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ABSTRACT

The materials in this compilation have been assembled from advance texts and abstracts provided by the program speakers and from on-the-spot reports from many of the panel sessions at the National Science Teachers Association (NSTA) twentieth annual meeting in New York City in April, 1972. Contents include presentations from sessions of the Association for the Education of Teachers in Science, the Council for Elementary Science International, the annual banquet, invited panels and symposia, contributed papers, late papers and reports of sessions. (Author/CP)

nsta twentieth annual meeting

ADDRESSES AND REPORTS

New York City • April 7-11, 1972

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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

NSTA — National Science Teachers Association

SECTION PROGRAMS

AETS-NSSA ANNUAL LUNCHEON

THE FLIGHT FROM SCIENCE

Paul Westmeyer, President, Association for the Education of Teachers in Science, Professor and Head of the Science Education Department, Florida State University, Tallahassee, Florida

We're told, and we can certainly also see it for ourselves, that people are shying away from science in droves. Voters no longer respond favorably to scientific financial pleas; legislators have other fair-haired children (science is actually a bad guy); kids aren't enrolling, when they have a choice, in science classes; and even the advertising agencies have given up the use of "scientific research" as a reason for our buying the products they are trying to sell. We are also told that physics and chemistry course enrollments have declined, if not in actual numbers at least in percentages of students, since PSSC, CHEM Study, and CBA, and even PPC hasn't helped. (Biology still seems to be a required course and so hasn't suffered the same fate.)

But all of this is old hat. We *know* we're not popular anymore – with either students, parents, voters, or funding agencies. The very theme of the convention of which this luncheon is a part recognizes this fact very dramatically – "Alternatives *in* Science! *or* Alternatives *to* Science?" Perhaps it will be useful therefore to spend a little time analyzing possible *reasons* for this *Flight From Science*.

Looking first at some ideas presented in a paper by an Australian educator[1] (apparently the USA isn't the only country experiencing a disenchantment with science) – D.R. Stranks suggests six possibilities.

(1) Whereas science used to offer entry to profitable vocations, recent trends have been toward its replacement by social studies. Management skills and interpersonal relations are now more emphasized in job descriptions than are scientific or other disciplinary accomplishments.

(2) Uninspiring science courses are blamed by some, but Stranks points out that "stirring of the educational broth with new up-to-date courses has [not] affected any drifts in science enrollment in the last few years."

(3) Science courses may be getting progressively more difficult because of the knowledge explosion and the consequent increasing need to teach more and more complex principles.

(4) Science teachers themselves are viewed negatively by their students. Former science students do not become science teachers because they do "not wish to perpetrate the same old things year after year."

(5) Science courses are monolithic almost totally whereas in reality there is considerable interdependence of the disciplines.

(6) It is said that "youth has become disenchanted with the material progress attributed to science and that it is turning instead to studies in the arts and the social sciences in the hope that they will be equipped to deal with the human problems which are at the basis of contemporary difficulties."

Of the first of these one might argue whether it is cause or effect, or chicken or egg. Of the sixth I shall say more later. The remaining four items are clearly things that we science teachers, educators, and supervisors need to be concerned about. Must science courses be uninspiring? Why do teachers persist in making even PPC *hard, uninteresting, and factual*? Why don't schools offer combined science courses – or integrated courses if you'll forgive the old-fashioned use of the word? Why are so many science teachers stodgy stuffed-shirts and so few like Harry Wong? Why, indeed! It's *our* fault; *we* made them that way. Now we've got to undo it.

In his 1970 address to the AAAS convention Walter Watson[2] was perhaps more blunt about our problem than Mr. Stranks. He said that science is not popular because it is considered immoral – "immoral because of the alliance of the scientific establishment with the political, military, and industrial establishments which are engaged in activities which have as their consequence the exploitation and destruction of human beings and the exploitation and destruction of the natural environment." This, of course, is a step beyond the sixth item above, and yet the two are really the same. They are both saying that science is not a *humanistic* enterprise.

Is science inhuman (perhaps I mean unhumanistic but that sounds like a strange word to use when "inhuman" would seem to do)? Apparently people think so; apparently *we* think so. We develop a Project Physics Course which is to be taught in the "humanistic" way. We establish in NSF a program on Interdisciplinary Research Relevant to Problems of Our Society, thus humanizing science by relating it to societal problems. We even try to humanize learning conditions, i.e., we individualize science instruction. All of these may be taken as admissions that science is in itself inhuman; it must be "humanized."

But don't we *really* all believe that science *is* a human endeavor? Remember Bridgman's definition of science as "what scientists do?" Remember Watson's account of the discovery of DNA? Remember all of the stories of accidental – even blundering – scientific discoveries related by Al Garrett in *The Flash of Genius*?[3] Remember the insistence in all recent curriculum projects of NSF on the "model" nature of science – meaning that scientific explanations are *made up* by men (and women) not somehow revealed. Remember Feynman saying that in science the individual "suffers no inhibitions of precedent or authority, but is completely free to adopt any course that his ingenuity is capable of suggesting to him."[4] Remember that DeBroglie and others *invented* the idea of waves to explain sub-atomic behaviors. As Watson says, ". . . science is perhaps the greatest of all examples of human ingenuity . . .".

Then it must be our *teaching* of science which is inhuman. And *if* the reasons stated earlier for the flight from science are accurate, it behooves us to present our science in its human form – not to humanize it but to let its human nature shine through the fog.

Now this, too, has been said before. But the interpretation of what it means has *not* had good results. We still see, as C.J.B. Macmillan[5] put it, ". . . rooms of school children studying the history of scientific investigation, being fed 'objective truth' about the human condition, 'inquiring' under the prodding of a teacher, or memorizing the principles that unify man and nature." These approaches do attempt to let the human nature of science shine through, but they miss any real connection with the lives of students that might humanize the learning of science. Ought we then find out somehow how students live and then design curricula to show them how science is relevant in their daily activities? This, too, has been tried and it also misses the boat. Science is *not* particularly relevant in the daily lives of most people, especially students; those aspects of it that we can present as relevant are *trivial* both in our eyes and to students; and this approach doesn't interest very many people.

So far I've presented a very pessimistic view of the situation. It *is* pessimistic, and there is still one more major dehumanizing influence which must be fought. It is underlain by Skinner psychology and exemplified in the behavioral-objectives-mechanization-of-instruction move. This move is *very* widespread and is *not* in all cases bad, but it *can* contribute materially to dehumanizing learning. Merely stating a behavioral objective, of course, does not say anything about how to achieve it, and in its simplest application a mechanized individualized instruction program is nothing but an effort to get all students to learn the same things only slower or faster. To elaborate, I would like to quote from another paper by Macmillan.[6]

> The danger is not the use of behavioral objectives, but rather the belief that they give information that they do not. And what they don't give us is just as important as what they do.
>
> A teacher ought to have criteria for selecting objectives for his students; no bank of behavioral objectives is going to provide him with such criteria, how is such a bank going to provide him with objectives which will guarantee that he will choose appropriate procedures for their achievement.
>
> What criteria are appropriate for the selection of objectives and determination of procedures? This is a question which must be asked, and one to which I can give only a sketchy answer here. The criteria have to do with:
>
> 1. The level of the student, his background of experience and beliefs. (Has the student previously mastered the objective or a closely related one? Does he have any prerequisite knowledge or behavior?)
> 2. The nature of the subject being taught: its organizing principles, and its methods of investigation.
> 3. Respect for the individual child as an individual, the diminution of human suffering, the promotion of human pleasure and joy, and other such moral imperatives as ought to govern the relationships of decent people.
> 4. The nature of the society into which the student is being inducted; some behaviors are inappropriate for modern American Society, regardless of the ease of getting them (e.g., cannibalism).
> 5. The possibility of achieving the objective in the classroom or other setting which puts limits on the teachers' relationships with their students.
>
> It may seem terribly ordinary to stress such things as this, but it is very easy for teachers, under the press of having to decide what to do, to forget that they are, after all, dealing with people And the pervasive model of teaching that underlies the BOD and much of the lingo of modern educational administration is not that of people, but rather that of the factory: teaching is viewed as a productive enterprise, with inputs from various sources (the children, the subject matter, the teacher) and with the output of the properly behaving person. The crucial criteria for assessment seem to be those of efficiency, and the quality controls are tests provided by teachers or the State.
>
> The trouble is that this cannot be a literal way of understanding teaching and learning; we are dealing with people, not automobiles; with children as the learners, not "raw materials" which we form apart from considerations of their human nature. The children themselves have purposes and desires – something that no hunk of raw material ever had.

So if we operate under the BOD and if we mechanize any aspects of our science instruction we must do it – as the fellow answered when asked, "How do porcupines make love?" – very carefully.

