of the uranium atoms belong to uranium-235, the fissionable species, and conversion of the 9[illegible] percent abundant uranium-238 in water reactors allows about one percent of the uranium fission energy to be tapped, making a pound of natural uranium equal to 25,000 pounds of coal. The development of the power-breeder will allow much greater conversion of the U-238 fission energy so that perhaps 70 percent of the power of uranium will be exploited.

The growth of electric energy generation is illustrated in Figure 3, where kilowatt-hours of electric energy have been plotted for the past seven decades. At the beginning of the century the coal-fired plants required about seven pounds of coal to produce a kilowatt-hour of electricity. However, engineering advances utilizing high pressure, high temperature steam have brought about a tenfold increase in fuel efficiency. Nonetheless, even the best fossil-fired steam-electric plants have only a 40 percent thermal efficiency; and, as a result, 60 percent of the fuel heat is dumped as waste discharge to the environment.

Inspection of the growth curve for electric energy generation in the United States shows that it doubles approximately every decade—i.e., exhibits about a 7 percent annual growth rate. The electrification of the American economy is proceeding at an apparently relentless pace. In the gas-illuminated days of 1900 each person's share of the national electric energy generation was only 25 kilowatt-hours. In two decades this soared to 380 kWhr and by 1940 it exceeded 1,000 kWhr. The doubling-every-decade rate shot the per capita consumption of this energy to 4,300 kWhr by 1960 and by the mid-70s it will exceed 10,000 kWhr for every American. If we take a heat-rate of 10,000 BTUs per kilowatt-hour as a round number, then every American will demand an annual commitment of 100 million BTU fuel burn-up to produce his share of electricity. In more concrete terms this is energy equivalent to burning 4 tons of coal.

Although there has been no national referendum on the subject, the nation is pursuing an implicit goal indicated by the dotted line in Figure 3—that of generating 9,000 billion kilowatt-hours of electric energy by the year 2000. This projects uninterrupted growth of the electric power industry for the next two decades, then the curve bends over and the rate of electric growth slows. On this projection every American in the year 2000 will be demanding about 33,000 kWhr of electricity per year. That's more than a thousandfold per capita growth over the course of the century.

THE actual per capita consumption of all energy forms, as will be shown, rises very much more slowly over the course of 100 years, being less than a factor of 10. What is happening is that electric energy is emerging as the dominant energy consumer in our economy. At mid-century, electric energy generation accounted for only about a tenth of the national heat-inputs, but the year 2000 will see this fraction increase to one-half. In other words, we are witnessing the electrification of the U.S. economy.

Figure 4A displays the extent to which electricity is taking over as the energy consumer of the century. But the world will not end with the year 2000, and if

"Every American in the year 2000 will be demanding about 33,000 kWhr of electricity per year."

your convention theme of bridges to the 21st century is to be appreciated, we must extend the energy extrapolations into the next century. It's obvious, of course, that such projections are not meant as prophesy but merely to illustrate how the shape of our energy future may appear and what its demands on our resources might be. Clearly the uppermost curve—all forms of energy consumed—is underpinned by some critical assumptions about population, resource availability, life style, and the future state of the U.S. economy.

It is assumed that U.S. energy consumption will exhibit a rate of about 3.5 percent per annum growth for the next quarter century. Then the curve will slacken its upward course, conforming to a 1.5 percent rate, and approach a 1 percent rate at mid-century. I have assumed

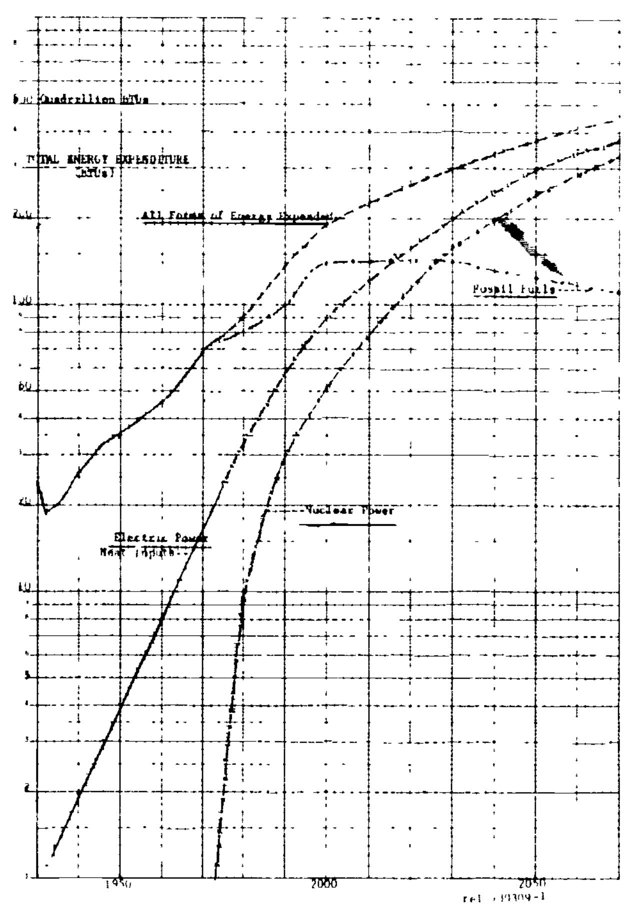

Figure 4A. U.S. energy (1930-2070) Thermal/electric/nuclear/fossil.

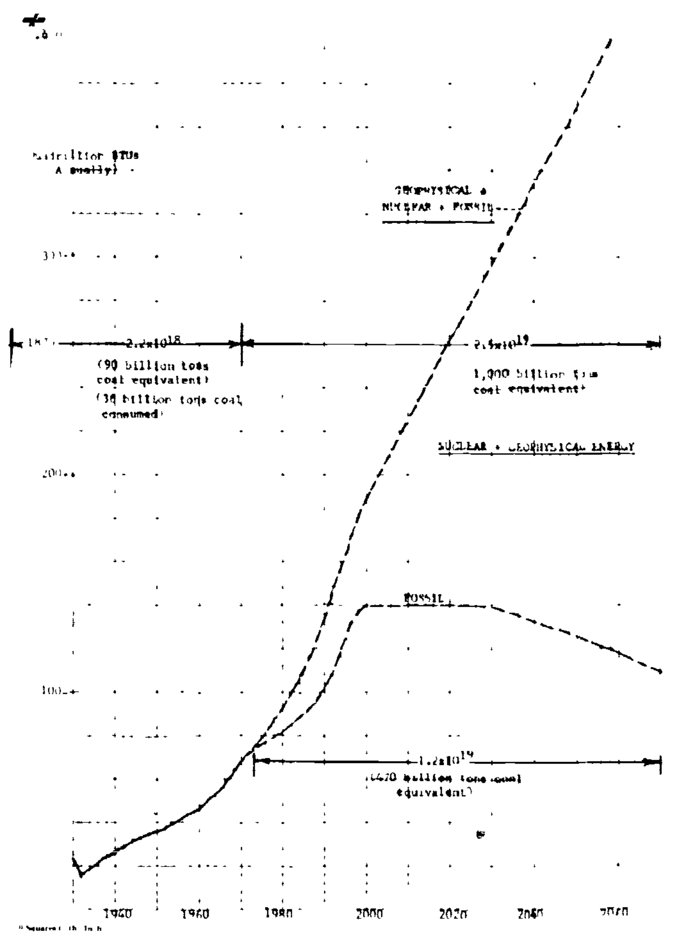

Figure 4B U S energy (1930-2070) Nuclear/fossil

a U.S. population of 340 million by the year 2040 and only 370 million by 2070 —i.e., population then controlled to 0.25 percent per annum increase. The per capita energy consumption is assumed to more than triple over the next 100 years. So far as my own household is concerned, my energy demands are pretty well satisfied and I do not see them increasing. However, many U.S. households are served with only a tenth of my energy totals and one must expect that people will want to have air-conditioners, more cars, and electronic accessories. My own household would require a substantial energy increase if I switched from gas to electric heating, or, in the more distant future, if I purchased an electric automobile. This alternative, however, as used for commuter travel, might reduce my energy requirements. So far as a switch to electric heating is concerned, this represents a Carnot crime if the electricity is generated by fossil-fuel-fired steam-electric plants. Burning a fossil fuel in a central station and wiring the energy to a home requires twice as much energy as would be the case if the fossil fuel, say natural gas, is burned in a home furnace Hence, the designation Carnot crime. You will remember that the Carnot cycle is named after Sadi Carnot, the French engineer who contributed so fundamentally to the science of heat.

ELECTRIC power is projected as demanding half of the fuel inputs in the year 2000 and thereafter increasing to 85 percent in the year 2070. The

"It appears inevitable that our future fuels will not be carbon-based or chemical in nature."

logarithmic presentation tends to obscure the comparison of energy generated from fossil and nuclear fuels, so these contributions have been plotted in Figure 4B. It is projected that coal, oil, and natural gas will supply energy that peaks in the year 2000, flattens out and then declines in the 21st century. The actual estimate made in Figure 4B could, of course, be far off the mark and the fossil fuel era in the United States might show a sharp peak and quite rapid decline. The actual shape of the fossil curve will be highly dependent on energy technology and on the degree of environmental control exercised in the future. If strip-mining is severely limited, then there will be no way to obtain the fossil energy estimated as totaling the equivalent of 470 billion tons of coal through the year 2070. In the past 100 years we managed to burn up fossils equivalent to 90 billions tons of coal, but the lion's share of this was oil and gas that flowed easily from the earth.

Given the run-out of America's natural gas and oil resources and the greater difficulty of mining solid fuels, it appears inevitable that our future fuels will not be carbon-based or chemical in nature. The specific projection given for the next 100 years of our fuel future involves a nuclear energy release equivalent to the burning of 1 trillion tons of coal. Thus, if the United States is to enjoy an abundant supply of energy in the next century, there appears to be only the nuclear option.

Enthusiasts who promote the potential of geothermal energy sources and geophysical energy conversions like solar power will argue this conclusion, but no other energy option possesses the engineering status of nuclear power.

Utilities have to make tough decisions in planning their future power supplies, and the historic pattern of electric energy revenues (see lower curve in Figure 3) demonstrates that they have managed to supply reliable and abundant electric power at rates which made it a bargain. The parallelism of the energy generation and revenue curves shows this to be the case. We must remember that the upper curve refers to the left scale and is reckoned in terms of an invariant—the BTU energy unit, whereas the right-hand scale refers to a wobbly unit—the current U S. dollar. Utilities managed to combat inflation by steadily reducing the cost of electric power, benefiting from the economies of scale achieved by bringing on line ever larger generators. It appears, however, that the power costs have bottomed out and that they will undoubtedly climb steadily in the future. Reckoned in current dollars, assuming a 3.8 percent escalation per year, I estimate the year 2000 consumer cost of electric energy at 5¢ per kWhr. If the Federal Power Commission estimates of electric energy generation come true, this will mean that the electric utilities will collect about $400 billion in revenue in the year 2000.

Demand may slacken as price for purchased power increases, and it is possible that the 8,000 billion kWhr of electric energy sales may be considerably reduced in the year 2000. But one thing does seem certain, and that is that the revenue curve will continue to inch toward the generation curve as the utilities find their costs rising. Looking ahead to such revenues, the utilities ought to fund a much more vigorous research and development effort than they have in the past. There are signs that the utilities are invigorating their R&D effort, and the recent creation of the Electric Power Research Institute gives hope that we may begin to address ourselves more seriously to national energy problems.

THE NUCLEAR solution to our energy future has met with strong environmentalist opposition. Most recently we have seen the Atomic Energy Commission compelled to deal with the critical problem of nuclear safety in the form of year-long ECCS (emergency core cooling system) hearings. This discussion strikes at the heart of an extremely complex technical issue, and it involves a risk assessment that taxes the ability of a democratic society to deal with the problems of technology.

Once a nuclear power reactor has operated for any length of time, it builds up an inventory of radioactive split atoms known as fission products. There's no way of "turning off" the radioactive power of this accumulation of fission products, with the result that it's physically impossible to abruptly reduce the power of a reactor to zero. At the moment of SCRAM, or shutdown, a power reactor still produces heat known as decay, or after-heat, amounting to as much as 7 percent of full power. In the unlikely event of an accident involving a loss of

"I do not envy you when students come to you with the question: 'How safe are nuclear power plants?' "

coolant (LOCA), it becomes essential to keep the reactor core covered so that water can remove the residual heat. Modern reactors are engineered with redundant safety features to provide emergency cooling, but these systems have been challenged in the ECCS hearings.

Bear in mind that the problem of control is thermal, not nuclear; there is no danger of an atomic explosion but rather one of a thermal catastrophe if the core is uncooled and proceeds to melt down. This could lead to escape of highly radioactive debris from the containment barriers. The issue at hand is a probability-consequences analysis. What is the probability of a severe nuclear accident—and what are its consequences? Given answers to these questions—and I warn you that no authoritative estimates bear the AEC imprimatur—how does a society weigh the risks? These are basic questions, and I do not envy you when students come to you with the question: "How safe are nuclear power plants?" As science teachers how do you reply? What suggested reading do you outline for the student?

The fact of the matter is that the safety issue is still unresolved in 1973, even though the AEC has operating licenses for 29 power reactors in effect and has approved construction permits for 55 more. However, the nuclear safety issue has really surfaced this year and the Atomic Energy Commission has prepared its first comprehensive report on power reactor safety. This is "The Safety of Nuclear Power Reactors and Related Facilities," available as document WASH-1250. I would suggest that it would be a very salutary development if you would write to your Congressman and request a copy of this report. It is not an overly technical report, being designed as a basic review to be used by the Joint Congressional Committee on Atomic Energy when public hearings are held later this year on the subject of nuclear safety.

The nuclear safety problem can be solved by a combination of three efforts:

1. Intensified research and development in reactor safety designed to prove out the performance of present reactor safety systems
2. Maintenance of high quality control in fabrication by vendors and in installation by engineers of reactor systems
3. Competent management of reactor operations by utilities, subject to vigilant regulation

To these three efforts I would insure the public safety by imposing a double restriction on power reactors. One, I would limit the power ratings of reactors to the 1,100,000 kilowatt size. Two, I would restrict the population-at-risk by setting siting restrictions on nuclear power plants.

Given the above safeguards, I believe that we can put faith in nuclear power as the basic energy bridge to the 21st century. The following advantages of nuclear power are so impressive that they make the nuclear option ineluctable:

1. The switch from fossil to nuclear energy, specifically away from coal in quantities required in the future, will minimize the numbers of acres-disturbed for availability of the fuel.
2. The nuclear option guarantees energy security by reliance on domestically available resources.
3. Utilities can sign long-term fuel contracts for nuclear supplies with less danger of mining, transportation, and cost difficulties.
4. Nuclear power can avert a trade deficit that would otherwise increase as we pay for foreign oil from the Persian Gulf.

5 Adequate control of the nuclear fuel cycle can provide an energy source with far less damaging stack effluents and environmental insult than that associated with coal-fired plants.

Although I have not specified that nuclear power be fission or fusion, the energy projections made for the 21st century can be met by fission energy, assuming success of the power-breeder. If the keys of science fit the technological lock barring the door to fusion power, then the way is open to virtually limitless sources of power. But I would stress that the Atomic Energy Commission has already applied $0.5 billion to fusion research, and the proper keys to the fusion lock remain to be fashioned.

I RETURN to the "cortical connection" concept, for it is through brain power that we will solve the highly complex problems of the future. However, brains are not enough—we also need the elixir of support for basic science and the mechanism of prudent management of developmental engineering. We need to husband our scientific and technical resources so that we assure the national well-being. This requires a proper balance in funding science and technology so that the nation realizes an adequate return on its investment in research and development. The United States continues to devote the majority of its R&D funds to programs and projects which leave the nation at a disadvantage when related to the R&D efforts of other countries.

Federal overfunding of defense research and development has negligible payoff value for U.S. industry as it attempts to compete with a flood of Japanese products. The much publicized space program, the civilian sector of which received over $40 billion in the past 10 years, has in reality had little economic payoff. Thus the United States enters the international R&D competition with 77 percent of its federal investment in defense-space activity with little hope of payoff. We should not be surprised when the Japanese forge ahead in the commercial exploitation of modern technology—our own R&D effort, large as it is, exercises little leverage on the balance of payments. Our real advantage is in the area of high technology, but this is being eroded as we see the scientific community suffer setbacks and see that it is apparently unable to develop leadership or to find the political muscle to apply pressure on Congress. As a minority group the scientific and technical community has an impressive numerical constituency, but it lacks political unity and may, therefore, be disregarded by the Congress when it tends to the affairs of research and development. The individualism so esteemed by the scientist does not lend itself to collective action. And the specialization of modern science and technology appears to inhibit the development of dynamic leadership so essential to determining the future course of this dynamic sector of our national economy.

Science and technology form the new frontier of our nation as it attempts to deal with the dilemma of finite resources and the demands of dynamic growth. Scientists must accept the role of pioneers and develop the innovations which will interconnect this century with the next. Those future innovators are now in your schools, and in your hands is the potential for much of the bridge-building that will extend the American quality of life into the 21st century. □

NSTA-SUNOCO SCIENCE SEMINARS (Abstracts)

OCEANOGRAPHY: THE NEW FRONTIER FOR THE 21ST CENTURY

Nelson Marshall. Director. International Center for Marine Resource Development and Professor of Oceanography. University of Rhode Island. Kingston

Oceanography had its origins in the latter half of the nineteenth century when the British sponsored the world-circling expedition. the voyage of HMS Challenger 1872-1876 under Sir Wyville Thompson. and when Matthew Fontaine Maury of the United States Navy established a systematic program for interpreting ocean currents from ships' logs. Following these earlier endeavors and continuing until the onset of World War II the field continued to be characterized by isolated great expeditions and limited participation.

The War across both great oceans suddenly made us realize that to operate beneath, on the surface of, and over the sea. and to work successfully along the coast we must understand the ocean environment. Suddenly we sensed the impact of the fact that the seas comprise 70 percent of the earth's surface. The wartime and subsequent peacetime impetus to oceangraphic research has never waned. The United States has been the leader in this growth. with Russia and Japan not far behind. Technological input has become increasingly sophisticated. and much of the later work has been interdisciplinary in nature. Some recent ventures have involved elaborate international cooperation. for example. the International Indian Ocean Expedition of the mid 1960s. and the present CICAR (Cooperative Investigation in the Caribbean and Adjacent Regions) program.

Within the last decade and looking toward the future the emphasis in oceanography has swung heavily toward marine resources considerations. In the United States this orientation is best known through the new Sea Grant program. On a worldwide basis plans for drilling for oil in great depths and mining hard minerals by retrieving manganese nodules from the sea bed illustrate the shift from dreams to impending reality in new ocean uses. Such developments augment international problems already at a peak with respect to contested fisheries. surface pollution. deep sea dumping and freedom of navigation and research. All such concerns are at the forefront of the upcoming Law of the Sea Conference preparing for a new era when mankind turns increasingly to the sea.

THERMONUCLEAR FUSION: AN ENERGY SOURCE FOR THE FUTURE

William E. Drummond. Director. Center for Plasma Physics and Thermonuclear Research. The University of Texas at Austin

The scientific discipline which underlies efforts to produce controlled fusion power is plasma physics. A plasma is a gas heated to extreme temperatures and its properties are so different from that of an ordinary gas that it is sometimes called the fourth state of matter. Plasmas do not occur naturally on earth, and as a result. the behavior of plasmas has become subject to study only in recent years.

Research in controlled fusion is currently aimed at finding methods to both heat and confine a hot plasma and is centered on the construction of devices called "magnetic bottles;" i.e.. the construction of magnetic field configurations which will confine the plasma particles.

The most encouraging results. after 20 years of worldwide research. occurred in the Soviet Union in 1968. The Russians. using a magnetic bottle called a Tokamak. announced that they had achieved confinement of hot nuclei for a time comparable with expected time. For the first time. it began to look as though fusion power was on the way to becoming a reality.

Research in the United States with magnetic confinement devices has confirmed the Russian experimental results. and work with Tokamak type experiments is now under way in four major laboratories. Each of these. while similar in many ways. has a different purpose. Three of the laboratories are national labs. The fourth. the largest academic program in the United States. is located at The University of Texas, where the Texas Turbulent Tokamak has just been completed. and encouraging preliminary results are being obtained. The Texas Tokamak is designed to test a new method of heating. called turbulent heating. and indications are that the necessary temperatures will be achieved.

Today. we are faced with the problem of satisfying an ever-increasing demand for electric power. while at the same time protecting the environment. If controlled thermonuclear power can be achieved. it will be a giant step forward in resolving these conflicting demands.

AMNIOCENTESIS AND PRENATAL DIAGNOSIS

Arthur D. Bloom. MD. Associate Professor of Human Genetics. University of Michigan Medical School. Ann Arbor

While there are numerous technical approaches possible to obtaining fetal tissues for prenatal detection of genetic abnormalities. amniocentesis is the procedure of choice at present. Amniocentesis is now being used at 14-16 weeks gestation in high risk pregnancies to obtain fetal cells for cultivation in vitro. The cells are then studied chromosomally or biochemically for the detection of abnormalities of the karyotype or of inborn metabolic errors. During this presentation. the technique of amniocentesis is reviewed. along with the methods of growing amniotic fluid cells in culture. Emphasis is placed on the indications for amniocentesis and on the types of chromosomal and metabolic errors which may now be diagnosed antenatally.

SOME ETHICAL PROBLEMS OF THE NEW GENETICS

James V. Neel. MD. Lee R. Dice University Professor and Chairman of Human Genetics. University of Michigan Medical School. Ann Arbor

In the past several decades there has been a near explosion in the possibilities for utilizing genetic knowledge. Chief among the developments are:

1. The extension of genetic counseling through amniocentesis and prenatal diagnosis, with the possibility of selective abortion.
2. Large-scale screening of predisposed groups for the determination of carrier states, such as for the sickle-cell trait or Tay-Sachs disease.
3. Growing insight into methods of repairing genetic damage.
4. Prevention of increased mutation rates.
5. Improved treatment of genetic disease, plus ability to diagnose those genetically predisposed to such diseases as diabetes and gout, with institution of prophylactic measures.
6. Artificial insemination with sperm from selected donors.

All of these developments are raising ethical issues whose solution belongs to society as a whole—not the geneticist. Furthermore, in the full realization of the potentiality of these developments, society m .y have to set priorities.

MEASURING UP, DOWN, AND AROUND

John B. Hart, Professor and Chairman, Roseville Area Schools, Roseville, Minnesota

A secret-agent device is used to depict the connection between our innermost consciousness and the outside world. Measurement is presented as the link between the outside world of physical reality and the inner world of mathematics. The correct way to teach how to measure avoids the mental conflict frequently induced in young students when they hear their mathematics teacher say "You cannot divide 10 mules by 2 houses," and then later hear their science teacher say, "Now divide the 10 miles by 2 hours." Even though these statements be made months and months apart they add to the obscure uneasiness many people have about science.

Length, weight, and time measurements are presented from the point of view of a primitive tribe on a south sea island. The ideas of measurement which are developed are applied to velocity and acceleration. It is learned, for example, that velocity is not a physical length divided by an actual time interval. It is shown that the idea of acceleration leads to the invention of mass which, in turn, leads to the invention of the most fundamental law of science: Newton's law of motion. It is this law which forms the basis of distinction between the British gravitational system and the metric absolute system which all of us must understand. The fact that the United States is joining the rest of the world in using the metric system gives each of us a wonderful opportunity to rethink fundamental ideas of measurement.

CHEMICAL EVOLUTION AND THE ORIGIN OF LIFE

Cyril Ponnamperuma, Director, Laboratory of Chemical Evolution and Professor of Chemistry, University of Maryland, College Park

Fundamental to all science is the problem of the origin of life. In considering this question, we are not limiting ourselves to how life began on the earth; rather, we are inquiring into the origin of life in the universe. The earth becomes one example of a sequence of events which may have taken place in innumerable sites in the cosmos. It is the model laboratory for our investigations.

According to the hypothesis of chemical evolution, life is a result of the evolutionary sequence in the universe. In this context, cosmic evolution may be considered to have taken place in stages: from the inorganic to the organic to the biological. In putting this hypothesis, postulated by Oparin and Haldane, to the test, we have two approaches in the laboratory—the synthetic and the analytical.

In the synthetic method, we try to recreate the conditions on the primitive earth and find out whether the molecules necessary for life can be formed in the absence of life. The raw materials consist of the components of the earth's primitive atmosphere. The energy sources were many and varied—ultraviolet light from the sun, ionizing radiation, electrical discharges, heat, and the energy from shock-waves. In laboratory simulation experiments, most of the building blocks of nucleic acids and proteins have been synthesized.

In the analytical method, we go back in time and examine the record of molecular fossils upon the earth. We can extend this to the analysis of lunar samples and meteorites. Very striking evidence from our recent study of meteorites indicates that the building blocks of life do exist in these samples that come to us from the asteroid belt. Chemical evolution must be taking place elsewhere in the universe.

Another factor which has helped very much to bolster the concept of chemical evolution is the information provided to us recently by radio astronomers. They have discovered a vast array of organic molecules. Although simple in composition, they are crucial to the entire sequence of chemical evolution. Formaldehyde and hydrogen cyanide are among those that have been identified. These are the very molecules which the chemist has postulated as being the intermediates in the synthesis of amino acids, and the nucleic acid constituents.

If the conditions for life to arise are common in the cosmos, our search for life beyond the earth must eventually be crowned with success. With our present state of technology this effort is restricted to our own planetary system. The Viking Mission which is planned to alight on the planet Mars in July 1976 will examine a handful of Martian soil and report back to us about the presence or absence of life. Recent observations of the satellites of the giant planets lead us to infer that conditions suitable for the existence of life may be prevalent on those planetary bodies. If we find life twice in our planetary system, it would be reasonable to conclude that it must exist elsewhere in the staggering number of comparable planetary systems.

ENERGY REQUIREMENTS—EXTRAPOLATING THE CURVE

Kenneth E. F. Watt, Professor of Zoology, University of California, Davis

There is an energy crisis, and if anything, it is much more serious than generally believed. To simplify the discussion of fossil fuels, all types can be expressed in barrels of crude oil equivalents. At the beginning of the industrial revolution, the ultimate recoverable totals for crude oil, gas, and coal were probably 2,000 billion, 2,000 billion, and about 10,000 billion of these units, respectively. This seems like an enormous amount, until we discover that current use rates for crude oil are about 20 billion barrels per year worldwide, and will probably be 80 billion barrels in 1993 if present growth rates continue. The likely future scenario, barring massive international efforts at conservation, is that all the crude oil and natural gas in the world will be used up by the turn of the century. All coal, tar sands, and oil shale will be gone a few years after. Misunderstandings about these facts stem from the tricky phrase in much advertising and writing about the energy crisis, "if present rates continue." However, present rates will not continue: worldwide growth in demand for crude oil, for example, is at about 7 percent per annum.

The situation for all other known forms of energy is far less optimistic than the conventional wisdom would indicate. Enormous problems are raised by each of the three broad classes of nuclear reactors, and funding for research on solar energy is grossly inadequate.

A computer simulation model can be constructed indicating, country by country, how demand per capita for each type of energy will grow in the future. This model is based on statistical analysis of all available data on recent trends in all countries. It indicates that most estimates underestimate the rate of future growth in demand in underdeveloped countries.

Six broad classes of strategies are available for conserving energy: reducing population size, increasing price, changing the mix of types of equipment; so we place more emphasis on efficient types, increasing the efficiency of each type, changing the spatial organization of society, and changing the dynamics of societal functioning. Inadequate experimentation has been conducted with all of these. Even such simple, obvious strategies as staggering working hours, to make more efficient use of rolling stock in commuter transit systems has been inadequately tested. Much more elaborate and sophisticated strategies are possible, involving reorganization of city design, and the design of our living and working quarters, and the way in which they are arranged with respect to each other.

Statistical studies on U.S. metropolitan areas suggest a variety of ways in which energy use could be cut sharply.

ENVIRONMENTAL CHEMISTRY

Fred W. Breitbeil, III, Chairman of the Chemistry Department, DePaul University, Chicago, Illinois

Air and water pollution are the focal points of this presentation, with some emphasis on the solid waste problem. By establishing a definition for the term "pollution" we discuss the problem of establishing safe limits for environmental contaminants. These contaminants have a source, a motion or movement from the source, and a sink, that is, a depository. And so we will deal with pollutants from a "source-motion-sink" concept.

Air pollutants emanate from power-generating sources, mainly electric power stations and the internal combustion engine. This naturally leads into discussions on the products of fossil fuel combustion, such as: CO_2 and weather modification; CO and blood hemoglobin levels, SO_2—sulfuric acid mists and respiratory ailments; nitrogen oxides—hydrocarbons and smog development; and particulates. Included in our discussion of particulates are such special problems as trace metals, asbestos, and ultrafine particles.

Hydrology and some important principles of water chemistry will be developed before dealing with the specific problems associated with water pollution. Lake stratification, water body types, and some special properties of water are considered. In discussing the eutrophication problem, algae types are considered along with their nutrient sources, such as feed-lot runoff and untreated sewage. The source and sink for trace metals such as mercury and cadmium receive special attention, along with the trace organics, pesticides, and polychlorinated biphenyls. Oil spills and thermal pollution are also discussed. If time is available, abatement methodology for contaminated air and water supplies will be covered.

Finally, the source, composition, and disposal of solid wastes will be discussed. Solid wastes can be categorized as metals, ferrous and nonferrous; as cellulosic materials (paper, wood, cloth, and leather); as plastics; as ceramics and glass; as garden wastes, and garbage. These materials can be dumped, incinerated, pyrolyzed, or recycled. Physical and chemical properties of these wastes and their recycling potential will be considered.

The gas, liquid, and solid states of matter are intimately related by the physical properties of volatility and solubility. So, too, our air, water, and soil environments are related, which implies that we cannot singularly deal with one "phase" of pollution.

MONITORING THE EARTH FROM SPACE

Robert E. Boyer, Chairman, Department of Geological Sciences, The University of Texas at Austin

Man's future on earth is largely dependent on the wise use of our vital resources. Aerial and especially space views provide accurate, rapid inventory of these resources, and their sequential monitoring allows efficient management. Applications of light wavelengths, not seen by the eye, yield a greater amount of information for man's use. These invisible energy frequencies afford a new look at the environment of this planet.

Infrared film sensitive to wavelengths just beyond the visible spectrum, reveals patterns and features otherwise undetected. This was first used in agriculture and forestry to recognize the early stages of plant disease, and is now applied to numerous aspects of crop production including insect infestations and the effects of smog. Other applications of infrared photography are, for example: in oceanography to aid in detecting undesirable effluents, discerning surface currents, tracking sea-ice, and locating areas potentially favorable to fish and other seafood catches; in geohydrology for sediment transport analysis, soil-moisture content studies, snow and ice surveillance, and water pollution monitoring.

Beyond near (reflected) infrared wavelengths, special detectors convert invisible electromagnetic energy to energy, which may then activate a light source to produce images. One such instrument, a radiometer, measures radiant temperature differences. Such images may indicate hot spots in a volcano, and signal its pending eruption, or detect colder fresh-water upwellings in seawater along a coastline.

Longer wavelengths like radar pierce clouds. smoke, and surface vegetation, to provide an image of the ground surface. Radar has proved useful in revealing terrain patterns such as major fracture zones in bedrock, leading to new understanding of groundwater migration—and the routes of pollutants contaminating rivers, lakes, and coastal waters. Radar may also be the key to finding new mineral deposits, especially in less accessible, sometimes heavily vegetated, parts of the world where conventional exploration techniques have proved unsatisfactory.

The perspective from space adds the uniqueness of extensive areal coverage within single views. Large-scale features are portrayed, whereas they are obscured by details on photo-images from conventional aircraft. Satellites afford the additional dimension of sequential coverage. This repetitive observation is particularly significant for following paths of major storms, and in dynamic areas (urban centers), where changes occur faster than are normally recorded cartographically.

The Earth Resources Technology Satellite (ERTS) initiated a program of systematic coverage for North America and selected world regions from space. This and future satellites will provide photo-images concerning our resources—agricultural and forest, cattle and wildlife, freshwater, land, marine, and mineral—and perhaps provide solutions to pressing environmental problems for mankind's benefit all over the globe.

ELECTRICITY, MAGNETISM, AND MOTORS

Max C. Bolen, Coordinator of Science Education, The University of Texas at El Paso

Various types of science experiences which lead children to develop intellectually, and provide positive attitudes toward science are discussed. The work of Jean Piaget in general learning theory, and the working science of such persons as Robert Karplus and John Renner, as well as various elementary science programs, i.e., S-APA, SCIS, ESS, IDP, COPES, Minnemast, etc., provide the basic philosophy for discussing the following experiences: static electricity; moving electricity; conversion of electricity to light; heat, etc.; making a simple inexpensive electroscope; simple circuits; magnets, compasses, and how to use magnets and compasses to map the earth's field, or distort the earth's field similar to reality; simple inexpensive motors, and how to illustrate the interaction of electricity and magnetism.

These are discussed by using the Piagetian Model and a Brunerian Spiral for all elementary levels. A discussion of the El Paso use of individualized packets using S-APA and "Concept" for enrichment, for slow, and exceptional children. (A joint Project—NSF, University of Texas at El Paso, El Paso Public Schools, and St. Clement's Episcopal Parish School.)

SPACE TECHNOLOGY: ITS IMPLICATIONS FOR SCIENCE EDUCATION

Ronald J. Schertler, Aerospace Physicist, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio

Over the last 15 years, this nation has taken the lead in space exploration through the successful development and deployment of scientific, exploratory, and applications spacecraft, culminating in the spectacular Apollo flights. Our country's investment in these programs has bolstered the economy, increased our scientific and technical competence, improved the quality of life of our people, and increased our sense of national prestige. We now stand poised to capitalize on the comparable benefits promised through the continued growth of our capability in space applications toward improved worldwide communications-satellite networks; more accurate long-range weather forecasts; and a better understanding of the earth; its environment, and its resources. In the area of remote sensing of the earth and its resources, data and imagery obtained from sensors aboard aircraft and satellite platforms can provide a valuable supplement to data collected by existing ground-based observation systems. Various applications of space technology to the U.S. Earth Resources Survey Program are explored.

Modern technology makes it possible to obtain imagery over a wide range of wavelengths within the electromagnetic spectrum including the ultraviolet, visible, infrared, microwave, and radar regions. Sensors currently being used on aircraft and spacecraft platforms to detect radiation in these various spectral bands are reviewed. Some techniques and problems associated with processing this imagery, in terms of real-time utilization of remote sensing information, are considered.

The spectral variation of reflected or emitted radiation is one of the most important properties used to distinguish between various resource phenomena. These spectral characteristics can also provide valuable information about their chemical, physical, and biological properties. The spectral reflectance characteristics (spectral signatures) of a number of vegetation types show the influence of leaf morphology, physiology, pigmentation, and moisture content.

Imagery obtained from low and high-altitude aircraft platforms as well as imagery taken from various unmanned and manned spacecraft illustrate the application of remote sensing in the areas of agriculture, forestry, geology, geography, cartography, hydrology, and oceanography. Imagery from the Earth Resources Technology Satellite (ERTS-1), launched in July 1972 to provide systematic photographic coverage of the earth, is also presented. Findings determined from initial analysis of ERTS imagery show how this imagery can provide valuable information about man's social, economic, and cultural environment.

NSTA CONCURRENT PANELS AND SYMPOSIA

SESSION A-3

INDIVIDUALIZED LEARNING IN CHEMISTRY: UTAH'S APPROACH

Richard S. Peterson, Specialist, Science Education, State Board of Education, Salt Lake City, Utah

Utah's approach to individualizing instruction in chemistry was outlined in the session. Seven program elements were discussed: Philosophy, Curriculum Framework, Objectives, Pre-Assessment, Learning Activities, Self-Assessment, and Post-Assessment.

The program is operating in six Utah high schools that vary in nature from rural to central city, from a total enrollment of 2,000 to fewer than 200; from a significant enrollment of minorities to virtually none; and from modern facilities to those which have no science laboratory.

Strengths of the program as identified by the teachers and their students seem to be a personal interest in and a genuine concern for each individual, the alternatives in program direction and in time allocation, a choice of many kinds of learning situations, the use of out-of-school resources (natural and human), the close correlation between evaluation items and the student performance objectives, and the self-assessment dimension.

Some of the inhibiting factors seem to be the amount of time required to prepare instructional units, the pre-assessment instruments (students simply say they don't know the material and there is no point in wasting time on a pre-assessment), the absence of a well-defined system for differential grading, a lack of para-professional help, the unwillingness of some students to move ahead without other members of their peer group, and the amount of time involved in record-keeping.

The program is still pretty much one-dimensional. It is (or can be) individualized on the basis of rate, and, to some extent, on the basis of sequence. Other dimensions that need to be added are those which provide for different learning styles. These dimensions will be added as rapidly as resources and time permit.

The content of this chemistry course, along with most others, is centered in the cognitive area. However, the emphasis that is placed on the individual in the program and the statements of basic philosophy upon which the program is built exhibit a strong commitment to factors in the affective domain.

This program can be used in year-round schools, in adult education programs, and for instruction where modules (rather than an entire course) of interest to a particular individual are selected for study.

Next steps include placing the pertinent information on key-sort cards so that it can be readily and accurately retrieved and updated. From key-sort cards it is projected that computations will be used to aid the teacher and a given student in selecting and evaluating appropriate learning experiences.

The ACS-NSTA Chemistry Test, the Watson-Glaser Critical Thinking Appraisal, and the Welch Science Process Inventory are given: pre- (in September), and post- (in May), to determine how effective the program is in the areas identified by these three tests. In limited samplings, using control groups in traditional chemistry courses, the gain scores of the experimental schools on each of the three tests are significantly higher than those of the control schools.

SESSION A-7

WRITING SCIENCE BOOKS FOR CHILDREN

Millicent Selsam, Author, William Morrow and Company, Inc., New York City

To write about science for children an author needs to know science, to know children, and to know how to write—particularly to understand how to communicate with them on their level.

Children are curious and ask questions. This is also a characteristic of most scientists at work. The question many younger children ask is often, "What is it?" Once they have found out, they lose interest, and forget. I have learned not to tell children the name of an object, no matter how familiar. I say, "Let's find out." I encourage them to do something with the object, which would maintain their interest and heighten their observations.

But knowledge gathered from observation alone is not enough. And a good science book is not just a collection of facts. A writer cannot just say, "Here is an exciting thing. See how a caterpillar spins a cocoon." The role of the writer is to write the book so that a child can feel he is participating in an observation. It should send him out to look for his own caterpillars. When I started to write *Play With Vines*, I felt exactly the way Darwin did about his book, *Climbing Plants*. He said he found himself so fascinated and perplexed by the revolving movements of tendrils and stems that he secured seeds of many climbing plants and studied the whole subject. Scientific books should, wherever possible, make simple observations lead to other questions that can be answered by simple experiments. Watching a twining morning glory vine move around in a circle is exciting . . . but what about the amount of time it requires? Does the amount of light have anything to do with it? What about other living vines?

The purpose of science books should not be to fill a child's head with facts but to give him some idea of the great advances in science made by the linking of many observable facts into fundamental concepts.

Children are excellent observers, and if they are given a chance to look at things themselves, they will begin to appreciate the kind of patience and effort that goes into careful observation.

Observation of natural facts should lead to an interest in discovering the cause of the processes and activities observed. Questions of this kind can best be answered by questioning.

Good science books should certainly avoid concepts such as teleology, which explains everything in nature in terms of purpose. Statements like, "birds suddenly leave one locality and fly hundreds of miles to another place so that they will have food and a warmer climate in the new location" seem to close off all further inquiry. A scientific presentation of migration gives the facts as known to date from observation and experimentation, gives the best theories available, and shows what areas are still to be explored.

Another common and equally inappropriate concept is anthropomorphism, which sees everything in nature from a human point of view. Modern psychology stops this trend by trying to find out how the animal's mind works by studying its behavior. The study of animal behavior is fascinating enough by itself without being clouded by an approach that ascribes human characteristics.

The question of accuracy with regard to matters of fact in a science book is less important than the goals above. As Eva Gordon said, "Accuracy means also a willingness to say, 'I don't know,' and in general, avoidance of sweeping statements and sparing use of such words as 'all,' 'every,' and 'always.'" 1

Good science books should communicate some of the excitement of discovery—and the triumph that goes with the solution of scientific problems. Books about science should help young people to see that our human goals must be shaped by science and that science must be enriched by human hopes and ideals. Science books can help to develop the idea that science is not mere knowledge of things independent of our human purposes, or merely a means of giving us material comforts and gadgets, but is part of the fabric of our lives. The methods of science can be used to create rational attitudes free of superstition and prejudice.

This paper has been drawn from two previously published pieces by the author. They are "Writing About Science for Children," *The Library Quarterly*, January 1967; and "Scientific and Non-Scientific," *School Libraries*, January 1958.

[1] Gordon, Eva, "Reviewing and Selecting Nature Tools for Children," *School Science and Mathematics*, Volume 49, November 49, pp 604-5.

ILLUSTRATING SCIENCE BOOKS FOR CHILDREN

Jeanne Bendick, Illustrator, McGraw-Hill Book Company, Inc., New York City

About a thousand years ago when I first started to read, I was fired with ambition to be an illustrator. I even knew what kinds of books I wanted to illustrate—the ones that were called, "Information Books." Nobody called them science books then. Science was a majestic subject, certainly too complicated for children.

Maybe I made up my mind because I was so frustrated by the pictures in those books. And I made up my mind that when *I* reached the exalted state of being a book artist I was going to do things differently. I hope I have.

Resolution One was that in the books I illustrated, nobody would *ever* have to flip through pages looking for the picture that matched the text. Maybe "matched" isn't the right word. I think that the text and pictures should complement, not duplicate each other. Of course words give information in one way, pictures in another. But I think an illustration should add new information. Maybe it shows scale, in relation to the child. Maybe it locates and labels parts. Maybe it simply shows something or somebody as part of the world—growing or being alive, enjoying and being enjoyed.

I have always been allowed to lay out the books I illustrate, so I can put pictures where I want them. It is certainly more work to do this. It means counting type, and figuring and "dressmaking." Maybe it's easier to have someone else to do all this and just give me a description of the picture and a size, but, "I'd rather do it myself," and I think most illustrators would. Drawings in a science book aren't an extra, added attraction. They are part of the book itself and should be right from the beginning.

Generally, these days, I am illustrating books that I have written myself, and I find that I write the book and draw pictures in my head at the same time. I almost write the book in spreads, writing a paragraph or two where I know the picture will be big or detailed, writing more words where they can do the job better.

Even before I was writing it seemed to me to be the artist's obligation to find out what pictures the writer had in his head and to get those on paper. Of course this means direct communication between author and artist, a contact which for some reason many editors and agents feel would be fatal to both. But I have never seen a documented case of such a fatality. I have only seen books come together with a wholeness when there is a real exchange of ideas.

Another resolution I made as a future science illustrator had to do with the somewhat amorphous, wholly idealized character of the pictures. Everything was soft, pretty, and rather picturesque. All children were beautiful, which I grant they are in their own ways, but have you ever seen a picturesque vacuum-cleaner motor? I wasn't cynical but I *was* lazy and I had an immediate jolt of recognition for those artists who took the easy way of drawing from photographs, or from another artist's illustrations, instead of looking at real things for themselves.

One of the best things any illustrator can give to a picture is his own viewpoint—the special way he sees things. That's hard to do, once removed. Someone else's viewpoint gets in the way. So I made up my mind to look at things myself, in my own way. I've looked at the insides of wasps nests, the insides of flowers, and the insides of toilet tanks; I've watched spiders make webs, people make cars, and chameleons shed skins. I learn a lot that way!

Along the same lines, it used to disappoint me—and it seems as if I became an illustrator out of sheer frustration—when I tried to build something from pictures, or make an investigation, and found that the thing I was building couldn't be built or that the investigation wouldn't work. So whether I am drawing a milk-carton elevator or a sundial that *really* works as a clock, I always build it myself and try it out before I draw the picture. The placement of a tack or a paperclip, the position of a light bulb or the thickness of a piece of string can make the difference between a working model and a disappointment, or a successful investigation and a confusion.

Sure it takes longer, but it's worth it. If I were "into" needlework I would embroider a sampler to hang over the drawing board: *THERE ARE NO SHORT CUTS.*

I am certainly not the best artist in the world. (Once an art editor told me that my people looked as if they were made of spaghetti.) But I get a lot of letters from children saying that they like my pictures because that's the way *they* would draw things. Children do see things in a different way from adults. Maybe that's because they look for different things. I like the way they look and what they see. I've tried to keep looking at the world their way, adding a little of what I see to that and coming up with a picture that is theirs and mine—*our* way of looking at science and the world we live in.