The counter-movement in the educational world today to the BOD-mechanization movement is what is called the "open classroom" plan. This isn't really a plan at all and the classrooms aren't as unstructured as the word "open" suggests. The key in the operation of an open classroom is interpersonal relations but subject matter content is *not* ignored. Teaching science in such a context would consist of treating *children* and *science* together in such a way that the child's own humanity is enhanced by his understanding of science as a *human* invention which can be engaged in by anyone (and *is*, though it may not always be called "science"). Here I wish to quote again from another paper by Macmillan.[7]

> The problem in the humanization of *learning* has little to do with alternatives in the subject matter and much to do with the way that we treat students. For it is their humanity that is at stake, their own attempts to find out who and what they are, their questions about the world and themselves, and their learning that must be humanized.
>
> The problem is how to do this – how to make the learning of science a truly human experience for ourselves and our children. There are no easy answers to this question; despite the educationist's search for teaching formulas (most curriculum development searches for "teacher-proof materials"), and despite the rising quality of recent educational research, we continue to fail to treat children as humans, and science as a humanizing influence. The solution will involve institutional reform (just lowering the number of students in the average classroom should have some effect, for humanity is individual)... But the most important aspect of the solution will be changes in the way that we view the encounter between teacher and student; the typical view of the teacher – as someone who has something to give to a student who must learn it – depersonalizes teaching and

learning even where successful. A more honest conception of teaching sees it as a relationship between *people*, involving essentially a respect for the child as a questioning, curious, self-defining individual. Without radical changes in our teachers' views of this relationship, and without radical changes in the institution which will allow such relationships to develop, I see little hope for humanizing learning in science or in anything else.

This kind of situation can exist in the open classroom, and I suggest that it is only by espousing this movement and preparing teachers to do science as described above that we will be able to stop the Flight From Science.

1. Stranks, D.R. *Stanhope Oration: Drifts From the Sciences*, Supplement to the *South Australian Science Teachers Association Journal*, December 1969.
2. Watson, W. "Humanizing Learning in Science," address at the AAAS Convention, 1970.
3. Garrett, A.B. *The Flash of Genius*. D. Van Nostrand Company, Inc., 1963.
4. Feynman, R.P. "What Is Science?" Paper presented at the 1966 Annual Convention of NSTA.
5. Macmillan, C.J.B. "Humanizing Learning in Science: A Response to Walter Watson," presented at the AAAS Convention, 1970.
6. Macmillan, C.J.B. "The Behavioral Objectives Doctrine as a Theory of Teaching." Manuscript prepared at Florida State University, 1972.
7. Macmillan. "Humanizing . . ." (see footnote 5).

AETS CONCURRENT SESSIONS

SESSION A-2

EVOLUTION OF AN ELEMENTARY SCIENCE METHODS COURSE

Leslie W. Trowbridge, Chairman, Department of Science Education, University of Northern Colorado, Greeley

Changing times produce changing emphases. In the preparation of elementary teachers to teach science, evolution rather than revolution is the normal response to these new emphases. Our program at the University of Northern Colorado has undergone considerable change as a response to new directions and philosophies in science teaching in the elementary school.

How it was ten years ago. Our elementary science methods course was a three-credit-hour course for one quarter. It was a lecture type course and met three times a week. There was no laboratory work. The class met in a classroom with no particular science environment in evidence. It was taught by one instructor and classes ranged from 50 to 70 in size. One textbook was used as the basis for reading and discussion. The course dwelt on materials of science teaching, general theories, and philosophies with some attention paid to activities and methods. Children were not in evidence. The students had no opportunity provided to deal directly with children in this course. There was no graduate assistance and regular grades of the A, B, C variety were given by the instructor.

How it changed through the years. A laboratory was incorporated. Three lectures per week were changed to two lectures per week. The lab was scheduled as a block on one day of the week.

At this time new facilities became available. They offered considerable flexibility with moveable tables, perimeter facilities for gas, water, and electricity; and preparation rooms became available. A new textbook for elementary science methods was wirtten by one of the instructors in the department. This was accompanied by a laboratory book written by four collaborating instructors. The sizes of lectures were limited to 30 students per section, and the laboratories were similarly limited. Instead of one individual instructor, several instructors became involved in the methods teaching. However, there was no team teaching attempted at this time. Graduate students were employed as laboratory assistants.

After two years the laboratories were changed to three hours per week in a three-hour block. This caused some problems of student scheduling with other courses, so a change was made and the laboratories were changed to one-hour labs three times a week. This adequately solved that problem. During this time the numbers of students grew to about 400 per year or 100 per quarter

New elementary curriculum materials were secured and used for laboratory experiences. Children were brought over from the Laboratory School or public schools in small groups on occasion. Some self-evaluation techniques were applied in addition to instructor evaluation.

How it is now. The laboratory has become an open resource lab. It is kept open 20 hours per week including one evening per week. Students can attend lab whenever their schedules permit. However, they are required to provide evidence that approximately three hours of lab work has been accomplished. Three instructors from the Science Education Department team on the lectures and the lecture schedules are more flexible. In this plan each instructor can present his strengths and areas of interest.

An elementary science methods coordinator was appointed from the present staff. Multi-textbooks are used as well as a variety of other materials. Kits of materials for elementary science curriculum projects are more abundant.

Laboratory school children are used on a regular basis. Each methods student has a teaching obligation with them, either on an individual basis or in small groups. Laboratory tasks are provided the students, and records are kept as to the completion of them. Self-evaluation, conferences with instructors are used in conjunction with instructor evaluation.

How it might be in the future. We envision the future evolution of our elementary science methods course might trend toward an instructional systems approach. In this approach, performance objectives will be identified, instructional techniques will be designed to facilitate achievement of these objectives, and evaluation of the criterion-reference type will be used. There will be goal-oriented instruction, the goal being successful interaction with children. It is likely that there will be one or two large lectures with members of the staff providing a team approach to the topics dealt with in these lectures. In addition, there will be several small group discussions per week with the groups not exceeding 15 students.

The open resource lab will continue with the lab activities being competency-based. Evaluation will be on a criterion-reference system. It is likely that diagnostic pretests will be given when the students enter the program and branching programs will be provided them. Students will be allowed to emphasize either the primary or intermediate level as their chosen area of concentration.

It is expected that more attention will be given to follow-up procedures after graduation. These might consist of seminars, visits by science education staff, and closer liaison with the student field experiences department.

Conclusion. It is expected the elementary science methods course will continue to evolve in the years ahead as we become cognizant of new thrusts in Science Education. In this day of concern for humanitarian consideration, and attention to people's interest and needs, the major criterion will be that of providing the best quality education for the preservice elementary teacher of science so that she may enter her profession confidently and enthusiastically with full recognition of her responsibilities in promoting good science learning among children in her charge.

ALTERNATIVE APPROACH TO ELEMENTARY SCIENCE TEACHER PREPARATION

Daniel Ball, Graduate Student, Department of Science Education, University of Northern Colorado, Greeley

One of the primary concerns in science education today rests in the area of elementary science teacher training. Many elementary teachers freely admit their apprehension toward the teaching of science. This apprehension probably stems from two sources. First in their contact with science as undergraduates, teachers may have had little or no opportunity via methods courses to "try their hand" at science teaching.

This paper outlines an attempt by the Department of Science Education at the University of Northern Colorado to alleviate this concern in elementary science teacher training.

Students at the University who have declared an elementary education major are required to take the elementary science methods course "Teaching Science in the Elementary School." The standard approach for this course prior to January 1, 1972, involved 2 lecture hours per week along with 3 hours laboratory per week.

The alternative approach, involves a slightly different format which provides a greater degree of flexibility and relevance both for the instructors and the students.

Flexibility is provided by allowing students more freedom of choice in the activities required for the course. For example, students may choose their time of attendance for the large group sessions; also the time spent in open resource laboratory is left up to the student.

Relevance is provided by activities with elementary children. Former methods students have indicated a desire to have more opportunities to work with children in the science discipline. Therefore, the Science Education Department arranged a program in which the methods students are required to complete one activity with children each week. These activities range from a one-to-one pupil-teacher relationship to the micro teaching of science lessons to small groups of children.

The accompanying flow-chart is presented to help clarify this new approach to the methods class. In addition, the basic requirements are listed to elucidate the course format:

1. All students are required to participate in the two "large-group" meetings twice each week. (The large group meetings are scheduled at 9, 11, and 1 o'clock on two days of the week. Students may choose their own meeting times.)
2. All students are required to complete the assigned "resource lab" activities outlined each week. Attendance is again at the students' convenience, and the resource room is kept open approximately 20 hours per week. Each week has a special emphasis (required activities) plus optional science, or science-related activities.
3. All students are required to participate in one scheduled activity with children each week. This scheduling is in cooperation with the University Laboratory School and the Franklin Elementary School in Greeley.
4. All students are required to complete the assigned readings and take the self-tests on the material.
5. Evaluation consists of a variety of measurable tasks:
   A grade of C = Successful completion of the above minimum requirements
   A grade of B = Additional energies expended in directions of student choice
   A grade of A = Evidence that you are a superior student
   A grade of D
   F = We hesitate giving these grades. If a student is not working toward completion of the minimum requirements, a conference is held with that student, and he is asked to drop the class or improve his work. If both of these suggestions fail, then the student will be graded accordingly.

Faculty input. One of the prime advantages of this alternative approach is the opportunity for all methods students to be exposed to the entire science education faculty. Each faculty member can make contributions, emphasizing his area of specialty or strong points. In addition to the three professors involved this quarter, there were five graduate students assisting and contributing their expertise, while gaining experience in this type of approach.

Student reactions. The vast majority of the methods students expressed positive reactions to these experiences. They especially liked the micro-experiences with elementary children. In addition, most of the students appreciated

WEEK	LARGE GROUP	RESOURCE ROOM	ACTIVITIES WITH KIDS
1	Introduction Discussion of facts, concepts, and processes in science	ID photos taken Familiarization with facilities of Resource Room Sign up for a "kid"	
2	Lesson-structures cookbook vs. discovery activities Use of pictorial riddles States of learning	Activities to identify facts, concepts and processes; Focus: Heat, temperature	Mini trip with one child
3	Discrepant events and brainstorming activities Film: "Don't tell me, I'll find out."	Do cookbook activities Rewrite as discovery activities	Try a pictorial riddle with a group of children; Tape this lesson (cassette)
4	Questioning techniques Piaget's developmental theory	Mystery lab (Analyze tapes Types of Questions Cognitive levels of questions, etc.)	Another lesson with kids Critique by fellow classmate
5	Piaget continued Lesson plans	SCIS emphasis Focus: Ecology activities	Teach a SCIS lesson Critique
6	Micro teaching Multiple talents (Calvin Taylor approach)	AAAS – (Forces) (E-Kit) Focus: Mechanics, measurement	Teach SCIS lesson Critique
7	Evaluation procedures Behavioral objectives	ESS Focus: Physical properties classification	Teach your lesson Critique
8	Self-concept Herring Gull Behavior film	Textbooks Instructional materials	Teach your lesson Critique
9	About "kids" guest speaker	Self-selection Focus: Designing lesson plans	Teach your lesson Critique
10	Evaluation	Self-selection Focus: Designing lesson plans	Teach your lesson Critique

the open resource room and the flexibility of attendance times.

Recommendations for change. Several difficulties arose as a result of the initial pilot. Some of the important problems to be overcome were the logistical procedures, organizational efficiency (excessive paperwork), and lack of student-professor small group interaction. Provisions are being made to overcome these problems. For example, small-group clinical discussions are scheduled for next term, involving 15 students with one instructor. From these discussions, more interaction is anticipated. This interaction will strengthen evaluation, logistical strategies, and student individual needs.

Summary. The alternative approach to the education of elementary science teachers at the University of Northern Colorado was instituted to give more flexibility and relevancy to the existing program. Provisions have been included to allow for more faculty involvement, methods student involvement and micro-experiences with elementary pupils. This has been possible through the use of the open resource laboratory, the cooperation of the University Laboratory School and various public schools, and the dedication from the Science Education Department of their extended time and expertise put forth in allowing this project to proceed.

SESSION A-5

FREEDOM TO LEARN IN SCIENCE EDUCATION

William Torop, Professor of Chemistry, West Chester State College, West Chester, Pennsylvania

Synopsis. A seminar in science education was presented as part of a new graduate program designed to prepare highly competent science teachers. The unique aspect of this seminar was the implementation of the philosophy of Carl Rogers as described in his book *Freedom To Learn* (Merrill, 1969). The professor was a facilitator who placed the burden of learning on the shoulders of the students. Although an extensive bibliography was prepared, the students were free to ignore it if they wished, without penalty. The students established their own criteria and graded themselves accordingly. The results of this "Freedom To Learn" were quite varied, ranging along a continuum from extremely positive to very negative feelings.

Graduate education has been described as being based on ten implicit assumptions.

1. The student cannot be trusted to pursue his own scientific and professional learning.
2. Ability to pass examinations is the best criterion for student selection and for judging professional promise.
3. Evaluation is education; education is evaluation.
4. Presentation equals learning: What is presented in the lecture is what the student learns.
5. Knowledge is the accumulation of brick upon brick of content and information.
6. The truths of . . . (science) . . . are known.
7. Method is science.
8. Creative scientists develop from passive learners.
9. "Weeding out" a majority of the students is a satisfactory method of producing scientists and clinicians.
10. Students are best regarded as manipulable objects, not as persons.[1]

What would happen if: the students themselves selected the topics to be studied in a graduate course, there were no examinations in this course, the students assigned their own final grade for the course and knew this from the first day, the course employed no formal lectures, a predetermined structure were absent, alternate pathways to "truth" were provided, vigorous procedures and statistics were not emphasized in science, the only course requirement was class attendance and participation, every student knew he would "automatically" pass, or the students were treated the same way as the professor?

Would the answer be chaos, lowering of standards, and little effort on the part of the students? Perhaps. I wish to report my experiences with such a course. Notice the difference also in my use of the personal pronoun "I" instead of the "writer" or the "investigator." This is one of the keys to what happened.

Background. After ten years of "teaching" I read *Freedom To Learn* by Carl R. Rogers.[2] The basic thesis is that the professor is a *facilitator* of the learning process rather than the encyclopedia of knowledge. The burden of learning rests on the student's shoulders rather than the professor's. However, I did not accept this point of view right away. My first response came in freshman chemistry when I sat at my desk, after reading Rogers, to assign problems for the semester. I found myself rebelling at this traditional practice of mine. Instead, I decided to let the students select both the type of problem and level of difficulty on which they wished to work. The only requirements was to hand in a set of problems each week. This left them free to work on one type of problem—if they were encountering difficulty with one type—or take the easy way out by doing problems with little difficulty for them. This procedure also provided for individual differences in ability by allowing the student to choose problems of varying levels of difficulty. This, of course, meant I had to be able to respond to any of the 100 problems at the end of each chapter instead of the ten I had previously chosen. I was able to take the risk. However, my graduate teaching assistant (who alternated recitation sections with me) was uncomfortable with this arrangement. Student response, nevertheless, was excellent although no such choice was allowed in other parts of the chemistry course. This "contractual agreement" arrangement is now being considered for adoption by the rest of the chemistry department.
ment.

My next step in implementing Rogers' philosophy was in a graduate education course. A bibliography of recent trends in education was prepared for the students. They could read these references—or their own—but the general topics were assigned by the professor. Exams, term papers, and grades otherwise followed the traditional pattern of being prepared and administered by the professor. To be completely honest, several of the major books of readings in the bibliography had been revised and rather than the professor updating the bibliography the students were charged with locating current references. This also proved to be a very satisfactory procedure. I was now ready to "go all the way."

Science Education Seminar. A new graduate program in science education had been instituted at St. Joseph's College in Philadelphia to prepare highly competent science teachers. One requirement was a seminar in science education. Because of an expected low initial enrollment, this seminar was opened to all graduate students, whether or not they were majoring in science education. The resulting class of 18 students consisted of three industrial chemists, two college teachers (one administrator and one graduate chemistry teaching assistant), five high school teachers (two chemistry and one each of biology, German, and social studies), three junior high school teachers (two life and one general science), and five elementary school teachers (two upper and two lower elementary plus one kindergarten). Nine of the 18 had a previous course with the professor. Upon preregistration each student was mailed a letter instructing him to read Rogers' *Freedom To Learn* before the first class meeting. Although the idea of an assignment before the course officially began elicited an initial negative reaction, this changed upon reading the book and the realization that the seminar would indeed be conducted in this manner.

The five major areas for study identified by the professor were: (1) nature and philosophy of science; (2) research in science education; (3) objectives of a science education program; (4) science curriculum in biology, chemistry, physics, physical science, junior high school science, earth science, unified or integrated science, or elementary school science; and (5) teaching strategies such as computer assisted or programmed instruction. An extensive bibliography was prepared by the professor and each student pursued his own area of interest.

Initial Student Reaction. Let the students speak for themselves in retrospect.

> When I first entered this class I was really unprepared for what eventually took place. I had read most of the required book . . . but I had not been able to determine just how this book was to fit into a science course.
>
> Upon entering this course I was very apprehensive simply because I lacked a strong science background . . . I never really learned . . . science . . . because of a few unsuccessful laboratory experiments, and the ensuing degradation of myself by the science teacher.
>
> When the course began . . . (I thought) I would side-step the tenor of the course and belong in name only. But I got attracted by what I saw happening.
>
> I read Rogers' *Freedom To Learn* like a novel. I was so impressed with the *TRUST* and *FREEDOM* he gave his students . . . just the opposite of the philosophy involved in my 18 years of structured schooling.
>
> It's a change to be trusted in school and the fact of being put on "your honor" so to speak, makes one perform by his own standards and this aids one in finding out what type of person he really is—that's what education is all about.
>
> I had no idea how someone who taught high school chemistry, junior high school biology, or worked in industry, could learn from the few of us who taught elementary school.