USING SCIENCE BOOKS FOR CHILDREN

Glenn O. Blough, Professor of Education Emeritus, University of Maryland, College Park

Let's begin by saying that *it is still all right to read!* The pendulum of emphasis has swung so far in the direction of firsthand experiences, of discovering for yourself by observation, experimentation, and similar processes that some teachers, perhaps many, are inclined to relegate reading to the back room and feel guilty when they suggest that it's part of the program. That's probably an overstatement. Nonetheless, in order to achieve the overall objectives for science teaching there must be an opportunity to explore what print has to offer. Let's temper our use of books with one "do" and one "don't." *Do* use reading when it's appropriate and *don't* overdue it to the exclusion of other ways of discovery.

The fact is that children cannot discover everything through firsthand experiences. Neither can adults; nor do they try. How do *we* seek to find information to solve our problems? Ten to one we rely on books and other print for solutions to many of them. We are constantly seeking to increase our skill in reading and our knowledge of reliable sources. Books are part of everyday living. This is not to belittle firsthand experiences. No one questions their importance. It suggests that an educated person depends on reading for information, inspiration, and appreciation and that early satisfying experiences with reading to discover are important for children.

Our discussion here is limited to the use of so-called supplementary—library—trade books in the elementary schools, although some of the considerations apply also to the use of textbooks and other printed sources.

Choosing the Books

Choosing and using science books are so closely related that we can hardly consider one without the other. Effective use of books *begins*, in a sense, with selection. Generally children need help with both choosing and using books. The Brontosaurus on the cover of the book of fossils does not necessarily mean that it will excite Perry, age 5, when he looks inside and tries to read it. The picture on the cover may appeal to any age but the content may be advanced for Perry in terms of sophistication, vocabulary, development, and tone.

Planned, formal instruction on how to select a book does much to help put the right child in touch with the right book. Suggestions for examining the content, for sampling the reading level, and other suggestions for judging are a part of good programs that introduce children to books. While it is often important for children to stretch themselves intellectually as they read, too much stretching can snap the interest when we most want to expand and deepen it.

Books are made available to children to help inch them along toward achieving the goals of our science program. Some books broaden the interest and appreciation of the reader; others attempt to describe how scientists work to make discoveries—how they experiment, observe, draw conclusions, classify, and engage in other such processes. Some books intend to give straightforward information that will help to inform the reader; others describe activities, suggest experiments and experiences that help children to carry on their own investigation. Ideally, many books of various purposes should be available to choose from. Children will, with help, learn to select books in accordance with these and other objectives.

In order to help children in choosing books, librarians, teachers, and parents must, insofar as possible, be knowledgeable about the content and intentions of the books that are available. With this knowledge to draw on, the books that are selected for use will come nearer to meeting the interests, abilities, and needs of the specific group of children. An examination of the books that never leave the shelves, as well as those whose worn condition testify to their demand, help to tell us the kinds to make available.

"Reading" the Pictures

"Reading" the illustrations is a skill we sometimes overlook as we use books with children. The excellence with which many of today's books are illustrated should not escape the user. Children learn to differentiate between photographs and drawings, recognize the use of fractions to show relative sizes, learn to interpret various graphs, maps, charts, and tables, and examine drawings of experimental apparatus to see just how they are assembled. Some children, in fact many of them, need help in getting the most from such illustrations. Here again direct teaching is in order. It may be built around helping children answer: What does the photograph tell you? What does the graph show? What can you learn from the drawing of the material? and What does the caption tell you? As children progress from grade to grade they should increase their skill in interpreting book illustrations. If the books are well illustrated, much can be learned by examining its artwork—provided we have helped readers to do so.

Motivation

Skill of motivation on the part of the teacher or other adult can send children scurrying to the shelf for a specific book which might, without this motivation, remain untouched. Adults, who know the books as well as the children, can generate enthusiasm that makes the book a great learning tool. Reading an exciting paragraph, showing science material that raises a problem, sharing an illustration, reading the table of contents, are usual ways used to introduce children to the door the book can open. Introducing children to the fun and satisfaction that can come from books rests on a foundation of good motivation. Not much learning goes on unless children want to learn.

The motivation that children give to each other as they share books may result in increased reading or it may not. The old book report technique that consists of the reader sharing such trivia as the author's dog's name and that they live in Laguna Beach hardly ever produces a run on the author's latest. But with some help and guidance from the teacher and/or the librarian children can learn to communicate their satisfactions and feelings for books they have read and liked—as well as those that give them more information about alligators than they care to have. Encouraging them to find interesting ways to share their reactions is part of making the most effective use of books. The same ideas used by the adults in introducing books to children may be used by young readers: raising questions, showing pictures, making a poster, showing a science object or an experiment or reading a paragraph, may help listeners decide if this is a book for them or not—a fine opportunity to help children learn how to communicate.

Learning from Books

We encourage children to read from many sources and they read for a variety of reasons. Often they read to find information to answer their own questions or to solve their own problems. When this is the case, there is a real reason to improve their skill in using the card catalogue to identify a source and then to examine the table of contents and the index. They see the sense of exploring those helps, rather than paging through the volume to run across something that might be helpful.

Having located the section and pages that may possibly contain the desired information, they are urged to reread the question and problems to be sure they have in mind exactly what is being asked. For example, *Why* do birds sing? is quite different from *How* do birds sing? Keeping the problem in mind the skill of *selecting appropriate information* from a large batch of subject matter becomes essential. We expect children to grow in ability to select relevant material and to disregard the irrelevant, to collect and organize appropriate data, to see relationships, and to organize the findings. These skills will stand them in good stead.

This does not mean that we discourage reading other interesting material as they skim for answers. We have all had the experience of going to a trunk in the attic to look for an old picture and being attracted by all sorts of other memorabilia which lead us into delightful (or otherwise) avenues. So it is when we search for specific information—we don't want to discourage such diversions. The skill, however, of recognizing material relevant to the problem is a valuable one to be developed.

The Facts, Please

As they read from many sources children are almost sure to run across disagreements that demand some attention. This may lead to careful analysis of exactly what is said and how it is said. "Evidence seems to indicate," "some scientists say," "it is generally believed," or "the latest information available indicates" and other similar phrases take on importance when children attempt to track down information. Good teachers make opportunities for discussions of disagreements and qualifying statements to help pupils read more carefully, report exactly, and evaluate.

"What makes you believe what you have read?" should often be a consideration as children share information from many sources. It is an opportunity for helping children evaluate sources that is sometimes overlooked in our zeal to keep things moving and answer the questions. Is the author a scientist? a news reporter? Is there a reason to believe the author is reliable?

A child who thinks he may have discovered an error in a book may write a letter of inquiry to the author (in care of the publisher) to set matters straight. If there is a reply, the total experience may far outweigh the importance of the search for information in the first place. It may be the child's first contact with the fact that everything that gets into print is not necessarily so, that it is desirable to check several sources, and to look into qualifications of the author when ever possible.

An examination of the many science books for children published during the immediate past reveals great progress in the production of readable, attractive, and accurate volumes. Granted, a few throwbacks creep in, but generally the progress toward improvement has been nothing less than phenomenal. A survey of how effectively these learning tools are being used might not reveal quite such dramatic progress. How well are adults who work with children acquainted with this wealth of available material? How skillful are we in introducing children to books? How knowledgeable are we in helping them to get the most from the experiences that are supposed to open new doors for them? Hopefully, more adults have better answers to these and similar questions every year.

SESSION B-4

THE OPEN UNIVERSITY: THE BRITISH EXPERIENCE

M. J. Pentz, Dean and Director of Studies, Faculty of Science, The Open University, Walton, Blatchly, Bucks, England

This session was an informal audience-participation arrangement which included:

1. A 16 mm documentary film "The University is Open" as a general introduction to the Open University
2. General questions and discussion on problems of science teaching in the Open University
3. A 16mm film illustrating the use of television as a component of an integrated multi-media system for teaching tertiary-level science at a distance.

SESSION B-9

ARE GOALS AND EVALUATION APPROPRIATE FOR COLLEGE SCIENCE COURSES?

Edwin B. Kurtz, Chairman of Life Sciences, The University of Texas of the Permian Basis, Odessa

This paper will not attempt to justify the use of behavioral objectives (observable instructional outcomes) at all levels of education, K to 16. Rather two sets of objectives will be presented with a brief rationale for each. Criteria for standards of student performance are not included but such criteria can be readily described. The objectives are presented with the terminal tasks first and progress hierarchially to the least complex tasks at the end of each list.

SET A. For the non-science major in a biology, chemistry, ph[illegible]s, earth science, or other related course.

1. Construct and demonstrate a revised study and report that is accepted by a majority of a panel composed of three students and a faculty member.
2. Describe what you would do differently or additionally if you were to do the investigation a second time.
3. Demonstrate and construct a written report of the investigation and distinguish whether the prediction or inference was supported or not, or whether the question was answered.
4. Describe the scientific or other content basis for the prediction, inference or question of your choice, with appropriate bibliographic citations.
5. Construct a description of a test of the prediction, inference or question about a topic of your choice.
6. Describe the personal basis for your choice of the prediction, inference, or question to be tested, including reasons for your interest, basis of your satisfaction with the difficulty, originality or com-

plexity of the study, and how the study will benefit you or others.

7. Identify and name variables to be held constant, manipulated, and allowed to respond in the test of inference, prediction, or question.
8. Describe the kind of anticipated observations and data that you will accept as supporting or not supporting the prediction, inference, or question of your choice.
9. Construct a statement of a prediction, inference, or question for a topic of your choice which you intend to investigate.
10. Identify the inference, prediction, or question that you believe is most worthy of investigation, and describe the evidence upon which your belief is based.
11. Construct alternative inferences, predictions, or questions based on your observations, knowledge, and intuition, including having all terms defined operationally and a brief description of the basis for each inference, prediction or question.

12-25. A hierarchy of objectives that may be considered prerequisite knowledge and skills for the above tasks. These would include observing, measuring, classifying, defining operationally, and various behaviors regarding knowledge of concepts and principles in the area of a student's choice.

SET B. For the science major at the time he is to be awarded the Bachelor's Degree. These are all terminal tasks.

1. Construct and demonstrate in an oral report (before faculty, peers and career colleagues) a research or design study, and the rationale for the study.
2. Construct and demonstrate in a written report (to be reviewed and evaluated by faculty, peers, and career colleagues) a research or design study and the rationale for the study.
3. Construct statements of possible consequences, impact, and/or limitations of governmental policies, and cultural changes on science and science policy.
4. Construct hypotheses and predictions about the possible economic, social, and political impact of an invention, technology, or innovation on life and society.
5. Demonstrate instruction that brings about the acquisition of a specified competence in a learner (peer, lab technician, and so forth).

The action verbs used in all of the above objectives are those operationally defined in *Constructing Instruction Based on Behavioral Objectives: A Manual for Managers of Learning*, Walbesser, Kurtz, Goss, and Robl, 1971, Engineering Publications, Oklahoma State University, Stillwater.

SESSION C-5

THE UNGRADED SCHOOL AND INDIVIDUALIZED LEARNING IN THE SCIENCE ROOM

Nancy Glass, Science Coordinator, St. Patrick's School, Cleveland, Ohio

This paper discusses:

1. Definitions of "ungraded" and "individualization"
2. Description of classroom management in an ungraded classroom
3. Letting children's interest areas help with individualization
4. Commercial kits versus materials already present in the classroom
5. Benefits and pitfalls of the ungraded school and individualized learning.

THE OPEN SCHOOL PHILOSOPHY AND ORGANIZATION

Waltina Mroczek, Teacher, Hilltop Elementary School, Beachwood, Ohio

This presentation explores open school philosophy and organization by means of an imaginary visit to three individualized alternative education classrooms. Layout diagrams for: Programmed, Laissez Faire, and Open Education alternatives are included. The following basic ingredients will be discussed. The Child, The Teacher, Environment, Curriculum, Physical Space.

RECOGNIZING, ACCEPTING, AND NURTURING CREATIVITY IN CHILDREN

Alan J. McCormack, Assistant Professor of Science Education, University of British Columbia, Vancouver

Here's good news for housewives! Tired of spending long hours making beds, cleaning floors, and picking up the children's toys? Your salvation is the ingenious new "Bed-Making-Pillow-Plumping-Toy-Picker-Upper," guaranteed to do your housework in half the time. The inventor (age 8) claims it can easily be installed in your bedroom, and—now don't miss this—also will wake the kids at a pre-set time. If you order now you will also receive, free of charge, the "Automatic Suit-Getter." This amazing device consists of a series of ropes, levers, and magnets and will deliver your clothes from closet to you. Since it uses no electricity, this is a bargain you can't afford to miss.

Another handy little gadget is designed especially for fathers troubled by persistent late-hour pleas by baby for a glass of water. Just drop a marble into a long tube attached to the "Marble-Activated Drink of Water." The marble releases a pin attached to string, a series of pulleys, and the mechanism from an old alarm clock. The clock spring unwinds and hoists a cup of water from a pre-filled reservoir. Baby is happy, and Daddy gets his sleep.

These inventions, and a great many other oddball contraptions, were dreamed up by children of grades 2-6 in Vancouver (British Columbia) public schools. "Invention Workshops" have been incorporated into the elementary science program in some of our schools, and children's responses have been nothing less than sensational. The workshops are designed to stimulate and nurture whatever creative thinking talents children have. Teachers are encouraged to operate on the basis of two assumptions: All children have some inborn creative potential, but the degree to which this ability develops is linked to environmental influences: and stimulation, opportunity, materials, and encouragement are important creativity-inducing factors of the classroom environment.

Psychologists have identified a variety of divergent thinking abilities involved in creative thinking. Some of these are:

1. *Fluency* of idea production—the ability to think of a *large number* of ideas related to a problem:
2. *Flexibility*—the ability to produce ideas in a *variety of categories*.
3. *Originality*—production of ideas that are *novel* and statistically *uncommon;*
4. *Elaboration*—*embellishment* of ideas with detail and refinement.

A classroom environment involving only convergent, analytical thought processes which emphasize only "Right" answers and structured experimental procedures probably contributes little to the development of the above abilities. Alternatively, classroom conditions *can* be purposely adjusted to stimulate and focus children's thinking in divergent patterns. Given the opportunity to "mess about" with ideas and materials, elementary school children can easily forget the anti-creative constraints that com ly stifle originality in adult thought. And, if encc ..aged to do so, many children can assemble ideas and everyday materials into astonishingly creative products.

Invention Workshops are an attempt by teachers to involve children in divergent thought processes. The workshops begin with an interest-seducing experience focusing attention on a project open to unlimited creative interpretation. The most effective devices found so far for accomplishing this have been cartoons! (Heresy! Cartoons in science class?). Perhaps we should take a look at how this is done.

An Invention Workshop

Before the lesson, it was not uncommon to hear childr i's comments and inquiries about the mysterious packages labeled "Rube Goldberg Inventors' Kits" which lined the classroom shelves. Finally, at the beginning of what is supposed to be a science lesson, the teacher projects a slide onto a screen, showing an unthinkable conglomeration of unrelated objects (a lawn sprinkler, an aquarium, a hound sleeping on a table, etc.). "Can any of you invent an automatic garage-door opener using these items? The pupils stare at the teacher in utter disbelief—he is really off his rocker this time! Impossible task? On the screen flashed a picture, one of the "Inventions of Professor Lucifer Gorgonzola Butts" made famous by the master machinist of the comic strips, Rube Goldberg. Since the late R.G.'s famous "inventions" were popular during the 1920s and 1930s, these space-age children had never seen such contraptions. The children were obviously delighted. More inventions are projected. "That's super!" Next a film—"The Mouse-Activated Candle Lighter"1—shows an actual contraption operating in the true Goldbergian manner.

The teacher reached into one of the Rube Goldberg Inventors' Kits and pulled out a piece of cardboard. "How many different uses can you think of for this brown, square-shaped, lightweight, flexible-yet-strong, piece of material?" Involvement was obvious as the children engaged in the spirit of discussion, producing a wide spectrum of ideas. Incubation periods were short as hands would wave as an insight or new idea came. Creative production is an attitude of the mind—making the familiar seem strange. The secret of inventing lies in detecting new combinations for using quite simple and ordinary things. The "Inventors' Kits" (packages of junk) included such things as cardboard, straws, paper clips, elastic bands, pie plates, and string. The availability of a variety of materials provided a good starting point but all agreed that additional inexpensive materials could be used. With packages in hand, the students were off. To a casual observer, the groups of children working in all areas of the classroom would seem chaotic compared to orderly rows of children reading textbooks. For the next two weeks, the regular class time for science, and many student-requested after-school overtimes were spent by the neophyte inventors—sometimes frustrated but always fascinated because they were transforming ideas into tangible objects.

In one corner, a group of children busily unites a makeshift treadmill, a replica of the family dog, and a tantalizing bone to form the world's first "Automatic Dog-Walking Machine." For the harried executive who has everything, other children invent the perfect device—an ultramodern rocking chair equipped with a bellows and a series of air tubes so the over-tired man can sooth both his nerves and temperature simultaneously. Cool air automatically flows across the executive's face as he enjoys his late afternoon martini (which, of course, is mixed in a special shaker attached to the chair!).

Some girls decide to make mother's life a little bit easier: a "Rapid Grape Seed Remover" combines pulleys, a windlass, and a grape-sized trough. To operate, a weight is dropped which unwinds string attached to a complicated series of wheels and cams with the result that each grape rolling down the trough is punctured by a pin, thus removing the seeds. If the accumulated grape seeds become bothersome, they can be fed to your pet canary.

The children's inventions combine art with logic and blend humor with simple everyday objects. They haven't been directed to be "fluent," "flexible," or "original" in their thinking, but instances of these thought processes abound as the inventions are planned and constructed. Soon, the whole classroom takes on a comic atmosphere, and seems filled with active but pintsized Rube Goldbergs.

By the way, if you don't recall Rube Goldberg yourself, you will find the name in *Webster's Third International Dictionary* defined as ". . . accomplishing by extremely complex roundabout means what actually or seemingly could be done simply." The man Rube Goldberg was also extremely complex and often "roundabout." His creative abilities were highly developed, encompassing the writing of stories, poetry, song lyrics, play scripts, and the art of sculpturing (which he began at the ripe age of 80!). The Rube Goldberg most often remembered by the general public is the Pulitzer Prize-winning cartoonist, and inventor of outrageously amusing comic strip contraptions. Another hilarious example:

A "Device for Nominating a Candidate for High Office" places a "fresh air fiend" next door to the candidate. When the windows are opened, the fresh air addict's pet owl catches cold and sneezes into a toy bugle. This summons a company of National Guardsmen who think war is declared, and in their hast · they upset a milk man, spilling milk which attracts hundreds of cats. The howling of the cats wakes

[1] Prism Productions, Incorporated, 531 Dawson Dr., Camarillo, Calif.

up the neighborhood, whose own angry yells and howls the candidate mistakes for the voices of his constituents calling on him to save the country. The candidate thereupon jumps out of bed, throws open his window, and launches into a speech of acceptance.

As a young man attending the University of California at Berkeley, Goldberg ran up against "The Barodik"—a series of pipes, coils, beakers, gears, wires, etc. designed to measure the weight of the earth. Casting a leery eye at the proud professor who invented "The Barodik," he tackled the problem. *Six months* later he was left with the answer, and, admittedly, a head full of unprintable thoughts about the professor who assigned such a task. With a few years behind him, Goldberg looked back and saw "The Barodik" as a perfect example of how man can use so much to do so little. This was the beginning of the age of the so-called time saving inventions, and looking about he noticed that most of these machines managed to complicate life in other ways. So began the famous Rube Goldberg contraptions—an effort to make people laugh at themselves and not take the new inventions *too* seriously. At the same time, Goldberg seems to urge us to keep looking and wondering at the marvelously unpredictable passion of Man for creating things.

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: I maintain that children learn as much as they might from a more usual science activity, but also a great deal more. Most assuredly, children develop many of the same ideas about pulleys, gears, levers, etc., ordinarily included in a unit on "Simple Machines." The key difference is that ordinarily dull information concerning elementary mechanisms really means something if you need to "figure out" how to build an invention you are really excited about. And, if you are concerned about engaging children in the process of science, the skills of observing, hypothesizing, measuring, predicting, and inferring are clearly involved. All of these are combined with an important "plus"—children are intimately involved as *creative* thinkers.

Granted, creativity, as such, cannot be taught; the process 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 thing, I 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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FLANDERS INTERACTION ANALYSIS

Joan H. Zurhellen, Assistant Professor and Teaching-Learning Project Director, University of Tennessee College of Nursing, Memphis

Teaching and instructional processes are essentially interaction events. The types and levels of interaction that take place in classrooms are as many and as varied as the personalities and socio-emotional climates 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, etc. Usually, it is all these—and more. The two sureties about classroom interaction are: (a) it is omnipresent; and (b) it is multifaceted, and usually many facets of interaction are present at any one instant of time.

The phenomenon of interaction and its importance are often stressed by social psychologists and educators:

Sherif says, "To an important extent, the locus of change lies in the interaction of people with people." [1]

Guba and Getzels point 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." [2]

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." [3]

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." [4]

Despite such realizations on the part of many experts concerning interaction, it is a phenomenon often ignored or at least not attended to by teachers. Why? First, there is often a lack of awareness on our parts of the impact and effects of classroom interactions. Even after awareness, there is another serious obstacle 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 us and assess. 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." [5]

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 feedback on which teaching and instructional judgments can be sensibly based.

Ober has described systematic observation as "method of strategy-building and instructional improvement," [6] 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 . . . ." [7]

Systematic observation, then, 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, rightly, 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 says, devote itself to "paucity of detail." [8] 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 more 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 at a time, analyzing and improving that 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." [9] 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, [10] Medley and Mitzel, [11] and Whithall. [12] 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, [13] Amidon, [14] Hough, [15] Ober, [16] Bellack, [17] Ryans, [18] Gallagher and Aschner, [19] Combs, [20] Galloway and French, [21] Good and Brophy, [22] and Smith and Meux, [23] 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, [24] 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 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 [25] 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., [26] Bellack et al., [27] Gallagher and Aschner, [28] and Ober's ETC system are cognitive in nature. [29]

Affective systems focus on the social and/or emotional climate of the classrooms and the behaviors constituting that climate. Flanders' system [30] and those developed by Hughes, [31] Whithall, [32] Galloway and French, [33] and Ober's RCS system [34] are affective in nature.

Multi-aspect systems focus on several classroom aspects—emotional, sociometric cognitive, etc.—at the same time. Bales' system [35] and that of Medley and Mitzel [36] are multi-aspect in nature.

The Flanders system has become by far the most familiar; widely-used and copied, revised, or built-upon, of the systematic observation forms 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 it is often represented as. 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 40s, 50s, and 60s 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, [37] 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.

Flanders system, which is the main one under study here, is an affective category system which focuses exclusively on verbal behavior. In its original form it included ten categories. Seven of them describe teacher-talk patterns; two describe student-talk patterns; one describes silence or confusion.

The ten categories with brief definitions are: [38]

Teacher Talk

with categories 1, 2, and 3 summarized under the heading, *Response*

1. Accepts feelings. Is aware of and receives, then uses, translates and/or clarifies an attitude or feeling tone of a student in a non-threatening manner
2. Praises or encourages. Verbally rewards or supports pupil action or behavior.
3. Accepts or uses ideas of a pupil. Similar to number 1, but this awareness, use, etc. is of an idea expressed by a pupil rather than a feeling.
4. Asks questions. Directs questions, based on teacher ideas, about content or procedure to student(s) with intent that pupil(s) will answer.

with categories 5, 6, and 7 summarized under the heading, *Initiation*.

5. Lecturing. Gives content material, opinions, own ideas, or those of authorities other than pupils
6. Giving directions. States directions, commands, or orders to which student is expected to comply.
7. Criticizing or justifying authority. Gives statements intended to change pupil behavior from non-acceptable to acceptable; bawls out a student; states why teacher is doing what he is doing; etc.

Pupil Talk

8. Pupil-talk—response. Talk by students in response to teacher.
9. Pupil-talk-initiation. Talk by students which they originate or initiate.

Silence

10. Silence of confusion. Pauses, short periods of silence, or periods of confusion when communication cannot be understood by observer.

In order to use the Flanders system, these ten categories must be learned and easily identified by the observer. During an observation period, the observer writes down the symbol (the indicated digit or digits) for a behavior category every three seconds or whenever a behavior changes if that is more often. Generally, these symbols are recorded in vertical columns during a short observation period.

This page of symbol notations is then analyzed by summarization on a ten by ten matrix. First, tallies are entered for each cell. This is done by grouping the numbers recorded in two's, using each number except the first and last twice. Example:

10
5
5
6
9
3
10

The pairs are then entered on the matrix using the first number to establish the vertical coordinate (row) and the second number to establish the horizontal coordinate (column). After tallying is complete. totals are recorded in each of the 100 cells. and column. row. and matrix totals are obtained.

The most commonly used interpretations of these totals are calculations of the percentages of teacher talk to student talk and the percentages of indirect teacher talk to direct teacher talk.

Flanders and his associates have further worked out detailed analyses of the meanings of tally clusters in various areas on the matrix so that a great deal of helpful information concerning several components of verbal classroom behavior can be obtained from a single matrix analysis.

This brief and parsimonious summary of systematic interaction observation scales. in general. and the Flanders scale. in particular. 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 a finger. fork. or other utensil in. 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.

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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 way 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.

Part II of this session will be a workshop on methods of applying these social science concepts to the analysis and teaching of "modern" science curricula.

[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.

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SESSION E-2

SETTING A CLIMATE FOR CREATIVITY IN THE SECONDARY SCIENCE CLASSROOM

CREATIVITY

Eugene E. Nalence, Physics Teacher, Marple-Newtown Senior High School, Newtown Square, Pennsylvania

I believe there are three ways the teacher can stimulate creativity. First, the teacher should establish a classroom situation that allows for at least some independent action by students. Second, the teacher should provide materials and activities that provide incentive for student interest and involvement. Third, the teacher should demonstrate his own creativity and active interest in science and science teaching. Let's consider each of these ideas.

It is clear that young people need some guidance in their learning experiences. This means that any independent study program must provide some built-in guidance. The best means for providing this is to establish behavioral objectives in a logical sequence that clearly state what is to be expected from the student. The means by which these objectives are achieved, and the time devoted to them, can be at least partially determined by the student. More area for independent action can be created by building into the program, optional objectives not required as a basic part of the course

At Marple Newtown Senior High School, in Newtown Square, Pennsylvania, an independent study science program has been in existence for several years. Students enter the program on the basis of teacher recommendation and student desire. About 10 to 20 percent of the students in our college preparatory program are in an independent study class. Students in these classes proceed at their own pace. Testing is on an objective-by-objective basis, at times selected by the student. Grades are determined by both the quality and the quantity of the work done.

Data comparing the achievements of independent-study students with students in the regular college preparatory program having similar abilities show no significant difference. Then, one might ask, what value does an independent study program have? First, the program obviously must be more student-centered and individualized. Second, the attitude of students toward their work is very positive since most activities are initiated by the students. Finally, students are released, at least partially, from artificial barriers of time.

We have been satisfied enough by our efforts in independent study to increase the number of students involved. We hope to be able to offer the possibility of independent study to all who wish to take it.

I mentioned that a second means for encouraging creativity was to provide stimulating materials and activities. At Marple Newtown, we offer a program in general science as well as the usual academic program. In trying to put together a quality program in general physics, we have been very satisfied with the use of case studies. Case studies are independent units within the course. They focus attention on either a contemporary technological problem, or a recent technological development. The student is asked to propose and evaluate solutions to technological problems or to consider implications of technological developments. To do either of these things, the student must learn some physics — probably the same physics he would learn in any teaching approach. But case studies provide incentive for learning by providing immediate application for what is learned. They also give the student practice in reacting to situations he will face as a voter, tax-payer, and consumer; long after his formal education ends.

We have collected data on achievement by students of case-study and non-case study objectives. Some data indicate higher levels of achievement on case-study-related items. Nonstatistical data — such as statements by students, reference materials gathered by students, and the level of student involvement in classroom activities — indicate greater student interest in case-study activities. We think it might be possible to contain all basic principles in physics within a set of case studies. We would also like to have enough case studies to provide several alternatives for both students and teachers.

The last, and perhaps most important, means by which student creativity can be stimulated is by example. Our students will never retain all of the principles which we so carefully establish in our classes. But they will probably remember us as people for a very long time. It is therefore essential that we clearly display our interest and concern with our students and their ideas as well as our concern with science-related principles and problems. We must also display our own creativity in our teaching techniques, our quest for new knowledge, and our own search for rational solutions to contemporary problems. By demonstrating these attitudes to our students, we can provide them with ideas useful in facing unexpected problems in an unknown future.

ROLE OF THE RESOURCE CENTER IN SETTING A CLIMATE FOR CREATIVITY

David L. Cross, Science and Environmental Education Consultant, Lansing School District, Lansing, Michigan

A slide-cassette-tape program relates the role of the science and environmental education center, the SEE Center, in setting a climate for creativity. The SEE Center serves 50 elementary and 9 secondary schools in the Lansing School District in the disciplines of science and environmental education.

FREE SCHOOL SCIENCE

Baxter J. Garcia, Science Teacher, Alternative and Independent Study Program (AISP), Toronto, Canada

As a science educator in an alternative high school, I am directly concerned with the relationship between the climate of creativity in the science classroom, and the overall climate of the school itself.

The present crisis in science education—evidenced by declining enrollments, and widespread disillusionment with science as a career—is inseparable from the wider crisis in education generally. These circumstances dictate the necessity for radical changes both in the science classroom and in the total school environment. Some of these changes are beginning to be realized in the alternative high schools.

The Alternative High School

The Alternative and Independent Study Program was established in Toronto in 1970 as an experiment in secondary education. Its general features and philosophy are patterned after other established alternatives, such as the Parkway Program in Philadelphia, the Metro School in Chicago, and the SEED program in Toronto. The characteristics of these programs may be familiar to most of you, but let me summarize briefly the essential aspects and goals of AISP.

1. Any student from the school district (serving a population of one-half million) may apply to AISP. Selection for the 160 spaces is by lottery.
2. To maintain a human scale at AISP, numbers are kept small—160 students, 9 staff.
3. Compulsory aspects of schooling, related to attendance, dress, etc. do not exist at AISP.
4. Informality and close personal contact are stressed in staff-student relationships. Growth, for both teachers and students, is assessed in terms of moral, emotional, and psychological factors, as well as the traditional academic ones.
5. Staff function primarily as resource people, not as teachers in the traditional sense.
6. The school program is closely integrated with community resources. We attempt to make fruitful use of the vast resources of an urban setting: museums, universities, libraries, theatres, etc.
7. Students are given the widest possible choice as

regards both *what* they choose to study, and *how* they choose to study.

8. Community government; involving staff, students, and parents, is evolving at AISP. Students and parents assist staff in dealing with administrative, curricular, and other aspects of the program.

Science at AISP

How does the science program at AISP function? The process begins when students identify an interest area. Then, my first task as science resource person is to build a communications network, finding out what students want to study, how they want to study; *i.e.*, independently or with a group, and if the latter, putting them in touch with other students who want to study in the same area. Then, getting them started—what resources are available, books, course outlines, films, community resources and catalysts, or resource people, space for groups to meet, supplies and equipment for experiments, etc. As you might imagine, this process is enormously time-consuming and tedious, and as such is inefficient in traditional terms. But time isn't really being lost in this organizational phase because students during this period are having a most significant learning experience; they are learning how to assemble resources and take responsibility for their own learning.

A fundamental premise underlying our operation at AISP is that most schools fail completely in this latter area—most schools assume implicitly, if not explicitly—that students are incapable of making significant decisions about their own education. Hence it is necessary to compel students to attend school, as if *learning* could be compelled. And so it is often stated that students are not mature enough to bear responsibility for their own learning. The irony of this lies in the simple fact that human beings become mature through the very experience of bearing responsibility, and being allowed to make significant decisions about their lives. If schools are to encourage the development of maturity in young people, let them begin by realizing that learning cannot be compelled—that it can only flow from the free choice of the learner and that the learner gains maturity as he learns to accept the consequences of his own free choices.

Alternative Learning Forms in Science

The forms of learning in science that evolve at AISP are diverse, and highly individualized. Some students choose to study on an independent basis, some work in small seminar groups, with me or another resource person as a leader, some groups work within the school, some work at universities or other institutions in the community. Generally, each student's learning pattern evolves in a unique way.

Alternative Learning Content in Science

I have discussed alternative *forms* for learning in science at AISP. What about science *content* in an alternative context? What will students choose to study in science if they are given a free choice?The pattern that I have found is not a surprising one—it mirrors the general trend evident in recent years across the United States and Canada. Biology is by far the most popular science area. Chemistry is a distant second, and physics a lagging third. Clearly, placing students in a free school context does not imply that they will be liberated from their preconceptions and prejudices about science courses—in particular the physical sciences. School, and perhaps society, in a broad sense, has turned off students to these areas of science, physics and chemistry, and it is no easy matter to turn them on again.

Curiously, biology is an exception. Students see this area as one with human content, as one with relevance to society in general, and to them individually. Within the scope of biology, extremely successful courses have evolved at AISP in such areas as ecology, nutrition, the human body, human sexuality, behavior, and survival; although classical area studies such as botany and genetics have also been popular. Also, it is interesting to notice that students are not averse to learning physics and chemistry when it is introduced in the context of a subject like the human body, or nutrition; *i.e.*, in a context perceived as *relevant*

Implications for Science Educators

There are some interesting implications for science educators involved in the observations I've discussed above. Perhaps we need to recall that the current generation of students came of age in the scientific-technological era, and that they have lived long enough to assimilate some of the connections between science and technology, and the social ills that currently plague us; poverty, urban decay, environmental destruction, militarism. These students grow up to confront a technological juggernaut—a society apparently out of control, unable to use its vast wealth and resources to create a more humane level of existence for its people.

The challenge for us, as science educators, is clear. We must work toward bringing humanistic content into all science areas. We might begin by encouraging students to develop integrated approaches, crossing subject boundaries to topics of interest to them, such as the human body. One idea here might involve a systems approach, stressing the applicability of a single set of concepts to different systems such as cell, organism, and society. The immediate relevance of such studies could be underscored by using current research such as the MIT report "Limits to Growth." Or perhaps an entire curriculum could be set up around the theme: Alternative Science/Alternative Society. In this way students could explore different aspects of science, as a key to the future, and as a tool in the transformation of society.

In summary, I want to affirm the need for far-reaching changes in both the form and content of science education at the high school level. Furthermore, I wish to emphasize that reforms limited only to the science classroom will not in themselves lead to a climate for creativity. What happens in the science classroom is indeed dependent on what is happening in the school generally. If the school environment is based on compulsion and restrictions, it will be unlikely that a truly creative atmosphere can be established in the science classroom. But if, on the other hand, the school environment is based on freedom and openness, then this atmosphere will infuse itself into all aspects of the school program, setting the foundation for a truly creative and liberating climate for learning in science.

SESSION E-4

PERFORMANCE OBJECTIVES: NECESSARY OR SUPERFLUOUS

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

Whether performance objectives are springboards or coffin lids will depend on the intent of the user. Just as beauty is in the eyes of the beholder, the necessity for performance objectives is a function of the people in the learning context. The learning context is being used to describe the coming together of many for the purpose of education. An assumption basic to this discussion is that we all are agreed that the outcomes of this "coming together" should be self-actualizing people—people who can make "wise choices and worthy decisions." For this potential of decision and choice-making to mature, our students must have the freedom and opportunity to make decisions or choices within known parameters. In this way, feedback on the consequences of their choices makes it possible for the student's action to become intentional rather than accidental.

The essential nature of parameters is that we must know the name of the game and the rules in order to be a fully functioning participant. As one participating person in the learning context, it is my responsibility as the teacher-guide, director, monitor—to make the name of the game and the rules or the parameters openly available to all the participants.

Performance objectives are an illustration of intended parameters. They are devices that can help clarify tasks and open channels of communication between key people in the learning context—the student and the teacher. Please note the conditional nature of this statement—*can help*. Performance objectives do not make good learning, they facilitate people.

In a learning context, students learn because of the teacher's instructional program, school environment, personal motivation, and home background. Without too much difficulty, we could make impressive lists of creative efforts to show that each of these factors is a necessary and sufficient cause for successfully functioning people who can make wise choices and worthy decisions. But, it is equally simple to make alternative lists of evaluation studies that negate each of these factors, with the exception of the teacher. If learning is an individual accomplishment, then the personal nature of this interaction between one who has a greater insight cannot be overemphasized.

Performance objectives can facilitate this interaction if we define them as indicators or as assertions of what I as a teacher want my students to do because of the learning context. There is a very real distinction between open statements of intent which are useful for clarifying and communicating instructional intent. There are also closed descriptions that are hypothetical statements of what a learner should be able to do in a post instructional testing situation [1, 10].

In the former (open objectives), the emphasis is on communicating the intended outcome in the language of the learner and a sharing of the relevance of this outcome in a way that will communicate to the learner.

In the latter (closed objectives), you will find careful attention to the precise description of tasks, conditions, and criteria of the behavior which the learner is to demonstrate. While these are useful in constructing tests for assessment purposes, I see little value in closed objectives to facilitate communication between the teacher and student in the learning context.

Then what good are they?

"Goodness" is a value judgment. We may wish to use Charlie Brown's answer to this question:

> I think the best way to solve (it) is to avoid them. This is a distinct philosophy of mine. No (question) is so big or complicated that it cannot be run away from.

We can do a cop-out and merely ignore the question.

We can answer the question with a clear cut "None." This is a result of using the philosophy, know your stuff, know who you are going to stuff, and stuff them. Or we can say "good" because performance objectives facilitate: directions for the learning context, selecting learning opportunities, fitting the learning context to the learner, assessing success. For any learning context, there are intended (implicitly or explicitly known) goals. Performance objectives make it possible for a teacher to define what it is that schools need to do relative to the basic goal, that is to teach children to work and relate to each other [5]. Performance objectives push the teacher to be clearer and more specific in intentional outcomes, thus, resulting in greater teacher insight into the total tasks [1]. Performance objectives also help a teacher to search out alternative sequences of goals and to coordinate many goals together. Because analysis of goals into smaller performance objectives requires careful study, the objectives reveal situations in which there are goals but no learning opportunities; and help both the teacher and student spot trash or trivia in the learning context [8].

Performance objectives provide a base of insight for the learning context which facilitates selecting many learning alternatives. The more I know about a subject, the greater the freedom I have to act. The converse is equally true. The less I know, the more I am restricted to two pages a day of directed instruction. With performance objectives, a teacher has a basis to search for relevant activities appropriate for individual children [6]. A clear goal provides an insight into selecting and using a variety of materials because the performance objective helps us to focus on the consequences, or the matter of the learning context, rather than on the manner [6].

Performance objectives have their greatest impact in helping us fit the learning context to the individual child. Personalizing learning means greater freedom for the child to decide pace, style, and substance of his learning. With the performance objectives, a greater clarity and mutual understanding about the intent of the learning context between the teacher and the student is possible. Everyone knows what is expected [1,8] because mutual thinking and planning are essential in the communication of these intentions in student's language [8]. Performance objectives are a way to focus on a variety of performance levels, e.g., knowledge, consequence, exploratory or knowledge, practice and application. The variety of expected performance levels known thus permits the teacher to focus on the variety of needs of learner's interests and abilities as important dimensions in organizing instruction to fit the child. Clear goals help teachers gain expertise in observing students and in recommending alternative activities within the learning context [1]. Thus, performance objectives facilitate the shift from the "telling" information-giving-teacher who makes all the decisions and choices to one who organizes the context with many options and recommends that the learner consider those choices. The performance objective makes it possible for a teacher to develop sensible objectives and then to help students to work toward these instructional outcomes. [5].

Assessing success is not new. We always have and always will be involved in judging how well students are performing both in short term tasks and longer term goals. When we do this, we are using performance objectives, for we are basing our judgment on observable behavior. We may not feel comfortable in being specific about the shallow level of the objectives that our assessments indicate. Indeed, we may elect to debate performance objectives rather than face the shallowness of our judgment. Performance objectives permit us to gain more evidence that the learner has gained what we had hoped [3]. They make more precise evaluation possible [9] in that they help us translate our intentions into measurable or observable evidence. Performance objectives also help us see where we have evaluation or tests with no instruction or goals [3] and where we have goals or instruction with no evidence of success.

As used here, please note that performance objectives are part of a broader picture. Goals are the broad target and performance objectives are the target sheets. For the performance objective to be valued, it must exist within a larger conceptual context. Thus, the model of the learning context here is not a closed narrow system of performance objectives, instruction, performance assessment, but rather an open system of job, task analysis, learning, performance assessment.

Performance objectives are not the first step on the ladder to perfection. They are inanimate until someone does something with them. But in our consideration, we must be careful to distinguish between our concern for the outcomes, consequences, or products of the learning context, and the manner or processes of interaction within the context. We may be so uncomfortable with the process that we use a focus on the performance objective as a substitute because it is easier to reach for technology for solution than it is to face our real problem.

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SESSION E-5

TEACHING COLLEGE SCIENCE

Mildred W. Graham, Assistant Professor of Science Education, Georgia State University, Atlanta

The colleges and universities are the training grounds for science professors. Some science departments are cognizant of this role. Others, by awarding graduate degrees, give teaching credentials without even a cursory glance at the competencies of their graduates in other than their knowledge of the subject matter and their research capabilities. The question is whether this is a problem for the science departments, and if so, how should they deal with the problem?

We do not deny that there are intuitively good professors. The multiplier effect of these professors on future college science teachers who emulate them must be great. However, there are some who cannot emulate a model. In addition, a given professional model may not be appropriate to a particular student because of differences in personalities, beliefs, and attitudes. Furthermore, the prospective college teacher has little opportunity for appropriate practice of a model.

We cannot believe that a particular chromosomal makeup will produce creative college professors. Nor do we believe that a great textbook knowledge of science will guarantee effective college science professors. Neither do we say that a given number of college education courses will automatically produce an effective college teacher, particularly without a scholarly base. Perhaps some insight into the problem is provided by the impression that college professors value their roles as researchers more than their roles as teachers.

Much time has been spent in science faculty meetings debating graduate internships and similar issues concerning the training of prospective college professors in skills relative to communication of knowledge about and attitudes toward science. Have we used internships to their maximum effectiveness? There are some outstanding illustrations where this experience is maximized, but often it is just a role that is played in isolation toward financing a graduate degree. Studies show the extensive role strain or conflict this places on a graduate student.

We *do* believe that it is possible to help prospective college professors attain skills in handling the complexities of college teaching. How can we help the graduate intern become an effective teacher? We must study the programs in operation and study the situational aspects of our own departments. We must develop programs which will offer optimum learning experiences for our assistants as well as improve the instruction of the multitude of undergraduate students who are under their tutelage.

SESSION F-1

ENVIRONMENTAL EFFECTS OF ELECTRIC POWER GENERATION

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I have been asked to discuss the comparative environmental effects of energy usage and, particularly, of alternative methods of electric power generation. This is a difficult assignment under any circumstance since the areas of influence of electric power generation are quite widespread, extending from the mining operations through the transportation of fuel, and the emissions from the generating stations themselves, to the transmission of the energy generated to the ultimate consumer, and of course the disposal of waste products from the generation process. In comparing the alternative methods of electric energy generation, one frequently finds that the effects of one or another of the segments of the operations are not strictly comparable. Nevertheless, there are sufficient means for comparing these effects to make a reasonable assessment of available alternatives.

In this presentation, I will deal primarily with the environmental effects of currently developed technology for electric energy generation: hydroelectric generation which utilizes the energy of falling water to turn turbines which in turn drive electric generators; a method which utilizes the stored chemical energy of fossil-fuels in the form of heat; and a method which uses nuclear heat resulting from the fission of atoms. All three of these energy sources are and have been in use to generate electricity on commercial scales.

I will not deal with such exotic methods of energy generation as solar power, geothermal energy, tidal power, wind power, and thermonuclear fusion. None of these sources are likely to provide any significant fraction of the electrical energy needs of this nation or of the world over the next two to three decades, at the earliest.

One of the earliest and, where available, one of the cheapest methods of generating electric energy is from the energy of falling water. It requires about 300 acre-feet or 370,000 cubic meters of water falling 100 feet to produce about one megawatt day or twenty-four thousand kilowatt hours of electrical energy. Most of the available sites and water in the United States suitable for hydroelectric energy generation have already been developed, and it is estimated that a very small increase in this method of energy generation will occur over the next 20-30 years. In 1970, approximately 16 percent of the generating capacity in the United States derived from hydroelectric or pumped storage facilities. In 1980, this is projected to drop to 14 percent of the total capacity and in 1990, to 12 percent of the total capacity.

The environmental impact of hydroelectric generating facilities is, of course, not negligible. Substantial land areas are inundated by the impounded lakes behind these dams. The dams are large structures requiring substantial quantities of concrete and steel, and these structures may impede the migration of certain fish species. The impoundment of water will usually increase the surface area exposed to sunlight and often waters in reservoirs are several degrees above those temperatures naturally reached in the unconfined stream. Thus in this instance, we have an example of a thermal enhancement of confined water. [illegible] lly, the flow of water through the turbine, and its discharge to the stream below the dam may create changes in the dissolved gas content which may in turn lead to specific diseases in fish.

Fossil-fuel steam electric plants provide the bulk of electric generation capacity in the world at the present time. Fossil-fuel plants are those which burn carbonaceous materials to release heat energy. Of the total energy generated by fossil fuels, about 56 percent derived from coal, 29.5 percent from gas, and 14.5 percent from oil. It required approximately eleven tons of coal to produce one megawatt-d[illegible] of electric energy; about forty-four barrels of oil and two hundred and fifty thousand cubic feet of gas were burned per megawatt-day of electric energy. The conversion of each of these fuels to electric energy results in some environmental impact which, of course, varies between the different fuels.

Looking first at coal, which provides the major portion of our electric energy needs at the present time, a number of areas of environmental effect can be identified. The first is the effect on land use, including the ecological effects of mining operations, the commitment of substantial areas of land for power plant sites, rail delivery facilities, and coal storage areas, and the requirements for disposal of solid wastes associated with the flyash collection and (probably) from processes for the removal of sulfur from flue gases. Second, there are effects on air quality stemming from the discharge into the atmosphere of combustion products including nitrogen oxides, sulfur oxides, and particulates. Effects on water quality from the discharges of waste heat and some chemicals, and effects on land use associated with transmission rights-of-way are essentially common to all thermal generating stations and are not necessarily specific to the use of coal as fuel.

The country's resources of coal are extremely large. However, coal is not uniform in quality, varying quite widely in both physical and chemical properties, and in terms of its costs to mine and transport. For example, the bulk of the low sulfur and inexpensive coals which are found in the western part of the country are located quite far from utility demand centers which are predominantly in the east. Coals which are nearer to load centers are generally rather high in sulfur, or are expensive to mine.

The sulfur content of United States coals ranges from about 0.2 to 7 percent by weight. The ash content normally ranges from 5 to 20 percent by weight. The bulk of the coal burned by United States utilities has had a sulfur content in the range of 2 to 4 percent. Increasingly, electric utilities are being required by air quality considerations to burn fuel having a sulfur content of one percent or less and, in some instances, the allowable limit has been set below 0.5 percent sulfur. The supplies of coal available with sulfur contents as low as one percent are very limited in relation to the substantial needs of the power industry. Nearly 70 percent of the toal resources of all types of coal are located west of the Mississippi River; all of the low sulfur sub-bituminous coal and lignite resources and about one-half of the bituminous coal containing less than 1.5 percent sulfur by weight are located west of the Mississippi. In the east, the bulk of the low-sulfur bituminous coal reserves are located in Appalachia; three-quarters of that is metallurgical grade coking coal, which is in great demand both in the United

States and abroad. Substantial reserves of this coal, therefore, are either dedicated to the metallurgical and export markets, or are directly owned by steel companies

The burning of coal results in the emission of oxides of sulfur, and nitrogen and particulates; the disposal of the ash resulting from the burning of coal is also a major area of impact. For example, in 1970 the three hundred and twenty million tons of coal burned by electric utilities resulted in the generation of approximately thirty-thirty-five million tons of ash requiring disposal as solid waste, and approximately twenty-four million tons of sulfur dioxide assuming an average of 3.5 percent sulfur in the coal burned.

The control of particulate emission from coal-burning plants is well established from a technological point-of-view. Techniques include the installation of mechanical collectors and electrostatic precipitators which can yield removal efficiencies in excess of 99 percent from the flue gas streams at these plants. The control of sulfur emissions from coal-fired stations is not nearly as well develolped as the control technology for particulate emissions. The present status of these processes can best be described as developmental. A number of processes have demonstrated a reasonable capability in small scale experiments or pilot plant operations and are now in the testing phase at a number of different utility plants around the country to determine their effectiveness under realistic operating conditions when associated with generating plants. One of the major dialogues presently underway relates to the actual status of these processes. The Environmental Protection Agency has generally stated that technology has been demonstrated for the sulfur removal processes; most utilities and the Federal Power Commission disagree with this position.

The emission standards issued last year by the Environmental Protection Agency would require coal with a sulfur content of 0.7 percent or less to be burned, or its equivalent in removal efficiency to be provided in flue gas processes. As I indicated earlier, the availability of coal with appropriate sulfur content is restricted in availability either due to location (at substantial distances away from the site of generation), or is committed to or owned by the metallurgical industry. Additionally, the substitution of low-sulfur coals for those of higher content will usually reduce the efficiency of installed lectrostatic precipitators, due to the higher resistivity of the low-sulfur coal ash. The status of technology available to assure the ability of removing sulfur reliably in commercial power plant operation is also in dispute.

A final consideration is that the low-sulfur coal available in the western states would be extracted almost exclusively through strip mining techniques. As you are probably aware, strip mining practices are currently under serious challenge by both environmental groups and a number of members of Congress. Thus, although reclamation practices are available for dealing with strip mining problems, the advisability of permitting mining companies to use these techniques to recover low-sulfur coals is open to some question.

Turning to oil, its use has increased substantially by utilities as environmental restrictions on coal usage and the lack of availability of gas have grown. In 1970, approximately three hundred and thirty-five million of barrels of oil were consumed in United States generating stations. This increased by over 18 percent in 1971 to about three hundred ninety-six million barrels of oil, while coal usage in 1971 was only 2 percent higher than in the preceding year and gas consumption increased by only 1.5 percent. Since oil typically contains less sulfur than does coal, it has been utilized in many instances as a replacement for coal since burning coal violates air quality regulations. Assuming an average of 1.5 percent sulfur for the three hundred thirty-five million barrels of oil burned in 1970 by electric stations, the emissions of sulfur oxides in that year totalled approximately two hundred thousand tons, or less than 1 percent of the total contributed by utility coal combustion in that same period

Although processes are available for desulfurizing oil, the capacity of existing refineries does not now (nor will it for several years) match the demand for fuel oil with a low sulfur content. Additionally, the requirements for oil have led many suppliers to purchase oil from foreign sources a factor which has played a significant role in the United States balance of trade and which has raised questions of national security involved with the dependence on foreign governments for significant fractions of our total energy sources. Oil imports at the present time approximate three million five hundred thousand barrels per day; this is projected to increase to approximately 50 percent of the total United States oil supply by 1975, according to the National Petroleum Council.

There are other environmental problems associated with the use of oil as a fuel including: the potential contamination of ocean waters during exploration, recovery or transportation processes associated with the development of oil resources. Certainly the controversy about the Alaskan pipeline, or the periodic episodes of oil spills from wells or from tanker mishaps in near coastal waters have not escaped public notice. Additionally, the marine terminal facilities required for docking and unloading of the so-called "super-tankers" have found substantial opposition to their construction in most locations, due to concerns about potential environmental effects.

The third fossil fuel, natural gas, which provided almost 30 percent of the electric energy generated by all fossil fuels in 1970, has been plagued by a shortage of proven reserves. Thus, despite its desirability as a clean-burning fuel for many uses, including utility generating stations, it has been increasingly unavailable for the latter. Gas contains essentially no sulfur content and no significant quantities of particulates are generated during its combustion in comparison to coal or oil. However, in common with the other two fossil fuels, nitrogen oxides are produced and emitted to the atmosphere with the flue gases.

In order to fully utilize our domestic energy resources of fossil fuels and meet the stringent air quality standards being legislated, efforts have been underway and are being intensified to develop synthetic gas supplies from available coal resources, to develop the energy contained in oil shales located in large areas of the western United States, and to develop and utilize processes for removal of sulfur oxides from flue gases. However, the fraction of the total electrical energy requirements of the United States able to be supplied by these cleaner energy sources will probably be insignificant until at least the end of this decade.

Nuclear energy provides a substantially different alternative to the fossil-fuel generating capability which at present provides the bulk of the nation's electric generating capability. Although nuclear energy provided only 1.6 percent of the total electric energy generated in 1970, that value increased to 2.8 percent in

1971, to 3.4 percent in 1972, and is projected to provide almost 19 percent by the end of this decade, and 44 percent by 1990. Although nuclear energy has been widely promoted as "clean energy", it is not without its own environmental effects. In many cases, of course, these effects are similar to those associated with fossil energy generation, such as the transmission lines required to move the energy from the generating station to the consumer; the necessity for structures to house the generating station, and the land required for that purpose; and the mining activities associated with the extraction of the uranium fuel for the nuclear plants. However, there are, in addition, a number of effects which are unique to the nuclear power generation field, and which generally relate to the nature of the fuel and process used to generate this energy.

Despite these other effects, the generation of electricity using nuclear means is substantially "cleaner" than the methods involving the combustion of fossil fuels. In the resource extraction area, the weight or volume of nuclear fuel required is many orders of magnitude less than that associated with coal or with oil, since the energy content of uranium is many times greater than that of the fossil fuels. For example, the 10 tons of coal or 45 barrels of oil needed for one megawatt-day of electric energy, can be replaced by about three and one-half ounces of slightly enriched uranium. Not only does this reduce the amount of land necessary for mining uranium, but it also reduces the needs for transport of the fuel, and the requirements for large fuel storage facilities and areas at the power plant site. There are, of course, no combustion products since the generation of heat results from the nuclear fission process.

For all of its attractiveness, however, nuclear generation is not free of potential environmental impact. The extraction and processing of uranium does result in an element of risk for the miners (although to a substantially lesser extent than in underground coal mining), and in the generation of substantial quantities of tailings, which do contain some residual natural radioactive materials. Small quantities of radioactive gases, liquids, and solid wastes are produced in a nuclear plant as a result of its operation, and these radioactive materials are many times more toxic per unit weight than are the combustion products from fossil fuel. At the generating plant site also, there is a substantial increase in the amount of heat released to the environment as compared to equivalent fossil plants, due primarily to the lower thermal efficiency of the nuclear units. Following their use in the nuclear power plant, the radioactive fuel elements are transported to fuel recovery facilities at which the radioactive materials generated in the fuel are separated from remaining fuel values. This process is the source of the long-lived, high activity waste which has been much deplored in the press during recent months.

Looking first at the radioactive wastes generated at the power station site, there is a substantial body of experience which indicates that the processes available and in use at the present time are entirely adequate to essentially eliminate any change in the radiation environment of a nuclear power station from that which existed prior to plant operation. Nuclear power plants have operated in this country since the late 1950's with surveillance of their surroundings by both state and federal agencies in addition to the plant operators themselves. By and large, there have been no changes in the radiation in the environment of these power plants as a result of power plant operations. A recent report by the National Academy of Sciences - National Research Council supports this view. The experience in fact has been sufficiently favorable that within the last few years the Atomic Energy Commission has proposed reducing the discharge limits at these plants by a factor of approximately one hundred, based on the fact that operating experience has demonstrated the capability of maintaining releases at about one percent of present radiation exposure standards.

Continuing with the radioactive waste issue, by far the majority of the radioactivity associated with nuclear power generation becomes available as a waste in the fuel recovery processing which is conducted at a central location for a number of nuclear power plants. Federal regulations require that all such wastes be solidified and transferred to a federal repository for ultimate storage. The site and nature of this repository has been in controversy over the past year or so. A deep salt mine in Kansas, tentatively considered by the Atomic Energy Commission as the storage site was, in fact, not entirely acceptable due to the existence of penetrations from other mineral explorations into or near the proposed storage area.

The use of salt beds was recommended in 1954 originally by the National Academy of Sciences as the type of geologic formation most likely to be acceptable, and the AEC is currently exploring other salt bed regions for suitable storage sites, but the AEC is also proceeding with an alternative plan for massive surface storage facilities for these wastes. It must be recognized, however, that the volume of these wastes, (a few tenths of an acre per year for solidified nuclear "ashes") and hence the facility required to deal with them, is of a substantially smaller magnitude than that associated with the burning of coal and the disposal of the ash (30 to 35 million tons of ash per year). Although the time period over which protection must be assured is long—measured in hundreds of years or longer—currently available materials and technology should be able to match the relatively primitive engineering techniques available to the Egyptian pharoahs which served in many cases to protect artifacts for 3,000 to 5,000 years.

There remains, however, the question of heat discharge, which is common to all steam electric stations, whether fossil or nuclear. For a given energy output, the amount of heat rejected and released to the environment depends on the efficiency of the system, which in turn is a function of the maximum temperature at which the boiler can operate. The 1969 average thermal efficiency for all United States fossil plants was about 33.2 percent. This results in slightly over two kilowatts of heat energy being rejected for every kilowatt of electrical energy generated. Of the total, approximately 15 percent is rejected in the stack gases and the remaining heat is wasted to the condenser cooling water. The most modern fossil plants have thermal efficiencies of up to 40 percent with correspondingly lower heat rejection to both the stack gases and the water. Since nuclear reactors do not reject heat via combustion gases, all of the waste heat is rejected to the condenser cooling water. Present light-water reactors operate with an efficiency of about 32 percent, just slightly under that of the average United States fossil plant, but with greater heat rejected and released to water. The high temperature gas-cooled reactor has a thermal efficiency of 40 percent, equivalent to that of the best United States fossil plant. However, again in this case no heat is rejected to a stack and there is a higher heat rejection to the cooling water than is the case with fossil plants. It is estimated that the fast breeder reactors currently under development will have efficiencies of between 45 and 55 percent which will reduce the heat rejection to the environment below that currently attained with the best fossil plants.

The combination of lower thermal efficiency and larger unit size for central station nuclear plants has resulted in a more difficult situation with respect to heat rejection problems. This is particularly true since the tendency is to establish as much generating capability on a site as the environmental conditions will permit. Thus, although the waste heat problem has been raised primarily in association with nuclear power plants, the difference between nuclear and fossil plants is literally one only of degree, which relates both to thermal efficiency and station size. By the end of the century, the potential development of new processes currently in the research stage, such as fusion or magneto-hydrodynamics which would operate at extremely high temperatures, offers considerable promise for still future increases in efficiency and resulting decrease in heat rejection to the environment.

For the present, techniques are available for controlling the discharge of heat to the water environment on its way to the atmosphere, the ultimate repository for waste heat. These involve the use of cooling ponds or cooling towers to dissipate the waste heat directly to the atmosphere from a more confined volume of water. However, these alternate methods of heat rejection also have their own disadvantages which must be weighed carefully before a choice is made. Neglecting economics, cooling towers which may be as tall as a 40- or 50-story building for a large plant, have been considered esthetically unattractive by some and, more importantly, they discharge a considerable amount of water vapor into the atmosphere which can have significant climatological effects in the vicinity of the generating station. In cold or humid weather, the likelihood of fogging and precipitation is increased, and in some cases with cold climates, these towers have created icing problems on nearby plant structures, roads, and streets.

Cooling ponds or lakes (sometimes augmented with sprays) are another alternative. These require substantial land areas which, depending upon the climate, may average one to three acres of water surface per megawatt of plant capacity; thus a plant with 1,000 megawatts of generating capacity might require as much as 3,000 acres for a cooling lake or pond. These ponds also will create some local fogging on cold days due to the evaporation of water from the surface.

Studies are underway to develop useful applications of this wasted low-grade energy, but there are presently no established uses for all of this waste heat. It is, therefore, important to consider all possible environmental interactions when choosing a heat rejection system for whatever kind of power station is proposed, particularly since the benefits to the aquatic community in a limited area near a plant discharge may in some circumstances be greatly outweighed by the disadvantages to the human population over a much wider area.

In summary, the environmental effects of alternative electric generating means require careful, and individual assessments since there are few uncomplicated issues which lend themselves to straightforward resolution. As H. L. Mencken once noted, "For every problem there is a solution - simple, neat - and wrong". Unfortunately, some of the approaches proposed both by regulatory agencies and by the so-called environmental interests appear to follow Mencken all too closely.

ENERGY OPTIONS FOR THE FUTURE

William R. Gould, Chairman of the Board, Atomic Industrial Forum, and Senior Vice President, Southern California Edison Company, Rosemead

I am honored to have been asked to address the National Science Teachers Association.

I have always felt that I owed a great personal debt to the teachers who awakened my interest in the sciences—and I can think of no contribution more important to our nation than that of kindling this vital spark.

The habit of learning—once acquired—is not easily broken. I recall reading a friend of Oliver Wendell Holmes who asked the great man why he had taken up the study of Greek at the age of 94. Holmes replied: "Why, my good sir, it's now or never!"

Watching a recent television newscast—with its kaleidoscope of tragic, and hopeful, events—I found myself thinking of a paragraph from an old novel, which I'm sure you will recall:

"It was the best of times, it was the worst of times...it was the age of wisdom, it was the age of foolishness...it was the epoch of belief, it was the epoch of incredulity...it was the season of light, it was the season of darkness...it was the Spring of Hope...it was the Winter of Despair.'

Charles Dickens' "Tale of Two Cities" was published more than a century ago—but to me it seems strikingly relevant to the America of the 1970's.

We, too, have the best, and the worst of times, existing side by side—and viewing the parallels in history, one is tempted to say, "Nothing, essentially, has changed."

But it has.

In a number of important respects, the generation which is now in your care is unique—and so are the responsibilities you face, as teachers.

The pressures on our young people are unparalleled.

They are the *first* generation to be told—by our gloomier prophets—that they might be the *last* generation.

They boarded the space ship Earth just in time, some said. There were already too many passengers, and there might not be room for their children.

The air and water life-support systems were about to give out, putting an end to life on this planet.

They are the first generation to grow up with the constant awareness that one miscalculation by their government could destroy the world in a few minutes—by nuclear holocaust.

Also, theirs is the first generation which, from childhood, had an opportunity to observe the entire march of events through their own little window-on-the-world—television.

Through this window they have witnessed the apparent disintegration of the dream of *our* generation.

Ours was the first generation to see the light at the end of man's tunnel of toil—for the technological revolution promised to give every American a life of comfort and luxury.

Now, however, our children have been told that the affluent society has been achieved at the cost of frightful pollution and irreversible damage to the environment. Science has been blamed for designing the flood of consumer products, and industry for producing them.

We have heard shrill calls for a no-growth economy, for a return to a more primitive life.

Fortunately, most young people—and most Americans—realize, intuitively that there is no turning back the clock of history And they would not wish to do so if they could.

As you people all know, the problems created by advancing technology can only be solved, or alleviated, by more and better technology.

So far as my own industry is concerned, one thing is clear—it is going to take a lot more, not less, electricity to help clean up our environment. Just about every important environmental project one can think of requires an enormous amount of electric power—whether it's recycling, rapid transit, sewage treatment, or operating air pollution control equipment.

For example, just one air pollution control system employed by Bethlehem Steel takes as much electric power as 1,700 average homes.

We have machines that can gobble up a junked car and shred it into small chunks of raw material in 15 seconds. This conserves valuble resources, but it takes 4,000 horsepower to operate—and it's electric!

One could go on indefinitely with similar examples. During a recent 12-month period, more than 500 patents granted by the U. S. Patent office dealt in some way with environmental problems. More than half of them have one thing in common: they need electricity to make them work!

Our economic health, of course, also depends heavily on electric power production. An industry magazine reported recently that 2-1/2 cents worth of electricity in U. S. industry produces a dollar's worth of gross national product. Therefore, taking away a million kilowatts of electricity—the capacity of one large power plant—could depress the U. S. economy by 3-billion dollars in a year if that energy were not replaced by other sources.

Less than 50 percent of the world's population consumes close to 90 percent of its commercial energy—which is a major reason for the great chasm between the advanced and the undeveloped nations.

Most utility companies, including Southern California Edison, have long since halted all promotional advertising and are devoting a major part of their communications efforts to the conservation of electric power. Nevertheless, it is unrealistic to expect that our best efforts will do anything more than alter the upward demand curve by a few degrees, because it is built into our economy.

Similarly, our best efforts at population control—for the next several decades, at least—can only slow, not halt, the increase in our population.

It is obvious, then, that my industry must continue to provide at least an adequate supply of energy to provide for the needs of our people and to maintain a viable economy.

But this, as you know, has become an increasingly difficult task—due partly to environmental problems and partly to problems of fuel supply. I should like to direct myself chiefly to the fuel problem and energy options for the future.

As this audience is no doubt aware, we are running out of most fossil fuels, which required millions of years to form and cannot be replaced. As oil and gas supplies run lower and lower, it becomes more and more difficult to extract the remainder

Within the last three decades of this century, the United States is expected to consume more energy than it has in its entire previous history!

By the year 2010 AD, less than four decades from now, we are expected to reach the last 10 percent of the Earth's supply of natural gas—which is the cleanest-burning of the fossil fuels. A few decades later, we will reach the last 10 percent of the Earth's petroleum supply.

Coal, fortunately, is not expected to reach this stage until about 2300 AD—but its use is severely limited in many areas by air pollution problems.

So far as power generation is concerned, natural gas is rapidly being phased out right now. As recently as 1968, my company—for example—was fulfilling 86 percent of its fuel needs with natural gas. By 1974 it is expected to drop to 16 percent, and by 1976 to less than 10 percent.

The only other environmentally acceptable fossil fuel, for many areas, including ours, is low-sulfur fuel oil, which must be imported from far corners of the globe—principally from Indonesia. Many utilities are bidding for it, of course, and the price has more than doubled in the last few years. Consequently, my company's fuel bill for 1975 is projected at about one million dollars a day!

In addition to the problem of scarcity, all fossil fuels, of course, are combustion fuels—and all combustion creates *some* pollutants. So how about creating electricity without combustion? Let's take a quick look at the alternatives.

We can just about write off hydroelectric power, so far as future expansion is concerned, for the simple reason that virtually all sites large enough to be economically feasible are already developed.

Geothermal power obviously has potential, but it presents a number of knotty problems—both technological and environmental.

If we could tap the molten rock, or magma, which is at the center of our earth, we could utilize large amounts of energy from this source. We have tried many times, but always failed, in efforts to drill deep enough to tap the magma.

What we are doing is scraping around in the crust of the earth, which is floating on the magma, trying to capture bits of heat which have escaped through relatively shallow fissures. In doing so, we run into the problem of how to extract this heat. Do we take it out in the water that's there with it—or do we inject water into a dry rock heat source and use the steam that's produced to drive a turbine? This latter procedure—injecting the water—is probably more feasible so far as large-scale development is concerned.

The alternative method depends either upon finding an absolutely clean source of steam—which is most unlikely—or finding a method of disposing of the residue salts and minerals which remain when you take the energy out of the steam.

No one has found an economic method of disposing of these salts or putting them back in the earth. The places where it has been tried are surrounded by pools of dirty green water. Salt encrustations clog and ruin the generating equipment, and hydrogen gases—which smell like rotten eggs—permeate the atmosphere for miles around.

This is true even at the Geysers, 90 miles north of San Francisco, which is the only geothermal field now producing power in this country And the Geysers is the cleanest source of steam ever found in America. The problem is much more acute in other geothermal areas, such as the Imperial Valley of California, which several companies—including my own—are now investigating.

My assessment of geothermal power is that it will make a contribution to our vast power needs, but not a meaningful one. Unless man learns to tap the magma, I think he will do well to achieve 10 to 20 percent of his requirement from geothermal energy.

I would make a similar assessment of solar energy, so far as electric generation is concerned. It may serve as a useful supplement to our production of electric power, but I do not see it as a main resource, or even a substantial resource, in the forseeable future.

Nevertheless, utilities are contributing to a solar research program at the University of Arizona—which I believe is one of the world's most advanced research efforts in this area—because we are going to need all the power sources we can get in the future, large and small.

A basic problem with solar power is that in its present state of development it requires more than 4 square miles of the earth's surface for enough solar collection equipment to produce 1-thousand megawatts of electricity—which is about the output of many conventional steam plants.

I don't believe most people—and certainly not the environmentalists—are ready to cover the earth with solar collectors. The thrust of our research, of course, is to miniaturize this process, but we have a long way to go to make solar electricity a practical reality.

There is also the problem of what to do about cold and overcast days, when you're getting little if any infusion of energy from the sun.

As for economic considerations, with present technology, the cost of solar generation is approximately 100 to 1,000 times that of other, conventional methods.

Some thought is being given to less concentrated lower flux wave transmission—but this increases the area occupied by the collection equipment back on earth. Obviously, much more work is required on this concept.

Still another experimental concept is tidal power. Harnessing the power of the ocean tides to spin generators is an attractive idea, but unfortunately there are only a few places in the world which have been equipped by nature for this job.

A suitable site requires a beach area that has, first, a tidal rise of at least 20 feet, and preferably higher; and, second, a natural bay which can serve as a holding reservoir for the water.

If a bay has to be dredged out, this means that an area perhaps 5 miles deep and 10 miles long would be alternately flooded with water, as the tide came in, and then converted to a mud flat as the tide receded.

To produce 1,000 megawatts of electricity in this fashion would also require a vast array of equipment spread along about 50 miles of beach. With recreational beach areas already at a premium, it is safe to say the public would not take kindly to such projects.

If my outlook on the immediate potential of all these experimental power sources has sounded pessimistic, I appologize. But through this process of elimination I have led you to a happier conclusion. For there remains one practicable alternative. I'm sure you all know I am referring to nuclear power—the only presently-available source of combustion-free power capable of meeting the energy crisis, with minimum impact on the environment.

Nuclear power has appeared on the scene at the precise moment in human history when it was desperately needed to solve an otherwise impossible dilemma.

It is as though Providence had laid out a path for man to follow. For each step in man's exploration of resources of our planet appears calculated to carry him just far enough to reach the following step.

Fossil fuels have lasted long enough for us to discover uranium, and the process of nuclear fission. Uranium reserves are sufficient to carry us to the age of the "breeder" reactor, which creates more fuel as fuel is consumed. The breeder will greatly extend our nuclear fuel supply—buying time enough, if all goes well, for scientists to reach what appears to be the ultimate phase of power development: nuclear fusion.

There is great confidence in the scientific community that—despite the enormous problems involved—we will have the fusion reactor as a viable power source by the end of this century. If so, ordinary sea water will provide all the energy man will need, into infinity.

Meanwhile, among the various converter reactors now available, I would expect to see much development centering around the gas-cooled variety—a relatively new and advanced concept which offers great promise because of its higher efficiency.

Also, the gas-cooled reactor utilizes a thorium fuel-cycle, and there are almost as many thorium reserves in the world as there are uranium reserves.

I have not had time to cover the so-called "hydrogen fuel economy," which you may also have read about in recent years. But even here, the nuclear reactor is regarded as a primary workhorse, producing electricity which, in turn, would be used to make hydrogen from sea water through the process of electrolysis. Obviously, this would be an expensive process—and short-cut concepts are still in the research stage.

As you are no doubt aware, the nation's nuclear power development is now under violent attack from a relatively small, but highly vocal, minority of Americans who view it as a threat to public health and safety.

Since nuclear power was born with a bomb, it is not surprising that there should be a residue of fear among those who are not familiar with modern technology.

It is disappointing, however, to find some of the opposition coming from another small, but highly vocal, minority of scientists.

The conflict here, I believe, stems from differences between the engineering approach to problem solving, and the purely scientific method.

It is inherent in the scientific approach to demand precise answers to every question—some of which, in this instance, are unobtainable, or only obtainable through actual operating experience.

The engineer, however, knows that he can design safely if he can determine the parameters within which a piece of equipment operates, and then design well beyond those parameters to achieve a large margin of safety.

Most scientists understand this, but a few cling to the insistence that all precise answers be known in advance—even if this is impossible. Had this theory prevailed. I might add. man certainly never would have reached the moon.

I should like to discuss the issue of nuclear safety in detail—but since time does not permit. I will settle for a few general observations. in closing.

Nuclear power plants. on the record. are among the safest devices ever built by man. Not one person has ever been killed. or even hurt. in a nuclear accident at a commercial power plant. And we have had a combined total of more than one-hundred years of power reactor operation.

Frankly. I am puzzled over how we can be expected to improve on a safety record of 100 percent.

As for nuclear waste. its handling and storage is a complex process which must be accomplished with great care and constant surveillance. However. it need not be dangerous or fearsome. Furthermore. we are constantly improving the technology. The accumulation of this waste is a short-term problem—in that when we reach fusion power, we will be adding little or no waste to the total stored.

Meanwhile. the volume of waste involved is much smaller than is commonly realized. If we chose to store all the wastes that would be produced by all the nuclear plants contemplated between now and the end of the century in a single warehouse, it would occupy land therein equivalent to a football field and would be approximately 50 feet high. If you then contemplate dispersing this volume of waste among several locations. the problem quickly comes into perspective as one that is manageable.

I don't believe it is generally realized that of all the waste currently being stored by the AEC. far less than one percent is from nuclear power production. All the rest is from nuclear weapons development.

I do not claim that the nuclear industry is without any risk whatever. There is no such thing as a risk-less society. If man had insisted on zero-risk throughout history. he never would have progressed so far as to utilize fire. or the wheel—much less the internal combustion engine. with which we killed 53,000 people on U.S. highways last year.

Man's progress, it seems, to me depends in large measure upon his wisdom in deciding which risks are acceptable. and which are not.

If you weigh the minimal risks involved in handling the atom against the enormous benefits of nuclear power . . . and if you consider, also. the mounting risks involved in continuing to escalate our use of fossil fuels . . . the choice is clear.

We must go forward.

SESSION F-3

ENVIRONMENTAL SCIENCE INVOLVING FIELD STUDIES AND LABORATORY WORK IN SECONDARY SCHOOLS

Bruce L. Barrett. Head of Science Department. Cedarbrae Collegiate. Scarborough, Ontario. Canada

This paper is about an Environmental Science Course which is currently being taught to the students in their second year of the high school science programme at Cedarbrae Collegiate in Scarborough, Ontario. The course was planned and developed by the fourteen teachers of the Cedarbrae Science department in the 1970/71 school year. It was taught. evaluated. and revised by those same teachers during the 1971/72 school year. and is again being taught and evaluated during the current school year. It will undergo another revision in June. The planning. development and implementation processes that we have been following are so inexorably linked with the product that they are quite inseparable. and the success of an innovation depends as much on how it was developed as on what it contains. We hope that you learn something useful from our successes and failures. and will be able to improve on the methods. procedures and content of your own courses.

In 1969 the Department of Education. now the Ministry of Education. introduced a subject credit system into the secondary schools. Instead of students passing or failing a year. they can now pass or fail individual subjects—a significant policy change for the Ontario teachers. Students are now permitted to choose the subjects they wish to study. right from Year 1 through Year 5. Some schools. like Cedarbrae Collegiate have maintained a system of core subjects. including science. in Years 1 and 2. but for the most part subject departments are now in competition with other departments.

The most interesting part of this innovation is that the Department of Education has relinquished responsibility for curriculum development. evaluation. and improvement to the local Boards of Education. The local Boards, in turn. have directed the responsibility to the individual schools. In practice. this means that each subject department in each school is in the business of curriculum development. Ultimate approval to introduce a new course must still come from the Ministry of Education by way of the local Board, but change must be initiated by the subject department heads in the individual schools.

In the fall of 1970 the Science Department heads at Cedarbrae decided to introduce an environmental science course at the Year 2 level. There were several reasons for this decision. despite the fact that we felt that environmental science was the sum total of all of the other sciences. and that a broad background in biology. physics. and chemistry was a desirable prerequisite. Here are some of the reasons:

1. Both teachers and students were experiencing a growing disenchantment with the relevance of much that was being taught at the Year 2 level. For example, a detailed study of the parts of the buttercup was of relatively little interest to the modern fourteen-year-old urban dweller who has the whole world at his fingertips by way of the television set. While we weren't prepared to let the students with their limited scientific experience. dictate what they would be taught. we were prepared to listen to their suggestions and make a critical appraisal of what we were doing.
2. The teachers were becoming increasingly aware of the fact that a science course with emphasis on the environment and environmental problems is essential for every student. While the news media tend to emphasize the negative or pollution aspects of the environment. we felt that in order to provide a proper perspective we should offer a course which involved an analysis of environmental interactions, not just a description of environmental problems. Since Year 2 is the last year that we are guaranteed

of reaching all of the students in the school, we decided to design a course to be taught at this level.

3. The teachers wanted to stimulate student interest in science through a study of the environment in order to provide motivation for further study in biology, chemistry, and physics. Students have often asked the question, "Why are we studying this?" and we are becoming increasingly embarrassed by our standard answer, "Because you are going to need it later." One objective in the design of the course was to make the students aware of what science they need to know to keep pace in a fast-changing world where more and more stress is being placed on environmental issues.
4. The science department heads wanted to balance the total science programme in the school to satisfy the new Ministry of Education policy requirements. In addition to the introduction of a credit system, the scope, depth, and variety of curricular choices was to be expanded to ensure that suitable courses were available to satisfy all possible student needs and desires. The goal is unattainable within the existing physical and financial framework, but we were, and still are, prepared to implement the current Ministry policy as fully as possible.

Before briefly discussing the development stage of the course it should be pointed out that all of the work was done by classroom teachers who were teaching a full timetable. No special concessions were made with respect to the regular teaching work load, so the entire project had to be carried out after school hours, and our curriculum meetings were constantly in competition with extra-curricular activities, additional help sessions for students in difficulty, lesson preparation, the marking of tests and laboratory reports, and other regular school meetings. It should also be pointed out that the course is very much the work of curriculum development amateurs, a fact which resulted in more of a pragmatic than a theoretical approach to the development of the course.

Undoubtedly, the most significant decision made during the entire development process was the decision to involve all fourteen members of the science department in the preparation of the course outline. Despite the problems of continuity and timing that resulted, and the problem of maintaining the central theme of the course from beginning to end, there was a sense of committment to implement the course successfully that would not have existed had the development of the course been more rigidly controlled by the heads of the department. Furthermore, the long range benefits to be gained in terms of building up the skills of the teachers in course development and of having colleagues work closely together on major projects are of far greater significance than short-term inefficiencies.

The Implementation Stage

In September of 1971 twenty-one classes comprising some 550 students and 12 teachers began the environmental science course. The main feature of the implementation stage was that the teacher who developed each sub-unit was put in charge of the entire group while his section of the work was being taught. Not only was he asked to present a detailed final briefing about his portion of the course to the other members of the department before the work was taught, but he was also made responsible for the preparation and distribution of any resource materials, experiment sheets, and projectuals to all of the other teachers. It was not the intention of the department heads to stifle individual ingenuity in the teaching of the subject but rather to provide the teachers with a common starting point, and to reduce the amount of individual preparation to a minimum. Coincidentally, with the introduction of the environmental science course the work load of the science teachers was increased to six classes per day from five classes the previous year.

Shortly after the beginning of the school year it became clear that despite the effort put into lesson-by-lesson planning for the course outline, the timing of the course had been badly misjudged. To do a meaningful job of the work in a unit required approximately twice as long as had been planned, meaning that only half of the entire course could be taught during the school year unless significant adjustments could be made. In retrospect, it seems unreasonable to have expected that we could teach as much as we had planned in one school year. It was quite a demoralizing experience to realize that despite the time and effort that had gone into the development of the course outline, radical changes had to be introduced to make it viable. A number of other factors such as a dissatisfaction with the quality and quantity of the laboratory and field work further contributed to a general feeling of frustration among the teachers. I am firmly convinced that unless all of the teachers had been directly involved in the planning and development of the environmental science course, it could very well have collapsed during the first year of implementation. Education has a long history of innovations that have failed because they were imposed on classroom teachers by external agents. The successful institutionalization of an innovation is highly dependent on how involved the implementers were in the planning and development processes.

In addition to the day-to-day informal evaluation of the course by small groups of teachers and the inevitable classroom comments of the students about the course, a summary of the ideas of the entire group concerning the work that had been recently completed was made at the regular monthly department meetings. At the completion of the Rural Environment and Urban Environment units, 105 students were asked to submit a written appraisal of the course content and the methods used in its presentation. Of the 98 students who responded to the questionnaire, 50 indicated that they thought the course was "relevant," "up-to-date," "useful," or at least, "interesting" or "enjoyable." Twenty-six thought that the experiments were generally "interesting" or "relevant to the course;" 25 found that the films "helped their understanding" or "helped relate the course to the real world," and 18 particularly enjoyed the class discussions. A further 14 students specified that they liked the outdoor work and the field trips, and another 14 especially enjoyed the group projects and independent studies. On the negative side, 21 students felt that there were "not enough class experiments;" 15 criticized the difficulty or fairness of the tests; 14 felt that there was "not enough detail in the course" and 13 said the course involved "too much writing."

Needless to say we were fairly well satisfied with the students' responses, and we generally agreed with their criticisms. In the revision of the course, we have paid particular attention to improving the quantity and quality of the experiments, and to increasing the amount of detail in some of the subject areas

By far the most popular subject topic with the students was the pollution study, including noise and its effects on the human organism. Fifty-seven students showed a preference for this work, while 38 students indicated that the least enjoyable subject matter was dairy husbandry and poultry production. We felt that the main difficulty in these areas was the lack of direct contact with the animals being studied. To alleviate the problem this year, we included a field trip to the Royal Agricultural Winter Fair in Toronto in November for as many students as possible, and are currently working on a series of field trips to working farms in the vicinity of the school for the remainder of the students.

Because of our time difficulties we dropped the drug section of our *Urban Environment* unit and replaced it with most of the work that we had intended to cover under population and resources in the unit, *Future & Man*. Our *Space and Man* unit was dropped entirely, and most of the final term was spent on the unit, *Water and Man*. Immediately adjacent to our school is an excellent park, part of which is covered by a relatively undisturbed forest. Through the park runs a stream which is wide enough and deep enough to make the study of cross-sections and flow-rates moderately exciting, and which is sufficiently polluted to make water quality studies both interesting and slightly disturbing. Undoubtedly the combination of laboratory and field studies in the unit on *Water and Man* was the highlight of the year for both the students and the teachers.

The Cedarbrae teachers were firmly convinced that the course warranted a second year of implementation despite the difficulties of the first year, but we are also certain that some substantial changes in the course outline were necessary.

Even though the Year 1 course is specifically oriented toward the processes and methods of science, with particular emphasis on graphical and organizational techniques, experimental procedures, and model building, there was still an inadequate general background of biology, chemistry, and physics for the kind of work that we wished to carry out in the Year 2 environmental science course. The amount of work that was done on the natural environment in the early part of the Year 2 course was insufficient for the students to be able to grasp the extent and the significance of man's manipulation of the environment for his own purposes. The decision was made, then, to reorganize the course.

The revision process, which in fact has been going on throughout the current school year has not been carried out in the same way as the development of the original course outline. Instead, the department heads and two or three of the teachers who have a particularly keen interest in the course have been meeting regularly to detail the changes. Once the revised outline for the work of a unit or portion of a unit is completed, it is discussed, criticized, and altered by the teachers of the course at a special meeting. It is then written up in a lesson-by-lesson form and circulated for implementation. Since the specific skill, concept, and attitudinal objectives for each sub-unit are essentially the same as for the previous year, and since we offer 11 other courses that also place severe demands on our non-teaching time, the revised outline describes only the content of the course and a possible methodology to be used. A complete revision of the outline will be carried out in June when we have had a chance to evaluate the work of the second year of implementation, and to evaluate the position of the environmental science course in relation to the science courses we offer in earlier and later grades.

Since we are now just two-thirds of the way through our school year it is still difficult to assess the changes we have made in both the content of the course and the procedures followed to make the changes. A formal assessment of the content and methodology involving both the teachers and the students is scheduled toward the end of May. Meanwhile, the preliminary reports by the teachers are generally, quite favourable. The amount of experimental work has increased considerably, and the quality of the experiments has been somewhat improved Also the continuity of the course has been improved, primarily because we have had the benefit of a year's experience at implementation.

On the other hand, not all of the changes have had desirable effects. Because the first half of the year has been spent mainly in building up the basic science skills and knowledge necessary for an understanding of man's role in using and changing nature, the key theme of man as a manipulator of the environment cannot really be exploited until the latter half of the year Last year the buildi g of the knowledge and the analysis of man's role were carried out concurrently. While the change was made to improve continuity and to allow a more rapid development of complex environmental interactions involving man, we will have to wait to assess the overall effects on the course. The most obvious improvement with regard to revising the course is in the general efficiency of the operation. With the benefit of the original course outline and a year's experience teaching the course, the three or four people involved in the course revision have been able to suggest improvements with a minimum of time and effort. Since no one who wishes to help with the course changes is excluded, and since the entire group of teachers discuss the proposals for change before they are implemented, there is a minimum of teacher feeling that the course is being taken out of their hands. Understandably enough, however, the people most directl involved in altering the course are the ones who are the most enthusiastic about the revised outline. One particularly healthy aspect of the second year of implementation worth mentioning is that there has been a much greater diversity in the interpretation of the outline and the approaches used by individual teachers than there was during the first year. This trend to individuality has been further encouraged by the department heads.

It must be stressed here that this course is not "finished" in any sense of the word. Any course dealing with the environment and environmental issues must constantly be revised and up-dated. This is one of the challenges to the science teachers of the seventies.

SESSION F-5

THE PORTAL SCHOOL PROGRAM OF THE UNIVERSITY OF WYOMING

Bill W. Tillery, Director; and Vincent Sindt, Coordinator: Science and Mathematics Teaching Center, University of Wyoming, Laramie

The Program

The Portal School Program of the Science-Mathematics Teaching Center of the University of Wyoming is well under way, and in operation in several schools in Wyoming and other states in the region. The program, as it relates to the University's Comprehensive Project to Improve the Teaching of Physical Science, is supported by a grant from the National Science Foundation, by the University, and by the schools and teachers.

Arising from the needs generated by the geographic expanse of the State of Wyoming and the surrounding region and by the rapid explosion of curricular developments in science and mathematics, the Portal School Concept operates from a local leadership base. Many local master teachers and administrators of the state and region have, through attendance at National Science Foundation Institutes, participation in varieties of professional workshops, and other graduate studies, qualified themselves as leaders in the curricular areas of science and mathematics. Often these leaders develop a philosophical orientation toward the teaching of science and mathematics which leads to a richer, more active environment in their classrooms. Students in these classrooms are often actively involved in the process of science and mathematics. They are allowed to experiment in the broadest sense of the term: manipulating symbols, posing questions, and seeking their own answers. Students actively reconcile what is observed at one time with what is found at another, and have ample opportunity to compare findings with fellow students.

Basic to the Portal School Program of the University of Wyoming is the concept that once recognized, the leading educators previously described should be encouraged, given certification credentials, and then allowed to work with their colleagues in the further implementation of the philosophies, materials, strategies, and techniques which are found prevalent in the leaders' classrooms. In many cases these leaders are secondary teachers who are helping elementary teachers implement new science programs.

Programs now under way at the University can help qualify people in critical curricular areas. Identified leaders who need competencies in the curricular areas can receive training at the campus. In many cases funds from our National Science Foundation grant are available to support this leadership development.

The program is implemented through a variety of natural science and mathematics courses offered on a flexible basis. Local areas are encouraged to determine their own objectives and basic goals regarding what direction they would like their science and mathematics program to take. It is suggested that local school districts carefully develop statements as to why science and/or mathematics is taught in the schools, what science and/or mathematics students should be able to do upon completion of the programs, and how programs might be directed in order to meet these local needs. The Science-Mathematics Teaching Center of the University offers advisory services to assist area schools in arriving at these important conclusions. Once the basic ideas are established locally, course formats can be developed cooperatively which aid in the implementation of these ideas. The persons responsible for the actual local conduct of the courses will be the previously identified leaders

The Portal School operation requires considerable commitment on the part of many groups, before successful establishment. If new materials are to be explored during the courses, the administration, curriculum committees, teachers, and school boards should be ready and willing to implement whatever materials are recommended. If, during the courses offered, the teachers are "turned on" to a new way of teaching and new materials to use, the district ought to be committed to providing materials for teachers to use with their students.

With the above considerations in mind, we request that the following points be firmly established before Portal School courses are launched:

1. The courses are usually designed to explore the new curricula in science and mathematics, i.e., ESS, SCIS, etc., for the elementary teachers, and ISCS, IIS, Project Physics, etc., for secondary teachers. Before the courses begin, materials to be explored should be available in representative quantities so that teachers can perform the activities in the course, and, utilize the units in their classrooms.

2. The environment of the course should be non-threatening in terms of grading and requirements if we expect teachers to establish the excitement and flavor of science and mathematics in their classrooms. We strongly suggest that the participants be encouraged to register for S/U (Satisfactory/Unsatisfactory) grading.

3. Establishment of courses should be flexible with the changing needs of school districts. The financial details have varied from situations where the school board paid the entire cost of the course to those where tuition paid by the participants covered the entire cost.