Student Motivation. The students came to the course for various reasons. Some were present for the original course purpose—that of fulfilling a science education requirement and preparing a thesis proposal. Other students used the course for teacher certification requirements while for the remainder it was simply a free elective. Some students took the seminar because of previous courses with the professor.

> It was in many ways the best of the three (courses). I'm not saying this to "butter you up," for this will probably be the last couse either of us will have the privilege of having *with you.* I believe we've just hit upon your key to success. *With you.* You do not make a student feel as if he is just passing through your courses. You *allow* him the honor of feeling that we are *experiencing* the course together.

However, not all students came with this attitude. One student wrote "I did not like you at first because you were too direct and open." Another student thought the "professor seemed bulldozed by one student, who while certainly very bright, evidenced severe problems." A third reported "I did not do my best. I did not try to exert myself."

Role of the Professor. The professor did not sit back, as frequently happens in a graduate seminar, and simply have the students make reports to the class. Nor did the professor "lecture" except as noted below. Rather the professor was a facilitator—one of the group instead of the single dominant figure. The sharing of responsibility was likewise noticed. "Your contributions and sharing of your vast knowledge in science definitely played an important role."

> The instructor acted as a facilitator . . . very successfully because he supplied much material for the students use; directed the students to books and other sources of information such as experts in the field and kept the students up to date on the newest developments pertinent to science and science education.
>
> Your enthusiasm was apparent and it was communicated, so I did not feel you were merely caught up in a fad, but moreover believed very strongly in what you were trying to do.

However, not all students were reached right away. One reported "I felt that you didn't know my name for several weeks and noticed that you didn't know Sue's name for at least half way through the course."

Two of the 15 three-hour class meetings were dominated by the professor. On one occasion I thought the class was lagging due to a lack of preparation in outside reading on the topic of the evening, so I took over, i.e., "lectured." The other time I wanted to contribute my knowledge in a particular area of current interest. One student remembers this.

> On only two occasions do I remember you

having entirely taken over a class period, and I must admit that these were our least enjoyable sessions. I imagine that it was because we were so accustomed to freedom that the lecture type of approach seemed a real infringement of our rights. On those occasions I felt you could have given us xeroxed copies of what you had to say.

Diversity, however, was the rule with the opposite comment.

> The presentations given by the professor were enjoyable and informative in that they required class participation.

Another student saw

> ... times in the class when a more definite outline for the night would have been helpful. At times the night was wasted by useless talk. I think you could have been more active in your role in this matter.

This was echoed by yet another student who added

> ... that in many cases the general caliber of student in our group led to somewhat dull and unimaginative discussions. Also many articles listed in the bibliography, which at first glance appeared interesting, gave no positive conclusions. These articles, in my opinion, were generally a waste of time.

Class Atmosphere. This "Freedom To Learn" nevertheless was not a "license" to do nothing. One student described it as "structured-unstructure within the limits that were imposed by the college."

Another wrote

> From the beginning the class atmosphere was free from the normal constrictions which are found in most classroom situations ... Because I was given credit, from the very first class, for having the capability of learning on my own, I felt more compelled to do my best ... Because of this non-compelling attitude I felt more compelled myself to read more than was expected of me.

Yet another student reported "I find myself reading science articles that once I normally would have put aside and think were of no interest to me."

The seminar was NOT conducted as an encounter group, T-group, or sensitivity group. However, it was a very process oriented group.

> What happened in the class was indeed a unique experience ... The seminar was allowed to develop in such a way that I was gradually introduced into the personalities of these people in such a way that I believe I came to know them in a very special and personal way ... in an unusually open manner.
>
> The warm, accepting atmosphere of the classroom setting with the coffee and cake restored the emotions and restored humanity to the classroom–and a science class at that.
>
> I learned so much from the others. It made me more fully aware how narrow is my knowledge of problems in other science areas.

Reported Outcomes. In conclusion, one student observed "that this course represented a change that should be reproduced in a few more classrooms on the college level, but I know that if any change comes it will be slow. But a reassuring thought is that some of the teachers in our group have opened up and will try in some way to change their classrooms."

This has indeed been the situation. For one teacher

> This seminar course was the beginning of an exciting step in teaching ... enabled me to be courageous enough to implement numerous ideas that have been stirring around in my mind for a few years. Our class discussions have spurred me to initiate an independent study program in my high school ... first education course that has had real practical value.

For another

> This seminar was definitely one of the most vital courses I have ever taken. Even after our first meeting I felt more alive and interested in the world ... I even decided to start trying to pass my chemistry comprehensives so that I could eventually obtain a master's degree in chemistry. Previously I had avoided those tests out of inertia and fear ... I know it altered many of my ideas of what a good teacher is. I only hope that I can someday manage to be a decent "facilitator."
>
> I am leaving this course with a high degree of satisfaction and personal achievement. I feel richly rewarded with my personal effort and interaction with other students.
>
> After reading Rogers, I attempted a modification of my teaching practices to combat the lack of motivation in my classes. I set about to experiment with allowing a little more freedom and pursuit of individual goals. I consider the new technique a success but not overwhelmingly so.

Finally, as noted by a student who has yet to be quoted,

> The "gospel" of *Freedom To Learn* should be spread throughout this graduate school and to other graduate schools as well–each professor adapting this philosophy to his own subject matter.

Conclusion. The result of allowing the students to direct their own learning–within the task oriented outline of science education–resulted in more, rather than less, learning and satisfactions. The following comment is typical of the majority.

> I have never had such interest in he science education realm before ... I enjoyed doing the research paper because it was a subject that interested me.

The few others who indicated negative feelings such as "outside reading requirements are excessive and term papers are circa 1940 (administration pressure on the prof?)" were a definite minority who probably would have reacted the same way to a more traditional approach.

In reviewing the grades assigned by the students to themselves, I agree with 17 of the 18–although I issued all 18 as submitted to me. How accurate could I have been in a more traditional evaluation is a question that cannot be answered.

In retrospect, I think my limited implementation procedures with other courses helped me to adjust to this philosophy. I do not think I was ready to try it any faster—even though I "believed" in the approach after reading Rogers.

The last student quotation, voiced in one form or another, by all the teachers enables me to conclude "Freedom To Learn In Science Education" was a success.

I tried to incorporate some of the "Freedom To Learn" methods of Rogers into my teaching.

I suggest you read Rogers and decide for yourself.

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2. I must acknowledge my debt to Dr. William Romey, Director of the Environmental Studies Project in Boulder, Colorado, for introducing me to *Freedom To Learn.*

A COMPARISON BETWEEN TEACHERS AWARE OF THE POPULATION EXPLOSION AND THEIR STUDENTS

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The news media in the United States of America has recently described in many ways the human population explosion and its consequences. Garrett Hardin[1] listed 28 controversial concepts on this topic in his article "Can Teachers Tell the Truth About Population." These concepts served as a basis for a questionnaire which was completed by most of the students in a high school in Texas during the Spring of 1971. The 27 participants in a biology course for high school teachers supported by the National Science Foundation completed the same questionnaire during the summer of 1971 at the University of Texas at Austin. The 493 high school students had considered the issue of the population explosion in several classes and assemblies. The high school teachers were involved in an intensive study of environmental education. Both groups were considered as relatively well informed.

The purpose of this study was to consider possible differences in responses to the questionnaire. The following questions were asked: (1) Are there significant differences in responses between the sexes in each grade from grade 7 through 12? (2) Are there significant differences in responses among the different grades? (3) Is there a significant difference in response between the high school students and the high school teachers?

Questionnaire Used in the Study

Circle either A (agree) or D (disagree) to indicate your response to each of the following ideas.

1. A D There is a population problem.
2. A D Our population problem is an evil byproduct of the conquest of disease.
3. A D Conventional wars do not solve the population problem.
4. A D As regards population growth we are living in very exceptional—perhaps even abnormal—times.
5. A D The world is limited in space, resources, etc.
6. A D "Space" is no escape from our earthly population problem.
7. A D The limit of human population depends on what you assume (or want) to be the limiting factor, e.g. food, etc.
8. A D Zero population growth must soon be accepted as the normal state of affairs.
9. A D The maximum population is not the optimum population.
10. A D We must reject our traditonal concept of progress which implies that technology can do no wrong.
11. A D Without the guidance of standards, measurement, and conscious controls, people will naturally breed until they are near starvation level.
12. A D If freedom to breed is not restricted, breeding will not come to an end until sheer misery acts as the controlling factor.
13. A D Population control cannot be achieved by an appeal to conscience because people vary in the extent and power of their consciences.
14. A D Population control requires coercion by some means, e.g. punitive taxes, or rewards given for desired behavior, etc.
15. A D The social control of individual breeding will ultimately be accepted as a necessity and hence compatible with freedom.
16. A D We should never send food to a starving country unless we also incorporate with this aid an effective program of birth control.
17. A D Including food in foreign aid should always be viewed as an evil act, unless it can be shown that it will diminish suffering.
18. A D Nonselective immigration is indefensible, as it results, not in a sharing of the wealth, but a sharing of poverty.
19. A D In important matters the demands of conscience must always be supported by legal sanction.
20. A D In a rich country increased population means decreased amenities, e.g. privacy, freedom, share in the nondivisible goods of the world, etc.
21. A D The good life must include a share of nondivisible goods, e.g. solitude, use of the wilderness by nature hikes, etc.
22. A D For nondivisible goods to be enjoyed by any, they must be restricted to only a few by lottery or by merit.
23. A D Because we have already overshot the optimum population, we will have to achieve a negative rate of growth for a long while.
24. A D Every "need" has at least one contradictory alternative that should be considered before reaching a decision.
25. A D Just as mass starvation cannot be eliminated by food, so also traffic problems cannot be elim-

inated by building more roads.