4. Local determination of the curricular materials to be examined, at least to the extent that materials considered are philosophically consistent with the new curricula developed with funds from the National Science Foundation are recommended.

The Science-Mathematics Teaching Center

Intimately associated with the Program is the Science-Mathematics Teaching Center on campus. An interdisciplinary endeavor, sponsored jointly by the College of Education and the various Mathematics and Science departments of the College of Arts and Sciences, the Center is now in its third year of operation. In this time it has become a major influence in the development of science and mathematics teachers in this region. It is a resource center with a multitude of materials recently developed for science teaching and available for consultant use, and as such is the focus for many facets of the Comprehensive Program.

THE PETER PRESCRIPTION FOR INTERDISCIPLINARY TEACHING

Peter M. Metro, Elementary Science Coordinator, Rocky River Public Schools, Rocky River, Ohio

"The Peter Principle" as explained by Dr. Lawrence J. Peter, spells out why the author feels so many people become frustrated and ill at ease in our day. The thesis of his principle is that "in every hierarchy every employee tends to suffer from the final Placement Syndrome."

According to Dr. Peter, our society is filled with people who have been promoted beyond their level of competence. This is generally a result of doing your job well and as a "reward" being promoted to a job requiring a greater responsibility. Such promotions continue until that person reaches a level that is too much for him, and there he remains in a state of frustration until he dies or retires.

We often jokingly refer to "The Peter Principle" particularly when we, as teachers, discuss school administrators and sometimes coordinators. However, have you ever considered "The Peter Principle" as applying to the classroom teacher? It is true that we are not seeking a higher position through our efforts, but we are always seeking new approaches to teaching. We are constantly seeking better ways to make our educational program more relevant. We are constantly seeking better ways to individualize the student learning situation so that the student may progress at a speed commensurate with his abilities. We are constantly seeking methods through which a student might develop a healthy self-image. We are here today to share ideas on how we can implement interdisciplinary approaches in the classroom. For the teacher who is conscientious and sincere in his effort to do the best he can by his students, there must be a point where he realizes that he cannot hope to teach as well as he already knows how.

I believe that every good teacher is a victim of "The Peter Principle." The good teacher, however, is a victim of his own ambitions for his students. His urge to continually improve their educational program is commendable, but he must learn to approach such improvements in logical steps. In some cases I have observed teachers who were in such a hurry to change a program or adopt a new idea that they floundered in the organization and mechanics, and lost some of the personality traits that made them outstanding educators. Acts of kindness, understanding of student needs, inflections in the voice, courtesy, respect, are only a few of the isolated traits that, put together, make up the quality teacher. Any program a teacher or school adopts should be done in such a manner that it has every chance of succeeding. The teacher must be comfortable in the program and not be harried by lack of materials, equipment, etc.

My talk today should be entitled, "The Peter Prescription for Interdisciplinary Teaching." If you are interested in investigating the possibility of the interdisciplinary approach the few suggestions I am about to share with you may help to ease the interdisciplinary syndrome.

My school system is relatively small. We have only five elementary schools with an average of two classes/grade level. My responsibility in the school system is to coordinate K-6 science and manage a 26-acre outdoor education center. I have ample time to act as a resource person for individual teachers and teaching teams.

At present, we have four basic organizational teaching patterns within the school system for grades K-6:

1. Pattern A - The self-contained classroom
2. Pattern B - Two member teams teaching at one grade level
3. Pattern C - Two member teams teaching across grade levels: 5-6 or 4-5
4. Pattern D - Three member teams teaching at one grade level
5. Pattern E - Three member teams teaching across grade levels: 1 and 2.

Our K-6 science program has also taken several patterns over the past 10 years.

1. Pattern A^1 - A conceptual approach
2. Pattern B^1 - A thematic approach
3. Pattern C^1 - A process approach.

Pattern A^1 was developed as a complete and thorough conceptual guide for teacher use with activity packets for student use at the upper elementary school level. The conceptual approach was moderately successful but was difficult for the teacher to manage due to a lack of sufficient hands-on materials for students, and a lack of conceptual knowledge on the teacher's part. It was, however, a good stepping off point for the thematic approach.

The thematic approach, which is what I would call the interdisciplinary approach, had a relatively short life span. It was used sporadically throughout the system, and generally took the form of selecting a theme and using science in a supportive role. Students often initiated the theme and helped in the planning of the program. The big drawback was that the thematic approach required much more planning time than teachers had to devote, and that it was difficult to secure hands-on materials in science. The thematic approach did not provide an opportunity for students to develop process skills in science prior to undertaking a problem. Much of the science was done because of the dramatic impact, and youngsters seldom took the time to investigate a problem objectively.

We now have Pattern C^1 as a program within our schools. S-APA has been implemented in grades K-3 and grades 4, 5 and 6 are using process-oriented materials developed by our staff and put into kit form. Such a program is designed to give youngsters an opportunity to develop observation, classification, measurement, inference, and communication skills. In addition, youngsters are given an opportunity to manipulate variables and experiment. This is a self-pacing program and is flexible enough to fit into any pattern of teaching. To the teacher, one great advantage is that she need not worry about materials; they are supplied with a minimum of confusion.

Our next step may well be to branch, once again, into the thematic or interdisciplinary approach. The science skills we hope will be developed through our present K-6 program can then be put to practical use.

Summer school has been our time to test new programs. On several occasions over the past years the thematic approach was used. In each case, a great deal of planning was involved, and in each case the teaching team consisted of a well-trained science teacher, a music teacher, an art teacher, and at least two elementary teachers; one of which could handle drama. The average teacher-pupil ratio was 1 to 10. An actual working outline of a typical thematic program is as follows:

Theme - Water

I. *Water - Scientific*
   A. Pollution
   B. Uses
   C. Conservation
   D. Ecology
II. *Cultural*
   A. Art
      1. Crayon etchings
      2. Geometric designs
   B. Music
      1. Group singing
      2. River music appreciation
      3. River chants
   C. Literature
      1. Huckleberry Finn and Tom Sawyer
      2. Individual research projects
   D. Drama
      1. Mark Twain stories
      2. Minstrel movements
      3. Pantomiming

Another thematic program that had been preplanned in greater detail, and one in which students had more selection of areas they wished to explore, was that of "Our Heritage." A brief working outline of this program is given here for your convenience.

Each area of study was then broken down into supportive activities.

I. Art
   A. Museum
   B. Investigation of various media
   C. Investigation of various techniques
   D. An on-going project
   E. Contribution to society
   F. Scenery for a dramatic presentation
   G. Sources of information
   H. Creation of an expanding, system-wide gallery
II. Music
   A. Creative sounds and rhythms
   B. Orchestra rehearsal
   C. Instrument-making
   D. Cultural influences on "American" music
   E. Original words and music
   F. Contribution to society
   G. Sources of information
III. Natural Resources
   A. Definition and investigation
   B. Uses and misuses
   C. Conservation
   D. Contribution to society
   E. Sources of information
IV. Government
   A. History and development
   B. Investigation of local government
   C. Strengths and weaknesses
   D. Contribution to society
   E. Sources of information
V. Bodies of Knowledge (history, science, economics, geography, mathematics)
   A. History and development
   B. Techniques and skills peculiar to each
   C. Interrelationships
   D. Contribution to society
   E. Sources of information
VI. Drama
   A. History and development
   B. Investigation of techniques and media
   C. Student development and presentation
   D. Karamu and/or other appropriate examples
   E. Contribution to society
   F. Sources of information
VII. Literature
   A. Development of American literature
   B. Contribution of foreign literature
   C. Investigation of types
   D. Contribution to society
   E. Sources of information
VIII. Vocations and Avocations
   A. In-depth investigation by interest
   B. Aptitudes and abilities required
   C. Contribution to society
   D. Sources of information
   E. Future possibilities and limitations

The two programs outlined here were summer programs for grades 5, 6, and 7. They were exciting for students and teachers, but they were conducted under the most ideal conditions We have never, however, tried to implement them during the normal academic year. They simply were too ambitious and too time-consuming from the aspect of planning and staffing.

But need you be so ambitious? Last year a first-grade team and their students decided they wanted to study fish. Utilizing resource people such as parents, other teachers, the school principal, etc., they were soon studying what fish eat, which fish live in our region, what is meant by mercury poisoning, how pollution affects fish, how fish get oxygen, how fish hear, the importance of fish as a world food, and how to tie a fishing fly. The entire program was topped off with a fishing contest at a local pond. Prints were made of the fish that were caught—this was an art project; the fish were weighed and measured—a math project. And we should not forget that while practicing with rods and reels the students had a good lesson on simple machines. With a little outside help, a little imagination, and a great deal of enthusiasm on the part of students, parents, and teachers, an idea turned into a beautiful interdisciplinary experience. The teachers want to repeat the program this year. I am sure other teachers will want to do the same. This is the type of interdisciplinary exposure I like. The youngsters are involved in the planning and the entire project simply grows.

A three-member team at the sixth-grade level was discussing pollution problems with their students. It wasn't long before the discussion turned into a full-fledged project with committees established to study various aspects of pollution; clean-up projects got underway, local government agencies were soon involved, and local pollution problems were identified. The end result was an evening program in which students exhibited homemade movies of pollution problems, tapes of noise pollution, and photographic studies of attractive and unattractive aspects of our community. The program was so successful that parents wanted it continued the following year.

Our big push now is to develop a 26-acre tract of land centrally located in our city into an interdisciplinary outdoor education center. We feel that all of the experiences we have had to date will be of help in developing a meaningful outdoor educational program that is interdisciplinary. To date we have written much of the K 6 science material for the site and some of the history of the land. We are not going to be in a big hurry to develop the social studies, math, art, and music portions of the curriculum. We hope that they will develop gradually. Now that we have a start with science, teachers will contribute ideas they have tested in the other disciplines. Ultimately, we will have enough material to weave into a meaningful interdisciplinary outdoor education program.

We have already found that we may not want to clean up the junk on our 26-acres. This was one of our first objectives. Much of the junk is turning out to be artifacts of past life. The place is an antique pot luck. You can imagine the excitement and resulting discussion that took place when a youngster found a bottle that originally contained honey and tar. This was the start of a discussion and study of old time remedies. Old pieces of harness, milk cans, shaving mugs, bed springs, hand-made tile, and unusual kitchen devices all tell us something about the people who lived on this land in years past. Is this our key to social studies? It may be, but we are not going to be in a great big hurry to develop a social studies unit. We are going to let the students and the teachers help in a gradual development of such a program.

Our site will offer many opportunities for interdisciplinary student involvement. A group of fifth- and sixth-graders have already given us a great start on our outdoor education program. They have mapped trails, conducted surveys of trees, birds, insects, and virtually all types of living organisms on the site. They have developed taped educational programs related to the site.

High school students have designed a temporary shelter for the site and plan to construct it this spring. These students must work with city hall and the site manager, secure a building permit, and calculate the amount and type of material they will use in the construction. They must be concerned about the effects of freezing and thawing on the structure's footing. If the activities these youngsters are doing on the site are not interdisciplinary, and if they are not worthwhile, I simply do not know what is.

In closing, if you want to avoid the frustration of many interdisciplinary programs, you may want to follow this prescription:

1. Work as a team either at grade level or across level. A three- or four-member team offers support in many areas.
2. Be certain you have sufficient hands-on materials to do the job. Avoid wasting valuable time by making do with odds and ends.
3. Utilize local talents. Mothers are good resource pools.
4. Start with small, manageable programs.
5. Avoid the tendency to include activities simply because they are dramatic.
6. Plan well but provide enough flexibility in the planning to permit student participation.
7. Good planning is the most critical aspect of interdisciplinary teaching. Avoid situations where the team hurriedly decides on the day's activities just prior to the opening of school.
8. Don't bite off more than you can chew. If you do, you may soon become a member of a not too select group suffering from the "Peter Principle" syndrome.

SUMMARY OF CONCEPTS INVOLVED IN EARTH SCIENCE ACTIVITIES

John A. Wirth, Science Teacher, Mt. Pleasant High School, Mt. Pleasant, Michigan.

As Science is generally a required course of study in the intermediate and junior high school programs, considerable difficulty is encountered with student disinterest as well as lack of background in the subject. Areas of earth science lend themselves very well to this problem because the subject can be directly related to the student's own environment. In order to encourage student interest in the immediate surroundings, activities should be tailored to the situations that students might encounter in everyday life. With this in mind, I would recommend the following procedures:

1. As many activities as possible should be of the "hands on" type.
2. Observations and activities conducted in class should correlate with later activities that deal with earth history and geologic processes.
3. Each step in the activity sequence should relate to upcoming concepts used in future activities in the same general field.
4. The school yard can be a very effective workshop in the study of geologic processes.
5. Equipment and procedures should be kept as simple as possible so that the student can more fully comprehend the activity.

SESSION G-3

PUTTING LIFE INTO THE LIFE SCIENCES

INNOVATIONS FROM ME AND MY ENVIRONMENT

Josephine A. Bennett, Biology and Chemistry Teacher, Whitehaven High School, Memphis, Tennessee

The initial entry of the BSCS into the field of special education began several years ago with the preparation of instructional materials for the tenth grade "underachiever" or "academically unsuccessful" student. This effort resulted in publication of the BSCS special material, Biological Science: *Pattern and Processes*. Two other publications were concerned with the gifted students in high school: *A Guide to Working with Potential Biologists*, and the BSCS second course, Biological Science: *Interaction of Experiments and Ideas*.

However, in spite of the breadth of concern for differing student populations, a significant portion of that population was, until recently, essentially ignored—the educable mentally handicapped. The increasing size and visibility of this population, and new commitments on the part of the Bureau of the Handicapped in the Department of Health, Education, and Welfare, provided the challenge and the means by which the BSCS could turn its attention to the needs of these children.

During the last ten years, special educators have seen many innovative changes in educational programs for the mentally handicapped child, and in the expectations and attitudes that society has toward the child. Research has found that the trainable retarded child is a competent worker, displaying abilities to learn, attend to, and complete a task. He can adjust to a work situation and can socially integrate with the normal work force. The changes in societal attitudes, coupled with research findings, have greatly affected the preparation of educational programs.

All children are entitled to equal opportunities for self-development to the fullest extent of their individual physical, mental, and emotional capacities. Instructional programs specifically designed for their needs and abilities require learning experiences that facilitate mastery of useful concepts and provide a sense of personal satisfaction with the learning experience. It is true that what children can be expected to accomplish and to contribute to society is a function of what we, as teachers or curriculum designers, can contrive as interventions and improvements upon their usual experiences "Inquiry teaching" with the involvement of students is the only way to "Put Life Into the Life Sciences." This approach is definitely stressed and reflected in the content materials of "Me and My Environment," a curriculum of four units of study developed for ages 13-15 years. Unit I—Exploring My Environment.

This introductory unit contains activities of an exploratory nature which assist the student in learning to communicate about his environment, and to relate various environmental components to his own needs, problems, and interests.

In activity 1-6 the child explores his immediate environment through a variety of sensory experiences and physical contacts. For example, students identify various components of the environment by listening to pretaped sounds, and slides picturing the source of the sounds reinforce the students' guesses. (Demonstration)

Activity 1-7, "The Environmental Orchestra," develops an awareness that sounds are generally heard in conjunction with other sounds rather than in isolation, and that certain sounds are clues to certain kinds of environments. This activity will further stress the importance of listening.

Unit II—*Me As A Habitat*

In unit two, the students are introduced to the word "habitat" as, "a place where something lives." In this activity, through a series of slides, students will discover that animals and plants can be habitats for other animals and plants, and ultimately that man himself can be a habitat.

Experiments with agar dishes and the growth of microbes from areas of the environment reinforces the statement that microbes are a part of the living world.

In activity 2-16, students develop smoking machines from plastic bottles and a type of filter in the cap. The children actually filter smoke in the classroom. This may be extended by comparing the smoke blown on the filter paper to a person who inhales smoke. Surprising results occur—no tar appears on the filter paper—where did it go? From this activity students are equipped to make a personal decision about smoking.

Activity 2-17 emphasizes that the human body can be vitally affected by both living and non-living factors in the environment. The effects of certain elements in his environment (disease, drugs, alcohol, and smoking) and some of their social and psychological aspects are explored. Hopefully, the child will realize that he has some control over his immediate environment and can obtain a greater degree of well-being through conscious efforts. (Slides)

Unit III—*Energy Relationships in my Environment*

In Unit III the student explores how the environment meets his needs for food, air, water, and shelter—the energy inter-relationships between organisms.

Activity 3-9, "Food, Go Power" establishes a relationship between energy and the food students eat after defining energy as anything that moves or changes something, and that there is energy stored in chemicals. A demonstration of hycopodium powder in a can with a top will definitely "put them where the action is" as the explosion reinforces the topic of "Go Power."

Another living activity is found in activity 3-15, *My Source of Food*. By tracing food chains to their source, the students will say that plants are the source of energies in the food they consume. This is an important concept for their understanding of man's dependence on green plants for food. Flash cards can be used to illustrate the activity. (Demonstrate) (Game time)

Unit IV—*Transfer and Cycling of Materials in My Environment*

This unit allows the student to explore societal needs, population dynamics, and utilization of space. The ecological themes that are interwoven throughout the materials enable the student to interact with nature.

Do you need real "grabbers" for initiating discussions in your classroom? Try using *Me and My Environment* to accomplish your goals in science instruction. For inquiry teaching is much needed in all classrooms today if we are to prepare the student to cope with problems of tomorrow.

Florence Haag, one of the 1971 summer writing team members, responded with a short story when asked, "What is Inquiry Teaching?" I would like to share this story with you:

Master, Is Your Damper Turned Down?

As we look to the far end of town we can see a house that is closed to all who may wish to enter. The doors and windows are kept locked so that those who do come by feel like intruders. The lovely fireplace is never used, therefore, the damper remains closed. When a "passerby" does stop in to offer a bit of news, they soon walk away with an overwhelmed feeling because the master of the house has a constant compulsion to do all the talking. What a cold, dreary, and unfriendly atmosphere!

Could this cold, dreary place be an example of your classroom environment? Is it a place where the powers of thinking are locked out because you have a compulsion to do all the talking; provide all kinds of information and answer all the questions? Is it a place where the fire of creativity is never kindled because the damper is closed and the ideas only filter into the crevice of the walls. If this be the case, let us seek a new master for the house. A master that will open up the windows so that we may look out into the world of wonderment! Open up the doors so that we may go out to make observations, to explore, and experiment. Allow us to seek and find answers to questions which confront us.

Yes, we now have a master of inquiry in our house. He has opened up the windows and doors of our minds, and we now look forward to each new day with anticipation and enthusiasm. Yet, there is one thing that our master of inquiry doesn't keep open and that is his *mouth*.

As you, my fellow colleagues, return to your hometowns, I hope that you will rededicate anew the philosophy of inquiry as a method of teaching. This is a sure way of "Putting Life Into the Life Sciences."

THE LIFE SCIENCES AS PREPARATION FOR LIVING

Barbara G. Clark, Science Teacher, Houghton High School, Houghton, Michigan

It has been said that education is "preparation for living." Even using this limited definition, education is in trouble. What kind of "living" are we trying to prepare students for? How can we "prepare" them when we have little idea what the world they will be living in will be like? In the life sciences, especially, knowledge is outmoded in a few years and even basic concepts are becoming obsolete within decades. So we are shifting the emphasis from "what to know" to "how to learn" and we are trying to teach values, attitudes, and processes which will help in this endeavor.

The conscious effort to teach values is tricky business. The question immediately comes up, *whose* values? This is pertinent because it recognizes that we've always been teaching values, if not on purpose, and quite successfully. If we think now that we haven't been teaching the most useful ones for the 21st century citizen it must also be recognized that it is *our* values, our society's values, which need examination and maybe relearning. We surely can't teach values we don't believe in!

Within the life sciences, however, I assume we all believe that there will be a future and that an individual life has importance and meaning. We also believe in the desperate need to understand and preserve the planet we share with all living things. Based on this evaluation, what are some of the attitudes we can develop and processes we can employ in the classroom which will be useful to students in their unknowable future?

One group of attitudes I think are important are those I associate with scientific inquiry. These include: dependence on careful observation before making inferences, acceptance of new ideas, willingness to investigate, and admission of fallibility. Teaching these attitudes is partly a matter of providing an example. This means that the teacher can't jump to conclusions, be inflexible, or know all the answers.

These attitudes can also be developed by providing students with the opportunities to actually practice scientific inquiry. I don't have a classroom with desks in rows; we meet daily in the laboratory where students conduct their investigations, usually in groups of four. Too often the typical laboratory sequence provides a recipe which leads to the "right answers" and those who get the answers (by guess or by gosh) get the prizes. Instead I try to develop the feeling that we're all in this together, to learn what the outcome is as we set up certain conditions.

It is not really easy to get students to cooperate with each other. There are several reasons why. One is that it's usually been forbidden. Another is that they have their own "pecking order" and if students who belong to different social or intellectual levels find themselves in the same small group it may be very hard for them to work together. This can begin to work if the goal of learning from a jointly prescribed situation is clearly defined. There must be several jobs to be done, and all must be essential. An example of such an experience could be investigating the relationship of heart rate to exercise. Obviously, in groups of two, one is the subject and one the data taker. The roles must be reversed to obtain all the data required, and each person's contribution is essential to making a class-wide generalization. A more sophisticated example might pose the problem—how does light affect the uptake of water by a branch. Many hands are needed to set up the experiment, then someone must watch the clock, someone must watch the bubble in the potometer, someone must record the data, and someone must watch the lamp, the branch, and the nearby elbows. Slowly the students learn to depend on each other, and maybe more important, learn that they are themselves an important part of the group.

In most of their investigations the students are left to choose their own hypothesis and to devise their own procedure to test it. This decision-making is hard for them but improves as the year goes on. If the problem posed is what effect plants have on each other, and the available organisms are a variety of seeds, twigs, and roots, there are many decisions to be made. "What particular plants or plant parts shall we try?" "How do we proceed?" "What do we measure?" Much communication and cooperative planning must occur before even a simple experiment can be started. It would probably teach as much about seeds and plant inhibitors to prescribe the experimental procedure and the materials to be used but that doesn't help develop the skills of working together, making reasonable decisions based on scanty information, finding out that as a group more can be done than by one alone, and that even the kid who was in the slow English class last year can be involved and useful. One last result is that each group must ultimately describe and defend its work before the rest of the class. It is gratifying when the usual loud-mouth bossy type finally lets another member of his group make the report. This may never happen, but by rearranging groups occasionally, different combinations of kids may work out these difficulties satisfactorily.

Simulation games can be used to extend imaginatively the opportunities in the lab. One which I have used provides data cards by which students can "test" hypotheses concerning the maze-running ability of a variety of laboratory animals in an assortment of mazes. Again, the goals of the investigation are to involve the student in making hypotheses and analyzing the data obtained.

A second set of attitudes which I value highly, and try to teach, relate to an understanding, respect, and even affection for all living things. To accomplish this goal, living plants and animals are used almost exclusively in my laboratory. Rather than prepared slides, a hand microtome, razor blades, and simple stains are used to make wet-mounts of leaf or stem sections. What is lost in detailed accuracy is more than made up by the reality gained. The activity of the earthworm found alive and burrowing in a shoebox of soil in which items of feed and trash were buried two weeks ago is far more relevant to today's needs than identifying the seminal receptacles of an embalmed specimen.

Sowbugs can be collected in the fall, on a field trip if the schedule permits. Found under rocks and boards, they can be kept all winter in a large covered pail with some soil and lots of dead leaves. These are useful for experiments in animal responses to environment investigations into micro-habitats and behavioral adaptions for survival. Plastic petri dishes in which holes can be melted with hot rods, and the dishes joined, can provide a choice of "habitat." The sowbugs, when placed in the dishes, will show their preferences for wet or dry, salty or unflavored, light or darkness. Flour beetles may be kept from year to year in jars of wholewheat flour or wild bird seed. They show interesting similarities and differences in behavior compared to sowbugs and are examples of insects with complete metaporphosis.

Dime-store goldfish respond to temperature changes from near 0^0 to 35^{0}C with rare casualties. They also endure ordinary city tap water.

Frogs can be kept in a wire-covered plastic dish pan, tilted in a sink with tap water running slowly and holes near the bottom for drainage. The frogs will eat flies, meal worms, and other live animals (even smaller frogs). They can also be force-fed once or twice a week with liver—a job students love to help with.

My point is that common ordinary creatures which can survive laboratory use are available, easy to care for and invaluable teaching tools. Developing concern for their health and welfare, and responsibility for humane treatment of animals are goals in themselves in life science.

One other concern which I feel *must* be taught in the life sciences, as well as in all subject areas, is an understanding of man's environmental relationships. Several specific techniques are useful, but *none* is more important than the priority the teacher places on this issue.

A simulation game that deals with attitudes toward the environment involves managing a planet for 50 years by choosing the projects which will be funded. It is designed to show the effect of industrial expansion, agricultural mechanization, and environmental or educational expenditures on population, income, food supply and environmental quality. I have used two additional techniques to extend the use of the game. Before starting the play, the students, in their groups are given the choice of a project: to draw a typical humanoid inhabitant of the planet, to map a city, to describe a young inhabitant's day, to prepare the front page of a newspaper, to describe and picture the insects, to describe the symptoms of a disease. It is surprising how unimaginative some results are—but this is, after all, the first time the students were ever assigned to be strictly imaginative in a science class! To think concretely of the 21st century, however, is hardly less imaginative, and the practice is not without value. After playing the game through twice, and finding the inevitable population rise, it is determined by class discussion that, among other conclusions, the game isn't built right—you should be able to do something about the population. The students are then required to search out in newspapers or news magazines examples of how our nation, state, or city is spending its money—what are *our* priorities? What programs are funded (or unfunded by executive decree)? Do we, in fact, place a high priority on population control? on environmental quality? on education? It is an illuminating exercise.

Another type of game, a role-playing experience, has other uses and could be tailored to meet local situations. One game of this type establishes a hearing being held concerning setting aside land for a national park. Students are assigned roles as senators with described constituencies and as witnesses both for and against the proposed park. All sides of the issue are represented from the local mayor looking at taxes and jobs to the far out conservationist who can see only the trees. The students, pretty much in spite of themselves, get involved in the issues and begin to see how hard it is to solve the real political and social problems of the day. It was helpful in preparing for and interpreting this game to have been a witness at a senate hearing for wilderness status for Isle Royale National Park myself, last May. It was even more helpful to take my classes to a State Department of Natural Resources land-use hearing at which some students testified. These students will be voters in only two or three years, so although their experience in citizen participation isn't exactly biology, it surely is related to life.

In other ways, also, class work can be related to real life. Just after studying predator-prey relationships, using coyotes in the western states as an example, a call came out along the environmentalist line that President Nixon was being pressured to lift the ban on coyote poisoning. A student responded to this information by writing a letter, which was signed by 85 other kids, urging the President to keep the ban, for reasons the students understood.

The final point I will discuss here is related to the value I place on environmental education. I advise an extra-curricular club, The Students for Pollution Control, which meets at least one noon hour each week. The club gets involved in all kinds of local, state, and national issues. It belongs and contributes to other environmental organizations. Members send letters to legislators and testify at hearings. We have raised money for the local "Save the Pines" campaign, convinced a creamery to change its misleading carton advertising, and established a city-wide newspaper recycling procedure. We have had roadside litter pick-ups, and are now publicizing the values of buying returnable beverage bottles—a direct relationship.

Probably what these 20 or so kids learn as they deal with all levels of government and all aspects of the local community is my most successful teaching. They have found, for example, that grocery managers don't really want to publicize the difference in wholesale cost of returnable vs. throw-away containers. They have found that their state senator is dead set against wilderness areas or land use control, regardless of argument. They have found that about half of the people in Houghton are willing to save their newspapers for recycling if they're picked up monthly. They call the bank manager to request a courtesy ad, put on a radio program, talk to the Kiwanis Club, attend city council meetings, and speak before the state Natural Resources Commission. They really know what some of the forces are that are shaping their future, and they are tooling up for their contribution toward directing these forces.

THE DEVELOPMENT AND IMPLEMENTATION OF A DRUG EDUCATION UNIT

Leonard M. Krause Science Department Chairman, Akiba Hebrew Academy, Merion Station, Pennsylvania

The presentation is based on the development and implementation of a Drug Education Unit for ninth-grade level biology classes in a Philadelphia suburban private school, and includes a 10-minute slide-sound resume of the program described below.

1. The unit was developed inductively through student committees which functioned to evolve a series of open-ended biology laboratory activities during which the effect of various household drugs on several invertebrates was tested.
2. The unit is investigative, allowing individual student committees to analyze data collected, to reformulate hypotheses, to test these latter hypotheses, and to draw tentative conclusions.
3. The unit's challenges embrace the community as students visited numerous drug rehabilitation centers to study the extent of drug abuse in Philadelphia and its environs.

Beyond collecting sociometric data through interviews and questionnaires, two student teams taught drug education units in several Philadelphia junior high schools and in one elementary school, basing their instruction on the activities developed in their biology lab.

SESSION G-4

CHEMISTRY BRIDGES TO THE HUMANITIES

CHEMISTRY AND THE BUSINESS OF LIVING

Jay A.Young, Professor of Chemistry, Auburn University, Auburn, Alabama

Part of our obligation as educators of the next generation includes the engagement of a holistic perspective about the business of living; this perspective, if it is to be truly integrated, must address questions of relationships between and among artificially separated disciplines, in all areas of human activity . is possible to show that science is intimately related to any other broad field while it is at the same time distinct from each such field; that science in particular has a warrant to interact with and enrich the development of these other areas. To demonstrate these assertions in detail, I have selected an apparently disparate field of interest to humanity: the fine arts, to be compared with science.

I suggest that the words, imagination, critical judgment, and esthetics form a bridge joining science and the fine arts. That is, both science and the fine arts, considered together, can be said to have this purpose: To provide a means for contemplating the physical world with an ever new, ever deeper, admiration and awe, as a result of a display of the power of the imagination of the scientist or artist.

Both the scientist and the artist begin by observing their environment, carefully distinguishing between fact and illusion in what they observe. Those facts that are observed are, then, arranged in a kind of order, and certain facts are selected from this arrangement. The selection is based upon a discernible connection between or among them, or upon an intuitively felt connection. Any other facts are discarded, or relegated to a secondary position.

Note that in these actions, the critical judgment of the scientist or artist is used, in depth. Further, except for the initial observations of the facts and illusions, imagination is used as the tool to order and to select, to discern obvious and intuitive relations between and among the facts

In a second step, the scientist or artist uses both the faculty of critical judgment and the faculty of imagination, to bring forth some kind of unifying statement (which may not be in words) that serves to show how all of the selected facts form an integrated, non-contradictory, whole.

Some of the facts obtained from observation are easily seen to be consistent, each with the other. If this is true for all of the facts obtained, there is no problem. But, if some of the facts, noted during the first step, contradict each other, it can be suspected that this is only an apparent contradiction; and now the artist or scientist has a challenge, to find out how the apparent contradictions can be related. The creative act, I suggest, consists in first recognizing that there is an apparent contradiction, and, second, in discovering the unifying ideas which demonstrate that there is no contradiction.

There are many examples. Consider first a masterpiece of the fine arts, Rembrandt's "Aristotle Contemplating the Bust of Homer." The contradictory facts, in this case, pertain to the problem of handling the light in the work. It is a fact that the pigments in oil paint reflect light; they do not, unless fluorescent, emit any light. It was a fact also, that Rembrandt wanted to use pigmented oil paints in such a way as to force these pigments to glow with their own light. This is clearly impossible; yet when you look at the work itself, it has been done.

Or, consider another, modern, contradiction. At temperatures of about $2^{O}K$ or lower, liquid helium behaves in an unusual manner. How is one to account for this behavior? Today, one explanation involves the emphatic statement that at temperatures of about $2^{O}K$ or lower, liquid helium is not composed of atoms; instead it is a continuum, one "thing." Here is a contradiction, perhaps an apparent contradiction, that still awaits the creative act which will show that there is no contradiction.

To find a unifving explanation which demonstrates that an apparent contradiction is not contradictory is useless unless the matter can be communicated to other men . So, in the third step, still involving the imagination, but in a different way, the scientist or artist must find a means of relating his unifying idea to some other idea which is already well known to many other men. In science, by using a mathematical equation, or by the description of an analogy between the new idea and what is already well known; in the fine arts, by the disposition of pigment on canvas, or the careful choice of words in poetry, or by the use of forms and shapes in sculpture.

Finally, in the fourth step, what has been accomplished, as now presented to others, is seen to be esthetically pleasing. Unless it is delightful in some way or other it clearly is not a fine work of art. And, even in science, though the esthetic beauty is sometimes discernible only to others who are themselves scientists, there is an esthetic aspect which if not present, renders the accomplishment suspect.

There are contrasts also, as expected; since after all, science is not the same as the fine arts. These contrasts are best shown in columnar form, as parallel statements;

Science	Fine Arts
1. Discoveries are often made by intuition, and later found to be logical.	1. Masterpieces are often conceived through intuition, and then materialized by expert technical skill, and logically executed.
2. Mathematics is used as a tool.	2. The corresponding tools are rhythm, proportion, harmony.
3. Work of average quality is often useful.	3. Work of average quality is usually sterile.
4. The aesthetic aspects usually are abstract, the beauty is expressed indirectly to the senses.	4. The esthetic aspects are abstract, but they are based upon a physical object (except perhaps in poetry); the beauty is experienced directly by the senses.
5. A work of science is first understood, and then experienced by one other than the scientist.	5. A work of art is first experienced and then understood, by one other than the artist.
6. An important idea usually arises during the period of active concentration which follows the period of intensive data-gathering.	6. An important idea usually arises during the fallow period of relative inactivity which follows active saturation with the problem. (In this respect, mathematics is like the fine arts.)
7. The value of a scientific statement depends upon its precision of expression.	7. The meaning of a statement in the fine arts (that is, the work itself) depends upon its richness of expression.
8. The symbols used must mean the same to all. Subjective feelings are eliminated, at least in the formal description of the finished work.	8. The symbols can mean different things to different people. Emotions, passions, faith, hope, all play a part in the completed statement.

The author will include two other diverse areas of interest in his presentation and challenges others to compare science with other areas. It seems to me that one value of this kind of introspection lies in the stimulus it has upon our teaching of chemistry, and also upon the increased enjoyment it provides when we enter into discussions upon non-chemical topics with our students, or with other adult friends, always asserting, (I would hope) the dramatic importance chemistry has for all, at the end of any such discussion.

CHEMISTRY: A STUDY OF IMAGINATION AND IMPLICATION

A. Truman Schwartz, Associate Professor of Chemistry, Macalester College, St. Paul, Minnesota

The title of this symposium suggests that chemistry can be a bridge between science and the humanities. This bridge rests upon two pillars—imagination and implication or, if you prefer alternative alliteration, concepts and consequences. There are few, if any, other fields of human endeavor, which reveal so much of profound beauty and wonder, and simultaneously exert so great a practical influence upon everyday existence. Of course, the correlation is hardly coincidental. It is precisely because chemists have succeeded in discovering so many unexpected and lovely things about our world that they have gained the power to change it.

Given this dualism or, to use the more apt term which Bohr applied to the particle/wave nature of the electron, this complementarity, it is somewhat surprising that chemistry courses for science majors have traditionally paid only scant attention to the applications of chemistry, or even to its creative aspects.

Perhaps the implicit assumption, that students contemplating careers in science, are already aware of the intellectual and practical significance of their chosen disciplines, is justified. I frankly doubt it; I fear we are producing too many technicians and titrators who are more or less ignorant of the nature and importance of chemistry.

On the other hand, the vast majority of nonscientists are probably even less well-informed about the science. Nor are they likely to gain such an understanding and appreciation from "exposure" to a diluted majors' course, bereft of both intellectual rigor and pragmatic relevance. On this there seems to be little debate. The "watered-down" majors' course is disappearing. But no widely accepted replacement has as yet emerged; there is no consensus on what chemistry a nonmajor should know. I do not consider this a serious problem, for heterogeneity in course content and approach reflects the humanity of the chemist/teacher and the humaneness of the science. However, I must confess to some serious misgivings about courses which overcompensate for past pedagogical errors by concentrating almost exclusively upon the applications and misapplications of chemistry, to the all-but-utter exclusion of the basic principles of science. Beyond feeling that it is dishonest to offer a chemistry course without teaching some chemistry, I fear that the "relevance" of chemistry appreciation courses may be illusory and ephemeral. A discussion of carbon monoxide and hydrocarbon exhaust emission will have little lasting value without a parallel study of combustion. And topics such as the energy crisis and thermal pollution are empty without a rudimentary understanding of thermodynamics.

Therefore, I return to my original thesis, that this bridge between science and the humanities must be based upon both the intellectual content of chemistry and its useful ubiquity. By leading our students across the chasm which seems to separate the two cultures, we can not only humanize the scientist, but simonize the humanist.

I would like to mention also some specific characteristics of chemistry which illustrate its humanistic nature. Along with these, I will cite examples which I have used in my teaching of both science majors and nonmajors. Originally, I attempted to classify the topics as being either in the "imagination" or "implication" category. But I soon discovered the arbitrariness and essential futility of such an artificial separation—a good argument, I think, for the importance of teaching concepts and consequences concurrently in an integrated syllabus.

1. Chemistry (and all of science) is full of ambiguity and the clash of ideas. Teachers often hide this fact from students and misrepresent science as a monolith rising majestically toward omniscience. Anyone growing up in the last half of the 20th century has probably developed some tolerance for uncertainty. Indeed, a student majoring in art, literature, or political science may have so chosen because he loves the ambiguity of men and nature and fails to see this ambiguity recognized by science. He may perceive only what a student of mine called the "antiseptic arrogance" of science and scientists. Fortunately, it is easy to dispel this misconception by re-introducing controversy into our courses and demonstrating that behind almost every law set in sacred bold-face type there was an encounter between conflicting ideas: phlogiston or oxygen, atoms or a continuum, particles or waves, and so on. You can supply many more examples, hopefully some contemporary ones like polywater. However, certain current chemical controversies are too specialized to be easily understood by beginning students. Pivotal issues in the earlier development of chemistry are often more readily comprehended. And, therefore, I find real merit in a hybrid historical/phenomenological approach to the subject. But I also grant that this approach may be more successful with nonscience majors than with their technically inclined fellow students who already know the "right" answers (though perhaps for the wrong reasons, or no reasons at all.) I think members of both groups could gain valuable perspective from Thomas Kuhn's *The Structure of Scientific Revolutions*.
2. Of course, the clash of concepts implies some way of evaluating hypotheses. Chemistry teachers have an excellent opportunity to illustrate the experimental, logical, mathematical, and even aesthetic bases for validation in the sciences, and to compare and contrast them with evaluative procedures in the social sciences, the humanities, and the arts. Why was Rutherford's solar system model of the atom more satisfactory than the Kelvin-Thomson raisin pudding? On what evidence did Count Rumford discount the caloric theory? And why is it reasonable to speak of an electron as both a particle and a wave?
3. The fact that the evolution of chemistry, through the process alluded to in my first two points, suggests a series of approximations, represents an interesting characteristic of scientific truth. Your more metaphysical (or metachemical) students could easily spend an hour discussing whether all truth is equally relative.
4. It is also important to emphasize that the interpretations of the ambiguities of nature have required the exercise of creative imagination every bit as brilliant and perceptive as that which has produced mankind's greatest music, painting, and poetry. Perhaps nowhere is this inner vision better illustrated than in its application to the unseen world of the atom—from Democritus through Dalton to de Broglie and beyond. And nowhere is the creative kinship between art and science better stated than in J. Bronowski's little book, *Science and Human Values*.
5. In their need to know, scientists have employed a wide variety of approaches, not a single method. Remember that the serendipidous discovery of Becquerel and the methodical search of the Curies took place in the same laboratory, only a few years apart. Moreover, the methodological diversity of chemists only reflects their personal variety. Ask your students to read Watson's *The Double Helix* if they need convincing. And, if they think science is a passionless pursuit, tell them about Davy cavorting in his laboratory or Travers rhapsodizing over "the blaze of crimson light" that signaled the discovery of neon.
6. In addition to their scientific contributions, many chemists have been deeply involved with humanity. Lavoisier's contributions to educational, economic, and agricultural reform would have insured his place in history, even if he had never written *Traité élémentaire de Chimie*. His contemporary, Joseph Priestley, is probably better known as a theologian, philosopher, and social theorist than as the discoverer of the gas which helped the Frenchman revolutionize chemistry. Indeed, several years ago, Priestley served as the focal point of a seminar in which students and faculty from the chemistry, philosophy, history, and English departments of Macalester College explored British intellectual history in the late 18th century. Most students of literature (and of chemistry) are probably unaware that Davy proofread the second edition of Wordsworth's *Lyrical Ballads* and shepherded it through the presses, and was himself a poet, if a mediocre one. Even antiestablishmentarianism is nothing new. A century ago hirsute Dmitri Mendeleev resigned his professorship over a dispute in which he espoused and advocated student objections to the irrelevancy of the curriculum, which says, I suspect, something about relevance. For more modern evidence of the social involvement of scientists one need only think of Linus Pauling debating Edward Teller on nuclear testing and policy, or Barry Commoner debating Paul Ehrlich on the ecological crisis and population growth.
7. But a chemistry course, even one which recognizes the diversity of chemists, should be primarily concerned with the specific science and its impact. An often-neglected aspect of this influence is upon the wider world of ideas. Admittedly, the most dramatic and far-reaching scientific intellectual revolutions—the Copernican, the Darwinian, and the Freudian—do not directly involve chemistry. But alchemy was an important manifestation of medieval man's self-conception, and the transmutation of that protoscience into chemistry had significant intellectual implications. On a somewhat more specific level, the idea of entropy comes as a great and often disturbing revelation to many nonscientists; and in lectures to art students and aesthetics classes, I have frequently found audiences fascinated with the fundamentals of quantum mechanics and the Uncertainty Principle. But what may well turn out to be the most mind-boggling scientific achievement in the history of thinking man still lies ahead, as biochemists and molecular biologists delve deeper into the mysteries of life.

8. As to the specific practical consequences of chemistry, the topic is currently popular, and the examples are legion. The Haber process lengthened World War I, but produces low-cost fertilizer which has saved thousands from starvation. The atomic bomb hastened the end of World War II but killed over 150,000 human beings in the process. Insecticides and herbicides increase crop yields in famine-ridden countries, but accumulate in song birds and children. Modern miracle drugs increase the span of existence, but not always the quality of life on an overcrowded planet.

It is, I think, instructive that all these instances of the implications of chemistry pose ethical dilemmas. We are back to ambiguity, often in matters of life and death. Traditionally it has been the role of the humanities to consider the human condition and the choices which mankind must make. And, without doubt, scientists need the wisdom of philosophers and theologians, the perspective of historians and anthropologists, the insight of psychologists and poets, the imagination of artists and composers. But I submit that science, too, can contribute to our common and universal cause, the enhancement of the human condition. Perhaps, in the final analysis, the primary achievement of science is, in the words of L. S. Kubie, "the humility and honesty with which it constantly corrects its own errors." It is this, he goes on to state, which makes science the greatest of humanities. Perhaps the chasm between the two cultures is an artificial creation, after all. And maybe the bridge of chemistry can demonstrate the fundamental unity of knowledge.

SESSION G-5

SHOULD SCIENCE EDUCATION BE DIRECTED TOWARD SOCIETAL PROBLEMS?

Lester Paldy, Associate Director, Student and Cooperative Programs, Pre-College Education in Science Division, National Science Foundation, Washington, D. C.

Today, more than at any other time in history, peoples throughout the world are becoming aware of the implications of basic scientific advances, and their related technological applications for the human condition. This audience needs no reminding of the great contributions of science and technology to the past and present quality of life in our society. Nor does it need a reminder of the harsh consequences of the failure to assess technologies before they are given free rein.

The National Science Foundation, as a principal supporter of science and as an important agent of government activity in nce, has a responsibility to take an active role in porting studies and projects involving the implications of science and technology for society and for the ethical and human value implications of scientific and technological progress. Projects relating to these subjects have already been supported by various organizational units of the Foundation, and it is intended that such s pport shall continue. For example, the National Science Foundation is now engaged in a collaborative enterprise with the National Endowment for the Humanities to encourage research activities in the fields of ethical and human value implications of science and technology. It is hoped that the results of supported research in these areas will illuminate many areas of current concern.

In addition to its interest in supporting research in these fields, the Foundation is very much aware that the institutions that you represent, the elementary and secondary schools, provide the major part of the education in science for the average nonscientist. Until the late 1960s, the Foundation's efforts in your schools were largely centered on identifying at the earliest possible stage those students with scientific talent and moving them along in scientific preparation as fast as their abilities allowed. Now we have come to see the importance of scientific literacy to all who live in a society that is ever more influenced by science and technology.