26. A D In the early stages of population control it may, for political reasons, be necessary to use largely indirect methods, e.g. taxes.
27. A D We need to tell children through public school education that it is possible to live a good life without having children.
28. A D Ultimately we may well have to come to direct coercive control of individual breeding.

Age Sex Grade

Five of these questions seem especially interesting. Questions 1 and 8 present basic issues. Questions 27 and 28 are related to attitudes toward coercion. Question 6 involves information which is commonly misunderstood by young Americans.

The responses to the questions were interpreted as scores in the following way: Each answer of "agree" counted as one point. The maximum score could be 28; the minimum, zero.

When differences in response between sexes in each of the grades were tabulated, the only significant differences between the sexes were (1) the slightly lower scores of eighth-grade girls when compared with eighth-grade boys and (2) the somewhat higher scores of twelfth grade girls when contrasted with twelfth grade boys. Because there seemed to be no general tendency for distinction between the responses of the sexes, the remaining considerations ignored the distinction between the sexes.

The average score of the twelfth-graders was significantly greater than that of any of the other students. The t-statistic for contrasting the teachers with twelfth-grade girls is 3.44, which is significant at the 1 percent level. The teachers' scores were therefore very significantly higher than that of any group of students.

Conclusions. In general there seemed to be no difference in response to the questionnaire between the sexes in grades 7 through 12. Nevertheless, the girls in grade 12 were significantly more in agreement with the statements of the questionnaire than were students in any other group. The high school teachers were significantly more in agreement with the statements than even the girls of grade 12.

The combined mean score of both the boys and the girls of grade 12 was significantly higher than that of any other grade. The average scores showed a trend that as the groups became older, the scores became higher.

All of the groups almost unaminously agreed with the first statement: "There is a population problem."

Question 6 required a judgment on the use of travel in space as a solution to our human population problem. Approximately half of the high school students believed that space can offer an escape. On the other hand, the teachers rather strongly considered "space" as no solution. The teachers usually balanced the cost of space travel against the immense numbers now in the population explosion.

Question 8 asked for agreement or disagreement on accepting zero population growth as the normal state of affairs. The teachers unanimously accepted this idea. Although the girls of grade 12 generally accepted this principle, approximately half of the high school students rejected it. Students in the ninth grade rejected the principle by a ratio of almost two to one.

Question 27 suggests that in the public schools, children should learn that "it is possible to live a good life without having children." There was a definite trend for the older students to agree with the statement, while the younger students disagreed. Nevertheless approximately half of all the students rejected such "education." Almost one-fifth of the teachers also rejected the idea.

The final question states that we may have to come "to direct coercive control of individual breeding." Almost all of the teachers accepted this statement. On the other hand, only slightly more than half of the students accepted this idea.

Summary. There is a significant difference between the opinions of secondary school teachers and the opinions of secondary school students on the topic of the population explosion. Stronck[2] has explained the need for including this topic in the modern curriculum. But Stronck[3] also recognized that teachers are often reluctant to present controversial topics. This survey demonstrated that the students do not wish any form of coercion, or the imposition of an education which may change their attitudes. The teachers are better informed and more realistic in their attitudes. They will need the support of school administrators and other informed adults to proceed with the needed project of population education.

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SESSION AA-2

EDUCATIONAL NEEDS ASSESSMENT

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"Why can't Johnny read?" This question, put to educators by critics of school systems, has long been a source of embarrassment. The critics persist in their demand for answers. Questions of this nature have led to the concept of accountability in education. If Johnny has spent six years in school and is still not able to read, who is responsible? Until Johnny has learned to read, the school system has not fulfilled its obligation to him or to the taxpayer. Taxpayers have invested considerable sums of money in schools, and the schools have not been held accountable for their product. How can school systems answer the taxpayer's question, "What am I getting for my money"? The answer may lie in better planned and evaluated programs. Part of the problem has been that we have not clearly identified our deficiencies in education or specified our goals. Consequently, any program has been acceptable under these conditions.

Accountability requires some systematic procedure for linking deficiencies with desired products. The procedure entails identification of student needs, establishment of realistic goals, implementation of planned programs, and evaluation of student outcome. This paper describes the first step in achieving accountability, the assessment of student needs.

The Federal Programs Planning and Evaluation Division of the Arkansas State Department of Education contracted with the Region VIII Education Service Center to develop a needs assessment model for ESEA, Title I, programs. The Elementary and Secondary Education Act, Title I, is specifically directed to serve educationally deprived children. Although the assessment model is designed for a specific target group, the techniques used may be applied to other educational programs as well. The model was developed in the spring of 1971 and tested during the 1971-72 school year in nine pilot schools. The schools were selected on a geographic basis and size of school so as to be located throughout the state.

The purpose of the ESEA, Title I program is to help educationally deprived students to become successful. (For the sake of convenience from here on, educationally deprived students will be termed EDS and non-educationally deprived students will be termed NEDS.) It is assumed that there are characteristic differences between EDS and NEDS. The procedure used in this model is to identify characteristics of each group and, by comparing the characteristics, establish the needs of the EDS. Performance objectives may then be written for eliminating top priority needs.

The criteria for designating a student as educationally deprived are based on achievement. Generally, standardized achievement test scores are used. EDS could be those students with scores falling one grade level equivalent or more below actual grade level placement, or those falling below the 30th percentile. In order not to suffer from data pollution, only a small sample of EDS and NEDS from several grade levels are studied. A random sample of EDS and NEDS from a grade level should reflect the characteristics of all the EDS and NEDS of that grade. Also, the characteristics of EDS and NEDS of one grade level should reflect the characteristics of students preceding and following that grade level. For example, if a study reveals that a sample of fifth-grade educationally deprived students are particularly deficient in mathematics concept skills, then it is reasonable to assume that, for this school system, educationally deprived students at the fourth- and sixth-grade levels would also be deficient in this area.

The procedure may be as follows: The study may be of the EDS and NEDS of four grade levels, say, grades two, five, eight, and ten. For each grade level, a pool of students identified as EDS and a pool of students identified as NEDS are established. In order to emphasize differences in characteristics, these students should come from extreme ends of the achievement score distribution. That is, the pool of NEDS may be all those students with composite scores above the 70th percentile on the SRA Achievement Test. The EDS may be all those students scoring below the 30th percentile. To obtain samples for the study, randomly select 25 students from the pool designated as EDS and 25 students from the pool designated as NEDS for each of the four grade levels.

Once the samples of EDS and NEDS are selected, the data are gathered. The first source of data is all the standardized achievement tests that have been administered to these groups. This will yield information in content areas and provide historical information on achievement. Other sources may also reveal differences between EDS and NEDS. Student records provide information on family income, history of broken homes, health problems, grade-point averages, absentee rate, and grade-retention. Special testing in the areas of self-concept, attitudes, and aptitudes may be helpful. Opinionaires may be given to teachers knowing these students to obtain subjective data such as disruptive behavior patterns, nonparticipation, personal hygiene, etc. The point is, when a small number of students are being studied, fifty from each of four or five grades, an abundance of useful information can be gathered. Critical weaknesses in the total school program as well as specific needs of the EDS can be identified by comparing the data between EDS and NEDS for each grade level sampled.

The following is a summary of some of the characteristics of educationally deprived students identified in one of the studies:

"The educationally deprived students of this school system are 68 percent male and 90 percent black. The average size family of these students is seven children, and the family income bracket is $3,000 to $5,000 annually. Over half of the EDS come from broken homes. The self-concept of these students with respect to their peer group and family is generally better than noneducationally deprived students. However, the self-concept of these students with respect to school and their attitude toward school is much lower than NEDS. Over half of them have been retained by the fourth grade. The average IQ for EDS is 79 compared to 118 for the NEDS. Academic areas where the largest differences occur between EDS and NEDS are in language usage, reading, and mathematics concepts, and in that order. Smaller differences occur in spelling and mathematics computation. Generally, there are smaller differences in rote-learning activities than in reasoning-learning activities."

From these data, several needs for EDS can be identified: the improvement of language usage skills, non-graded classes for grades one to three, black cultural courses, improvement in self-concept with respect to school, and increase in supportive services, such as counseling and social work. The needs of the EDS can be generalized to the educationally deprived students of this school system and community only. School systems and communities vary widely in many aspects; each school system must identify the needs of its own students.

The next step in needs assessment is to assign priorities to the needs. Few, if any, schools have unlimited resources. Thus, it is necessary to decide which needs are most important and to rank order them. While a number of methods might be used, some logical, verifiable procedure should be chosen. The method suggested in this model involves the ranking of the needs in four categories and then obtaining a final rank based on the average of the four. The first is an opinion survey of teachers, parents, students, administrators, and community groups. The needs are listed on a questionnaire. The surveyed group rates each need on a scale of one to five according to his opinion of the degree of importance of meeting the need. Each group is assigned a weight to its opinion, and a weighted average for each need is computed. For example, the teacher's opinion may be given twice the weight of a student's opinion. The needs are then ranked on the basis of the weighted average. The next three rankings are based on ratings made by a committee representing teachers and administrators. The three categories are: (1) the size of the deficiency of the need; (2) the likelihood of success of programs for fulfilling the need; and (3) the estimated cost of a program to fulfill the need. A final ranked priority list of needs is formed from computing the average of ranks obtained in each category.

The final step in the model is the writing of performance objectives for meeting the highest priority needs. The writing of a performance objective will not be elaborated on, other than to say it should communicate what the learner is to be like when he has successfully completed a specific learning experience.
For example:

"After participating approximately 35 minutes per day for one academic year in a laboratory-centered elementary school science program, the fourth-grade educationally deprived students will have a statistically significant increase in self-concept with respect to school, as measured by a pre-post school sentiment index."

This model provides a means for administrators of a school system to write specific performance objectives, based on identified needs, to eliminate deficiencies of educationally deprived students. A second phase of the project is now being developed to guide administrators in planning programs to achieve these objectives. The second phase entitled "A Program Planning Model" is being tried out in the same nine pilot schools in which the needs assessment model was used.

Students have generally been held responsible for their learning. If a student fails—whether it be a grade, a subject, or a specific learning task—it has been looked upon as the student's failure, not the school's. Can you think of other industries where the consumer is held responsible for the product? Who is responsible when you buy a piece of faulty merchanidse? You may agree that you are stuck with the product, but you surely make an effort to have the producer rectify the situation. Similarly, the school must assume partial responsibility for its product—student achievement. This is accountability. The model for assessing needs of educationally deprived students in the State of Arkansas is but one small step in the whole process of accountability. We feel it is an important, giant step.

CESI CONCURRENT SESSIONS

SESSION CC-2

A MODULAR METHODS COURSE AS A PORTAL SCHOOL COMPONENT

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Growing concern for increasing teacher effectiveness has led to specification of teacher competencies necessary to effect learning in children. Precise description of desired learning outcomes has emphasized inadequacies in existing instructional modes. Two types of criticism are most common:

(1) although the competence of beginning teacher-education-students varies greatly, the program is stereotyped for all students; and
(2) although many of the desired competencies involve working with children, most undergraduates have no opportunity to work in schools until senior student teaching.

Increasingly these shortcomings are being countered by flexible modular instructional programs and a series of well-planned field experiences extending throughout the entire undergraduate program. In Elementary Science Methods at the University of Georgia, modular instruction and a field experience have been combined since Fall, 1970.

Elementary Science Methods is one of three methods courses taken in conjunction with Principles and Practices of Elementary Teaching, a senior level field experience where students do supervised teaching in Portal Schools. Portal Schools are local public schools in which prospective teachers gain the practical experience needed to develop and refine the specific competency requirements set forth in the model program. These educational units serve not only as training centers, but also as demonstration centers for promoting change within a school system.[1] Portal Schools render *life* situations not "life-like" simulation, so that students are able to function at the operational level rather than being limited totally to the theoretical level. Thus, Portal Schools serve as an application of the principle of appropriate practice. University and school staffs work together in a cooperative enterprise toward the meshing of the theoretical fundamentals with practical experience. Portal Schools are characterized by creative practice, integrated approaches and competency-based personalized instruction. Generally, Portal Schools are more direct and comprehensive than traditional.

GOALS OF THE PROGRAM

The methods courses have a dual responsibility: they provide raw material, ideas and techniques, for use in the field experience; and they have the more important task of helping students develop a philosophy of teaching and a repertoire of techniques which extend beyond the field experience. Thus, in spite of the addition of field experiences, the methods courses have goals in common with campus based programs elsewhere. While the purpose of Elementary Science Methods is to prepare students to teach science, it is believed that science will not be taught well until three goals have been achieved. *One goal is to understand science* as an enterprise as well as a body of knowledge. Science teachers should know how science grows and learn its limitations. Prospective teachers develop the novel notion that science can be a skill subject as they become proficient in the use of processes such as observing, inferring, and constructing and testing hypotheses. These processes, used by scientists in developing "that body of knowledge," are viewed by students as both tools and goals of instruction in science. They learn techniques useful in teaching process skills and processes useful in developing science concepts.

A second important goal is to use an understanding of children and learning processes to structure activities which are within the limitations of elementary children. Students apply the theories of Bruner and Piaget by initiating activities with concrete materials and real problems. In addition to providing a motivative influence, these materials assure greater success for many children. The process of "sciencing" is very real to children who generate concepts from activity and observation. Students apply the Piagetian concept of equilibration to discovery learning and use the "discombobulatory experience" as a motivative technique. The contrast of assimilation and accommodation underscores the value of discovery by the self-directed learner. Throughout the program affective aspects of science instruction are related to the needs of elementary children.

The *third major goal* is to gain familiarity with a wide variety of programs, materials, resources, philosophies and teaching strategies. Activities from curriculum projects are used throughout the course to develop an understanding of the nature of science. Later students examine the major programs to compare teaching strategies and to find activities characteristic of the various projects. Students are encouraged to use the different teaching styles in their field experience. The curriculum projects are used in three ways—(1) as possible models for a total science program; (2) as reservoirs of ideas for later use; and (3) as examples of philosophies of science teaching from which an individual style can evolve.

A factor common to all current science programs is the non-authoritarian role of the tracher. Children learn to satisfy themselves, independently or interdependently, without receiving verification from the teacher throughout an activity. Learning this non-central, yet guiding, behavior is a difficult task for students who must first be convinced that significant learning can occur without the dominance of a teacher. It is in this respect that Elementary Science Methods at Georgia University is unusual. College students experience the same kind of freedom that many educationists advocate for children. Self-paced instructional modules are the key to the freedom offered in Elementary Science Methods.

INSTRUCTIONAL MODES

The course is designed around a series of behavioral objectives which have been partitioned into individual modules or learning units.* The speed and sequence used in completing the modules may be varied by the student. During the first class meeting students are divided into two groups based on an interest in primary or middle grades. The two groups are then given course outlines which differ in the processes stressed as well as in the nature of the activities used. The outlines are hierarchy-like charts which describe sequences in which the modules may be completed. Each module is outlined in detail on a flow chart and prospectus which describes the objectives as well as the entry requirements for the particular module. The flow chart also suggests a series of activities which should help students master the objectives. Although initial efforts involved establishing one activity for each objective, development has progressed so that many modules now contain alternate activities.

Students are advised that attendance is not mandatory and that they are free to work during any lab hour. During a typical day students can be found working in many different modules. Although options within modules are somewhat limited, a wide variety of techniques are used throughout the program. Students may be in seminar or discussion sessions, viewing video-tapes or slides, reading, doing an activity from a curriculum project or preparing materials for use in the school. Students are invited to seek their own alternate procedures using all available resources.

The instructor in this course is free to interact with students to a greater extent than is possible in more conventional programs. It is not unusual for four or five students to meet in a faculty office for an off-hour seminar. Because much of his information sharing function has been absorbed by media-techniques, the instructor is freed from burdensome preparation time. Students benefit from his saving when they are able to have small group seminars and individual conferences in lieu of large group instruction. More significantly, the variety of activity facilitates spontaneous discussion. Confident that assistance will be offered willingly, students learn to seek out the instructor or classmates when help is needed. Equally important, they learn that they are not forced to sit and listen should they be able to progress alone. Small group interaction is one of the strengths of the program. Whereas many self-paced or "modularized" programs are, or become, sterile because students have little contact with others, discussion and interaction are encouraged. Small group cooperation is effected by suggesting that activities be shared and then compared and by including discussion questions so that ideas can be nurtured.

Students respond to the openness in many ways. Initially most spend all scheduled hours in the lab in spite of optional attendance. The composition of the seminar groups is not static, a change that produces further exchange. Students report that they come to know the instructor better than in most other courses and that they come to know each other better, too. Students fail to realize the extent of other more subtle growth. The cooperation and interdependence increases tremendously after a few weeks. The ability to depend on other students or teachers is important for teachers who are, and will be, members of teaching teams in newer schools. While skepticism is prominent early each quarter, it largely disappears by the time students are due to apply techniques in the schools.