In recent years, the Education Directorate of the Foundation has sponsored institutes to provide interested teachers with the opportunity of obtaining special summer training to prepare them to inject interdisciplinary elements into standard science courses or, in some cases, to create new courses especially designed for the task at hand. For example, the February 1973 issue of *The Science Teacher* carried an article entitled "Science and Society—a Step Toward Relevance for High School Students" by Raymond W. Merry, which described an elective science course for grades 10 through 12.

Organized primarily around group discussions, the course had as its major general objective the stimulation and development of intellectual, physical, and social capabilities. Its specific objective was to increase the understanding of the mutual interdependence of philosophy, science, technology, and society as well as the effects that change in one will have on the others. In order to implement these goals the following topics were covered during this year: ecosystems, population biology, urban problems, cybernetics and automation, energy needs, the nature and history of science, the nature of engineering and technology, values, education, biological engineering and drugs, technological assessment, the future.

Not surprisingly, the instructor found that it was possible to cover a great deal of pure science in these topics. Quoting Mr. Merry:

> "Energy needs can introduce force, work, power, energy, electricity, fossil fuels, geothermal power, basic heat and thermodynamics, solar power, fusion and the like. Urban problems can be used to introduce the conservation of mass-energy. Air pollution and garbage disposal problems result from man's apparent inability to understand the conservation of matter on a large scale. What comes into the city must either stay or be hauled out! What is burned stays on the ground or goes into the air!

This example seems to me to provide convincing proof that an innovative and creative teacher can, if provided with a little ammunition, organize a course around these topics that is satisfactory both to him and to his students. In this case, ammunition was provided by a Foundation-supported institute at Knox College in Galesburg Illinois, directed by Professor Herbert Priestly. Other institutes designed along somewhat similar lines are scheduled to operate this summer and will undoubtedly provide fertile soil for other new course designs.

Are existing science programs in our educational institutions, both secondary school and college and university, adequate? If the major criterion for success is taken to be the production of first-rate scientists and technologians, the answer is undoubtedly "yes." However, examined from the standpoint of the expectations our society will have then, we cannot be quite as confident. All of our educational institutions have made great headway in building a core of traditional science courses. Nevertheless, it is clear that we shall have to accelerate the evolution of our science programs if they are to foster the kind of social consciousness and social perception needed by both professional scientists and the broader public.

Last April, seeking to bridge the gap between scholarship and public affairs, the National Endowment for the Humanities inaugurated an annual lecture series—The Jefferson Lecture in the Humanities—addressed to a national audience. The series was so named because Thomas Jefferson epitomized both theory and action; he was President of the American Philosophical Society as well as President of the United States. Lionel Trilling, a writer and teacher with an international reputation, was chosen as the first lecturer.

In a superb address, "Mind and the Modern World," Dr. Trilling examined our societies' diminished confidence in mind and in the concept and value of objectivity. The humanistic disciplines, he observed, have suffered. And we have lost confidence in science as well, which now "lies beyond the intellectual grasp of most men" except for the suspicion that it is dehumanizing. We do not lack resources to reverse this trend. The return of confidence is within our grasp—if we reassert humanistic values, if we seek the restoration of ethical criteria in human enterprise, and if we propose the renewal of rationality. Who will deny that a portion of this task must be borne by those who teach science in our schools and colleges? Perhaps, echoing Tennyson, " 'tis time to seek a newer world."

ABSTRACTS OF CONTRIBUTED PAPER

GROUP A

THE SYSTEMS APPROACH TO SCIENCE EDUCATION: THE DELAWARE MODEL (K-12)

A-1 DEL TECH/DEL MOD: THE ROLE OF A TECHNICAL AND COMMUNITY COLLEGE IN THE SYSTEMS APPROACH

Ethel L. Lantis, Dean of Development, Delaware Technical and Community College, Southern Campus, Georgetown

How can a college which prepares anyone at least 18 years of age for entry jobs through the technician level contribute to a system which prepares professionals to be better teachers and researchers? "Del Tech/Del Mod" describes the operation of a two-year technical college and its contribution to Del Mod. It also delineates benefits derived from participation in the Del Mod system.

This paper concludes that neither makes any attempt to be innovative, having a *modus operandi* based on educational and industrial experience. Modern management techniques and applied human relations make both systems go.

A-2 THE ROLE OF THE DEPARTMENT OF PUBLIC INSTRUCTION IN THE DEL MOD SYSTEM

John F. Reiher, State Supervisor of Science and Environment, State Department of Public Instruction, Townsend Building, Dover, Delaware

Within its current framework the Department has the personnel to conduct needs assessment and to measure student achievement and aptitudes in science and mathematics on a statewide basis. These assessments are a necessity *because* no other component can do them and *because* they have never been done in a reliable, systematic fashion.

The Research Division should gather the specific data required by the supervisors of science and mathematics.

It will be necessary for the science and mathematics supervisors to act in concert to assess needs and translate them into integrative programs. In addition, these supervisors must press for development of projects which reflect local district as well as statewide needs.

The Department of Public Instruction should alter its structure to permit the supervisors to exercise more control over all federal grants dealing with science and mathematics. Del Mod is a source of certain types of funding support, but the Department has access to ESEA and other federal funds which can complement the Del Mod spending.

Since the children of Delaware stand to gain from all Del Mod projects, regardless of the component conducting the projects, the responsibility for disseminating results of Del Mod programs would be an ideal Department of Public Instruction function.

A-3 THE ROLE OF FIELD AGENT

Barbara Logan, Field Agent, Del Mod System, Dover, Delaware

The Delaware Model: A Systems Approach to Science Education (Del Mod) is a cooperative adventure attempting to initiate change in an evolutionary way. Del Mod focuses on changing the behavior patterns of those involved in science education and addresses itself to the needs unique to the specific school districts.

One of the distinctive features of Del Mod is that of the Science Field Agent—individuals whose primary function is that of assisting teachers to attain a level of confidence required to sustain quality teaching.

The field agent's program is organized around three levels: confidence building, development, and implementation.

Level I activities concentrate on encouraging teachers who are afraid of science. Inservice workshops involving small groups provide the atmosphere in which the field agent can offer individual assistance to teachers at different cognitive and affective levels in science. The one-to-one relationship helps provide assurance for the teacher hesitant to use inquiry-centered techniques.

The Level II program centers on improving teacher effectiveness in the classroom. During bi-weekly inservice sessions the teachers are systematically exposed to the new curricula in science education, to the methodologies these curricula utilize and to the research from which they developed.

The sessions provide a variety of experiences centering on the various modes and methods of teaching, learning theory, planning and evaluation. On-site visitation by the field agent allows for diagnosis of the teacher strategies. During teacher-field agent consultation the effectiveness of the strategy is discussed and ways to improve determined.

A-4 THE DEVELOPMENT OF THE DEL MOD INFORMATION NETWORK

David W. Morgan, Information Dissemination Specialist, Department of Public Instruction, Townsend Building, Dover, Delaware

Concurrent with the first year of operation, Del Mod personnel and those supporting Del Mod efforts to improve science and math education in Delaware's schools became increasingly aware of the need to communicate more thoroughly and effectively with the educational community and the general public. The Department of Public Instruction, under the direction of the Del Mod Component Coordinator (*i.e.*, State Science Supervisor), developed and implemented a program of information dissemination for Del Mod.

The operational philosophy of this information-dissemination program is based on the assumption that every science and math teacher should be made cognizant of new research and developments in the field as well as the activities of their own state. It does not imply supervising or monitoring of school programs nor administration of programs in the schools.

The Del Mod newsletter, presentations to school facilities, displays, quarterly abstracts of scientific and math journals, news releases to newspapers, radio, and television, as well as contacts with civic groups, form a comprehensive network of communication.

A-5 RESEARCH WITHIN DEL MOD, A SYSTEMS APPROACH TO SCIENCE EDUCATION IN DELAWARE

John R. Bolig, Director of Research and Evaluation, Del Mod System, Dover, Delaware

The Del Mod System, a consortium of the University of Delaware, Delaware State College, Delaware Technical and Community College, and the public schools of the State of Delaware, is working to improve the quality of science education in Delaware through a large variety of programs.

Evaluation of these programs, and research opportunities within a systems approach, require a multi-faceted design. The programs include college and university courses and institutes, year-long field agent projects within the schools, local district workshops, and individual research in the sciences.

A-6 APPLYING THE DEL MOD MODEL

Charlotte H. Purnell, Director, Del Mod System, Del Mod System, Dover, Delaware

The Del Mod System has been in operation one year. Three points seem to contribute to its success: (a) development of a communication retrieval system, (b) grassroots input to needs and ideas, and (c) quick, appropriate action on requests.

The communications system depends on bringing people together who have similar problems and needs. It takes advantage of the demographic structure and utilizes a variety of feedback mechanisms.

Grassroots input at the teacher level is built upon to design programs suitable for local situations. Field personnel capitalize on their rapport with teachers to encourage expression of ideas.

After needs are known, quick action is taken either at the local or institutional level to satisfy the needs. All ideas are encouraged with the expectation that evolution will take place

A-7 DESIGNING AND EVALUATING THE DEL MOD SYSTEM

Robert L. Uffelman, Coordinator, Del Mod Projects, University of Delaware, Newark

The Delaware Model: A Systems Approach to Science Education (Del Mod System) identifies needs of teachers, schools, institutions of higher education, and the system itself; allocates resources to remediation projects; assesses its effectiveness and provides feedback information to participants. Del Mod evolved from a cooperative statewide plan for the public schools, State Department of Public Instruction, and the University of Delaware. Del Mod System expanded to include Delaware State College, Delaware Technical and Community College, and the private and parochial schools as components of the System.

Institutional roles and participant activities are planned to utilize existing resources. The Colleges and University provide education for technicians and preservice teachers. The State Department of Public Instruction coordinates curriculum revision, and the schools adapt or implement new science and mathematics programs. All three component agencies provide for inservice education of teachers and evaluate program changes. School district personnel participate through projects, symposia, field-agent workshops, or formal courses. Activities are conducted in local schools, Del Mod Resource Centers, and college classrooms or laboratories. Assessment data are processed by the Director of Research and disseminated to component coordinators at each institution to provide for systematic planning and implementation.

This System encourages research and evaluation directly related to the improvement of teacher education and to teacher adaptation of science and mathematics materials in their own classrooms. Evaluations assess the impact of institutional projects, staff members, teacher participants, and new materials on each other and on pre-college students. Time-series designs provide more useful data than do traditional experimental or quasi-experimental investigation. Variables related to teacher knowledge, classroom performance, student achievement and attitudes, and the information processing system serve as bases for judging the effectiveness of the Del Mod System.

GROUP B

TEACHER EDUCATION [ELEMENTARY]

B-1 COMPETENCY-BASED CERTIFICATION: IMPLICATIONS FOR THE SCIENCE TEACHER

Richard W. Gates, Director, Teacher Education Programs, St. Bonaventure University, St. Bonaventure, New York

Since 1936, New York has required the bachelors degree as a minimum standard for teaching. The requirements have steadily increased, and presently 30 graduate hours are required to qualify for permanent certification. Education of the teacher is looked upon as the first means of determining the certification of the teacher.

Along with several other states (Washington, Florida, Texas) New York State has proposed a competency-based and field-centered system of teacher certification. This new system dictates that:

1. Pupil performance should be the underlying basis for teacher competence.
2. Certification should be based on teacher competence rather than on completion of courses.
3. Teachers should be required to demonstrate their competence periodically to retain their certification.

By 1980, New York expects to be on a total performance-based certification and teacher education program.

Implications for the Science Teacher

1. Who will determine the competencies needed?
2. Will college degree requirements be disregarded?
3. What evidence is there to support that this change is necessary?

4. What effect will this have upon existing graduate and undergraduate teacher education programs?
5. What is meant by "field-centered?"
6. Can we adequately measure "Pupil performance?"
7. Who will assess teacher competencies?

Before New York State, or any other state mandates certification change, these questions must be answered. What role will professional organizations play in this proposal? Where does NSTA stand?

B-2 ACTIVITIES FOR THE DEVELOPMENT OF AFFECTIVE DOMAIN OBJECTIVES IN ELEMENTARY SCIENCE INSTRUCTION

H. Marvin Bratt, Graduate Instructor, Science Education, Purdue University, West Lafayette, Indiana

This study examined the effects of several activities on the attitudes of prospective elementary science teachers. The activities were chosen for their inherent problem-solving characteristics and relation to science instruction in the elementary school.

Experimental and control groups were pre-pre-tested, pre-tested, post-tested and post-post-tested in a time series design to determine the status of their affective behavior. The pre-pre-test was administered in spring of 1972, the pre-test in fall 1972, the post-test after the completion of the methods course, and the post-post test after the completion of student teaching. A parallel test has been developed for children and is in preliminary testing phase at the time of this writing. The test is designed to determine the carry-over aspects of the treatment to children.

At the time of this writing, data are incomplete, but it is expected that this study may provide insights into the following areas:

1. The use of factor analysis to revise attitude inventories.
2. The use of factor analysis to validate attitude inventories.
3. Further research concerning the attitude scale construction model proposed by Moore and Sutman (1970).
4. Activities which may be used to develop affective domain objectives in elementary science instruction.
5. Measurement of science attitudes in elementary children.

B-3 ONE APPROACH TO RELEVANT SCIENCE COURSES FOR PRESERVICE ELEMENTARY TEACHERS

Carl Stedman, Associate Professor of Science Education, Austin Peay State University, Clarksville, Tennessee

The relevancy of any science course or sequence of courses is directly related to the perceived needs of the educational audience for which the instruction was designed. It is difficult to translate the needs of preservice elementary teachers into classroom procedures and educational content. However, to provide a simplified translation to educational experiences for preservice teachers that are perceived as rewarding, relevant to needs, and productive in changing attitudes about science, certain assumptions are necessary. Concisely stated, these assumptions are:

1. One should proceed slowly from the known to the unknown in both content and methodology.
2. Teachers teach as they have been taught and to bring about a significant change in teachers' attitudes and behavior necessitates first of all a change in *their* teacher's attitudes and behaviors.
3. Preservice teachers learn science best in a teaching-learning environment that enables them to become personally involved and active in their learning.
4. If becoming an adequate teacher of science is viewed as being important, preservice teachers must be rewarded for desirable behavior in developing teaching skills as much as they are rewarded for comprehending scientific concepts.
5. Lack of adequate facilities and budget, although they represent a real problem, are no excuse for inferior teaching and providing inferior educational experiences.
6. More enthusiastic learning will occur if preservice teachers are given alternatives from which to choose and if they are provided with opportunities for self-evaluation.

Conclusion: The primary evaluation of how successful the college or university level science experiences have been for preservice teachers must be a measurement of how successfully these students perform in their own classrooms. In the author's experience, these assumptions have produced enough success to warrant their serious consideration.

B-4 A COMPETENCY-BASED ELEMENTARY SCIENCE PROGRAM FOR PRESERVICE TEACHERS

Ronald W. Cleminson, Paul L. Jones, and Nelle E. Moore, Associate Professors of Education, Memphis State University, Memphis, Tennessee

At present, we are witnessing a tremendous improvement in the preparation of elementary science teachers. The report of the AAAS Commission on Science Education, "Pre-service Science Education of Elementary School Teachers," has been primarily responsible for this improvement, providing an excellent basis for undergraduate program development.

Memphis State University, using the above report and additional resources, is attempting to identify competencies our students should possess to teach children successfully. They represent a minimal set of terminal behaviors for our students. The instructor or, as in this case, learning manager, provides a self-evaluation scale and competency checklist for each student and meets individually with students (4 to 6) during each class period to evaluate progress. During this time, each student demonstrates his success with each competency.

The competencies are grouped into three sections for organizational purposes. The first section, *Inquiry-Process Skills* (A), contains competencies appropriate for students at all levels. An attempt was made to describe the competencies so as to enable students to use this section in their own teaching. Section (B), *Instructional Skills*, lists the competencies necessary for teaching science to children. It has been designed to provide experiences that develop teaching and classroom organizational skills. Students select activities from available programs (COPES, ESS, MINNEMAST, S-APA, SCIS, etc . .) and/or develop activities to teach a concept to children during the academic period. The third section of competencies, *Research-Curriculum Knowledge* (C), requires students to read articles and books for the purpose of small-group interaction and comment. They are asked to examine and to compare the activity-based science programs currently available. In addition, students have an opportunity to present Piagetian-type tasks to children of different ages in order to understand better how they learn.

GROUP C

ENVIRONMENTAL EDUCATION [ELEMENTARY]

C-1 ENVIRONMENTAL EDUCATION-AN AWARENESS APPROACH

Kenneth Frazier, Project Coordinator, and Jerry Dunn, Project Associate Director, Ames Community School District, Ames, Iowa

This paper describes an environmental curriculum opportunities study funded by a grant from ESEA Title III, P.L 89-10 in May of 1971.

The project was undertaken to broaden and enrich the base of activities in an Iowa school system to enhance the understanding of, and stimulate a desire to preserve the environment. This was achieved by getting the students involved with the natural environment in a systematic manner, including some measurable learning outcomes.

Although the project includes both elementary and secondary involvement, this paper focuses on the elementary portion of the project.

Environmental education cannot succeed unless the general public becomes aware of the complexity of the environment because a commitment to preserve can only follow an awareness of existence.

Four components are discussed:

1. An outdoor, living laboratory on a school site.
2. A student transportation unit that is considered an integral part of the program.
3. A mobile laboratory for use in representative environments.
4. Teacher inservice training in the areas that are introduced to the student.

The following are statements of global objectives which have been further refined in the project to the point of individual behaviors.

1. Students will engage in activities appropriate to their level of maturation which will include observation, investigation, and evaluation of a variety of ecological relationships and conservation practices in central Iowa in order to develop the concept of stewardship of natural resources.
2. Teachers will support the major objective and assist in its accomplishment as a result of the activities of this project.

The methods of evaluation and the interpretation of existing data are also included.

C-2 SLIDES AS ATTITUDE INDICATORS IN AN ELEMENTARY ENVIRONMENTAL PROGRAM

Sylvia Leith, Assistant Professor, University of Manitoba, Winnipeg, Manitoba, Canada

Carefully selected and tested environmental slides are used as concepts or stimuli to measure attitude changes indicated by 12 adjective pairs from Osgood's Semantic Differential list of adjective pairs. Eight color slides of different environmental situations are used—2 positive, 2 negative, and 4 puzzling—in a pre-post-test to evaluate the ability of an Environmental Attitudes Program to change teachers' and pupils' attitudes toward the environment.

C-3 ENVIRONMENTAL BIOLOGY FOR ELEMENTARY SCHOOL

J J Olenchalk, Staff Biologist, Lawrence Hall of Science, University of California, Berkeley

Many teachers in elementary school are hesitant to introduce a study of the environment into their science programs because they feel they are inadequately trained in biology and they need specialized materials and equipment. This is an attempt to show these teachers that elementary science can become more relevant by using everyday materials found around the home and school. In addition, the schoolyard becomes more than a recreation area—it serves as the laboratory and becomes a place for discovery.

Three facets of environmental biology are studied: (a) an aquatic environment using the concept of the "Mini-Pond," (b) microclimates of the schoolyard, and (c) studying soil as an environment using the "Soil Box."

GROUP D

INDIVIDUALIZED INSTRUCTION [K-12]

D-1 INDIVIDUALIZING SCIENCE AT THE PRIMARY LEVEL—RATIONALE AND METHOD

Cecilia E. Grob, Third Grade Teacher, Airport Elementary School, Berkeley, Missouri

Educators have focused much attention recently on informal, or open, approaches to learning. Several writers have described the general philosophy of the open concept approach at all levels of instruction. Others have discussed the human interactions occurring in an open environment.

A survey of the various sources would find consistencies in descriptions of open learning environments. The consistencies would be found less in the methods that are used to establish the open environment than in the essence of the open environment itself—in the attitudes and beliefs of the persons involved in the open situation.

In order to integrate the major goal of education formulated by Goodlad and the central goal of science education defined by the National Science Teachers Association, the author derived a rationale for individualizing science at the primary level. Particularly, the author was concerned with the role of science in the total organization of a third-grade team room called the Individualized Learning Environment. This is defined as a classroom established on the basis of a set of attitudes consistent with the informal approach to learning.

Organization of science activities was related to three major considerations in designing an instructional program: the learning environment, the child, and the teacher. The rationale formed the basis for the author's attempt to individualize science through the regular program, as well as through development of individualized science packets. Description of the program includes materials, directions, notes to the teacher, and evaluation techniques.

D-2 THE MINI-PATT APPROACH TO INDIVIDUALIZING INSTRUCTION

Gerald H. Krockover, Assistant Professor of Science Education, Purdue University, Lafayette, Indiana
Jimmy R. Jenkins, Assistant Professor of Science Education, Elizabeth City State University, Elizabeth City, North Carolina

The preparation and use of audio-tutorial tapes can serve as an effective adjunct to the development of individualized instruction materials. However, the preparation of A-T materials has often been quite involved and time consuming. The Mini-PATT approach to the development of audio-tutorial tapes results in the rapid development of A-T materials. This method has been tested with teachers drawn from all educational levels (kindergarten through college) using a variety of content material and has been extremely successful.

Using a cassette tape recorder with microphone, a cassette tape, a partner (either a child or fellow teacher), and the necessary materials; an effective A-T tape can be prepared in 15 to 20 minutes.

D-3 IDENTIFICATION OF STUDENTS FOR SELF-PACED, INDIVIDUALIZED INSTRUCTION

Robert W. Bibeau, Teacher of Chemistry, Wayland High School, Wayland, Minnesota

Many teachers would like to incorporate the self-paced, independent study in their curriculum organization but hesitate to do so because they may be depriving students who are incapable of utilizing this type of instruction of a sufficient exposure to chemistry to meet the course objectives.

In view of the many advantages of self-paced, individualized, independent study instruction to the student, the teacher, and the administrator, the independent study opportunity should not be withheld from the educational scene because of uncertain quality expectations in the learning products.

It should be possible to reliably select from a random student population students capable of successfully discharging their responsibilities in the independent study situation.

A continuing, cumulative analysis of test scores in the teacher-paced situation should reveal the identities of students deserving to be trusted with much of the responsibility for their own progress—with teacher help when needed

Analysis of test scores, coupled with homework performance intent, should serve as a reliable indicator of success. Students working hard and earning consistent A, B, or C grades should be able to achieve the same level of performance in the independent study situation.

In an effort to develop a simple, reliable set of criteria for awarding the independent study opportunity, two medium groups (48 students) were started in the school year with teacher-paced instruction using curriculum materials suitable for either teacher-paced, or independent study instruction.

The results of the investigation are described in the presented paper.

D-4 INDIVIDUALIZED LEARNING IS BETTER

Ronald J. Snyder, Instructor of Chemistry-Biology, Hudson Community School, Hudson, Iowa

Individualized teaching is by far the most successful and most meaningful mode of learning to the student yet devised in education. The student can learn at his own level in his own time by doing things basically in his own way. Educators have said for years that students retain 10% of what they hear and 30% of what they do, but we are just now really allowing the student "to do."

Three years ago, fresh out of college, I had 20 students enrolled in chemistry. The second year 55 students were enrolled in chemistry. This year 35 students are enrolled from a junior class of only 45. However, with the nine-week chemistry courses, there are a total of 59 students in chemistry. Why such an increase in enrollment? This is exactly the same question asked by the administrators. I would like to think it is all due to me as the instructor, but, most of the credit goes to the teaching method: individualization!

On the Iowa Tests of Educational Development more students scored higher percentile-wise in the areas of Background in Natural Sciences and Interpretation of Natural Sciences in terms of their score the year before than in previous years, with each student's score either increasing significantly or remaining the same.

The second year six students who had been *D* and *F* students all their school careers, enrolled in chemistry. The reason? Simply because they had no where else to go except study hall and they needed credits. I, therefore, let them into chemistry. Results: three maintained at least a *C* grade, one a *B*, and the other two, *Ds*, which is quite impressive in spite of the last two. Results were similar on the ITED, though not quite so good as in the previous year. This was due to a larger population and a larger cross-section of students and abilities.

During class, students are free to come and go as they please since the lab is open. In this way biology and chemistry students often work side by side, and this initiates a lot of cross-learning between disciplines. As is obvious, the program is successful. The students are learning and having fun at the same time.

D-5 AN ENRICHMENT PROGRAM THAT PROVIDES FOR INDIVIDUALIZATION WITHIN A STRUCTURED CHEMISTRY COURSE

Jon R. Thompson, President, Colorado Science Teachers Association; Chemistry Teacher, General William Mitchell High School, Colorado Springs, Colorado

It is difficult to individualize instruction with large numbers of students. In this situation it is necessary to structure the learning process at least partially. In our chemistry program at Mitchell High School we feel that we have achieved a compromise. We have initiated individualization into a structured course. (The course is team-taught by Gary Modic and me.) Our course can be divided into two main headings: a required portion and an enrichment portion.

The required portion is much like the standard high school chemistry course. A student can earn regular credit by completing satisfactorily only this portion; however, the enrichment portion is quite inviting. Students who complete enrichment activities are introduced to the relevancy of chemistry and at the same time improve their grade.

Students can complete a variety of activities in the enrichment program. Activities available include field trips to industry and chemical laboratories, completion of: consumer experiments, environmental experiments, career chemist simulations, open-end inquiry type experiments, experiments utilizing instruments, experiments that are no longer used regularly (such as preparation of oxygen), experiments closely related to currently used required experiments, etc. Other activities may be: chem-art related projects, chemistry-photography projects, preparation and presentation of demonstrations, reports on chem-related articles and reprints, and work on the computer. As can be seen by this partial list many choices are available.

In order to provide as many choices as possible, we prepare the experimental activities in kits. We make available only a portion of the total list of enrichment experiments at one time. For activities that require supervision students must utilize contracts. To alleviate clerical problems the use of point coupons or "chemistry dollars" is utilized.

Students at Mitchell have responded quite favorably to this program, and the program is now beginning its third year. While working with this program we have realized several advantages. The program allows greater flexibility and individualization. It provides for the introduction of relevant topics. It provides students with a chance to get involved with chemistry in addition to the usual problem solving and required theoretical experiments.

GROUP E

AREAS FOR SPECIAL CONSIDERATION

E-1 OPEN EDUCATION: STATE OF THE ART AND SOME UNANSWERED QUESTIONS FOR SCIENCE EDUCATORS

Marvin D. Patterson, Research Fellow, Nova University, Ft. Lauderdale, Florida

This paper will explore these questions: What is open education? What are the theoretical foundations of open education? What is known about the effectiveness of the various approaches to open education, both in terms of cognitive and affective dimensions? And finally, what will an open education movement mean to science education research and development?

A brief review of the history of open education will be provided by tracing its development from the British Infant School to the U.S. Open Classroom. A description of how science activities occur in the open classroom will be discussed. Since the open classroom requires a new approach to instruction and classroom management, the pending impact on teacher education is predictable. A lack of experienced practitioners to retrain traditional teachers and train new teachers is rapidly producing an expertise gap in education. Science curriculum specialists will similarly need retraining to implement open science education programs that are not only child centered but more humanistic for all concerned.

E-2 CRUCIAL ISSUES IN SCIENCE EDUCATION—A "NITTY-GRITTY" VIEW

Jerry L. Tucker, Professor of Science Education, Boise State College, Boise, Idaho

The curriculum revolution in elementary science of the past decade has produced some outstanding programs. In spite of all these efforts by hundreds of educators, scientists, psychologists, and kids, a number of crucial problems face teachers of science. In fact, the revolution itself, its imperatives, character, and products, is responsible for some of these issues.

The purpose of this paper is to discuss three issues significant to the "nitty-gritty" level of science instruction: (1) the "Hurry up, so we can stop" syndrome; (2) "gatecrashing;" and (3) "abstraction foisting."

Issue (1) concerns the sterility of the objective-dissectionist approach to science and its effect with/on children. The development of programs for effectively training children to "science" in the technical sense has also led away from the real world of the child. Science teachers seem be be caught in a content-rationality race. Several suggestions for avoiding this type of "science" instruction are offered.

Issue (2), "gatecrashing" refers to the way unskilled teachers impose their own static imagery on children. The writer contends that few elementary teachers ever enter the child's world and communicate with him . . . by providing intrinsic motivation, fostering child-generated inquiry, and allowing ample time for free exploration.

Issue (3), "abstraction foisting," is not a new problem. However, *conceptual schemes, scientific generalizations, key concepts*, etc., are often foisted upon teachers (and subsequently children) at national meetings, summer workshops, and in teacher guides in the belief that understanding is concommitant. While conceptual schemes have provided a useful framework for curriculum development, the recent curricular revolution has generally ignored the societal implications of these ideas, or the interactions of science with culture and human values. Several suggestions are offered for selecting and developing science understandings as they relate to the child's total culture.

This paper outlines three issues implicit in an "illusion of science" which has led us to believe we must prepare our children to compete in the world knowledge struggle and train them to be more rational by our standards. Lessons from Sylvia Ashton Warner, Kenneth Grahm, and Richard Bach suggest that we must slow down, give kids interesting materials, prop up the wall, and join the slippery, sliddey, water world of "Mr. Water Rat," "Johnathan Livingston Seagull," and our children.

E-3 A PILOT PROGRAM FOR EMOTIONALLY DISTURBED CHILDREN

Lorne H. Cook, Senior Education Officer, Ontario Science Centre, Don Mills, Ontario, Canada

A Science Centre can play a vital role as an educational laboratory in the community. Free from the restraints of curricula, new programs and approaches can evolve in a true atmosphere of experimentation. One such program is outlined below.

Etobicomm was a special three-month pilot program for a small group of emotionally disturbed children, classified as dyslexic. These children, 8-12 years old, had physical and psychological problems resulting in their inability to relate to the printed word. After years of frustration and failure they had developed a poor self-image.

Initial meetings were held between the Science Centre staff and the special education consultants and teachers of one of the local school boards. The purpose of these meetings was twofold: first to identify the special needs of these children; second, to develop meaningful intensive nonprint learning experiences in three areas of science.

It was planned that each child would receive slides, tapes, or packages of material to take back to their classes so that they could share their experiences by demonstrating and teaching their classmates.

The three experimental programs developed were:

1. Kites and Aeroplanes, which explored the aerodynamic principles involved in designing and flying model planes and kites.
2. Chemistry, which involved the students in learning some of the principles of chemistry using common materials.
3. Weather, which introduced the children to the weather instruments at the Science Centre Weather Station, as well as interesting and unusual weather phenomena.

Final evaluation of the Etobicomm project is not complete. However, the enthusiasm and interest of the children involved indicate that it has been a successful venture. Initial reports from their teachers indicate that they have gained considerably in self-esteem and prestige among their peers.

E-4 EDUCATION FOR THE POST-PEPSI GENERATION

John Fowles, Senior Education Of · Ontario Science Centre, Don Mills, Or :nada

The African continent in the c ,th century was dominated by foreigners. Now it is a heterogeneous collection of independent nations having little in common and often being hostile to one another.

At present, African education is dominated by the "system" but the already strong vibrations of unrest are increasing in frequency and amplitude and must at some stage inexorably shatter the "system." The artificial structure of schooling will collapse. The teachers, unions, and associations which tend to perpetuate some of the most sinister aspects of the "system" must be completely remolded to ensure survival; the technology of education will be vastly modified.

Possibly, the most vigorous revolution will occur in the field of applied and natural sciences where the information explosion has been incalculable. Science education may well focus on industry but more particularly on science museums.

Having worked since its opening, in the Fall of 1969, with the Ontario Science Centre, which I believe to be one of the most stimulating science displays in North America, I feel that such establishments can offer some of the most innovative and exciting alternatives to the "system" and also recapture the human quality of education.

GROUP F

ENVIRONMENTAL EDUCATION [SECONDARY]

F-1 ENVIRONMENTAL SCIENCE—A STUDENT CENTERED APPROACH TO OUTDOOR LEARNING

Stuart Freudberg, Student Coordinator; Scott Saroff, Student Director; and David Keyes, Student Aide; Environmental Science, Newton Summer School, Newtonville, Massachusetts
Peter G. Richter, Science Department Chairman; Richard M. Staley, Earth Science Teache., Newton South High School, Newton Centre, Massachusetts

Environmental Science is a multi-faceted approach to truly student-centered learning, presented in the belief that students are the most important part of the educational process.

The program is sponsored by the Newton Public Schools in Newton, Massachusetts, and is given for four weeks in July to junior high school students. The course has been offered and modified for the past six years.

Environmental Science is a field-oriented ecology course. It is taught by a combination of former students and teachers with varying field experiences in education. Each member of the staff leads a small group of 4 to 7 students who have preselected their sites for that day. Many walking and bicycle trips are taken to local areas to observe contrasting habitats, as well as several bus trips to other New England sites. The climax of the month's study occurs during a three-day trip to Mt. Washington, New Hampshire.

Some topics dealt within the course of the summer include mountain zonation, the seashore biome, foodchains, decomposition, succession, and the effect of the weather upon an environment. Man's interaction with his environment, especially the idea of "pollution," is also covered.

Improvements and changes last summer were implemented by a student and teacher planning board. This group was composed of the previous summer's staff and the ninth-grade participants of that year. A similar group is planning the July 1973 program.

A feature which separates Environmental Science from other summer programs is its student-orientation—one without disciplinary pressure, and one in which the students and teachers are given the maximum freedom to learn within the public school structure.

This winter, a new expansion of the program is occurring. The expertise gained during the summer by the older students and past student staff is being used to help elementary and junior high teachers to take field trips with their classes, thereby further spreading the field approach.

A new idea to be experimented with this coming summer is the professional development of teachers who are unfamiliar with some of the field techniques used by the staff. These teachers will learn new methods by being a "student" in one of the small groups.

Thus Environmental Science is a program which develops and tests curriculum and at the same time gives teachers a chance to try out their ideas. It gives the student teachers as much responsibility as the adult members of the staff. Its continued success is the result of an open-ended approach to science education.

F-2 A RATIONAL APPROACH TO POLLUTION CONTROL

Gary F. Bennett, Head of Environmental Engineering, University of Toledo, Toledo, Ohio

In recent years the public has reacted to the plea—give more consideration to the ways in which we are neglecting our environment. Environmental science problems are considered by many to be the most important problem facing society. The attention given and concern expressed have mounted tremendously during the past three years.

F-3 SOURCES OF INEXPENSIVE ENVIRONMENTAL EDUCATION MATERIALS

J. L. Underfer, Associate Professor, Director Environmental Education Institute, University of Toledo, Toledo, Ohio

As an outgrowth of the Environmental Education Institute conducted this past year at the University of Toledo, numerous free and inexpensive materials have been collected for the participants' use. The various materials were obtained primarily from public and private service agencies, and these materials will be displayed and discussed in the session.

F-4 TEACHER'S EVALUATION OF INEXPENSIVE ENVIRONMENTAL EDUCATION MATERIALS

John White, Director, Natural Resources, Toledo Zoo, Toledo, Ohio

Utilizing the materials obtained for the Environmental Education Institute, the participants evaluated the materials and the results of this effort will be discussed at this session. The author has utilized many of the materials in his own classes.

GROUP G

SIMULATION GAMES IN SCIENCE EDUCATION [K-12]

G-1 PSYCHOLOGICAL AND ACADEMIC RATIONALE FOR SIMULATION GAMES

Don M. Flourney, Dean, University College, Ohio University College, Athens

Charges that education is irrelevant, impairs creativity, and fosters mediocrity seem to be increasing. What can be done for students at the elementary, secondary, and college level who find school a dull place?

Certainly the drop-out problem is more severe, and the necessity of having at least a high school diploma in our society is obvious.

Simulation games represent a promising innovative technique for learning. Several psychological reasons why participants of simulation games become motivated will be discussed.

Simulation techniques can be used in any area of the academic program, but techniques particularly geared to science will be discussed.

G-2 CRITERIA FOR DEVELOPING INSTRUCTIONAL GAMES AND TOYS IN SCIENCE

Mary Hawkins, Associate Executive Secretary, National Science Teachers Association, Washington, D. C.

Games should have wide age-grade appeal. They should be educational, appropriate for use in the classroom, yet suitable for use by children or adults with little or preferably, no supervision.

Games should be fun. While games may vary in the "academic load" they carry, they must be satisfying to the player. The game, or fun experience should be at least as strong as the instructional value.

Games should be original. The game board, materials for play, directions, etc., should be new rather than a modification of some existing game.

A good working procedure is to identify the name, title, topic, or concepts covered in the idea or game. This would help in the identity of components and materials required for completion of the game. The most likely age or grade level, number of players, and general method of play must be established. It is helpful to identify some of the features of the game which will make it fun.

Finally, the instructional value of the game and its relationship to the science curriculum, leisure time, general knowledge, etc., should be identified.

G-3 MANUFACTURING, PROMOTING, AND MARKETING EDUCATIONAL GAMES

Robert E. Cooley, President, Union Printing Company, Inc., Athens, Ohio

Manufacturing

The first step in manufacturing a science game is to identify the various components, presuming that ownership is established, and that copyrights, patents, etc., are in proper order. Make sure there is a good relationship between author and manufacturer.

Cost estimates, prior to commercial development, are contingent on the number and types of tokens, dice, gimmicks, cards, boxes, and printed materials necessary. Games should be developed with an understanding of production techniques in mind. Metal components, for example, unless already available (like washers, etc.), may be so expensive as to inflate selling price beyond realistic levels.

Promoting and Marketing

Few games have ever survived when marketed individually. A game developer has few alternatives to giving a game, idea, or scheme over to one of the several national game-toy manufacturers. In your cost of the game you should set aside a certain percentage for promotion and advertising, as it will cut into your profit. Make sure you are reaching the correct market in your promotion and advertising.

G-4 A REVIEW OF CURRENT SCIENCE SIMULATION GAMES

Jerry D. Wilson, Lecturer in Physics, 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, 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 familar, topics which might otherwise be avoided completely.

Within the last few years several scientific simulation games have been marketed. Some of these are described and their teaching effectiveness examined.

GROUP H

EVALUATION AND TESTING [SECONDARY]

H-1 EVALUATION AND ISCS

Sara P. Craig, Assistant Professor, Science Teacher, Florida State Developmental Research School, Florida State University, Tallahassee

I. Rationale for ISCS—with particular attention to kinds of evaluation needed for this kind of self paced course.
   A. Purposes of ISCS evaluation
      1. To gauge rate of progress along the main track
      2. To provide guideposts for excursions needed or indicated for that student
      3. To check on the stage of development of concepts and ideas
      4. To check on the development of the needed skills and attitudes
      5. To help the student progress as fast as his ability permits
   B. Cognitive domain—kinds of tests which have been used in this area
      1. Paper and pencil tests—Pre-, post-, chapter, etc.
      2. Teacher-given oral tests—individual or small-group
      3. Oral tests on tapes for poor readers
      4. Oral tests on tapes with oral answers on tapes for poor readers and writers
      5. Self-assessment tests
      6. Performance tests
   C. Affective domain—ways of testing to show progress in developing:
      1. Ability to work with partners
      2. Ability to work without constant supervision by teacher
      3. Independence enough to initiate activities without teacher suggestion
      4. Ability to assume responsibility for equipment
      5. Ability to pace self according to ability level
      6. Ability to fit into peer group activities
      7. Ability to solve problems without asking teacher help
   D. Psychomotor domain—ways of testing to show development of:
      1. Ability to manipulate equipment meaningfully
      2. Ability to assemble equipment
      3. Ability to make simple repairs

H-2 NONCOGNITIVE EVALUATION: A BRIDGE TO THE 21ST CENTURY

Ronald D. Simpson, Assistant Professor of Science Education, University of Georgia, Athens

Assessment, in one form or another, controls many activities in our life. All of us are products of an educational system that reinforced us negatively or positively by our cognitive performance on paper-and-pencil tests. The standardized aptitude and achievement test often dictates to students which college or university they may enter.

One of the most profound breakthroughs, sociologically, of the past decade has been the perfection of the opinion poll. Political campaigns are created and conducted on such data, TV shows live and die by ratings, and indeed the entire mood of the country can be quickly detected within a few days after poll-taking.

Most science educators agree today that how a student feels toward science and related issues may be as important as his understanding of science cognitively. Attitudes held by the non-science major toward science-based societal issues may exert as much subsequent influence on the future of science in our democratic society as the activity we generate from the future scientists we produce in our classrooms.

If we are to give more than lip service to the noncognitive (affective) domain in science education we will inevitably have to develop new instruments and methods of assessment. The 21st century may well find us designing educational strategies that will lead to significant gains on scores of evaluative instruments designed to measure group attitudes and cultural issues that pertain to phenomena central to the enterprise of science.

A few instruments have been constructed to measure attitudes toward science. There still exists a great need for valid and reliable instruments that are practical for usage with students in the science classroom. Once these instruments are perfected, it will be necessary for teachers to incorporate them into their normal evaluation procedures and, we hope, plan the future curricula, carefully designed to bring about desired results.

H-3 AN ANALYSIS AND CLASSIFICATION OF THE ACS-NSTA HIGH SCHOOL CHEMISTRY, ACHIEVEMENT TESTS USING BLOOM'S "TAXONOMY"

Kenneth V. Fast, Science Teacher, Kirkwood R-7 Schools, Kirkwood, Missouri

A total of 955 items from 12 tests were classified according to cognitive levels (Bloom's). Each test was described according to the number of items at each cognitive level.

Pretest forms and item analysis data were procured on each item in order to make comparisons of the difficulty and the discrimination with the cognitive level classifications. These values, as well as the percent of omits, were reported on each item.

The ACS-NSTA High School Chemistry Tests contained items in the following proportions: knowledge, 40.2%; comprehension, 25.6%; application, 24.8%; and analysis and/or above, 9.3%. No synthesis level item was identified. The six most recent tests contained a greater percentage of higher cognitive level items than did the six earlier tests. The average percent of analysis items in the advanced series was 13.7% as compared to 7.7% in the regular tests. The difficulty of the items increased with the hierarchy of the *Taxonomy* levels. The discrimination index averages indicated the application level items were the most discriminating. Application level items were most frequently omitted.

H-4 SELECTING A STANDARDIZED TEST FOR CLASSROOM USE

Janet Wall, Department of Science Education, University of Georgia, Athens

The number of tests measuring in the cognitive domain has increased over the past decade. Tests are now available for use at the elementary and secondary levels for assessing student achievement in specific science content areas, progress in science, and science understanding. The number of tests and the valuable information one can expect from interpreting test results can be confusing to a science teacher. The problem may be particularly evident to those who wish to use standardized testing instruments for assessing student achievement, evaluating the science curriculum, and judging the effectiveness of instructional techniques. It is the purpose of this paper to identify the critical points in selecting appropriate standardized tests and to highlight the valuable information the teacher can obtain by analyzing test items and test scores. The paper is particularly aimed at science teachers who wish to select and use standardized tests as part of their instructional evaluation.

Several factors must be considered for selecting an appropriate standardized instrument. The most important of these is the relevance of the test to the classroom objectives. Unless a test is examined by the teacher with this purpose in mind, test scores may not prove helpful in providing desired information. Validity and reliability are two additional characteristics which provide the teacher with information on the ability of a test to measure accurately and validly. Other qualities of a test such as balance, difficulty, speediness, discrimination, and objectivity are equally important in the process of standardized test selection and interpretation of the test results.

Before selecting a test, the teacher should seek information sources such as Buros' Mental Measurements Yearbooks, test reviews in journals, publishers test catalogues. None of these sources, however, surpass the close examination of test manuals and specimen sets by the teacher prior to test selection.

The paper may provide the science teacher with a set of guidelines for selecting an instrument that meets the specifications of a well-constructed test and provide data to the teacher in improving and understanding learning outcomes.

GROUP I

TEACHER EDUCATION [ELEMENTARY]

I-1 FIELD TAUGHT ELEMENTARY SCIENCE METHODS—THE PROMISE AND THE PROBLEM

Russell M. Agne, Assistant Professor of Education, The University of Vermont, Burlington

This paper reports on the conduct of an elementary science methods course for junior-year elementary education majors concurrently participating in a 16-week student teaching experience. Offered at a staff development center away from the University of Vermont's College of Education at the school where the interns were teaching, this field-taught science methods course forced substantive changes in the usual university-taught science methods course.

Major consideration includes: (a) what the instructor thought the experience was going to be, and how the course was initially planned; (b) what the constraints and opportunities were which modified the original course, and; (c) what the instructor and involved collegues would suggest as a better model for science educators participating in similar undertakings.

Is the science methods experience best offered before, after, or in conjunction with student teaching? How do the needs of the interns differ from those of the university-based methods student? How does the field-centered methods student get "shortchanged," and how does he get the "better deal?" Evidence on which to base partial answers to these questions is discussed.