EVALUATION

Positive changes in attitude are desirable, of course, and may reflect the most significant learning that occurs in such an atmosphere. At present no effort has been made to formally evaluate the course in this respect. Evaluation throughout the program has been designed to measure the objectives of each module. Rather than a mid-term and a final, each student has a series of "tests," each taken when he is ready. If the student feels "ready," after reading the objectives, he may use the evaluation as a pre-test in an effort to skip some, or all, of the activities. A student who does not elect to pre-test, proceeds through the activities and then requests a post-evaluation. He is then given tasks which require written response or other performance. In some cases a five minute discussion constitutes the evaluation. In the event performance is not adequate, the student is directed to additional activities to remedy the difficulty. If the problem is minor, the misunderstanding is cleared up on the spot and the student is free to continue. Thus, all students reach a standard level with respect to all objectives.

THE FINAL MODULES

The achievement of course objectives showing an understanding of science and children is important, but not always sufficient to develop a good science teacher. All may be worth little when twenty to thirty children are introduced. The final modules involve the field experience, and the component which focuses on the interaction between teacher and children and provides the opportunity to apply the techniques of science teaching. Unlike field experience elsewhere students in science methods courses at Georgia University are given no specific lessons to teach. With the assistance of classroom teachers, they individually select appropriate lessons based on the specific circumstances encountered in the field experience. During the level three experience, students are urged to attempt a variety of techniques. They attempt to evaluate their effectiveness based on the observed performance of their children. Both field coordinator and methods instructor are involved in observation and analysis of school activity. Free of traditional preparation and much tiring clerical routine, the instructor is placed in a creative role where he can respond with individual guidance and relevance.

The use of self-paced, science instructional modules facilitiates the implementation of the Portal School concept by allowing flexibility of on-campus scheduling. Precise description of experiences in programs such as science allows staff to avoid overlapping material in various courses. Individualized pre-testing provides the student additional opportunity to prevent unnecessary redundancy. On-campus instruction takes on more meaning as the students are given an opportunity to extract relevant techniques, skills, and competencies for direct use in the concurrent field situation. Thus the student is provided with an effective framework for combining theory and practical experience. The goal in science is to have all students develop a similar set of general skills involved in teaching science. Resources including texts, materials, and a methods instructor are available to assist students in applying the general skills to the particular problems in the field experience.

Feedback from students who have experienced this unique approach to teacher education, has been supportive. Most students report that their experience with the modular instruction and the field centered programs has been more relevant and meaningful than any other provided in their program. Certainly the present course is not a finished product. The program as it has been described is just now becoming competency-based. Pre-assessment has now been incorporated into many of the modules and post-testing is being improved. Hopefully, such assessment will move closer to the schools as the field center concept crystalizes.

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*Problems and strategies in development have been described elsewhere.[2]

A SCIENCE METHODS COURSE FOR ELEMENTARY TEACHERS – ONE INSTRUCTOR'S POSITION

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The AAAS Commission on Science Education has recently published a report[1] outlining suggestions for establishing more effective pre-service science education courses. The report, state the authors, was initiated largely due to the impact of the dramatic revolution in science curriculum development of the last decade. The resulting new elementary science programs, though each having a unique character, also possess striking commonalities. It is these common qualities which should provide focus for pre-service elementary science education.

Some of these "commonalities" are:

1. an emphasis on the investigative nature of science (inquiry and discovery);
2. a conviction that children need to be actively involved with materials that are conceptually rich for the learning of science;
3. an emphasis upon independent learning with opportunities to explore, "try out," "play with," and in other ways initiate their own learning;
4. an attempt to establish a sequence of instruction to help assure the child's acquisition of skills in the

processes of sciences as an important part of their intellectual growth; and,

5. a valid presentation of science materials so that concepts will not need to be corrected later.[2]

The stated aim of the AAAS report is to stimulate discussion among all persons concerned with the pre-service education of elementary teachers, and hopefully prompt teacher-education institutions to update their programs. Perhaps more important, the report may stimulate research and development activities related to the many questions raised and the philosophical position delinated.

The present paper results from the stimulation by the report of one science methods course instructor. The writer has done some rethinking regarding the nature of the elementary science methods course, resulting in the following position statement. The statement consists of a blend of the instructor's personal philosophy with adapted portions of the AAAS Report. In view of the dialogue-stimulating intent and spirit of the report, it would seem that an open forum of considered opinion regarding pre-service science-education should be initiated and disseminated in professional journals, meetings, and newsletters.

The following four major guidelines with related implications, then, are submitted for discussion, clarification, and criticism by interested members of the science education community. Criticisms and suggestions for modification would be welcomed by the writer. Position statements by others involved with the problem of pre-service elementary science education are also strongly encouraged.

POSITION STATEMENT REGARDING ELEMENTARY SCIENCE METHODS COURSES

Guideline I — The Elementary Science Methods Course (ESMC) should be taught in the same style of open inquiry that is encouraged in current elementary science programs. The course should have as its *primary aim* the development of *positive attitudes* toward science, science teaching, and an activity-oriented approach to science learning.

Implications:

1. ESMC students should be involved in a "sciencing," investigative mode of learning through representative laboratory, field, and discussion activities similar to those encouraged for children's learning of science.
2. ESMC students should be provided opportunities to guide investigative modes of "sciencing" with actual groups of children.
3. The ESMC instructor should aim to develop students' competence in the processes of scientific inquiry, i.e., observation, measurement, classification, hypothesis formulation, experimental testing, and model building.
4. Science should be approached as a dynamic, highly exciting, "turned on," *human* activity.
5. The inquiry mode of science should be considered always within the framework of society. More concern in curriculum development needs to be given to the social implications of the scientific enterprise. ESMC activities should develop in prospective teachers an appreciation for the historical, philosophical, and current significances of science to society.
6. As a result of completing the ESMC, the student should feel successful in achieving a higher mastery level of at least some elementary science concepts. These concepts will vary with the particular course section, and ordinarily would range through a great variety of science areas, e.g. matter, energy, space science, and biological science. However, the student should leave the course with a feeling of lack of completion or "open-mindedness" regarding his understanding of science, and desire to take further courses, workshops, or personal studies in science areas.

Guideline II — The ESMC should develop confidence and competence on he part of the student in designing his own individual teaching-learning activities, devices, lessons, and units.

Implications:

1. The ESMC instructor should provide opportunities for the development of the student's personal ideas for teaching science. All efforts should be made toward rewarding creative ideas of students. The instructor should provide a model through developing and using his own innovative activities, devices, etc., as part of the regular course instruction.
2. Specific activities encouraging divergent or creative thinking should be a regular part of the ESMC, i.e., brainstorming sessions, improvisation labs, *Invitations to Creative Thinking*,[3] take-home activities, "oddball device" shows, etc.
3. Course student projects should emphasize innovative, rather than repetitive, activities.
4. Class discussions might attempt to explore the multiple-talent nature of creative thinking, and relate the activities of the ESMC to activities appropriate to stimulation of creative thinking of children.
5. Large emphasis should be given to innovative local development of science units from readily available materials present in the child's environment.

Guideline III — The ESMC student should be familiarized with the characteristic cognitive functioning and cognitive development of elementary school children, especially as pertains to modes of reasoning inherent to science.

Implications:

1. ESMC students should learn and apply techniques useful in probing and analyzing the thinking processes of children. One method which appears fruitful in accomplishing this objective involves ESMC students in guidance of Piagetian-type activities with small groups of children.
2. Familiarity with a coherent theory of cognitive development, such as that offered by Piaget, provides a framework for understanding children's thinking. Background readings, films, etc., regarding Piaget's findings should be provided.
3. The ESMC student should be given opportunities from which he becomes aware of the widely differing characteristics of individual children, and should be

provided with a repertoire of teaching-learning techniques applicable to individualized learning.

4. The ESMC instructor should attempt to develop the students' *confidence* in guiding children's learning activities, and encourage *flexibility* in making reasonable alternatives in teaching procedures in the face of unexpected events.
5. The ESMC student benefits from course activities aimed at developing his abilities in alternative modes of questioning and discussion techniques appropriate for individual children and those appropriate for interaction with larger groups.

Guideline IV The ESMC student needs to become aware of the variety of materials now available from the many significant science curriculum development groups. Awareness should be encouraged of the diversity of philosophy and teaching-learning styles reflected in the curricula, as well as important common elements. The particular philosophy of science teaching held by any given ESMC instructor should be made clearly apparent, but should be developed within the context of possible alternatives. It is likely that the best learning might result from selection of the better aspects of several approaches and curricula, rather than from any one polarized point of view.