I-2 COMPETENCY IN UNDERSTANDING SCIENCE—OVERCOMING THE ELEMENTARY TEACHER'S FEARS

Darrel W. Fyffe, Assistant Professor of Education, Bowling Green State University, Bowling Green, Ohio

Overcoming the fear of science is a major concern of the teacher educator. It may be attacked in more than one way. One that shows good results, from comments of students, is the use of small-group laboratory situation in which a series of generalizations from one field are explored in mini-experiments.

Materials are arranged, before class, around the rooms available Small groups of students, the size depending on the number of activities, move from one activity to another. They individually record reactions and responses to questions about the activities.

Some of the activities are brief discussions, centering about a topic provided in writing. Others involve manipulation of materials and reporting the results. A few activities involve descriptions of the application of the generalizations of science to a specific area of teaching elementary science.

I-3 AN ON-SITE ELEMENTARY SCHOOL MATHEMATICS AND SCIENCE METHODS PROGRAM

H. Gene Christman, Assistant Professor of Education; and Ramon E. Steinen, Associate Professor of Education, The University of Akron, Akron, Ohio

We began with an opinion that one of the biggest weaknesses of teacher education programs was that too much time was spent on theory and not enough time on actual practice. Just as prospective physicians need an extended period of controlled and carefully supervised experience to acquire the art of medicine (as opposed to its science), we felt that prospective teachers need similar experiences—opportunities to contend with the realities of teaching.

In an attempt to accomplish this, we decided to teach two methods courses in a public elementary school. Our starting point was an informal discussion with a building principal We then gained approval from the city school system and the university and proceeded as follows:

1. We identified a group of students who wanted to participate in an experience program.
2. We would be at the school from 1 pm through 5 pm every school day for one quarter. The two methods courses would take place from 3:30 pm to 5 pm every day. The college students would be actively involved with elementary pupils from 1 to 3:10 pm every day. The college students received five quarter hours of credit for the science course, five quarter hours for the mathematics course, and five quarter hours for participation experience. This would give them fifteen quarter hours of credit with no class work required on the university campus.
3. We wanted to obtain the cooperation of as many of the elementary school teachers as were interested, because we wanted to put the ideas covered in the two methods classes into practice in the elementary school. The actual participation by our college students could take many forms, from helping one child for a day to teaching a unit to an entire class. The extent and duration of the participation was decided by the elementary teachers involved.

The program generated informal and formal data used in evaluation of the project

I-4 AN INSERVICE PROGRAM FOR PRIMARY (K-2) TEACHERS USING SCIENCE—A PROCESS APPROACH

Ward L. Sims, Associate Professor of Elementary Education, University of Nebraska, Lincoln

Forty-one primary teachers participated in a Cooperative College School Science* program to develop skills in teaching Science—A Process Approach to kindergarten, first- and second-grade children. A team consisting of three science professors and two science educators worked with the teachers during a two-week summer workshop. Emphasis was given to the processes of science, to contemporary science topics, and to peer teaching of selected S-APA lessons.

During the school year the 41 teachers taught science to their pupils and trained a colleague in their school who taught a primary grade. Six inservice meetings were held during the school year in which all of these teachers came together to share information and ideas.

Each teacher administered competency measures to her pupils for one or more lessons. The results of these competency measures were compiled and are being utilized in feedback to the teachers to improve the program.

There was enough enthusiasm for S-APA among teachers, children, and administrators that the Lincoln Public Schools will endeavor to have this science program K-6 by 1973-1974.

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GROUP J

ENVIRONMENTAL EDUCATION (SECONDARY)

J-1 ENVIRONMENTAL FORECASTING—AN ECOLOGICAL APPROACH TO THE WORLD'S FUTURE

Richard G. Dawson, Chemical Science Department, Shawnee Mission South High School, Shawnee Mission, Kansas

Students have been told the population bomb is our greatest threat—and also that it is unimportant compared to technology. Is a Utopia coming, or an Armageddon? Should we help industrialize the poor countries, or would that bring world disaster? The environmental trends discovered in the last 20 years have driven scientists from the lab into political and social action. Today's environmental crisis comes from ecological ignorance, as shown by failure to foresee the multiple interacting effects of technological solutions applied to supposedly simple problems. This module, based on cognitive and affective behavioral objectives, gives students experience with major future forecasting techniques as applied to the environment of Spaceship Earth. Simple predictions of single factors based on long-term trends and extrapolation of data pave the way for cross-impact matrix analysis and the more sophisticated Delphi methods of industry which involve multiple influences. Use of games and simple classroom computer simulations lead up to study of the large computer-based analyses of interacting factors found in the Club of Rome effort at MIT. A multimedia approach with many options uses video and audio tape, slides, filmstrips, movies, journal and book readings, and computer programs. Disagreements among experts are examined. Approaches to international environmental law are considered, and world goals are identified with plans by which students could work to achieve them. Parts of the module can be used in existing courses in earth, biological, or unified science for two weeks or more, or the entire module can be adapted to a unit or mini-course of from a month to a semester in science or humanities, from junior high to college.

J-2 PLASTICS AND POLLUTION: AN INTRODUCTORY CHEMISTRY LABORATORY UNIT

John W. Hill, Professor and Chairman; and Leon M. Zaborowski, Assistant Professor; Department of Chemistry, University of Wisconsin, River Falls

A small but increasing portion of the solid-waste problem is the disposal of waste plastics. Most plastics in use today degrade at an almost infinitely slow rate. Whether discarded along the roadside or buried in a landfill, the component elements are not returned to the natural carbon cycle. The burning of plastics does return carbon (as carbon dioxide) to the natural cycle, but other products are also formed. Some of these by-products are noxious; some are quite toxic. Thus the burning of plastics contributes to air pollution.

We have developed a series of open ended laboratory experiments based on the burning of plastics. Combustion is carried out in a simple apparatus which is easily constructed from readily available glassware and tubing. The products are analyzed for particulate matter. Gaseous products are trapped in aqueous solution and analyzed by conventional methods. We have determined that hydrogen chloride is produced from burning polyvinyl chloride and cyanide is produced from burning Orlon. These experiments yield either qualitative or semiquantitative data. The method is readily extended to other plastics and other analyses.

J-3 DEVELOPING CURRICULUM MATERIALS DESIGNED TO INCORPORATE ENVIRONMENTAL TOPICS INTO SECONDARY SCHOOL SCIENCE

James L. Milson, Assistant Professor of Curriculum and Instruction, The University of Texas at El Paso

A set of 80 instructional activities was developed for use with secondary school science students, here defined as students in science classes grades 7 through 12. These materials include guidelines which emphasized first-hand concrete experiences with special consideration given to compensating for problems with communication skills. The activities, which are competency based, followed a format which included behavioral objectives, equipment, an activity description including pre-lab discussion, lab instructions and post-lab discussion, and a competency measure. Environmental topics covered by the activities include air, water, noise and thermal pollution; population growth problems; disposal of waste, and use of natural resources. The activities were piloted during the fall semester in two school districts.

J-4 GUESS WHAT I SAW TODAY—TECHNIQUES OF TEACHING ENVIRONMENTAL AWARENESS

Felicia E. West, Research Associate, American Association for the Advancement of Science, Washington, D. C., and Thomas Gadsden, Assistant Professor of Education, P. K. Yonge Laboratory School, University of Florida, Gainesville

This paper will discuss the activities and methods used in an experimental attempt to bring about positive change in levels of awareness and observational skills of students in the environmental science classes at the P. K. Yonge Laboratory School. The students involved are the members of two environmental science classes primarily composed of ninth-graders with a very small percentage of 10th-, 11th-, and 12th-graders. Although this was a research study, this paper emphasizes the techniques and methods of treatment rather than the research design, etc. However, the results of this project are available and will be presented briefly to justify the treatment and/or its suggested revisions based on the results of the study.

The treatment for the participants in this project involved the use of "walking field trips" completed within the 1½- to 2-hour laboratory blocks for the classes and restricted to the community surrounding the school. The field trip route remained constant while the focu for each student changed as he participated in the same walk on three different occasions. During the four-week period over which the field trips were accomplished, each class participated in 7 to 10 specifically designed class activities woven into the introductory portion of the environmental program. These included situational activities such as staged incidences, optical illusions, situations that involved most of the senses, situations emphasizing interrelationships existing between objects, etc. The specific treatment ended after a four-week period when a post-test was administered. Regular class activities for the remainder of the year, however, continued to be designed to encourage the students to remain at a high level of awareness and to foster progress in the development of their observational skills. A follow-up test will be given in May or early June to identify the changes over the school year or any long-term gain that was accomplished.

GROUP K

TEACHER EDUCATION (SECONDARY)

K-1 PRESERVICE EDUCATION FOR THE TEACHER OF UNIFIED SCIENCE

Donald P. Altieri, Director, Arts, Science and Business Division, Caldwell Community College and Technical Institute, Lenoir, North Carolina

The paper presents a model for the preservice education of the teacher of unified science. The need for such a model will be discussed and documented.

The following assumptions upon which the model is based will be discussed in detail. It is important for the prospective teacher of unified science to have:

1. An indepth knowledge of at least one area of science.
2. Exposure to as many different science concepts as possible
3. Opportunity to be involved in some type of scientific research
4. Course work presenting the social significance and implication of science
5. Contact with students of the age they are preparing to teach in order to test out the learned academic and pedagogic ideas
6. A total unifying preservice program rather than an array of fragmented methods and content courses
7. Opportunity to design, plan, implement, and evaluate his own program for student teaching

The main thrust of the program lies in assumption 7. The prospective teacher of unified science must have freedom to explore many ideas and then have an opportunity to test these ideas. Implicit also in assumption 7 are some ideas quite foreign to many colleges of education. The ramifications of this idea will also be explored.

Flow charts and diagrams will be used to visually express the ideas presented.

K-2 MASTERY OF BIOLOGICAL TECHNIQUES: A MODEL FOR TEACHER EDUCATION

Paul C Beisenherz, Department of Elementary and Secondary Education, Louisiana State University, Lakefront, New Orleans

Are there techniques and skills that prospective biology teachers should master prior to their first teaching position? This report describes a completed study involving the utilization of a set of 154 techniques established by the author designed to provide a basis for identifying such skills and techniques.

The 52 classroom biology teachers participating in the study were full-time high school teachers from four metropolitan areas. In responding to each of the 154 techniques, they chose one of the following four alternatives:

I. I have utilized the skill or technique in my teaching
   - A. I did find prior training advisable before my initial use of it in my teaching.
   - B. I did *not* find that prior training was necessary before my initial use of it in my teaching.

II. I have *not* utilized the skill or technique in my teaching
   - A I find the technique potentially valuable in implementing my instructional objectives, but lack of initial exposure has prohibited my use of it in my teaching
   - B Knowledge of the skill or technique has *not* been essential in implementing my instructional objectives.

Thirty-five techniques were identified by 40 or more of the 52 teachers as those in which mastery *prior* to teaching was advisable (responses IA and IIA) Wide differences were found in the number of techniques mastered (responses IA and IB) and the number of techniques considered unimportant (response IIB) by each teacher. Significant, positive correlations were found between the number of techniques mastered *and* number of years of biology teaching and number of semester hours of biology taken by the teacher. A significant negative correlation was observed between number of semester hours of biology taken and number of skills and techniques considered unimportant by each teacher.

From this study, techniques have been identified that can provide the basis for courses for pre-service and inservice biology teachers.

K-3 TRAINING SCIENCE TEACHERS FOR THE INNER CITY: A HIGH SCHOOL AND UNIVERSITY COOPERATIVE PROGRAM

Martin N. Thorsland, Assistant Professor of Education; and Walter E. Massey, Associate Professor of Physics; Brown University, Providence, Rhode Island

There has been developed at Brown University an experimental program for the preparation of quality science teachers for inner-city high schools. The program is a cooperative effort of the Departments of Physics, Chemistry, Biology, and Education, and the Providence Public School System. The program is a four-year Bachelor of Arts concentration with the possibility of a fifth year leading to the AM degree. Students take a minimum number of introductory courses in biology, chemistry, physics, mathematics, and advanced courses in the discipline of specialization. The majority of the basic science courses have been developed especially for the program. These courses stress the unity of the sciences, emphasize student participation rather than formal lectures, discuss the role of science and technology in modern society, familiarize the student with traditional and recently developed secondary school science curriculum materials, and provide for direct interaction with local high school students and teachers The education courses are designed to combine theory with extensive practical experience in both classroom and community. Education courses specific to the program include inner-city education: methods of teaching science in the inner-city; and theory, design, and construction of scientific apparatus. The element of practical experience is a central feature of the entire program. In each year, beginning with the introductory science courses of the freshman year, the student spends substantial time in local secondary schools working with students and teachers. We will report on the progress made and problems encountered in the first year and one-half of operation of the program.

K-4 SKILL DEVELOPMENT IN PRESERVICE SECONDARY SCHOOL SCIENCE TEACHERS

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

Asking questions has long been accepted as a teaching technique. One of the current emphases in science education is the use of "inquiry" which implies the use of questions structured to enable students to discover information for themselves rather than the use of the lecture method. Teaching methodology advocated as desirable and that actually practiced in classrooms has not always been identical.

This study, originating from one completed for a doctoral dissertation, was designed to investigate problems of skill development in questioning as exhibited by students enrolled in the junior year of a science preservice education program. Problems investigated related to influence of length of instruction on skill development, progress in skill development, and effects of concurrent involvement in classrooms with instruction in questioning.

Three teacher behaviors were used as criterion variables in the study: (a) asking open questions (those to which there is a variety of acceptable responses), (b) pausing for at least three seconds after asking a question in order to allow pupils time to think before responding, and (c) questioning in a manner designed to decrease the percentage of teacher talk during the lesson. The design of the study was:

	QUARTER ONE			QUARTER TWO			
R_1	X_1	X_2	X_3	O	X_4O	X_5O	X_6O
R_2				$X_1X_2X_3O$	X_4O	X_5O	X_6O
R_3	X_1		X_6	O	O	O	O

R= randomly assigned groups of juniors
X= instruction in questioning
O= observation

For instruction in questioning the design appears as:

	QUARTER ONE		QUARTER TWO	
WEEKS	2	9	12	19
R_1	X Instructional Procedure			X
R_2			X Instructional Procedure	— X
R_3	X Instructional Procedure	X		

All three groups received the same instruction in questioning. Variation occurred in the timing of this instruction and in the intensity of instruction (concentrated vs. diffuse). Data were gathered by audio-taping science lessons with elementary school children as they occurred in public school classrooms during Quarter Two. Transcripts of the tapes were made and questions from the lessons were categorized using a Question Category System developed during the dissertation study. Data were subjected to tests of multiple regression, multivariate analysis of variance, Tukey multiple comparisons, and repeated measures of analysis of variance.

K-5 USING TAPE RECORDINGS AS AN AID IN TRAINING SCIENCE TEACHERS

Gerald C. Llewellyn, Assistant Professor of Biology Education, and Frances Briggs, Professor of Education; Virginia Commonwealth University, Richmond

It is generally agreed that beginning science teachers mimic their past instructors and often utilize, unconsciously, both the strong points and the undesirable traits gathered in their college training. We have expanded the idea of recording the teacher's presentation (especially that of the student teacher in science) a step further than just an occasional self-study of a lecture.

During the student teaching experience (eight weeks) our science teachers were requested to record a total of eight of their classes. It is fair to report that we had the normal complaints by the student teachers about these requirements, but the complaints quickly disappeared after the participants found that many secondary or middle schools have tape recorders available for use in the science department. Also many of our students utilize their own or a borrowed cassette tape recorder. The student teachers were requested to exchange one tape recording per week with the college supervisor. The return of the previous week's recording for the current recording normally occurred at the weekly seminar. At times tapes were returned when the supervisor visited the teacher's classroom.

Students could record as many classes as they wished or the same class several times. They were encouraged to select the best recording for submission. Obviously they listened to these recordings prior to submission and benefited in this process.

The college supervisor would listen to these tapes at a convenient time, often during travel from one school to the next. At the end of each recording he would record a brief series of comments about the lesson.

It was also found that the inclusion of an introduction to the lesson planned, and made by the student teacher at the beginning of each tape was of value. Often this introduction included behavioral objectives, concepts, and the logistics planned for the class or laboratory to be taught.

From the use of this tape-recording exchange system we found many benefits. Student teachers readily developed audio skills, notably that of using, successfully, at least one type of tape recorder. They were able, in addition to listening to their own voice, to become aware of other happenings in the classroom. These happenings were especially evident during laboratory sessions. Also the student teacher could document his own improvement in teaching by listening to earlier recorded tapes. At times exceptionally good recordings were used as examples during seminars. Also student teachers became interested in other classroom uses for the tape recorder, including enrichment centers and audio-tutorial teaching.

Benefits for the college supervisor included extra "audio visits" with the student teachers in addition, of course, to the normal observations. "Dead time" for travel between schools when the college supervisor was visiting and observing student teachers was better utilized; and if recordings for a particular student were played prior to the observation, the college supervisor was better informed about that particular situation and better able to assist the student teacher.

The evaluation of this program by the student teachers after the experience was very favorable.

GROUP L

TEACHER EDUCATION: TRAINING INNER-CITY TEACHERS

L-1 A RELEVANT MODEL FOR TRAINING ELEMENTARY SCIENCE TEACHERS

Rodger W. Bybee, TTT Project, New York University, Washington Square, New York City

During the past academic year the TTT Project at New York University taught a special section of science and methods classes in four New York City schools. Forty student teachers and eight TTT staff were located in Public Schools 11, 41, 42, and 188, in Manhattan.

Because of the teacher-student ratio in this course the majority of interactions were individual or small group. There was a greater emphasis on actual teaching and reduced time spent on "teaching more science" in the methods course. The actual course varied among the individual instructors; however, there were commonalities unique to this program.

First, the personalization of instruction had a tremendous effect on the student teachers. A great deal of planning, teaching, and immediate feedback on science lessons was available. Second, the student teachers had access to curriculum materials, films, and other supplies for their lessons. Third, the methods instructors served as a "support system" that, in the end, proved to be very important.

Evaluation of the program attempted to answer the following questions:

1. To what degree does this approach help the student teacher overcome problems encountered in the field?
2. To what degree does this approach aid the student teacher in an effective use of self in the actual teaching performance?
3. To whom and for what reason does the student teacher listen and respond with changes in behavior relative to teaching science?

There were some problems and some areas not covered for the student teachers; but, in general, this approach does appear to be at least as successful as traditional methods. This project did take a major step for the schools; it increased the staff student ratio and the interaction time. From the beginning we did not attempt to replicate what is; we attempted to demonstrate what can be done in the training of elementary science teachers. This type of methods class is effective; especially relative to teaching performance.

L-2 MESSAGES AND MEDIA: HELPING TEACHERS ANALYZE DIMENSIONS OF TEACHING BEHAVIOR

Fred Geiss, Adjunct Professor, TTT Program, New York University, Washington Square, New York City

As part of the clinical teacher training program, being supported by TTT, we have made use of both videotapes and classroom transcriptions to initiate the analysis of teaching behaviors by both student teachers and inservice teachers. The initial tapes present relatively clear examples of various teaching styles but in subsequent efforts more complex behaviors are examined, and the teachers and student teachers are encouraged to go on to self analysis of tapes of their own teaching. It is our opinion that different messages call for different teaching styles and that a clear understanding of the nature of a variety of teaching styles will help teachers select the approach which is most appropriate for a given lesson.

L-3 CHANGING THE SYSTEM FROM WITHIN

Elhannan Keller, Teacher Trainer New York University, TTT Program, Washington, Square, New York City

The science education component of the TTT Project at New York University as it relates to the schools, has been designed to accomplish three major goals. One is to find a dynamic method introducing prospective elementary school teachers to the teaching of science. Another is to use the student-teaching experiences of the prospective teachers as the clinic for bringing about change in the teaching of science in the elementary schools in which they are doing their student teaching. The third is to involve a TT, Elhannan Keller, and a group of regular teachers in a cooperative investigation of selected teaching materials as one means of changing the predisposition of teachers to teach science. The writer's approach to the accomplishment of these objects has been through the medium of COPES, of the new elementary school science curriculum.

In an effort to accomplish the first and second goals, ten prospective elementary school teachers have been encouraged to use COPES teaching materials for the grade level at which they are doing their student teaching. In preparation for teaching these materials, they go through the experiences they are expected to provide for children. Their experiences are carried out under a supervisor. Subsequently, he observes them when they teach the materials and uses his observations as the basis for critiques. Although the critiques are focused primarily upon observed lessons conducted by the student teachers, the supervisor uses these shared experiences to develop more generalized concepts, skills, and attitudes regarding the teaching of science. This is accomplished through discussions, demonstrations, observation of films and videotapes, as well as through reading of recommended literature.

The third goal is being accomplished through a research study in which the effectiveness of selected Guilford structure of intellect abilities predict achievement in the chemical bond sequence of COPES. The fifth- and sixth-grade teachers, who are involved, stand to benefit greatly from their participation

L-4 PREPARING INNER-CITY TEACHERS FOR ENVIRONMENTAL STUDIES: THE USE OF WEEKEND WORKSHOPS

Jack Padalino, TTT Staff, New York University, Washington Square, New York City

If elementary school teachers need help to acquire the confidence, knowledge, and skills to teach environmental education at a resident facility, then program components of resident environmental education should be provided for via teacher training.

Investigation of the environments that a child is a part of is one of the most salient ways to have him apply skills acquired in the classroom. A significant and timely application of the school's role as part of the total educative process affecting the child is to provide opportunities for observation, collection, and interpretation of data from the child's environment; exploration of cause-and-effect relationships; and identification of alternate modes for environmental stewardship.

People perceive their environment in their own personal way. Environmental perceptions are internalized through direct interactions and experience with that which surrounds us. Many educators and natural-resource managers are concerned with the lack of in-school learning experiences which will help a child relate to his environment. Some teachers are interested in providing their students with direct environmental learning experiences; however, they lack the skills and/or the experience to accomplish the task. For the purpose of this investigation, providing direct experiences for learners, both children and teachers, at a resident environmental education facility will be considered.

GROUP M

SCIENCE TEACHING AND THE COMMUNITY COLLEGE

M-1 TECHNOLOGICAL EDUCATION AND THE COMMUNITY COLLEGE

George Charen, Dean of Instruction, Bergen Community College, Paramus, New Jersey

This paper will trace the origin of the community college, emphasizing technological education. The speaker will develop the concept of service to the community as the college's major role, the need for technically trained young people in a technological society, and the parameters of technological education.

M-2 THE TECHNOLOGICAL STUDENT: NEW TEACHING CHALLENGE FOR THE COMMUNITY COLLEGE

Miles D. MacMahon, Director, Natural and Applied Sciences, Essex County College, Newark, New Jersey

This paper will discuss the problems of effective science teaching within the constraints of the traditional concept of allied health education, the need to develop new goals for the technological student, and innovations in teaching the technological student.

M-3 THE HIGH SCHOOL SCIENCE CURRICULUM: PREPARING STUDENTS FOR TECHNOLOGICAL EDUCATION

Robert S. Searson, Science Teacher, Barringer High School, Newark New Jersey

This paper will stress the need for cooperation between high schools and community colleges, examine new high school science courses as preparation for technological education, and highlight what an inner-city high school is doing for the potential technological student.

M-4 ALLIED HEALTH: NEW CURRICULA FOR THE BIOLOGIST

Carl D. Prota, Assistant Dean of Instruction, Bergen Community College, Paramus, New Jersey

This paper will discuss the parameters of allied health, problems of obtaining allied health faculty, how biology courses can be tailored for allied health curricula, and the implications and significance of allied health curricula to the biologist.

GROUP N

INTERESTING APPROACHES (SECONDARY)

N-1 THE BIRTH OF A MINI-COURSE: A STUDENT SELF-SELECTION APPROACH TO TEACHING SCIENCE

Joseph R. Barrow, Chairman, Science Department, Nordonia Hills Junior High School, Northfield, Ohio

Minicourses are the topical presentation of science units. When the student can choose from a great variety of such units he naturally becomes more interested and more motivated. This motivation can be utilized by the teacher to realize more achievement than might be otherwise possible.

The construction of a minicourse program can be long and detailed or brief. However, more planning time leads to more flexibility and efficiency. The important elements in planning a minicourse program are:

1. The evaluation of the existing curriculum to determine what is valuable and what is not.
2. An assessment of the students' desires and the community's wishes.
3. Allotting a common denominator length of time (six- or nine-week units) to fit the topics to be taught.
4. Writing the curriculum(s) for the minicourses so that it (they) will be of practical value to the teacher.
5. Construction of a departmental master schedule of the minicourses. The timing and sequence of the minicourses on this schedule are of critical importance.

6. Educating the students and their parents as to the nature of the program.
7. Devising an optimum sign-up procedure so that most of the students get their first choice most of the time.
8. How to track the students and report their progress.
9. Resource boxes of materials for each minicourse and construction of a filing system for each student involved (these items are optional).

There are a few disadvantages to minicourses, but these are far outweighed by their advantages. The extra work involved is a small sacrifice for the motivation gained. This program can be adapted to any junior high school or middle school program.

N-2 THE PROS AND CONS OF A MINI-COURSE CURRICULUM

John William Lakus, Science Teacher, Nordonia Junior High School, Northfield, Ohio

The minicourse method of curriculum presentation permits student selection of science courses at the junior high level. In a properly constructed program not only do the students select their teachers but the teachers choose the subjects they wish to instruct. Because of the built-in motivation for the teachers and the students, both seem to perform better.

Through the use of minicourses the following can be accomplished: individualized subject material; a common level of interest for instructors and students; increased student motivation; increased teacher motivation; improved use of school's facilities; more efficient use of supplies and materials; balanced class sizes; and reduced spending for materials.

However, a great deal of work is involved in scheduling and administering the program. Because of the registration procedure, students are sometimes forced into an unwanted course. Also, student-tracking and teacher-scheduling is difficult. Long-term relationships between students and teachers are reduced to the lowest level.

There are many variations of the minicourse curriculum, one of which will suit any school. Flexibility and motivation are the chief assets of the program while scheduling of students and teachers is the main drawback. Although the program is not perfect the advantages outweigh the disadvantages.

N-3 IDEA-CENTERED LABORATORY SCIENCE [I-CLS]—A "THIRD GENERATION"

Sharon E. Kitchel, Head of Science, Delton-Kellogg Schools, Delton Intermediate School, Delton, Michigan; and W. C. Van Deventer, Professor of Biology, Western Michigan University, Kalamazoo

Idea-Centered Laboratory Science (I-CLS) is an activity-based program for intermediate level students. It is a successor to the Michigan Science Curriculum Committee Junior High School Project (MSCC-JHSP). The writers have conducted a research program with slow learners based on I-CLS since 1968. As a result a "third generation" program is now being written for the "reluctant learner."

The writers hold two basic assumptions with regard to teaching this type of student. First, reluctant learners are of three types, students who (a) lack ability to *read* scientific material, (b) lack ability to *deal with* scientific material, and (c) lack *interest* in scientific material. Second, an unabashed teaching of vocabulary is necessary in helping reluctant learners to develop an understanding of scientific *ideas* and in learning to "think as a scientist does."

I-CLS for the Reluctant Learner requires only a minimal amount of reading, and subject matter is introduced only as it contributes to the understanding of an *idea*. Each laboratory experience is directed toward an *idea*, and stresses one or more *key words* which are necessary for understanding that *idea*. Vocabulary is thus taught through these laboratory experiences.

The student is guided to continually use the *key words* in solving scientific problems. Vocabulary usage and reinforcement through active application of these words aid the student in dealing with and becoming interested in scientific materials.

The student's understanding of the *idea* can be effectively evaluated by the use of Inquiry Technique Tests (ITT), as reported by the writers in 1971 and 1972. This method of testing evaluates the student's ability to think in relation to an *idea* by the questions he asks rather than by the answers he gives. Thus there is minimal emphasis on the retention of memorized facts and maximal emphasis on understanding and use of knowledge. Comparable methods of testing for understanding and use of vocabulary are yet to be developed.

N-4 THE DAY WE HUNG THE EIGHTH GRADE

Nancy Griffin and Robert Hawkins, Instructors, P. K. Yonge Laboratory School, University of Florida, Gainesville, Florida

This paper presents ways to use concrete activities to motivate students in middle school science.

Confronted with a hot science classroom full of less-than-eager learners, the authors recently broke through those common summer-session doldrums by involving students in a series of "body experiments." The exercises aimed at teaching concepts like center-of-gravity, density of mass, water displacement, etc. Rather than relying on the traditional blocks, weights and balances, students were asked to volunteer their own bodies. Borrowing ropes from the physical education department, we hung eighth-graders from shoulders, feet, and knees until their centers-of-gravity were determined. The effect on the learning climate was immediate. Our hanged students were ready for more! There followed other such experiences including immersion in tubs of water (measuring the volume of water displaced) and human pendulums. What had begun as another straining summer school ended with both students and teachers convinced they had learned from and enjoyed the "body experiments."

N-5 PROJECT AND OCEAN STUDY: AN INTERDISCIPLINARY APPROACH

August Botelho, Director, Guiteras School, Bristol, Rhode Island

Project Ocean Study is a joint effort between me, as Director and developer of Project Ocean Study and Roger Williams College as an assisting educational institution. The prime object of the project is to demonstrate to students, at the seventh-grade level, that science is important in all realms of learning. This is the second year the project has been in operation, and it has been expanded to include social studies and art as tools which will help the students to learn about marine science and its increasingly important role in today's society.

Areas included in curriculum content are the chemistry of seawater, the geology of the ocean floor, marine life in all three areas (benthic nekton and plankton groups), water pollution and its effect on man and his society, the importance of the fishing industry, sketches and drawings of beach areas for purposes of mapping and recording seasonal changes in beach areas, etc.

Roger Williams College supplies instruction in the classroom and on field trips, uses the marine science facilities for labs at the college to discuss the social aspects of the countries where oceanography has played a part, such as effects on commercial fishing and the ways in which water pollution has altered man's life, the effects of the ocean on the physical geography of New England, especially Rhode Island.

The facilities of the Rhode Island Department of Natural Resources are also utilized in that students are taken to the Wickford Marine Base of the Department where they tour the lab facilities and take a trip on one of the research vessels. The department will also send a representative to the school to give a series of three lectures on the roles of the Department of Natural Resources.

Field trips play an important role in the project as students are taken to the Ocean and salt water marshes for the purpose of conducting field research and making maps and drawings. Although the students receive similar information as one large group, each individual student chooses a particular area in which he specializes and performs additional research work in the preparation of a report showing how various subjects are interrelated through the study of marine science.

A final aspect of the project is career development in the marine sciences. Material on the various aspects, requirements, and employment opportunities of marine science occupations. The Department of Natural Resources is assisting in the compiling of this material.

My role as project director is to coordinate all of these activities, in the proper sequence, so as to meet the objectives of the program. This includes assisting and developing curriculum content for the staff of Project Ocean Study and the Guiteras School as well as working with the staff of Roger Williams College in informing them of the needs of the project participants.

GROUP O

EVALUATIVE STUDIES (K-12)

O-1 FACTORS RELATED TO ENROLLMENT IN SECONDARY SCHOOL PHYSICS

William F. Poole, Jr., Physics Teacher, Salem Classical and High School, Salem, Massachusetts

The percentage of students studying physics in secondary schools of this country has been steadily declining in recent years. Enrollment in physics in 1958 was 24.6 percent of the senior class, and by 1970 it had dropped to less than 19 percent. Thus, a research study was initiated to identify some of the possible factors related to the downward trend in secondary school physics enrollment in the United States.

The prime consideration was. Do the attitudes of students toward the study of physics differ between those students who study high school physics and those who do not? Secondary considerations were. Do the attitudes of students who study physics differ from students who take other science courses such as chemistry and biology and is the attitude of boys toward physics different from that of girls toward physics?

A 40-item Likert-type scale *Science Attitude Inventory* was developed and administered to over 3,700 science and non-science college preparatory students in 11 secondary schools in Massachusetts. Students were asked to respond to statements about physics, chemistry, and biology.

The re   indicated significant differences in overall attitude and in certain specific attitudes toward science between students enrolled and unenrolled in science and among the three science groups. Physics students had more favorable attitudes toward physics than had non-physics students, chemistry students who elected physics were more positive toward chemistry than were chemistry students who did not elect physics, and boys had somewhat more positive attitudes toward physics than had girls.

The conclusions reached were that overall attitude and certain specific attitudes toward physics and chemistry were important in influencing students' choice of electing or not electing physics. If the downward trend in physics enrollment is to be reversed, the attitudes of students toward science must become more positive.

O-2 BEHAVIORAL OBJECTIVES AND THE IPS-PS II PHYSICAL SCIENCE CURRICULA

Floyd M. Read, Jr., Associate Professor of Science Education, East Carolina University, Greenville, North Carolina

Granted that the objectives of a science program are clearly specified and the program is evaluated and modified to maximize the extent to which these objectives are achieved, it is equally crucial to select proper objectives. Questions that immediately come to mind are: (a) How well do the IPS-PS II physical science curricula satisfy the agreed-upon objectives of science education? (b) Can the stated objectives of these IPS-PS II physical science curricula be evaluated in the light of measurable changes in pupil behavior? (c) How can the new physical science curriculum programs best be evaluated?

These questions are explored and some comparisons are made concerning behavioral objectives and these specific physical science programs. The objectives of the IPS-PS II physical science curricula are stated in the form of behavioral objectives and the evaluation of these behavioral objectives is discussed.

O-3 PROBLEMS OF IMPLEMENTATION OF NEW SCIENCE PROGRAMS

Moses M. Sheppard. Associate Professor of Science Education. East Carolina University. Greenville. North Carolina

Today. 15 years after the first major impetus for science curriculum revision. many schools are not utilizing any of the recently developed science curricula. Probably this is due to the many problems encountered in the implementation of new science programs and the difficulties teachers. supervisors. and administrators have faced in finding solutions.

For the purposes of this presentation these problems are divided into five major headings:

1. Selecting the appropriate science curriculum program:
2. Getting the approval of the program from state and local authorities:
3. Obtaining adequate funding for materials. equipment. and facilities for implementing the program:
4. Preparing the teachers for teaching and using the new science curriculum materials: and
5. Providing an adequate follow-up and evaluation of the implemented program.

The problems and some possible solutions. as well as specific examples of solutions to these problems. are discussed.

O-4 A STUDY OF CONTENT DEVELOPMENT IN SELECTED SECONDARY BIOLOGY CLASSES

Betty J. Stoess. Assistant Professor of Science Education. Eastern Kentucky University. Richmond

The purposes of the study were to analyze interactive processes used by a sample of eight biology teachers (tenth grade) in developing content with their students and to describe predominant teaching patterns utilized. The analysis of interactive processes was accomplished by encoding 64 audio-taped lessons (full class periods) using the *Content Analysis System for Chemistry* (Ramsey. 1969). Here the unit of behavior coded is the "content event." Each content event is assigned three codes: (a) a semantic code (Background. Figure or Digression). (b) a syntactic code (one of 12 logical operations or Management) and (c) an Initiate-Supply code (identifying speakers). Differences among teachers and days (four for each teacher) and between class sections (two) were determined. Five hypotheses relative to these differences were tested by means of analysis of variance. Teaching patterns were described by means of a series of first-order transition matrices.

For the sample. the major findings were: (a) extensive teacher lecture (ranging from 45 to 93 percent of all content events). (b) a strong tendency for teachers to seek low-level responses from students. (c) a rapid pace of discussion (an average of 103 content events per lesson). (d) little use of either Background or Digression categories. (e) limited student participation in discussion except for responding to teachers' requests for factual information. and (f) when students did seek information they sought amplification

When relative uses of categories and subcategories of the CASC instrument were determined. few significant differences among teachers and days or between class sections were noted. However. three different teaching patterns were identified The most frequently occurring one (common to six teachers) was the presentation of concrete examples which were then named and or described. The seventh teacher used a major pattern of inferring followed by a personal example. The final pattern was a series of designating and describing events

O-5 AN INSTRUMENT FOR ASSESSING ELEMENTARY SCIENCE CURRICULUM PROJECTS

George P. Toth. Instructor in Elementary Science Methods. Doctoral Student. The Pennsylvania State University. University Park

The need for an instrument to assess programs in secondary school science was stated in NSTA's Life Members' Breakfast "Info Memo" of April 9. 1972. The need for such an instrument is even greater at the elementary school level since at this time there is *no* comprehensive rating-guide which can be used to evaluate the *characteristics* of the major innovative science curriculum projects (S-APA. ESS. SCIS. etc.) in the elementary school.

The purpose of this self-assessment instrument is to determine which project is best for a particular school or classroom. The instrument does not attempt to compare one project with another and allows for the unique approach of each project.

The format of the instrument was modeled after Suydam. (Suydam. Marilyn. "An Instrument for Evaluating Experimental Educational Research Reports." The Journal of Educational Research. January 1968.) who developed a scheme for evaluating experimental educational research projects. The content was synthesized from criteria published by USOE. NSSE. and the Pennsylvania Department of Education. It is made up of nine categories each further divided into sub "key points" to provide a more detailed and comprehensive rating of each category. The nine categories include:

1. Objectives and philosophy of school and project
2. Student-material interaction
3. Individual differences
4. Teacher training (inservice)
5. Integration of conceptual themes
6. Learning activities
7. Evaluation provisions
8. Cost of project
9. Organization of project

The actual rating is based on a five-point scale.

The instrument has been presented to:

1. Sixty-five undergraduate students in an elementary science methods class for clarification and suggestions.

2. Twenty-eight master's degree and doctoral students with teaching experience at the elementary level for revision and validation, and
3. A group of elementary teachers in a summer workshop for further validation and clarification.

The instrument will be revised and used in several local elementary schools within the next few months.

The instrument will be available for school use and may be part of the solution for those concerned with the need for accountability in elementary school science.

GROUP P

SCIENCE TEACHING AND CURRENT SOCIAL CONCERNS

P-1 VALUES EDUCATION IN THE SCIENCES: THE STEP BEYOND CONCEPTS AND PROCESSES

David J. Kuhn, Assistant Professor, Education Division, University of Wisconsin-Parkside, Kenosha

The 1960s emphasized the understanding and use of science concepts and processes. The newer science programs met these concerns quite well; they were a considerable improvement over what had gone on in the past. But the 70s are an age of new realities; a time that demands a greater relevance of the science curriculum to the social issues that affect our lives. This direction has been given much vocal concern, but there has been a conspicuous absence of realistic methods of implementation in the day-to-day science classroom.

This paper is concerned with the question of how the value systems of individuals may be clarified and applied in the science classroom and in the real world outside. Science teaching is considered as occurring on three levels: the fact level, the concepts-process level, and the values level. The fact level was often stressed prior to the 1960s; the concepts-process level of science teaching received added attention during the 60s; the values level will gain increasing importance during the 70s. Values education in the sciences must be built on the sound understanding of science concepts and processes.

Values education will require innovative strategies, a new perspective on science education, and different roles for teachers. A number of strategies including simulations, role playing, sensitivity modules, values continuums, and the use of attitudinal surveys are described. Appropriate teacher behavior in the classroom e.g., asking evaluative questions and promoting a classroom climate conducive to value exploration, are examined.

There is a pressing need for a citizenry that has the scientific literacy and the awareness of values necessary to make decisions or influence decisions about such questions as population control, radioactive fallout, pesticide usage, and industrial effluents. If this challenge is to be met, science instruction must reach a new plateau—one that makes the exploration of value systems paramount.

P-2 SOCIAL ILLUSTRATIONS IN PSSC PHYSICS INSTRUCTION

Gideon O. Hirsch, Science Coordinator, Dobbs Ferry High School, Dobbs Ferry, New York

Students today are interested in social and behavioral problems and don't really care why electrons orbit the nucleus. Social illustrations, where appropriate, immensely increase the class interest in the physical phenomena. Establishing these social illustrations as possible models of understanding, or at least as novel ways of describing social behavior is characteristic of the PSSC curriculum.

PSSC is different in concept from Project Physics because the social and behavioral phenomena discussed apparently have no relation to science. It is the similarity or analogy in principles and basic concepts which is emphasized. Students interested in only one of the disciplines gain, as a result, a better understanding of those concepts in that discipline and some motivated insight into the other disciplines.

Three years' results of social illustrations in PSSC physics instruction are very encouraging in both quantity and quality. Illustrations used include: (a) political influence—vector addition, (b) ecology—laws of conservation, (c) love—electrostatic induction.

Detailed example:

Newton's second law ($F=ma$) as applicable to the issues of Equal Opportunity and Education for the Disadvantaged, Head Start, its limitations and reasons for its relative failure.

P-3 POPULATION EDUCATION: CREATING A NEW DISCIPLINE AT THE SECONDARY LEVEL

Thelma M. Wurzelbacher, Lecturer, Biological Sciences Department, University of Cincinnati, Cincinnati, Ohio

The need for population education in the school system is a growing concern in some academic groups, in many professional circles, and in the lives of most students. Diversity of view-point surrounds need, content, and methods of instruction.

Whether or not an individual understands population dynamics, need can be assumed on the basis that educators have a commitment to examine objective and relevant problem areas; content, by its nature, should be conceived in a genuine interdisciplinary atmosphere. In addition, method of instruction rests heavily on the state of the art. At this time definitions of population education vary enormously; curriculum projects involving natural and social sciences are undeveloped; few school systems have inaugurated first steps; efforts for teacher training remain isolated; resources and clearinghouses do not exist or are scattered.

The setting is perfect for self-study, spontaneity, and creativity by the individual teacher on the theory, methods, and materials of population education. Communication of trials, errors, and successes is paramount in the development of operational curricula. With this in mind three dimensions arise: the individual unit construction at junior and senior high level—both single and multidisciplinary; isolated activity formulation, game construction, and simulation types; lesson plans based on the inclusion method;

and finally, semester and year-long course construction. Selected models and materials in each of the four areas, based on personal experience and the hybridization of patterns and processes developed by participants in a national population institute are presented.

P-4 VALUES AND SCIENCE: FACING THE CHALLENGE

Thomas Gadsden, Jr., Assistant Professor of Education, P. K. Yonge Laboratory School, University of Florida, Gainesville

Unhealthy attitudes toward science are widespread in our society. Science is viewed, on one hand, as the solution to man's many problems. Unquestionable faith is placed in the ability of applied science to stop death, starvation, overpopulation, discomfort, and environmental crises—before it's too late. The attitude that there is no need to worry, science will take care of us, abounds.

Just as frequently, and often by the same voices, science is criticized and held responsible as the cause, through its technology, of most of the problems of our society—war, pollution, the decline of morals, and many more. The result is a growing anti-scientism along with a willingness to let science "do it all."

Too often in our science classes we perpetuate the confusion of the role of science in our society. We do this by ignoring the issues and attempting to teach science as if it existed in a social void.

The students in our science classes are citizens of a technological democracy. Many of them will never again have a direct contact with science or scientists. Any further knowledge and attitude toward science will come from public media and from the way technology affects their lives.

This paper will raise and attempt to answer four questions:

1. Is it worthwhile for the science teacher to attempt to help students develop values and value systems concerning the interplay of science and society?
2. Can operational definitions be found which will permit teachers of science and social science to communicate and cooperate in this interdisciplinary venture?
3. Can instructional resources be developed which will be useful in meeting this challenge?
4. How radical a modification of courses designed to teach the concepts of science would be required?

In answering these questions an approach to dealing with issues of science and society is suggested. This approach centers on three broad areas of learning associated with each instructional input—the comprehension of the input, the relation of the input to the conceptual focus of study, and questions of values concerning both the input and the conceptual focus.

Specific examples are offered that, we hope, will encourage teachers to seek additional ways of dealing with the interactions of science and society.

This paper was developed as a cooperative effort among science and social science educators and classroom teachers.

GROUP Q

MOTIVATING THE UNMOTIVATED (SECONDARY)

Q-1 MOTIVATION OF STUDENTS THROUGH SUCCESS

Gerald Skoog, Associate Professor of Curriculum and Instruction, Texas Technical University, Lubbock

Many science classrooms in our nation operate under the assumption that failure or the threat of failure can be used as a continuous motivating force. That is, there is belief that failure is good for people.

However, there is a [illegible]ing body of systematic evidence and the[illegible]erated by individuals such as Arthur C[illegible] Purkey, and William Glasser which ind[illegible] that teachers should give the highest priority to establishing a classroom environment of success rather than failure. This body of research indicates that success, rather than failure, motivates students. Furthermore, there is much evidence that students who have positive feelings about themselves and their abilities are the ones who are most likely to succeed. Those who see themselves as less able and less worthy are more likely to be underachievers and nonachievers. These individuals are motivated in the direction that involves the least amount of pain—withdrawal and uninvolvement.

To achieve an atmosphere of success, a classroom must be structured so that the self-concepts of students are being enhanced rather than negated. The students must have opportunities to be involved with each other, the teacher, and the subject matter and the phenomena of science. There is growing evidence that the students may need us, the teachers, more than our knowledge. Then as the students grow in self-esteem, achieve success, and find involvement, they will be motivated in academic affairs and move toward, rather than away, from people.

In too many classrooms of the nation, an atmosphere of success does not prevail. Genuine involvement is not encouraged. Self-concepts are ignored. Student response to these conditions has been characterized by alienation, frustration, noninvolvement, and an alarming tendency to drop out and turn on to something outside of school.

Q-2 EXPLORATORY BIOLOGY—A PROGRAM FOR UNMOTIVATED STUDENTS

G. Wayne Mosher, Chairman, Science Department, Parkway North Senior High School, Creve Coeur, Missouri; and Lona Lewis and Steven Tellier, Biology Teachers, Parkway North Senior High School, Creve Coeur, Missouri

The exploratory biology program at Parkway North Senior High School consists of a series of single concept sheets called "Explorations." Major areas of concentration covered by Explorations include ecology, the cell, plants, and animals. For each concept to be learned there will be two to eight Explorations to choose from in order to complete the task. The number of Explorations to be done depends upon how many are available for a particular concept. Evaluation is quick and accomplished verbally or through laboratory reports. This is a multi-text, self-paced program.

Q-3 CAREER SIMULATION EXPERIMENTS IN CHEMISTRY

Jon R Thompson, Chemistry Teacher, General William Mitchell High School, Colorado Springs, Colorado; President, Colorado Science Teachers Association

In most h[illegible] chool chemistry courses the majority of the stud[illegible] [illegible] going to become chemistry majors. Sinc[illegible] [illegible] of future chemists it is necessary to demonstrate the important applications of chemistry in everyday living and to teach the students to be respectful of what chemists really do. I have developed a series of experiments that students can perform where they may actually experience what different types of chemists do in their work. These experiments are not required and are completed only by those who wish to complete them as part of an individualized enrichment program.

The experiments are prepared as a kit. To do an experiment, the student agrees to a "contract" that he will perform the necessary instructions safely and ask for supervision if he needs it. The student then may check out the kit and do the experiment at his convenience in the laboratory.

Some of the simulation-experiments are: The FDA Chemist, The Forensic Chemist, The Industrial Chemist, The Geochemist, The Chemist And Dentistry, and others. Each simulation-experiment consists of several "sub-experiments." For example the Forensic Chemist simulation-experiment provides the student with information about seven crimes that need to be solved in the Forensic Laboratory. The student chooses four cases to work on and reports his findings on an "Official Analysis Report" form. The analysis will determine whether a suspect is guilty or innocent. The seven crimes require the following experiments: classification of broken glass fragments, test for marijuana (catnip will give an almost positive test), test for blood, test for heavy metal poisons, test for aspirin, test for textile fibers, and fingerprinting. Each test solves an imaginary crime. For example, the test for textile fibers involves finding out if a fragment of clothing came from a murder victim or if the suspect was really telling the truth about where he got the sample! Students enjoy doing the experiment and feel that they are really a Forensic Chemist at the same time.

In other simulation-experiments, the students perform experiments representative of what that type of chemist does. In each one they may choose from several choices of sub-experiments. This lets them know that a particular type of chemist doesn't just do one experiment all of the time.

Q-4 CONSUMER RESEARCH—SUPERMARKET SCIENTISTS

Suzanne Zobrist Kelly, Sixth-Grade Science Teacher, Meeker Elementary School, Ames Public Schools, Ames, Iowa

Trends in science education have moved considerably from a factual, basic text approach, to an understanding of the scientific processes. If students must understand this process of inquiry to serve the future, then we, as teachers, must provide opportunity for this growth of understanding. To the educator who recognizes the necessity of teaching problem-solving, but feels limited by realistic circumstances, a consumer research project may serve the purpose of providing for individual needs.

This project was designed to provide a framework for learning, but also flexibility for various interests, ages, and abilities. Each student selected three similar products, such as three dry breakfast cereals, or laundry detergents, or kinds of chocolate candy. His research was a comparison of these brands. The project was organized into four topics: (a) collecting data on commercials and advertisements and formulating value judgment statements, (b) collecting data from companies concerning factual content material connected with the products, (c) organizing and conducting a field research survey, and (d) organizing and conducting an experiment of comparing products by controlling and manipulating variables.

Understanding of scientific processes was evident in an increase in individual student's interests, enthusiasm, and inquiry in problem-solving skills. Lab experiments which followed were conducted with more organization and depth. Later, generalizing experiences were given to substantiate evidence of progress in basic science processes.

GROUP R

AVIATION EDUCATION (SECONDARY)

R-1 STATUS OF SECONDARY AVIATION/AEROSPACE EDUCATION—SCHOOL YEAR 1972-73

C. E. Neal, Aviation/Aerospace Education Consultant, Sanderson-Times Mirror, Denver, Colorado

This presentation consists of statistical data and information pertaining to the organization, development, and operation of secondary aviation/aerospace courses throughout the nation. Facts are presented on scheduling, staffing, budgeting, plant requirements, teacher certification, course content resources, enrollment restrictions, flying activities and liability, field trips, justification, and program evaluation. All data were obtained from an extensive nation-wide survey conducted in September 1972 by the presenter.

R-2 AVIATION EDUCATION AT A TOTALLY AVIATION-ORIENTED UNIVERSITY

Daniel D. Sain, Dean, College of Aeronautical Studies, Embry-Riddle Aeronautical University, Daytona Beach, Florida

The purpose of this paper is to inform elementary and secondary school teachers of opportunities in aviation education both for themselves and their students.

A brief history of the development of aviation education in higher education is presented, pointing out that aviation or aeronautics has become a recognized academic discipline. There are presently 200 two-year colleges in the nation offering associate degrees in some aspect of aviation and at least sixteen senior colleges or universities offering the bachelor's degree in some phase of aviation. In addition there are approximately forty universities with aeronautical engineering degree programs.

Next a few statistics highlighting the many and varied career opportunities in aviation are given.

The paper deals primarily with the aviation programs at the nation's only totally aviation oriented university—Embry-Riddle Aeronautical University, Daytona Beach, Florida. This university offers training and education in aircraft maintenance, flight, aviation management, aeronautical engineering, and applied mathematics. By combining the applied sciences with the basic academic programs, six different majors are offered on the bachelor's level.

In the summer of 1972 an experimental aviation education seminar was conducted for elementary and secondary school teachers. This seminar will be offered again in 1973. It wil' involve the participants in the total realm of aviation in general, including field trips to airports, the John F. Kennedy Space Center, an air traffic control center, and to an airline operations center. Each participant will also receive the complete classroom course for the private pilot's license and approximately 18 hours of dual training in an airplane and flight simulator. In the seminar, each participant will gain the personal experience of piloting, as well as information to be used in teaching aviation at the pre-college level. The seminar will carry six hours of graduate credit.

R-3 AVIOLOGY—A COURSE WITH A LIFT

P. A. Becht, Instructor, P. K. Yonge Laboratory School, University of Florida, Gainesville

The field of aviation is becoming more and more a necessity of everyday life. Our world is shrinking because of aviation and soon almost everyone will be affected in some way by aviation. If education is to fulfill its role to society, it should prepare individuals to understand and meet the demands of aviation now and in the future.

Using aviation as a motivator, physical science courses can be made interesting and stimulating to most students. Aviology is designed to be taught by a physics teacher with a minimum of special preparation. The program uses regular high school facilities and requires no more expense than an average science program. The course can be offered as an elective in science for students in grades 9-12. It is taught using a multimedia approach. An *inexpensive* electronic flight simulator along with films, tapes, and actual introductory flights in light aircraft are used to stimulate student interest. Laws of physics are discussed in detail along with meteorology and environmental aspects of aviation.

Field trips are used to give "hands on" experience in aviation-related activities. People involved in aviation within the community are invited to discuss aviation-related topics with the students.

Aviology is being field tested this year in five Florida schools in different counties to test the effectiveness of the type of program in different types of public schools. It is designed to be low cost and teach the physical science, technology, and environment of aviation to high school students.

This program is designed to be one of the first economical and popular aviology courses to be made available to high school students throughout Florida and the nation. It is designed to be useful to a wide spectrum of students including the low-income, migrant, and Black student. It will not be expensive to the student or the school and will give the student an awareness as to the impact aviation will have on him and the future of the world. The outcome of the field study will indicate the effectiveness of the program in the pilot schools and, we hope, merit a larger scale field-testing and possibly translation into Spanish for the following year.

GROUP S

COLLEGE SCIENCE TEACHING

S-1 CONTEMPORARY TOPICS IN SCIENCE

Laurence W. Aronstein and Kathryn J. Beam, Assistant Professors of General Science, State University College, Buffalo, New York

A college-level course on contemporary topics in science offered to non-science majors at the State University College of New York at Buffalo is discussed. Comparisons of objectives, methods, and outcomes of the course for large groups (up to 200), large groups combined with small groups, and small groups are made. Considerable time is devoted to the practical aspects of offering the course, such as methods of topic choice, topics chosen, preparation, ways of dealing with current topics that continue to evolve, utilization of resource persons, and motivation. Teachers of such a course are constantly reminded of why so few of these courses get off the ground, but also informed that when successful, the reward is as great as the work to achieve it.

S-2 USE OF MATERIALS SCIENCE AS THE CONTENT FOR GUIDED INDEPENDENT STUDY BY SCIENCE TEACHERS

Philip M. Becker and Earle R. Ryba, Assistant Professors of Fuel Science, The Pennsylvania State University, University Park

A course in materials science designed for science teachers has used a "guided independent study" approach for the past year. During an introductory survey the teachers examine properties of vari us man-made materials around them and how these properties depend on the internal structure of the materials. The rest of the course consists of solving several problems.

In one problem each teacher had to design a beer mug by defining the properties of a good mug and choosing an appropriate composition of metal, ceramic, or polymer satisfying the requirements. Since the subject and the materials literature were new to them, they were forced to come to class asking questions. Through the ensuing discussions, they were guided through the problem. After two weeks they were ready to present their results and defend their decisions in a panel discussion.

Another problem included "hands-on" laboratory work. Teachers were given some pieces of metal from various parts of an automobile (such as carburetor, bumper, fender), shown how to use X-ray diffractometer and fluorescence equipment, and asked to determine the composition of the parts. Then they had to find out from the literature why each part had that composition and to suggest another material which would be an acceptable substitute.

Even though this field is new to most teachers, they found they could rapidly learn both the concepts and the experimental techniques by diving into the problems with the guidance provided. Most of them have felt that both the content and the methods will be useful to them as teachers. They obtained some specific examples of why some materials have particular properties, how to organize for themselves a body of knowledge which is new to them, and one practical method for having students generate their own desire for items of information.

S-3 SCIENCE IN THE EDUCATION OF THE HEALTH PROFESSIONAL

Pauline Gratz, Professor of Human Ecology, Duke University School of Nursing, Duke University Medical Center, Durham, North Carolina

In 1969 the Duke University School of Nursing initiated an interdisciplinary course in science for sophomore students planning to enter nursing or an allied health profession and for university students interested in a human-oriented science experience. The course was initiated on the basis of a recommendation by the Undergraduate Studies Committee, a task-analysis approach, a study of the learner product, and consideration of two questions pertinent to the development of a science sequence.

1. What are the goals of the sciences in a particular nursing and/or allied health program?
2. What is expected of the graduate as a member of his/her profession and society?

Consideration of two basic points of view involved in science teaching led to this recommendation by the committee. One advocates teaching a bare minimum of scientific principles underlying health, which is likely to result in a hodgepodge of "principles," scarcely, if at all, comprehensible to the student. The other requires students in health areas to take science courses identical to those required for a science major or minor in his respective field. Unfortunately, many of the prerequisites for science majors and minors are additional to those pertinent to nursing or allied health professions and make it academically and economically unfeasible for many students.

The task-analysis considered the development of a basic science sequence for students entering the nursing professions or allied health professions. [1]

How the content of the 1969 course evolved, was taught, and evaluated is also discussed in the report.

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1. Gratz, Pauline. *Integrated Science*. F. A. Davis, Philadelphia. 1966.

GROUP T

SCIENCE CURRICULUM DEVELOPMENT: AN INTERNATIONAL PERSPECTIVE

T-1 SCIENCE CURRICULUM CHANGE—HOST NATION AND PEACE CORPS EFFORT

Velma Linford, Recruitment Resource Specialist Education, ACTION-Peace Corps/VISTA, Washington, D. C.; Peter Dziwornooh, Professor of Physics, University of Science and Technology, Kumasi, Ghana

African developing countries, the Caribbean and Pacific Islands, and Asian school systems are asking for hundreds of Peace Corps science teachers who can help them shift schooling from the traditional "rote learning" method to one of discovery and problem-solving techniques. They want to preserve the strengths of their heritage while they shape their resources to modern society and technology. Host countries look to the Peace Corps teacher to bring knowledge of new methodology, a vocabulary of scientific terms, and an understanding of expanding science potential for their countries.

Volunteer abilities and capabilities are matched to specific requests, and Peace Corps teachers work with native teachers in local school systems under the ministry of education. Sometimes they replace teachers on leave for training.

Peace Corps Volunteers may be assigned to junior and senior high schools throughout the land—some of them modern and well equipped, but many Volunteers go to rural areas where buildings are small, inadequate, and overcrowded. Others work under ministries of education to organize workshops, provide inservice training for elementary and secondary teachers; they offer demonstration classes, participate in seminars and stimulate professionalism through national science programs. Some Peace Corps Volunteers teach in teacher colleges and universities.

Opportunity is limitless—participate in change, evaluate and improve curriculum, improvise apparatus from local resources, develop methods to stimulate learners to relate ideas, and analyze problems.

Peace Corps Volunteers involve themselves in such science-related programs as nutrition, food production, ecology, health, economics, and communications systems. They enter into a community partnership to build schools, obtain equipment, organize school food programs, and convert schoolhouses into centers for community education. Their overall concern is to help the host nation make the educational system relevant to the country's development of human and natural resources.

T-2 PHILIPPINES AND PEACE CORPS SCIENCE CURRICULUM

Bruce Taylor, Education Specialist, ACTION-Peace Corps/VISTA, Midwest Region, Cincinnati, Ohio

The Philippines, an Asian country with about 40 million people, has one of the highest literacy rates in the developing world today. English is the medium of instruction in the schools beginning at the third-grade level. The National System of Education is operated by the Bureau of Public Schools (BPS) of the Republic of the Philippines.

In the mid-60s the Bureau recognized the need to introduce modern curricula in all subject areas. Several highly qualified American and Filipino educators developed teaching guides in the process approach to teaching science. Peace Corps was invited to participate and Volunteers initially experimented with model classes and control groups; teaching, modifying, and revising the lesson plans until Filipino educational leaders were satisfied with the material. The Bureau published an initial series of teacher's manuals for grades three and four, followed by manuals for five and six.

Ten "Pilot Demonstration" schools were located throughout the country to try out the materials. In almost all the schools, a Peace Corps Volunteer worked with the guides and "co-taught" with Filipino teachers. The next, and most important, step was introducing the curriculum in all the elementary schools; the BPS didn't have enough supervisory staff to implement this program effectively and therefore requested Peace Corps Volunteers to work on inservice training programs and classroom follow-up. Today, the program has developed to the point of revising and updating the teacher's guides to meet the increased abilities of the students.

This co-operative program between the Bureau of Public Schools of the Republic of the Philippines and the Peace Corps offers an interesting example of the development and implementation of the process approach to the teaching of science on a national level. Significantly, this program attempts to break the yoke of traditional rote learning and substitute inductive reasoning on the part of teachers and students, making a cultural as well as an attitudinal change.

T-3 WEST AFRICA AND PEACE CORPS—PARTNERS IN SCIENCE TEACHING REVISION

Kenneth Shewmon, Area Manager, ACTION-Peace Corps/VISTA, Midwest Region, Cincinnati, Ohio; and Herman DeBose, Recruiter for ACTION/Peace Corps/VISTA, Chicago, Illinois

High school students in West Africa must pass the school examination for the Secondary Certificate (similar to the scholastic aptitude test prepared by the United Nations). Because they learn by rote and memorization, often as few as 5 percent pass—therefore, West African countries have requested Peace Corps to assist them in changing traditional teaching methods. Volunteers found no scientific understanding among students. They took for granted weather, disease, and water pollution.

Peace Corps teachers, working through local school systems, under the ministries of education, are faced with the problem of helping teachers modernize teaching methods and subject matter. They teach in a tightly structured situation among members of a highly respected profession. They must introduce a new method of teaching, but the method must fit into a rigid school system. Students resist the Peace Corps teacher's effort to have them observe, discover, and understand unless the teacher can show how this information relates to and is truly in the syllabus.

Peace Corps teachers and their African counterparts are involved in exciting experiences as they use such materials as salt, starch, sugar to teach by feel, taste, and texture—thus broadening the frame of reference of most pupils. Pupils learn problem solving, then discover that the new approach has helped them through the all important exam.

Examples of progress in the application of the unit teaching in science, problems and achievements, and the applicability to the experiences are discussed.

GROUP U

INDIVIDUALIZING SCIENCE PROGRAMS (SECONDARY-COLLEGE)

U-1 MINICOURSES AND MASTERY

S. N. Postlethwaite, Professor of Biology, Purdue University, Department of Biological Sciences, Lafayette, Indiana

A team of instructional developers at Purdue University is preparing minicourses for a core program in undergraduate biology. As the name implies, a minicourse is a short course usually requiring one or two hours of student time to complete. Each minicourse is accompanied by a statement of objectives, study guide, and suggested test items. The materials and media provided include tangible items, printed materials projected 2 x 2 slides and films, and audiotapes. The minicourses are self-instructional, allowing each student to proceed at his own rate, but an instructor usually will be available to answer questions.

The minicourses are subjected to three levels of evaluation by students and teachers which usually result in revision and retesting. The first level is Developmental Testing in which a few students go through the materials and provide feedback directly to the developer. Next, each minicourse undergoes Pilot Testing in an appropriate course at Purdue under actual classroom conditions. The final level of evaluation, Field Testing, is currently being conducted on a limited basis at ten cooperating institutions. Achievement scores are obtained to measure the effectiveness of the materials, and a scale to measure attitudes toward biology has been developed.

U-2 A SYSTEMS APPROACH TO MASTERY

Kenneth H. Bush, Science Coordinator, West Lafayette Community School, West Lafayette, Indiana; and David McGaw and Curtis Smiley, Biology Teachers, West Lafayette Community School, West Lafayette, Indiana

No abstract submitted.

U-3 INDIVIDUALIZATION-GIVE CREDIT WHEN IT'S DUE

John Edington, Science Teacher, Munster Senior High School, Munster, Indiana

The biology program at Munster Senior High School is an individualized curriculum utilizing a multi-sensory systems approach. The enrollment is presently (1972-73) 458 general biology students and 36 advanced biology students who are distributed among six 55-minute periods per day and taught by a team of three teachers and one para-professional.

Each student must complete 24 units to receive 2 credits in biology. The units are designed to include: unit title and number, a brief introduction, objectives, vocabulary development, reminders or announcements, approximate length of time needed for completion, reading assignments and self-evaluation, audiovisual presentation of self-evaluation, laboratory and self-evaluation, seminars, and a unit test. Students may elect to work a unit in any order but must conclude each unit with a seminar and a test. Students may complete units as quickly as their abilities allow. All labs, audiovisual presentations, and tests are given concurrently and continuously throughout the hour.

Credit for the course is issued on the basis of units completed rather than on the traditional time basis. Some students may complete all 24 units in 18 weeks or less. Others may require 52 weeks to complete the required units. Students are counseled to progress at their optimum rate, increasing the rate only when the desired level of competency is held constant or increased.

Presently being developed is a series of eight fundamental units. These units will be accompanied by 36 companion units of a varied degree of difficulty. The student may choose any 16 of these 36 units to complete the required 24. This freedom of choice will allow even further depth in the quest for more complete individualization.

U-4 NON-SEQUENCING OF PHYSICS CONCEPTS

Lawrence E. Poorman, Associate Professor of Physics, Indiana State University, Terre Haute

Defined concepts necessary to the successful study of physics are: length, time, mass, temperature, electric charge, and the photon. Using these concepts, five phenomena may be operationally derived: energy, flow, field, periodic and quantum phenomena.

Traditionally, it has been assumed that these *must* be taught in a highly sequential structure for mature understanding. It is my contention that sequencing is unnecessary, even futile, for most students encountering physics.

Evidence is presented to show: deeper understanding of the concepts using a random approach topic-wise with a group of beginning students at the secondary and college level a much greater retention of the concepts for longer periods of time, and a much greater application of conceptual ideas by students in a non-sequenced course than in a sequenced course.

U-5 STUDENT INTEREST SEQUENCING OF ISCS LEVEL III

Charles E. Richardson, Head of Science Department, Belzer Junior High School, Lawrence, Indiana

ISCS material? What happens when the eight units of the program are laid out for students to pick and choose? Doesn't the learning environment become chaotic? It does require some role changes on the part of the student and the teacher.

It does require a management scheme. It can become chaotic but in a rich learning environment it offers much hope

This paper reports on some of the experience gained over the past two years with this approach, success, failure, and future.

GROUP V

INQUIRY TEACHING (SECONDARY)

V-1 ASKING OPERATIONAL QUESTIONS: A BASIC SKILL FOR SCIENCE INQUIRY

Dorothy Alfke, Associate Professor of Science Education, The Pennsylvania State University, University Park

The writer has coined the phrases "operational questions" and "non-operational" questions to help unsophisticated science students become productive investigators. These terms evolved from a growing conviction that "why" questions are usually the least useful questions for children and non-science oriented students. "Why" questions (non-operational) usually solicit answers which can best be obtained from authority. Such answers are likely to result in theoretical explanations for which students lack sufficient background.

An "operational question" states or implies what one must do to seek an answer. It leads the investigator into doing something to yield knowledge which is his own. Cumulative answers to operational questions build the broad conceptual base essential for understanding theoretical and abstract answers to "why" questions.

Example: When students first study siphons they usually ask "why it works." But explanations of why have little meaning. However, beginners can generate and profitably investigate related operational questions (i.e.: Will it work with a long looped tube? What happens if we use a different liquid?). Such operational questions lead to investigations which, collectively, build meaningful background for eventual understanding of "why" siphons function.

The writer works primarily with future elementary teachers. Initially they tend to pose non-operational questions as they encounter science phenomena; seeking premature theoretical explanations, accepting them and struggling to reproduce them verbally.

However, when encouraged to generate operational questions as they investigate, more desirable behaviors become evident. Activity, involvement, creativity, positive self image, and confidence replace confusion and meaningless verbalizations. Sim[illegible] results have been obtained with elementary chil[illegible]

Teachers seeking to teach for developme[illegible] learning skills and meaningful knowledge might find that greater focus on skills of asking and pursuing operational questions is one key to success.

V-2 THE INQUIRY CURRICULUM

K. R. Ste. z, Associate Professor, University of Manitoba, Faculty of Education, Winnipeg, Canada

This work is a direct result of study and research in the area of curriculum development. A two-part format is utilized.

Part I: The purpose of part one is to report on the development of a preservice teacher education course which uses the inquiry mode of instruction to encourage prospective teachers to inquire into their own belief system and its associated teacher behaviors. The course is presented as a usable document for instructors and education students. It is structured as a one-term course of study (phase I), and a one-term student teaching experience (phase II).

Part II: The purpose of part two is to report on the methods used to determine a measure of effectiveness for the Inquiry Curriculum course of study. This was accomplished by investigating the course's influence upon a number of selected decision-making attributes of students who did and did not experience the course of study.

Results: The study identified a number of significant differences for both the experimental and the control group. Generally, the prospective teachers who experience the Inquiry Curriculum course of study are more able and or more willing to make decisions which focus upon their students and options for their students. The control group, who experienced a "conventional" methods course and student teaching experience, produced a significantly higher index of teacher focus. Members of the control group tended to focus their decisions more on themselves as teachers. The experimental course of study was generally well accepted by preservice teachers and their cooperating teachers.

V-3 BUILDING THE BRIDGES TO THE 21ST CENTURY THROUGH INQUIRY

Delivee L. Wright, Assistant Professor, University of Nebraska, Department of Secondary Education, Lincoln

BSCS teachers in Omaha and Lincoln, Nebraska, have applied a recently developed program in inquiry learning to prepare students of today for coping with the future.

The program focuses on: (a) skills to improve teacher-student communication as well as student to student communication, (b) cooperative group efforts when inquiring toward the solution of problems, and (c) development of student competencies in both the cognitive and affective behaviors of inquiry. The University of Nebraska Teachers College at Lincoln in cooperation with the Mid-continent Regional Educational Laboratory, Kansas City, developed the program over a three-year period. Lincoln BSCS and social studies teachers participated in the developmental phase and in 1971-72 Omaha BSCS teachers joined the program.

Developing inquiry skills in students begins with teachers in an Instructional Staff Development program designed to enable teachers to: (a) recognize the skills and behaviors which promote inquiry, (b) learn techniques of analyzing and of planning for appropriate behaviors, (c) practice and analyze behaviors they have identified, (d) implement the newly learned behaviors in their classrooms, and (e) assess the inquiry behaviors in terms of their planning.

Assessments of student behaviors in the classrooms of the Omaha BSCS teachers indicated not only an increase in the use of inquiry in general, but increased competencies in group cooperation, in communications skills, and in specific cognitive and affective behaviors which promoted the solution of identified problems.

The Instructional Staff Development (ISD) Program in Inquiry is a packaged program including

1. Procedural manuals for trainers working with teachers.
2. Instructional video and audio tapes.
3. Transparencies.
4. Handout materials for participants, and
5. Assessment instruments.

This package has been developed, field-tested, and is scheduled for dissemination to interested public schools or higher education institutions.

GROUP W

EVALUATIVE STUDIES (ELEMENTARY)

W-1 THE CORRELATION OF SCIENCE ATTITUDE AND SCIENCE KNOWLEDGE OF PRESERVICE ELEMENTARY TEACHERS

Robert L. Shrigley, Associate Professor, The Pennsylvania State University, University Park

Problem

The purpose o this study is to assess the correlation of (a) science attitude and (b) science knowledge of preservice elementary teachers.

Instrumentation

The Science for Concepts Achievement Test developed by Christman will be administered to assess the understanding of science concepts taught by teachers in the elementary school. *The Shrigley Science Attitude Scale for Preservice Elementary Teachers* will be administered to assess the attitude of the subjects in the study.

Design of the Study

The sample for the study will be 120 third-year undergraduates enrolled in a science education course for preservice elementary teachers at The Pennsylvania State University. The instruments will be administered by the investigator during the first week of enrollment in the course. The two scores, attitude and knowledge, will be tested by the Pearson product-moment correlation coefficient.

Assumptions and Implications

The investigator assumes that elementary teachers with a positive attitude toward science are more effective science teachers than those with a negative attitude. The investigator further assumes that a high correlation between the knowledge and attitude scores of preservice teachers could indicate that knowledge may be one of the variables that affects the science attitude of preservice elementary teachers. A low correlation between the two variables could mean that teacher educators need to explore variables other than science knowledge as a means of improving the attitude of preservice teachers toward science.

W-2 AN ASSESSMENT OF SCIENCE—A PROCESS APPROACH PROGRAM'S PLACEMENT OF CLASSIFICATION SKILLS BY COMPARING CHILDREN IN PIAGET'S PRE-OPERATIONAL AND CONCRETE OPERATIONAL STAGES OF INTELLECTUAL DEVELOPMENT

Theodore M. Johnson, Director, Curriculum Materials Center, The Pennsylvania State University, University Park

The Problem

The intention of this study is to determine how *Science—A Process Approach* program's placement of specific classification skills agrees or disagrees with Piaget's theory concerning preoperational and concrete operational stages of intellectual development.

Background

Piaget views intellectual development in children as occurring in four successive levels or stages which are invariant and cumulative. These stages include: the sensory motor; the pre-operational; the concrete operational; and the formal operational. This study is concerned with the following stages: *The pre-operational*—This stage characterizes the intellectual level of the two- to eight-year-old. A major feature of this stage is the child's attention to only one object, property, or experience at a time. His categorization of objects and experiences are on the basis of a single characteristic, such as color or shape. Because of this feature, children utilize single dimension classification strategies and can rarely verbalize logical classification strategies. Multi-classification is, thus, seen perhaps beyond the power of the child's prelogical thought. *Concrete operational stage*—at this stage a child is between eight and eleven years old. His thinking is concrete, and the use of abstractions is rudimentary. Multi-classification may be possible at this stage because dealing with part-whole relationships can be thought of in either order. The operation of reversibility also assists in performing multi-classification skills. These operations help the child deal with superordinate and subordinate classes in higher classification exercises.

Sample

A total of 80 second-grade children were initially screened using tests based on Piagetian theory. Thirty children, 15 pre-operational and 15 concrete operational were finally selected.

Procedure

The 30 students were divided into two instructional groups, each containing pre-operational and concrete operational children. Each group was presented with nine S-APA classification exercise and their prerequisites. Testing was done using the S-APA competency exercises.

Analysis of the Data

The matched T-test program at Penn State's computer center was based to compare the groups. The analysis of variances for repeated measures program checked for teacher affect and other interactions.

Results

The groups were significantly different in favor of the concrete operational groups as hypothesized on the multi-classification exercises.

W-3 THE EFFECTS OF TEACHING SCIENCE METHODS THROUGH AN OPEN LEARNING ENVIRONMENT ON SELECTED ATTITUDES AND PERCEPTIONS OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

Charles W. Mitchell, Assistant Professor of Education, State University of New York, College of Arts and Sciences, Plattsburgh

This study investigated two aspects of the science methods course for elementary school majors. The first measured the effects of three different instructional strategies of teaching science methods on selected attitudes and perceptions held by prospective elementary school teachers. The second measured the effects of these instructional strategies on childrens' interest in science; childrens' perception of teaching style, and of the teacher behavior variables of warmth, demand, and utilization of intrinsic motivation.

Three instructional strategies were developed and used as a basis for data with prospective teachers:

1. An open-learning environment allowing freedom to inquire, conceptualize, self-direct learning activities and to experience structured learning activities.
2. A formal lecture-discussion approach in a traditional, passive, inactive environment.
3. The classroom teacher situation where the prospective teacher received no treatment.

Thirty undergraduate education students were randomly selected by lottery from a total population of 40 elementary education majors slated to student teaching during fall 1971. The public school children utilized were those in classrooms of the prospective teachers. Due to the design of the instruments used in this investigation only grade levels 1, 4, 5, and 6 were appropriate.

The results of the analyzed data showed no statistically significant difference, at the .05 level, among the prospective teachers groups. The data gathered from the instruments responded to by the children, on the other hand, did show statistically significant differences, at the .05 level, relative to their perceptions of their prospective teachers and relative to science understandings.

The trends in the results, as indicated by a gain or loss in test score means within the groups of prospective teachers, do offer some evidence for intuitive clinical speculation.

The trends suggest that prospective teachers trained in an open-learning environment responded positively to instruments which measured experimentalism, open-mindedness, teacher-pupil relationships, and interest in science.

These same prospective teachers can positively affect student interest in science, student perceptions of the teacher behavior variables of demand and utilization of intrinsic motivation, science knowledge and skills, and at least sustain a neutral position relative to the students' perceptions of the teacher's style of teaching.

W-4 TEACHER RATING OF STUDENT LEARNED BEHAVIORS IN ELEMENTARY SCHOOL SCIENCE—WHAT SHOULD BE AND WHAT IS

Douglas R. Macbeth, Science Curriculum Coordinator, Lewisburg Area Schools, Lewisburg, Pennsylvania

Teachers in today's schools are increasingly concerned about preparing instructional objectives in a manner that permits an evaluation of the objectives as represented in overt student behavior. This concern has caused many teachers to reflect more critically on the types of learned behaviors that they perceive as being important for a child to exhibit. The merits of learning for simple recall or understanding and learning for critical or analytical thought are being weighed. The contribution of science teaching in the development of a youngster's attitudes and interests is also being considered.

During January 1972, 44 elementary school teachers (grades K-5) in the Lewisburg Area School District (Pennsylvania) were surveyed to determine their opinions about the importance of certain instructional objectives or student learned behaviors in elementary school science, *i.e.*, What *should* we teach or help students learn. Further, the teachers were asked their opinion of the extent to which the pupils in our elementary schools generally possess certain learned behaviors or are *now* being taught certain instructional objectives.

Sixty-two behavioral objectives, selected from elementary school science textbooks, programs, and professional books, comprised the opinionnaire. Objectives were chosen from each of the six levels of the cognitive domain and the first three levels of the affective domain.

The 44 teachers were asked to respond to each objective in two ways on an A to E Lickert-type scale. Their first response was to indicate their opinion on the "*should*" component; their second response the "*now*" component.

The results were analyzed using a discrepency measure technique; several conclusions and implications are suggested:

1. The K-5 teachers generally feel that the science teaching and learning in our elementary schools should be altered from its present condition.
2. This teaching and learning should be improved in all of the cognitive and affective levels sampled.
3. The greatest need for improvement is seen in the higher levels of the cognitive domain and in all three levels of the affective domain.
4. The total concern that teachers had for teaching and learning in the affective domain was greater than their concern for learning in the cognitive areas.

GROUP X

THE NATIONAL ELEMENTARY SCIENCE STUDY

X-1 DESIGN OF THE NATIONAL ELEMENTARY SCIENCE STUDY

Jerrold William Maben, Director, Bureau of Educational Grants, Herbert H. Lehman College of the City University of New York

No abstract submitted.

X-2 MAJOR SIMILARITIES AND DIFFERENCES IN NATIONAL TEACHING PRACTICES

Bess Nelson, Teaching Associate, Faculty of Science and Mathematics Education, The Ohio State University, Columbus

No abstract submitted.

X-3 THE CORRELATIONAL ANALYSIS OF THE NATIONAL ELEMENTARY SCIENCE STUDY

Melvin R. Webb, Associate Professor of Education, Clark College, Atlanta, Georgia

No abstract submitted.

GROUP Y

SOME SUGGESTED CONSIDERATIONS (JUNIOR HIGH)

Y-1 WHY NOT EVERYONE?

Thomas M. Baker, Science Teacher, Star Hill School, Camden-Wyoming, Delaware

A teacher is a person who arrives at an educational institution usually on time, approximately 180 days a year. What happens when that teacher enters the classroom? Does that teacher give everything he is able to give to help the students? Very seldom.

The role of the teacher in a classroom encompasses many assorted fields. A teacher's main responsibility in a classroom should be that of a motivator, but how do you really rank the many duties performed during the day? A teacher is a guide, an organizer, an evaluator, a bookkeeper, a research assistant, a moderator, and a tutor. How is one person able to assume all of these roles? Individualized instruction is one method.

Individualization has many connotations and one is an open school, no curriculum, and few guidelines for student or teacher. Individualization can mean the difference between instruction to each child at his unique ability level and force-feeding materials to a captive audience.

An educator concerned with helping all his students should be aware of the particular needs of the student and how he can best use any and all materials available. From efficient utilization of all educational areas in a school situation to student evaluation and selection of materials, the educator must be aware of their needs and try to meet them.

The main advantage to the student is the challenge that each student receives. No matter what the individual ability level each student should meet with work that is within his grasp but that he still must reach for.

Individualization necessarily causes more planning for an educator, but reaps its rewards through student success and high levels of motivation.

Y-2 WHAT IS THAT IN THE EYE OF THE BEHOLDER?

Kathryn J. Beam. Assistant Professor of General Science, State University College. Buffalo. New York

A study of Western New York Junior High School science classes attempted to provide some evidence as to whether teachers and students intend. perceive. and exhibit classroom interactions differently and the role of feedback in reducing any differences. Special reference is devoted to the effect of such differences on the meeting of educational objectives and the development of curriculum.

Other questions considered include:

1. What may account for the lack of display of classroom interaction patterns espoused by certain curricula?
2. Do teachers intend or perceive classroom interaction differently from their students?
3. What types of classroom interaction are difficult for teachers or students to perceive accurately?

Y-3 HAVE WE COPPED OUT ON THE PREPARATION OF JUNIOR HIGH SCHOOL SCIENCE TEACHERS?

Kenneth R. Mechling. Associate Professor of Biology and Science Education. Clarion State College. Clarion. Pennsylvania

More pupils study science in grades 7. 8. and 9 than in all the senior high school science courses put together. Yet, statistics released by the Pennsylvania Department of Education show that during the 1969-70 school year Pennsylvania's teacher education institutions produced five times more biology teachers than general science teachers—a gross imbalance between supply and demand for science teachers.

Even more disturbing were the findings of a recent survey of junior high school science teachers in western Pennsylvania. The study revealed that most junior high school science teachers had majored in undergraduate programs *not* specifically designed to prepare them for their jobs.

Although science has been a part of the junior high school curriculum for half a century, teacher education programs have traditionally ignored the preparation of science teachers specifically for the junior high school level. It's high time something is done about it.

Colleges and universities must accept the responsibility for developing preservice and inservice science teacher preparation programs specifically for the junior high school level. These programs must have staff and resources that are on a par with those now available for the preparation of biology, chemistry, and physics teachers.

State and national agencies must develop. publish. and enforce accreditation guidelines and certification standards for the preparation of competent junior high school teachers of science. The practice of certifying *any* science major to teach junior high school science must be stopped.

Professional organizations such as NSTA and AAAS must vigorously support undergraduate and graduate teacher education programs for junior high school science teachers. They must provide the stimuli for overcoming the inertia of past practices.

Junior high school science teachers have been prepared by default rather than design. It is now time to reverse the process.

Y-4 MIDDLE-JUNIOR HIGH SCHOOL SCIENCE FOR 1970'S AND 1980'S

John F. Reiher. State Supervisor of Science and Environment. State Department of Public Instruction. Townsend Building. Dover. Delaware: and Thomas M. Baker. Science Teacher. Star Hill School. Camden-Wyoming. Delaware

When Sputnik was launched in the late 50s. science assumed a new prominence in education. Since that time accelerating change and rapid growth have characterized all areas of education. and in particular. the field of science education. The area of greatest concern is the middle/junior high school.

We are witnessing an explosion of knowledge. and yet we are still on the frontiers of new scientific discovery. The big questions that come to an educator's mind are: How do we prepare our teachers to meet these new challenges? Do we need emphasis on the content areas? Do we need emphasis on the methodology of science teaching? Other questions to consider are: How well are we teaching science? What are we teaching in science? How well have we evaluated what is going on in science?

A number of basic changes in the philosophy of science education have gained prominence in recent years: more student centered activity. more individualized instruction. use of the inquiry method. etc. It is an experiential fact that in a specified act of teaching. a new environment is created and in responding to the new environment. a learner gains abilities not achieved through prior experience. but which are specified in the given art of teaching.

We are no longer concerned with the facts but rather the concepts: not information but experimentation; not teacher demonstration but teacher directions; not rapid procedures but flexibility: not conformity but creativity; not learning situations but problem-solving; not telling but hypothesizing: not learning rules but learning how to learn; not observation but participation.

All these terms have become the slogans. not only of the philosophy of science education, but also of all major areas of education. Since experiments with the physical. chemical. biological forces have helped to shape students' lives and influence their destiny. it can be assumed that the primary purpose of science education is to develop individuals capable of such independent thought and action as to be self-directive and self-educated.

GROUP Z

INDIVIDUALIZED INSTRUCTION: DETAILS AND DANGERS (ELEMENTARY-COLLEGE)

Z-1 DIAGNOSTIC AND PRESCRIPTIVE ASPECTS OF INDIVIDUALLY GUIDED EDUCATION

V. Daniel Ochs, Assistant Professor, Miami University, Oxford, Ohio

For many years educators have been attempting to educate the masses while meeting the needs and interests of the individual. Techniques, methodologies, and mechanics were all lacking, however, we seem to be drawing closer to the goal of individualization as each of these problem areas has been solved. Today, individualization is nearing reality, yet many teachers are not prepared for the next step: assessing what has and what has not been learned and prescribing the necessary remedial steps.

This paper describes the techniques used at the McGuffey Laboratory School in diagnosing learning needs, in considering student interests, and in prescribing remedial steps, if any are necessary. Extensive use of packets, programmed instruction, various packaged materials, and a well-equipped media center free the teacher from the front of the classroom. The time saved is spent in meeting with students, evaluating their work, locating their interests, and then prescribing future activities which will provide the necessary opportunities for learning.

Z-2 DANGERS RELATED TO THE MISUSE OF OR LACK OF PLANNING FOR INDIVIDUALIZED SCIENCE INSTRUCTION

J. Truman Stevens, Assistant Professor of Science Education, University of Kentucky, Lexington

Frequently, schools and school systems become enamored with change for the sake of change. As a result, we often adopt a "new idea" or program with little or no prior planning. Too little consideration is given to the applicability of the "innovation" in a given situation and its relationship to curricular objectives. Due to this lack of planning and subsequent misuse of a "new idea," new problems are often created. Thus, the creative work of a given classroom teacher or school district fails to become the "godsend" for other teachers and other school systems.

In light of the above discussion, this paper will consider selected approaches to individualizing science instruction and examine some of the problems which are commonly associated with the implementation of these approaches. Special consideration will be given to questions dealing with a possible conflict between the increased use of certain types of individualized instruction and the inherent structure of many of the scientific disciplines.

Z-3 INDEPENDENT RESEARCH PROJECTS—A PRACTICAL MEANS OF INDIVIDUALIZING INSTRUCTION

Stephen A. Henderson, Assistant Professor of Science, Supervising Teacher, Eastern Kentucky University, Model Laboratory School, Richmond

Independent research projects can add dimension to any science curriculum. Very often the "project" becomes the most meaningful part of the student's science program and serves as motivation for future scientific pursuits.

Independent research projects fit into any type of curricular or scheduling pattern, and only time and student imagination curtail the output. Research projects can play a major role in contract science courses, phase-elective curricula, and open classrooms as well as bolstering existing traditional approaches.

Teachers are often reluctant to encourage independent projects due to previous encounters with noncompletion, student frustration, and the extra effort required on their part. However, the pitfalls of independent study can generally be identified and eliminated prior to undertaking the activity and the resulting product is well worth any extra time. Most problems, such as identifying a challenging, yet reasonable topic, locating materials and equipment, and receiving adequate consultant help can be overcome with teacher student pre-planning and resourcefulness.

Independent study comes closest to the actual activities of a scientist. The quality of independent work in a school may very well be the measure of success of the total science curriculum.

GROUP AA

INSTRUCTIONAL MATERIALS (K-12)

AA-1. THE USE OF TOYS IN THE TEACHING OF SCIENCE: A UNIT FOR TEACHERS

Mitchell E. Batoff, Associate Professor of Science Education, Jersey City State College, Jersey City, New Jersey

The use of toys in the teaching of science can be traced back to the 1890s in Germany, when "science teachers produced a complete series of miniature toys with which to demonstrate the basic principles of physics through home experimentation" (Meister). Since that time a number of distinguished educators, scientists, and entrepreneurs have developed and used toys or quasi-toys for educational purposes. Among those who have worked in this field are St. John, Porter, Gilbert, Woodhull, Meister, Lynd, Lunt, Zim, Joseph, Taplitz, Miller, Roskin, and Ruchlis.

Despite the long history of toys in science teaching, there has never been a teacher's guide or modular unit developed on the subject until 1972. As part of this presentation the author will expose the audience to a recently published unit, "Science from Toys," developed in Britain by Don Radford and the Staff of the Science 5/13 Project.

Also to be used in the presentation are an assortment of scientific toys from the author's extensive personal collection (accumulated over four decades).

AA-2. VIDEOTAPED MINI-LESSONS FOR ELEMENTARY SCIENCE TEACHING

Donald J. Schmidt, Associate Professor of Science Education, Fitchburg State College, Fitchburg, Massachusetts

A series of short (three-minute) videotaped science lessons were developed by students and used at the elementary school level (K-6) to introduce a full-length science lesson and then were followed by a 30-minute science activity in the classroom. The presentations used a wide variety of simple equipment, materials, and visuals to present a single idea or concept. Both video and sound are on the mini-lessons.

Examples of mini-lessons include:

1. Carbon Dioxide Production During Exercise
   Students demonstrate phenolphthalein titration method of determining CO_2 in breath, before and after exercise.

2. Balance, With and Without Eyesight
Videotaped demonstration of the ability to perform tasks requiring balance with and without a blindfold.
3. Protein in Daily Diet
Actual foods high in protein content are used along with charts to develop the idea of including adequate amounts of protein in daily diet.
4. Body Temperature
Visuals are used to indicate normal body temperature, actual demonstration of proper use of oral thermometer in taking body temperature.
5. Structure and Function of Lungs
Live demonstration by student of chest movements during breathing. Models are used to illustrate the basic function of lungs, diaphram, and trachea.

Other mini-lessons include: (a) Reflex Action, (b) Anatomy and Function of Joints, (c) Coordination.

AA-3. TEACHER, LET ME DO IT MYSELF

Joyce Swartney, Associate Professor, Buffalo State University College, Buffalo, New York

With the increase of open classrooms in western New York the students enrolled in Laboratory Techniques for Elementary School Teachers have seen the need for materials that a child can use in a science interest center. These teachers have developed materials for children to use with little personal teacher-direction. These materials may be individualized materials developed from any of the existing elementary or junior high school curricula or they may be developed independently by the teacher.

The graduate students who have developed these materials are *not* science majors. This presentation discusses their personal experiences in developing the activities, the use of the materials in the classroom, and the students' reactions to the materials.

AA-4. SUPPLYING ELEMENTARY AND SECONDARY SCHOOLS WITH SCIENCE KITS AND MATERIALS VIA THE OSACS SCIENCE CENTER

J. Bruce Holmquist, Director; and Jack Head, Science Education Specialist; OSACS Science Center, Gretna, Nebraska

and

AA-5. LIVE MATERIALS BANK FOR ELEMENTARY AND SECONDARY SCHOOLS

Joe Pinkall and Gary Brown, Science Education Specialists, OSACS Science Center, Gretna, Nebraska

The Omaha Suburban Area Council of Schools (OSACS) Science Center is a Nebraska ESEA Title III Project serving seven school districts which include more than thirty-seven thousand students. Slide tape presentations outline the development, organization, and operation of a live materials bank which supplies the schools with science kits and materials.

Cost benefit data are presented to encourage other schools to adopt these procedures and operations.

GROUP BB

INTERESTING APPROACHES (JUNIOR HIGH)

BB-1. UNIQUE CAMPING AND TRIPPING PROGRAMS FOR SECONDARY STUDENTS

Larry A. Hardt, Chairman, Science Department, Valley View Junior High School, Omaha, Nebraska

The Omaha Suburban Area Council of Schools Science Center, a resource area for seven school districts, has grown tremendously in its four-year lifetime. Emphases have been on developing inservice training programs, maintaining a system-wide materials bank, and supplementing student programs not normally found in the usual school curriculum. The camping and tripping programs involve a mobile day camp program for the seventh- and eighth-graders, overnighters for ninth-graders, and extensive travel for high-schoolers.

Day camp programs involve moving students out-of-doors into local field situations: rock quarries for studies of stratification and fossil collection; flood plains and bluffs to study contrasting vegetative forms; native prairies to study life forms as they once existed throughout our area; industrial sites to visualize some of man's technological impact on his environment; and museums and historical sites to interrelate man's cultural background with his modern-day influences.

Overnight programs involve student groups canoeing down the wide shallow sand-covered rivers typical of our area, or studying the water life of a deep glacial blue water lake some two-hundred miles from our schools.

High school students trip the length and breadth of the country. During this past year, for example, students studied glaciation and alpine ecology by backpacking over the Continental Divide in the Wind River Range in the Rockies. Some journeyed to the Texas Gulf Coast, engaging in beach collection and marine investigation aboard an ocean-going floating laboratory, while others traveled to Prince Edward Island, Canada, to observe, photograph, and study last summer's solar eclipse.

All tripping programs are planned and staffed by experienced, qualified science instructors and are available for credit. They are designed to bridge the gap between the classroom situation and random family-type vacationing and balance a combination of long-term recreational skill development with high intensity field science education in a way that is both interesting and educationally rewarding for the secondary student.

BB-2. INSTRUCTIONAL FLOWCHARTING IN SCIENCE AND MATHEMATICS

Michael Szabo, Associate Professor of Science Education, The Pennsylvania State University, University Park

The act of specifying multistage processes in a logical and ordered fashion (flowcharting) has been developed and utilized by computer scientists, systems analysts, and others. Recently, educators, in attempts to systematize certain components of the educational process, (e.g., PPBS and PERT) have adopted flowcharting as a useful tool for depicting certain algorithms.

Flowcharting has recently been further extrapolated from the business-industrial world through educational administrative levels and has emerged as a useful tool in classroom instructional procedures. An instructional flowchart (IF) is a graphic method for representing an algorithm for a cognitive or psychomotor process which has a beginning, some definable path or paths to follow to completion, and at least one identifiable endpoint. This paper is an attempt to increase the awareness of public school science teachers to techniques and advantages of instructional flowcharting. Examples from actual classroom use are presented.

Instructional flowcharts (IFs) assume some of the tasks of instruction borne by the teacher. There are numerous purposes for which IFs are well suited, including the handling of classroom management details, laboratory classification functions, and decision making (problem-solving) algorithms.

Some of the potential benefits of development and use of IFs by the classroom teacher are that they

1. provide a vehicle for the teacher to be thorough and detailed,
2. provide replicable and permanent means of communication and instruction,
3. portray to the student what is expected of him (much like behavioral objectives),
4. force the student to actively participate, and
5. provide a method of increasing a student's self-reliance through reduced dependency upon the teacher.

BB-3. A RESOURCE UNIT ON POLLUTION FOR JUNIOR HIGH SCHOOL STUDENTS

Frances Weiss, Coordinator, Teacher-Life Science, Warren Junior High School, West Newton, Massachusetts

The rationale behind the development of this kit and unit was to provide the classroom teacher with a variety of materials, written and audiovisual, dealing with pollution on a local and national scale. The materials included in the kit and the purposes they serve are listed below:

1. Student pamphlets and books—can be used with whole classes or for individualized instruction.
2. Teacher pamphlets and books—provide the teacher with subject-matter background information.
3. Activity sheets—illustrate pollution concepts with laboratory activities that require little specialized equipment.
4. Reports—furnish useful local data for students and teachers.
5. Filmstrips—provide an alternative to reading about pollution.
6. Slide sets—deal with local pollution problems and recycling; make the subject matter relevant and suggest ways in which students can become actively involved in recycling.
7. Films—dramatize pollution problems and present possible solutions to these problems.
8. Games—provide opportunities for students to use their knowledge of pollution and ecology in role-playing situations.
9. Individual investigations and student projects—provide suggestions for controlled experiments and projects dealing with pollution.

Teachers probably would not want to use all of these materials with a class, since some would be repetitious. The variety of materials offered in the kit can be tailored to teachers of any "type," e.g., subject-matter oriented, activist, large group versus individualized instruction, etc.

GROUP CC

INTERESTING APPROACHES (SECONDARY)

CC-1. A ONE-SEMESTER ACTIVITY-ORIENTED COURSE IN ASTRONOMY AS A HIGH SCHOOL SCIENCE ELECTIVE

John F. Koser, Instructor, and Richard W. Snydle, Teacher, John F. Kennedy Senior High School, Bloomington, Minnesota

Elective science courses can be highly rewarding and very activity-centered. These courses can be structured around a well-defined framework of behavioral outcomes.

The semester-long elective astronomy course described includes well-structured activity-oriented packets in the following areas: telescope optics, constellation orientation, celestial coordinates, planets, comets and meteors, the earth-moon system, stars and star systems, galaxies, and solar and lunar eclipses. Students operate independently in the class between scheduled unit exams utilizing references, audiovisual materials, laboratory and field activities, and problems and questions from various sources.

Data from tests were obtained through the use of a test-analyzing computer program. Results considered were quantity and specificity of material learned. Comparisons were made to relate students' general success and academic ability, achievement and previous mathematics and science background, and general student appeal.

CC-2. UTILIZING SCIENCE VIA SPECIAL EXHIBITS IN MUSEUMS

Phil Gebhardt, Education Officer, Ontario Science Centre, Don Mills, Ontario, Canada

The program offering the greatest reward and satisfaction in our exhibit, Ham Radio station, is the involvement of school groups. Students, generally between ages 9 and 13, are invited to the Science Centre to become involved in an actual transmission to other locations. Armed with a list of questions and a tape recorder, approximately half a dozen students represent their class in a quest for first-hand up-to-date information from station operators from Newfoundland in the east to British Columbia in the west and up to Alert in the North. Some groups are involved for several visits in doing a study of Canada, whereas others come for a single session when they are interested, particularly, in a region such as the Canadian North.

The variations are almost limitless on this theme, so that we can sometimes have one school group contact a similar group elsewhere, either as a one-time effort or as a penpal relationship. Occasionally stations in Australia or Tanzania call in and offer to speak with the pupils. But these contacts are by no means limited to general background information about the area—we have helped one high school group who wanted to calculate the circumference of the earth. Contacts were made with several stations to determine the angle of the sun's rays, and thereby provide the information needed. Eratosthenes did it in the 3rd century B.C. in Egypt. We did it using science in the 20th century A.D. at the Ontario Science Centre.

At the other end of the educational level, we were able to link a group of university level sociology students with remote Northern communities to gain information unavailable elsewhere.

To all of these people science has become a tool, something they can use to further other aims.

CC-3. FROM PAPER AIRPLANE TO SST

George Vanderkuur, Education Officer, Ontario Science Centre, Don Mills, Ontario, Canada

The teaching of simple aerodynamics is a long neglected topic in elementary and secondary school programs. The Ontario Science Centre uses slides, films, and stuffed birds to first investigate how nature designed her "airplanes." From the simple flight of a dandelion seed to the spectacular soaring of an albatross, the various fundamentals of aerodynamics are illustrated.

The class then builds a series of paper airplanes which illustrate these fundamentals. The flying of the paper planes is the climax of the course and even the most reluctant students are eager to participate. Adapting this program for the needs of the classroom teacher is discussed.

CC-4. PORTA-PAKS AN EFFECTIVE TEACHING AID

William Sorenson, Education Officer, Ontario Science Centre, Don Mills, Ontario, Canada

The use of 1/2" videotape porta-paks can occupy a valid place in the modern curriculum. They are especially useful for pupils that have difficulty expressing themselves in the more traditional terms of note-keeping or direct individual-to-group verbal reporting.

Pupils as young as nine years of age can effectively use a 1/2" system. Given a TV camera that is portable and that has a built-in microphone system a student rejects our idea of TV and its ultimate use and the porta-pak becomes an extension of his eyes, mouth, and thoughts.

After one session of picture-taking most people can quickly point out their mistakes and approach the use of the camera more effectively on the second try. The limits of a TV camera and portable system are held only to the confines of the students' imagination once the basic techniques have been mastered.

GROUP DD

DD-1. THE ELSA CLUBS OF AMERICA—HELPING TO SAVE ENDANGERED SPECIES OF ANIMALS

Elaine A. Alexander, Teacher, Life Science, Hanley Junior High School, University City, Missouri

No abstract submitted.

DD-2. AN ANALYSIS OF THE LITERATURE OF SCIENCE EDUCATION

Jerry B. Ayers, Associate Professor of Education, Tennessee Technological University, Cookeville

The growth of the literature of science education has been rapid in the last decade. This growth has led to many changes in the scope of journals and the addition of new journals. The purpose of this present study was to analyze nine journals, that are highly related to science education, with regard to such factors as who are the authors, the type of articles being published, and the scope of articles.

All issues of the nine journals published in the calendar years of 1970 and 1971 were included in the study. Frequency counts were made of such factors as the number of articles in each journal specifically related to preschool and elementary science education and research and history of science education. Analyses were made of the employers of the authors of the articles and the geographic area in which the author was employed.

Results of the study showed that the nine journals contained a total of 2,092 articles during 1970 and 1971, that were an average of 3,000 words in length. About twenty-five percent of the articles were related directly to preschool, elementary, or junior high science education. The remaining articles were divided about equally between secondary and college science teaching and a category of miscellaneous articles. About thirty-five percent of the articles were related directly to the application of methods of teaching science and thirty percent to either research in teaching or pure research. The remaining thirty-five percent of the articles were divided between such categories as philosophy and history of science education. Over seventy-five percent of the articles were prepared by authors associated with more than four-hundred different colleges and universities. Based on the geographic divisions of NSTA, the largest percentage (17 percent) of the authors were employed in Region II. The smallest production of articles was from Region XI.

This study of the literature of science education has implications for future publication of articles in the area of science education. It appeared that some areas of concern have been neglected and that other areas have been overworked.

DD-3. COMMUNICATION DYNAMICS

Laurie Fountain, Education Officer, Ontario Science Centre, Don Mills, Ontario, Canada

This program deals with the problems involved in communicating simple concepts from one intelligence to another. Based on concepts developed by Piaget, Cherry, and McLuhan, it allows analysis of communication processes and communication breakdown. The program consists of an introductory lecture and a practical communications laboratory situation.

In the lecture session, children are introduced to the problems of communication and are given the opportunity to participate in experiments demonstrating the principles and inherent problems of communicating. Some concepts used are the one-way communications technique employed by NASA in developing the Pioneer 10 spacecraft message to hypothetical aliens, as well as the earthbound problems that have produced communication gaps. Selected topics in linguistics, logic, mathematics, and principles of information flow are discussed prior to the laboratory activities.

The laboratory program is designed as a problem-solving situation where the children are challenged to apply their new knowledge in communicating information, they consider relevant, to a second party located in a duplicate lab. Various modes of communication are available, excluding voice transmission. Thus, the development of information coding and decoding principles in the child's mind occurs as a natural part of the laboratory situation. The potential for discovery is limited only by the ability of the children involved.

Demonstrations as to how this program is being presented at the Ontario Science Centre and a comprehensive outline showing how a similar program could be used in the classroom situation are part of the program.

DD-4. WHAT'S MISSING? IMPLEMENTATION

William Phillips, Director, Habitat, Inc., Belmont, Massachusetts

Modern higher education does a reasonable job in helping students identify problems and a credible job in helping them generate solutions. It has failed miserably, however, in teaching anyone how to implement solutions.

The result—drop outs, demonstrations or disillusionment. The classroom is a center for ideas, but lacks the practical knowledge of the market place which is necessary to implement ideas.

Scientists have been particularly troubled by the so-called misuse of their discoveries. This arises from an appalling lack of implementation-training.

The author presents some techniques for establishing implementation training.

DD-5. A COOPERATIVE COLLEGE-HIGH SCHOOL PROGRAM FOR ADVANCED HIGH SCHOOL CHEMISTRY STUDENTS

Gary A. Greening, Chairman, Science Department, Jefferson Senior High School, Division of Technology, Bloomington, Minnesota

The advanced chemistry program at Jefferson Senior High School in Bloomington, Minnesota, is a cooperative program in chemistry between the high school and the Augsburg College Chemistry Department in Minneapolis, Minnesota. The main objective of the program is to enhance the advanced chemistry program in the high school by introducing new experiments and concepts that are not now a part of the course during visits to the college by the high school students and their teacher.

The sessions at the college include lectures, problem discussion and experiments on topics such as gas chromatography, visible and infrared spectrophotometry, and electrical-analytical methods. After introduction and some basic experiments students are encouraged to bring samples of their own choosing for analysis.

GROUP EE

EE-1. CUYAHOGA RIVER WATERSHED PROJECT—A NATIONAL DEMONSTRATION PROJECT FOR ENVIRONMENTAL EDUCATION AND SERVICE

Joseph H. Chadbourne, President, and Deborah Lloyd, Adjunct Instructor, Institute for Environmental Education, Cleveland, Ohio

The Cuyahoga River Watershed Project, begun in July 1972, is the largest single Project funded by the Office of Environmental Education, and it is designated a National Demonstration Project, one of only two in the country.

This Project is a regional environmental *education and service* program with nine member school systems, including Akron and Cleveland Public Schools plus several service agencies, including the State of Ohio Three Rivers Watershed District and the US Army Corps of Engineers.

It is co-sponsored by the Cleveland Health Museum and Education Center, Cleveland State University and the Institute for Environmental Education—the successor to the former Ford Foundation and Department of Interior funded Tilton Water Pollution Project. IEE conducts an inservice Master's of Environmental Science course series with a mobile faculty of professionals, college graduates, undergraduates, high school students, and ACTION personnel who work with teacher trainees in their own respective schools.

As a result of the first few months of the three-year Project, teachers and students are studying and working to supply information to many regional agencies, expanding the career skills of students and becoming trainers of other teachers and students in their own and neighboring schools, libraries, and community associations. This regional *education and service* model is being examined by other regions. The first two volumes of their written activities are being published by GPO later this year.

EE-2. AN APPRAISAL TECHNIQUE FOR ESTABLISHING AN ENVIRONMENTAL PROGRAM

Patricia M. Sparks, Instructor, Temple University, Philadelphia, Pennsylvania; and John T. Hershey, Environmental Specialist, Project KARE, Blue Bell, Pennsylvania

The necessity for concern about the rapidity of environmental deterioration has been voiced by several writers in the past few years. As education is seen as a major key to solving our environmental problems, many people have attempted to establish working environmental programs.

In planning an environmental program three dimensions must be considered, assuming that the program can be tailored for any size group: that is, a small group of students, a class, an entire school, community or region could be involved in your environmental program. The three dimensions can be phrased as:

1. Where are you—rural, suburban, urban?
2. With whom and what are you working—students, teachers, administrators, community, resources (human and material)?

3. How do you proceed—operational (problem studies), transition, awareness?

EE-3. ECOLOGY FIELD WORK DURING WINTER

James E. Murphy, Research Assistant, The University of Iowa, Iowa City

This lecture-slide presentation will be designed to expose teachers to some basic techniques for collecting ecology data with their students during the winter months. Consideration will also be given to the interpretation of field information collected. All activity is designed for use in parks and vacant land that exists around most schools. Specific areas to be covered are:

1. Methods to record the temperature above, at, and under ground level. This information will be related to the winter survival of plants and animals.
2. Readings for wind speed, the wind chill factor, and its effect on living things.
3. The intensity, distribution, and role of sunlight in the winter environment.
4. How to study and observe hibernating animals in the laboratory and field.
5. Field techniques for investigating animal life that is active during the winter months. Emphasis will be placed on the organism's food sources and the selection of living areas.
6. How to survey active and passive plant life. Special consideration will be given to seeds, plant remnants and plants that are green during winter.
7. The nature of snow and ice. The emphasis will be on snow and ice measurement as well as the environmental conditions that produce them and how they in turn have an impact on other living things.
8. A look at how pollution affects a frozen environment.
9. How to put the winter ecosystem together.

EE-4. THE DEVELOPMENT OF MINICOURSES IN ECOLOGY

John O. Towler, Associate Professor, Department of Education, Purdue University, Lafayette, Indiana

Class work on the environment and man's effects upon it is becoming more popular as our awareness and concern grows. However, since few, if any, school systems have courses specifically devoted to environmental education, there is a great deal of confusion as to where and how to introduce units on the topic into existing curricula. In the absence of a specific "slot," teaching about the environment tends to be rather "hit and miss" depending upon the teacher's knowledge, interests, and energy.

A better and more practical method for dealing with this subject is the creation of minicourses which can be used by individuals, or small groups of students. Each course is audiotutorial in nature and gives the student accurate background information about a specific area, poses a problem for investigation, and then outlines and demonstrates the investigative procedure to be followed. The courses consist of audio tapes, filmstrips, and worksheets and cover topics relevant to teachers in chemistry, biology, physics, and general science classes. Each course takes from one to ten days to complete and has the advantages of: supplying background information not readily attainable to the teacher, helping students set up experiments and reports without demands upon the teacher, and enabling the teacher to be extremely flexible in his choice of how the course shall fit into the regular course of study.

EE-5 ENVIRONMENTAL EDUCATION ACTIVITIES FOR SCIENCE CLASSES

David L. Branchley, Professor of Environmental Engineering, Purdue University, West Lafayette, Indiana

Environmental education activities which are to be used in science classes were developed during the past three years. These include units on air, water, noise and land pollution. During spring of 1972, 18 units were field-tested by about one thousand children in the Chicago and northwest Indiana areas. Results of this field study and remarks from teachers and children regarding the effectiveness and acceptability of the method and materials will be presented.

GROUP FF

INQUIRY TEACHING (SECONDARY-COLLEGE)

FF-1. PATTERNS OF ENQUIRY: MODULAR UNITS IN HOMINID EVOLUTION

Geraldine A. M. Connelly, Biology Head, St. Joseph's High School, Toronto, Ontario, Canada

We believe that a curriculum is effective if it fosters in people the outlook and habits of thought that encourage independent learning This is the central aim of the Patterns of Enquiry Project at the Ontario Institute for Studies in Education, which seeks to humanize instruction in science through classroom discussion that centers on the more enduring aspects of science-i.e., on the nature of scientific enquiry, and on how enquiry functions in establishing scientific knowledge.

The Project had its origins in workshops for science teachers that have been held at OISE since the summer of 1968. In these workshops, the teachers are provided with the conceptual framework and the skills useful in developing enquiry curriculum materials. They examine and discuss "Enquiry into Enquiry" (a teacher education film on the enquiry method of learning), study original research papers in science, writings on the history and philosophy of science, textbooks, case histories, biographies, enquiry-oriented films and film-loops, and selected science fiction stories. They also construct short units of discussion-based curriculum materials, which they are expected to use in their classes during the following school year. Most of the materials that have been developed in the Patterns of Enquiry Project originated as projects in these workshops. To date, the Project team has produced a film and user's manual, four major discussion units (each divided into modules), one puzzle, and one game. In addition, preliminary work has begun on the use of science fiction literature. These experimental materials are currently being used in a variety of schools and are undergoing evaluation.

This paper gives a description of the theoretical structure of a series of instructional units (The Role of

Paleontology in the Formulation of Theories of Hominid Evolution). Special attention is given to competing theories and their corresponding sources of evidence using casts of fossils finds, especially skulls of teeth.

Aspects of classroom teaching, student responses and the place of these units in a half-year course in Evolution are discussed.

FF-2. PATTERNS OF ENQUIRY: TEXTUAL ANALYSIS OF A UNIT IN ANIMAL BEHAVIOR

Richard W. Binns, Research Assistant, Ontario Institute for Studies in Education, Toronto, Ontario, Canada

This paper deals with another unit of the Patterns of Enquiry Project at the Ontario Institute for Studies in Education. Various sections of a classroom discussion unit (Honey Bee Communication: An Enquiry into Two Conceptions of Animal Behavior) with particular reference to the goals and orientation of the unit, the structure and format of the textual materials, and suggested ways of using the unit are analyzed. The textual analysis is directed toward the practical aspects of implementing an enquiry unit. However, brief considerations concerning the philosophical basis of this approach are made.

FF-3. PATTERNS OF ENQUIRY: A PRACTICAL TECHNIQUE FOR SMALL GROUP DISCUSSIONS IN LARGE CLASSES

Stewart A. Robinson, Research Assistant, Ontario Institute for Studies in Education, Toronto, Ontario, Canada

This paper describes experiences in the use of a discussion technique for large classes detailed in a unit of the Patterns of Enquiry Project at the Ontario Institute for Studies in Education. The textual material used was the unit, The Role of Paleontology in the Formulation of Theories of Hominid Evolution. Consideration is given to the place of the discussion unit in the context of a high school science curriculum.

GROUP GG

SCIENCE FOR THE MENTALLY HANDICAPPED

GG-1. THE USE OF MOTOR ACTIVITY IN THE DEVELOPMENT OF SCIENCE CONCEPTS WITH MENTALLY HANDICAPPED CHILDREN

James H. Humphrey, Professor of Physical Education, University of Maryland, College Park

The idea of motor activity learning is not new. In fact, its origin can be traced to the Froebelian kindergarten around 1830. In the present context motor activity learning refers to things that children *do* actively in a pleasurable situation in order to learn. This suggests that motor-learning activities can be derived from basic physical education curriculum content. Thus, motor-activity learning might also be referred to as the physical education learning medium.

The opportunities for science experiences through physical education are so numerous that it would be difficult to visualize an activity which is not related to 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.

The way in which motor activity learning is used to teach science involves the selection of a physical education activity in which a science concept is inherent. The activity is taught to the children and used as a learning activity for the development of the science concept. An attempt is made to arrange an *active* learning situation so that a concept is being acted out, practiced, or rehearsed in the course of participating in the physical education activity.

The underlying theory of this approach to learning is that children, by their very nature, are movement-oriented and live in a "movement world" so to speak. Thus, when engaging in such a learning experience the development of the concept becomes a part of the child's physical reality. He is involved in an enjoyable concrete experience rather than an abstract one, which is an important consideration when dealing with the mentally handicapped child.

Our research over the years has built an objective base under this hypothetical postulation, and our experiments with mentally handicapped children have been most gratifying when this approach to learning is used.

GG-2. A PILOT SCIENCE CURRICULA FOR EMR (EDUCABLE MENTALLY RETARDED) CHILDREN EMPHASIZING CHILD-CENTERED ACTIVITIES

Dave Brotski, Curriculum Coordinator, Riverview School, Manitowoc County, Manitowoc, Wisconsin

Riverview School is a central facility providing educational services for approximately three-hundred and fifty mentally handicapped children. The school, with its open concept design and multi-unit approach, provides services to a population of 20,000 students in grades K-12 from five participating school districts in Manitowoc County, Wisconsin.

In April 1972, a proposal was granted under Title VI-B of the Elementary and Secondary Education Act to develop a science curriculum for EMH (educable mentally handicapped) children attending Riverview School. During the following summer a four-week workshop was held to begin work on the curriculum. The five participants in the workshop were the unit leaders from Riverview School representing all age levels of students at the school.

The workshop participants developed a philosophy of science that reflected our concern with helping the individual child become interested in and aware of the immediate world in which he lives, and to relate himself to it and become better adjusted in it. To accomplish this, it was felt that the mentally handicapped child must be prepared and taught with the awareness of his particular need to develop independent thinking skills. In turn, this could be best accomplished in an activity-centered approach, emphasizing direct experiences, giving the child the opportunity for socialization, discussion, and the trying out of his ideas on his peers. Such experiences will broaden and improve the child's self-concept.

The workshop also provided an opportunity to look at many of the new science materials available and to look more closely at the science materials already in the school. Many of the Elementary Science Study Kits have been purchased and are being used in our program. These ESS kits have helped to implement our science philosophy of active student involvement with an emphasis on the processes of science.

GG-3. SOME SCIENCE IDEAS FOR THE MENTALLY RETARDED

Lloyd M. Bennett, Professor of Science Education, Texas Woman's University, Denton

There is a definite need to include adequate science training in the academic teacher-in-training programs for the various types of special education students learning to be teachers of mentally retarded, physically handicapped, etc ; if these students are to have a well-balanced educational background when they enter the public school classroom. It is even more important for the special education student to learn something about science in a balanced, integrated behavioral program of education if he or she is to be a contributor in society as well as a user.

A limited number of science programs developed at Texas Woman's University have been tried in various types of special education classes around the Dallas - Fort Worth - Denton area. The curricular programs discussed have been developed mostly by undergraduate students, with a few being developed by graduate students who are teachers in one of the area public school systems. There is some concrete evidence (data) to support the contention that science is applicable as an academic area for the various special education classes and that special education students can and do learn science.

Each curricular program that has been developed and implemented in the classroom followed this format, generally: (a) rationale/overview, (b) behavioral objectives (cognitive, psychomotor, and affective domains), (c) concepts in science, (d) activities/experiences/experiments, (e) pre-assessments in many cases, (f) initiating and culminating activities in most cases, (g) audiovisual materials, (h) references, and (i) often a post-assessment.

Some of the science topics that have been developed into curricular materials for special education as well as a few of the "more or less" standardized new science curricula that have been purchased and adapted to special education groups include: soil, weather, your body—it grows and changes, seeds and plants in the Spring, magnets, animal behavior, ocean, light and color, sound, the fly (WIMSA), AAAS-K package, SCIS. The teacher need not have a background of depth or sophistication in science to teach science to special education youngsters; just a real desire to learn with them and to try new ideas and innovations.

GG-4. BSCS LIFE SCIENCES FOR THE EDUCABLE MENTALLY HANDICAPPED

Manert Kennedy, Associate Director, Biological Sciences Curriculum Study, Boulder, Colorado

The Biological Sciences Curriculum Study has developed *Me Now*, a life sciences program for educable mentally handicapped youngsters in the intermediate group (11-13 years of age), and is developing *Me and My Environment* for the junior high EMH youngster (13-15 years old). To help compensate for the various learning disabilities characteristic of this population, the materials use a multi-media approach that permits the students to participate in all sensory areas and provides for built-in redundancy and overlearning in a manner that greatly lessens the disinterest inherent in unimaginative drill.

One of the objectives in the "Digestion and Circulation" unit of *Me Now* states, "Students will associate the circulation of blood with heart action and pulse." To accomplish this objective, the students listen to their own heart beats, and locate and feel their own pulsebeats. They watch a filmed sequence of a human heart beating during open chest surgery, locate the pulse and surging of blood through an arteriole in a motion microphotograph and observe and feel the flow of "blood" in a functioning torso model as they squeeze the model's heart. They describe their understanding of the relationship as they look at a daylight projection slide of any of a number of pulse locations and assess their understanding through questions that are visually and verbally presented in a multiple four-choice format.

The "hands-on" varied-approach philosophy of the program has been highly successful. Teacher feedback on this particular objective is typical of those in which the multi-media approach was used; for example, "These devices aided even my slowest (students) in discussing the questions freely and in a knowledgeable manner." Success is indicated further by the fact that most teachers felt that 75 percent of their students were able to perform all of the behaviors asked for in reaching the objective. In addition to the subjective indications of success, all objective measures of the various pretest/posttest assessments, including multiple stepwise regression analysis, item analysis, biserial correlations, and residual gain scores, indicated significant learning.

GROUP HH

UNIFIED SCIENCE (ELEMENTARY)

HH-1. HOW SCIENCE AND MATH COOPERATE

Alan J. Holden, Consultant, Educational Development Center, Newton, Massachusetts

Mathematics is about what goes on in the head, and science is about what goes on in the external world. But their methods are both invoked in the solution of many problems, and hence there is much reason to mix them in elementary instruction. The reason is exemplified in the problems of counting corners on polyhedra, making five-sided dice, and making solids faced by triangles.

HH-2. USMES: PROBLEM SOLVING IN THE ELEMENTARY SCHOOLS

Robert M. Farias, Teacher, Adams School, Lexington, Massachusetts

My paper deals with actual experiences of elementary school children with USMES materials. These experiences revolve around specific problems children were confronted with and how they went about finding solutions to these problems. Major emphasis is placed on problems related to the following two USMES units: Pedestrian Crossing and Soft Drink Design.

In addition the paper evaluates the criteria used in selecting USMES units as to their relevancy and workability in the elementary schools. These criteria are:

1. Attainable results—each challenge is practicable in that it allows students to reach some results within the time and resources available to them.
2. Academic Achievement—each problem has the potential for a substantial amount of the acquisition of facts and scientific concepts, and also for mathematical structuring appropriate to the ability level.
3. Interdisciplinary Nature—problems selected have a large amount of overlap between the natural and the social sciences, and different aspects of math.
4. Long-Range Nature—long hours are available to permit the important process of investigation to take place, and the student is able to exercise options or build on a series of models.

HH-3. USMES AND THE PRESERVICE TEACHER EDUCATION PROGRAM: A MODEL FOR CHANGE

David H. Ost, Associate Professor of Science Education, California State College, Bakersfield

California State College, Bakersfield, became associated with the Unified Science and Mathematics for Elementary Schools project in fall 1971. At that time it was the first school in a pilot program to educate preservice teachers of elementary schools in the rationale and approach of USMES. The preservice teachers were schooled sufficiently in the materials to use them during their student teaching experience.

A common problem facing any new approach to teaching is one of acceptance by the inservice teacher. This was of particular importance in our case since student teachers were being trained in an open, hands-on approach to science and mathematics teaching in the elementary schools which was not in full agreement with the conservative philosophy of many teachers who serve in the master teacher role. It was decided to face this problem with the development of a model which included all aspects of our teacher education program. The focus being upon implementation of innovative teaching strategies and materials. Essentially the model has four components:

1. We endeavor to provide the prospective elementary school teacher with experiences in learning science, mathematics, and social science in an open environment. In addition, we attempt to provide prospective teachers with skills related to the teaching of these disciplines in a unified manner stressing student-centered activities.
2. Efforts are made to identify and prepare master teachers for supervisory roles. It is particularly important that the master teacher understand and appreciate the program which the preservice teacher completed and understand USMES activities, in general. This necessitates providing the master teacher with experiences in unified science, mathematics, and open learning environments. Emphasis is not only on developing teaching strategies but fostering a tolerance to allow the preservice teacher to try these various approaches.
3. One of the main problems encountered was that the master teacher did not have sufficient guidance in developing an open learning environment for science, mathematics, and social science. Assistance was provided to the master teacher so that if he or she was so inclined USMES units could be tried in his or her classroom. The prime ingredient appears to be one of support, both emotionally and physically, with the provision of science, social science, and mathematics manipulatives.
4. An effort is made to match student teachers with master teachers based on factors suspected to be related to success in a student teaching experience. Three such factors are rigidity, dogmatism, and self-actualizing abilities.

In all phases of the program, emphasis is on the rationale of the USMES program. Preservice and inservice teachers go through at least two of the units to see for themselves the requirements for independent thinking and problem solving placed upon the student.

GROUP II

TOTAL EDUCATION IN THE TOTAL ENVIRONMENT

II-1. TOTAL ENVIRONMENT-SCHOOL-COMMUNITY WORKSHOPS

William R. Eblen, Executive Director, Total Education in the Total Environment, Wilton, Connecticut

Total Education in the Total Environment (TETE), Wilton, Connecticut, and The Center for Curriculum Design, Evanston, Illinois, are conducting nine regional EE workshops involving an average of 24 key EE and community resource leaders from each of the 50 states.

The Total Environment School-Community (TES-C) Workshops are designed to be useful for the following individuals/organizations who are directly concerned with environmental education, or who have a significant environmental responsibility or impact:

1. State Department of Education
2. Local/state/federal agencies
3. Business/industries/professions
4. Teacher-educators
5. Teachers/professors of environmental subjects, K-adult
6. Students (high school, college, graduate, at large)
7. Directors of local/state/federal funded EE projects and programs
8. Community resource leaders (youth, civic, and environmental organizations)
9. School officials and administrators
10. Environmental designers
11. Environmental activists

Systematic attempts are made to invite individuals from each of these constituencies to each of the workshops.

The objectives of the workshop are:

1. to expose participants to EE approaches which focus on School-Community interaction within a Total Environment perspective, engaging students (K-adult) in direct research, study, and problem-solving in the social and natural environments of

their immediate community:

2. to motivate participants toward local as well as statewide applications of Total Environment-School-Community approaches to EE.

The TESC Workshops are not an end in themselves. Participants in each of the Workshops receive significant feedback from other Workshops as well, and will have the opportunity to participate in a continuing Environmental/Education network of, eventually, international scope. The ultimate goal of this networking project is the development of a computer-facilitated system of information exchange among all network participants.

II-3. A TOTAL COMMUNITY PROGRAM

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

We believe that mounting socio-economic-environmental problems and issues have reached such proportions that we are in critical need of effective systems-approaches of similar magnitude to achieve acceptable solutions.

The major objectives of the Total Community Program are:

1. To improve the structure for information storage and processing (projects 1-5, and 8);
2. To marshall facts and generate new information (projects 6-8);
3. To communicate the above, initially at the community level and later among communities (projects 9 and 10);
4. To encourage student learning through participation (projects 1-10);
5. To accomplish the above inexpensively.

The projects in the Program are:

1. Community resource personnel, community resource groups and agencies, and community problems and issues which all handle inventory for storage, retrieval, and school-community use.
2. Learning experiences, and instructional materials which both deal with inventory, evaluation, and storage for retrieval and educational use.
3. Development of new learning experiences and instructional material based on identified need.
4. Goals for Madison.
5. The SEESM, a computer-based total community Socio-Economic Environmental Systems Model.
6. The SEESM Game, a total community Socio-Economic Environmental Systems Model game simulation.
10. Implementing the school-community communications network.

II-2. INTERNATIONAL IMPLICATIONS OF TOTAL EDUCATION IN THE TOTAL ENVIRONMENT

Ruth A. Casey, Executive Secretary, Total Education in the Total Environment, Wilton, Connecticut

Total Education in the Total Environment was established in Wilton, Connecticut, in 1964, to provide a blueprint for the redirection of any curricula through a "Total Environment Approach to Learning."

In 1970, TETE was awarded a grant by the New York State Council on the Arts to direct a pilot project in New York, illustrating the Total Environment Approach. The Hudson River was selected as a "microcosm of the world" and the Environmental Arts and Science Division was established at the Hudson River Museum. The program was initiated in four schools in four cities along the Hudson River from New York City to Albany.

In 1971, TETE was requested to submit a case study as an action model for the United Nations Conference on the Human Environment in Stockholm in June 1972. The case study, one of two American programs included in the official library of the Conference, was cited as an excellent contribution. The UNA-USA and TETE co-sponsored an exhibit, "The ABC's of Ecology" at the UNA Center on the United Nations Plaza from September 1971-June 1972, and held two receptions for the Stockholm Conference Preparatory Committee and International Youth Conference.

In January 1973, TETE was funded to conduct international workshops for teacher training experts and curriculum specialists. The primary objectives are to share our Total Environment Approach to education with educators from varied geographic and cultural areas; to stimulate other countries to organize similar environmental education exchanges, fellowships, and workshops. The long-term objectives are to motivate and develop more comprehensive, integrated approaches to teaching, incorporating all relevant aspects of the learner's environments.

At this point in history, the only relevant scale upon which to work is a global one. To the degree that people believe their solutions are the only ones, they begin to limit themselves and their futures. We must share and compare.

LATE PAPERS AND REPORTS OF SESSIONS

NATIONAL ASSOCIATION OF GEOLOGY TEACHERS MEETING

POLLUTION AND WEATHER

Janet Woerner, Earth Science Teacher, Freeland Senior High School, Freeland, Michigan

Many earth science students spend weeks in their courses studying the atmosphere, meteorology, and weather. Although local conditions are often observed, little time is spent in correlating these observations with other local phenomena. For the student with even a twinge of curiosity, the range of air-pollution activities is almost limitless. Correlation between the local weather patterns, the quality of the air, and the ability of the air to disperse pollutants can be dealt with by all students, and offers enough variety to interest nearly everyone. Some students can be involved in library research to discover how the air quality affects the health of the population, while other students are outside gathering information about relationships in their own environment.

The particular activity in which we will b. involved requires correlating several different sets .f observations, which were gathered by my students, in order to determine whether there are any relationships between concentration of pollutants and weather conditions.

NSSA CURBSTONE CLINICS

CLINIC N-3

ATTITUDES OF SCIENCE STUDENTS AND TEACHERS: IMPORTANT? MEASURABLE? CHANGEABLE?

Michael Gonzales, Science Learning Specialist, Adult Education, 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 depends on the empathetic responses that other minds have for this one struggling primate. The educational environment is for many students such a hostile and toxic environment, but teachers have the opportunity to alleviate the negative aspects of that environment.

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

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

The teacher faces in the classroom the same type of potentially tragic experience that he faces in the "outside" world. A good analogy springs from encounters with co-travelers on a recent trip to Spain. Most of the people on the trip were traveling to a different location without getting involved with its unique features. They were concerned only with the physical aspects of their glorious visits; only the highlights were important.

The tendency to avoid involvement with unique features and to concentrate on highlights characterizes many teachers in the classroom environment as well as these American tourists abroad. Michael is viewed by the teacher in terms of his credentials as a student who:

1. Does his laboratory work
2. Never answers back
3. Always does his homework
4. Gets "A's" on his tests
5. Dresses nicely.

It doesn't concern us that he may have some inner feelings which desperately need expression. That isn't part of our role. Our role is to objectively report the degree of success at which he functions in the classroom.

I submit that it is part of our role to get involved. It wasn't enough for me to report the physical beauty of Spain, because that wasn't all that interested me. I was interested in the human beings that made Spain what it 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.

Michael isn't just someone who received an "A" on a test. He is someone who cries, laughs, thinks. Should we be concerned about his thoughts? Would it be feasible to become more empathetic . ith Michael? It may mean that we would have to spend more time relating to him. Could it be possible that Michael made an "A" on his test and really dislikes science? How can a human being do well in something he dislikes? Measuring Michael's success in terms of how well he memorized the specific subject matter is no index to his likes and dislikes.

In the past teachers have viewed students almost exclusively in terms of their performance as it related to the classroom environment. From my own experience in science courses my teachers and professors responded with excitement primarily to:

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 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 relates beautifully what I sincerely feel is happening in the classroom today. On 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?" 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. Wouldn't it be great if all students were asked that particular question.

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

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. Schweitzer 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 dream? They want to be shown that their likes and dislikes are part of the makeup of Camelot. It is important to know how the student feels 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 students 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.

I sincerely submit that we owe it to ourselves to appreciate the "love" entwined 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.

There are several factors to consider in relating to Michael 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 a 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 we should not force our attitudes on him
7. We should all be in the business of growing, and this art should never cease
8. Let our dreams be forever heard, since they are part of us. It would be a great 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.

LaMoine L. Motz, Director of Science Education, Oakland Schools, Pontiac, Michigan

The development and fostering of scientific attitudes has been a much neglected area in education and particularly in science instruction. Scientific attitudes can be identified behaviorally. Proper attitudes are an imperative prerequisite to problem-solving. Attitudes are developed as a student *sees*, *understands* and *interprets* reasons for experiences presented to him. Attitudes, of course, are concerned with motivation and discipline. Motivation must be effective at the individual student level, hence it must be created by the student. Certain attitudes that can be fostered and recognized through behaviors are.

1. Curiosity-seeking reasons for phenomena,
2. Evaluating the extent of reason-inquiry willingness to participate.
3. Objectivity,
4. Open-mindedness,
5. Persistence in solving problems,
6. Continued search for reasonable causes—cause and effect relationship.

The key to building positive and realistic attitudes in students lies largely in what the teacher believes about himself and his students. These beliefs not only determine the teacher's behavior, but are transmitted to the students and influence performance as well. Yet we cannot ignore what the teacher does in the classroom, for the behavior he displays and the experiences he provides, as perceived by students, have a strong impact in themselves. There are two important aspects of the teacher's role: the attitudes he conveys; and the atmosphere he creates or develops.

It is difficult to overestimate the need for the teacher to be sensitive to the attitudes he expresses toward students. Even though teachers may have the best intentions, they sometimes project distorted images of themselves. What a person believes can be hidden by negative habits that have been developed or picked up long ago. Teachers should ask themselves:

1. Am I projecting an image that tells the student that I am here to build rather than destroy him as a person?
2. Do I let the student know that I am aware of and interested in him as a unique and individual person?
3. Do I convey my expectations and confidence that the student can accomplish work, can learn and is competent?
4. Do I provide well-defined standards of values, demands for competence and guidance toward solutions to problems?
5. When working with students and parents do I

enhance the academic expectations and evaluations which are held of the student's ability?

6. By my behavior do I serve as a model of authenticity for the student?
7. Do I take every opportunity to establish a high degree of private or semi-private communication with my students?

These questions attempt to indicate how the teacher may check himself to see if he is conveying his beliefs in an authentic and meaningful fashion. Teachers' attitudes towards students are vitally important in shaping the self concepts of their students.

What goes on in the classroom or in our instructional programs must reflect people values rather than merely factual information. These people values are the attitudes with which we face the opportunities of living and the behaviors that accrue from them. Content must be relevant to the fostering of desired attitudes in students. We can no longer assume that attitudes will develop of their own accord. Teachers must exhibit and teach so that desired attitudes are openly cultivated. Effective evaluation (there are a few valid and reliable measures available) and practicing what you preach also exhibit and assist in developing and fostering desirable attitudes.

To effect positive attitude change a teacher must be enthusiastic and use more indirect. than direct teaching behaviors. Teachers need to radiate enthusiasm for science and show an eagerness to interact with. relate to. and to understand students.

Students should be granted more open-ended learning experiences. more freedom of choice. and experiences to help foster problem-solving and decision-making skills.

Teachers need to recognize that *all* students can learn. and help these students with experiences that will provide them with maximum success and the reward for success. The experiences that a student encounters in science should nonetheless help him to be successful. enable him to develop a positive self-image and also to develop a value system and to be able to operate on his value system in his own way.

Science should help young people:

1. Make free choices whenever possible in the whole range of living.
2. Search for alternatives.
3. Examine the consequences of the alternatives.
4. Consider what they prize and cherish.
5. Affirm those things and experiences they value.
6. Do something about their choices.
7. Consider and strengthen the patterns in their own lives.

The development of several attitudes enforce the development of values. Values dictate behavior.

The attitudes of teachers and students are important for effective learning to occur in the classroom. The attitudes of teachers and students are measurable. such as by a self-report inventory. and they are changeable by the use of different instructional strategies and techniques by teachers. The importance of what the teacher believes about himself and about his students and attitudes oward students are more important then the instructional strategies and techniques and materials utilized. The attitudes conveyed and the atmosphere created is directly proportional to the kinds of attitudes exhibited by both students and teachers.