Implications:

1. The student should become familiar with the philosophies, teaching-learning styles, and representative materials of at least the three most significant elementary science projects, namely the *Elementary Science Study* (ESS), the *Science Curriculum Improvement Study* (SCIS), and *Science–A Process Approach* (developed by AAAS).
2. The ESMC instructor should demonstrate the ability to select and use a variety of learning strategies appropriate to various learning requirements. The same flexibility should be encouraged in the student.
3. Attempts should be made at helping the student develop a full repertoire of teaching-learning strategies. Most fundamental would be strategies involving direct, child-centered, inquiry into natural phenomena *by children*, with strong emphasis on pursuit of the natural interests and questions *of children themselves*. This basic strategy should be supported by a wide variety of mutual teacher-child exploratory learning activities, such as Suchman-type inquiry development sessions, counterintuitive demonstrations, pictorial riddles, science inquiry games, stimulation games, film loops, overhead projector activities, etc.
4. Whenever possible, dependence upon ready-made (and expensive) kits should be discouraged. Instead, emphasis should be placed on improvising materials for use in teaching the various curriculum group-prepared units. Representative kits should be available, however, as "archetypes" or models of materials to be improvised.

[1] American Association for the Advancement of Science Commission on Science Education, *Preservice Science Education of Elementary Teachers* (AAAS Miscellaneous Publication 70-5, Washington, D.C., 1970).

[2] *Ibid.*, p. 6.

[3] Alan J. McCormack, *The Effects of Selected Teaching Methods on Creative Thinking, Self-Evaluation, and Achievement of Students Enrolled in an Elementary Science Education Methods Course* (Unpublished doctoral dissertation, University of Northern Colorado, 1969).

NSSA CONCURRENT SESSIONS

SESSION N-7

AMERICAN CURRICULUM UNDER TEST IN GERMAN SCHOOLS

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Until a few years ago German school systems followed instructional guides of a very conserv ve style. The results grew ungratifying in a changing world as experienced during the last decade. The revision of the existing curricula led to an outlook for new ideas. Foreign material was taken into consideration, the programs exported from the USA being favored because of their unique design. In Germany all outlines were of the smorgasbord-type, i.e., they tried to cover every part of the scientific fields. Curriculum research was an unknown concept, never was an attempt made of a sequence of processes or principles or attitudes in a curriculum.

The Institute for Science Education, IPN in German abbreviation, at Kiel University, Germany, invited a number of internationally known scientists, University staff and science personnel in schools to a discussion. This symposium was held in October, 1970. A number of distinguished American researchers presented their programs. Some of the offered curricula aroused particular interest. There was Science Curriculum Improvement Study (SCIS), Science – A Process Approach (S-APA) and Idea-Centered Laboratory Science (I-CLS). It was decided to try out curricula based on these before an innovation could be attempted. The choice was made because of the new view of science in German schools.

The organization of the experimental stage of the innovation was carried out by the Teacher's League of Hamburg, GEW in German abbreviation. Teachers with particular interest in experimental educational work offered their assistance. The SCIS course was tested in primary grades. The life science part had to be translated by the teachers in charge of the unit they wanted to test. The translation, however, is the first step only. A rather difficult problem was the adaption of the material to German conditions. Different plants had to be used, other life cycles to be investigated. So the German version may have a completely different look than the original, the basic idea of a conceptual framework being the only fact in common. The physical science part of SCIS is printed by a recognized publisher and introduced into schools throughout Germany. Again the curriculum material appears in a different container, but uses the idea of a sequence of concepts.

The Idea-Centered Laboratory Science, I-CLS of Dr. VanDeventer, did its very first step. Four pilot classes worked on single units. The curriculum is still being tried, first results becoming visible at the moment. The adaption of I-CLS has to face more problems than SCIS. The course is intended for junior high grades. German junior high schools are not uniform, the organization being different from state to state. The school system still is selective. There are high, medium and low levels of students and schools. Introducing an innovation into the extremely conservative system faces resistance from parents, teachers, students, the administration, and politicians. It is the Teacher's League that provides the common ground for all activities, being a neutral institution in this respect. Another problem arises in the preparation of the material for the different levels. A unit to be performed in Volksschule, the low level schools, has to proceed in small steps avoiding a language using too many scientific terms. The high level schools with fast learners can involve the students in rather abstract ideas and lead them to more sophisticated conclusions. The problem of different levels may develop in another direction with the innovation of Gesamtschule, a school very similar to the comprehensive high school which Americans have had for decades. However, in Germany this is a political problem not within the competence of educators.

Science – A Process Approach is being adapted. The experimental stage of field testing is being organized at present. Therefore no results can be reported. The acquaintance with ideas that came from the states has proven to be very fertile. The discussion will promote better science teaching, be it be based on American material or on their ideas. The time has come to unify all efforts in educational research on an international basis.

NSSA CURBSTONE CLINICS

CLINIC N-1

EFFECT OF TEACHERS AND STUDENT ATTITUDES ON THE LEARNING PROCESS

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Traditionally, teacher effectiveness has been judged on what the teacher knows (his competency), what the teacher is as a person, and how the teacher reacts or interacts with the students, in that sequential order. Based on this, inferences have been made as to how the teacher will behave in the classroom and effect the learning process of the students.

The contention of this writer is that the inverse order is to be desired. One cannot deny that teacher competency and teacher attitude are important, but the "principle of supporting relationships" between teacher and student is most important. The interaction between teacher and student is most important and essential in evaluating teacher effectiveness and student response.

The central purpose of education is to develop in students the capabilities of exhibiting rational thinking and behavior in order that they might become effective, contributing members of society. Thus, the dynamics between the teacher and the students must be such as to allow for this.

Teachers must react in such a manner as to link themselves with students in light of their background, values, and expectations in order that their personal worth and dignity is built and maintained. Teachers must be concerned with communicating with students, group involvement in decision-making, and leadership allowing for organizationally relevant behavior.

There is much literature concerning student learning; but, there appears to be a definite lack pertaining to behavioral skills a teacher must possess in order to be effective with students.

The teaching-learning process has been so intellectualized by so many for so long that it is little wonder that students exhibit a "no or who cares" attitude.

The basic premise I would like to enlist is that for the teacher it matters that he should be competent in the subject-matter field, but it matters less what you know than that you care about people knowing, and that the students' behaviors demonstrate that you care.

Teaching-learning is for people. What goes on in the classroom or our 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 and practicing what you preach also exhibit and help foster desirable attitudes.

To effect positive attitude change a teacher must be enthusiastic and use more indirect than direct teaching behaviors. Teachers should radiate enthusiasm, demonstrate enthusiasm for science, and show an eagerness 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 should recognize that *all* students can learn, and help these students with experiences that will provide them maximum success and the reward that succeeds.

NSTA ANNUAL BANQUET

SCIENCE AND SOCIAL ACTION

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In the nine years since I last spoke to this organization, we have all become familiar with DDT, PCB, NTA, and many other letters that were just coming into our ecological consciousness in 1963. Tonight, I want to go a step further than a recitation of ecological sins, and connect science with social action. The ecological problems which we now all recognize will be solved and can be solved in a democratic way only by means of social action, by society as a whole, not by scientists.

Science is, after all, a subsidiary part of society. We tend to get a little arrogant sometimes and to think that science is a force unto itself, that we are training priests, rather than public servants. On the contrary, we teach only a part of human experience, science, and our students, and we ourselves, are a subsidiary part of society. Nevertheless, science does have a very special role. It is designated by society to report on what is happening in the world, to Nature, to people, and to the relation between them.

Today what we have to report is very grim. My own city, St. Louis, has degenerated physically in the 25 years that I have lived there. I have seen entire neighborhoods boarded up, the buildings destroyed, the people out of work, the children suffering from lead poisoning. Here is a magnificent human association, a city, literally falling apart before our eyes. All of you have seen the same thing. Consider, too, the more esoteric signs of degradation: The air is a burden to breathe, the water is foul, the soil is being destroyed, the food we eat is less nutritious than before, the necessities of life are becoming adulterated. Have you gone down the supermarket shelves lately and looked at the fruit juices? Most of them are now called "fruit drinks," not juices. A "drink" is a juice adulterated with water, among other things. Have you asked any poor families whether they are now feeding their children the same volume of "drink" as they did juice? Is this one reason why the vitamin intake of the average U.S. citizen is declining?

We are destroying–physically, biologically–the habitat in which we live. Obviously there is something exceedingly wrong in our society. Most of us feel that something has to be done–not understood, not spoken about–but *done*. But if we would act successfully we must understand the origin of our present predicament.

Within the last two to three decades we have experienced an order of magnitude increase in environmental degradation. In 25 years in St. Louis I have seen the bowl of air pollution from the basin near the river extend westward block by block. I can remember the day last summer when photochemical smog spilled over into the suburbs and began to attack the pines in the area between my home and my lab.

Generally, there has been about an order of magnitude increase in the emission of pollutants since World War II. This date is an interesting one. We have all taught about the great scientific revolution of the 20s and 30s; about modern physics, theoretical chemistry, and new development in biology. At about the time of World War II much of that abstract knowledge was converted with dramatic suddenness into practical technologies in industry, agriculture, communication and transportation. The esoteric experiments of physicists were converted into nuclear bombs and nuclear reactors; DDT was taken off the shelves and used to kill insects; synthetic chemistry produced plastics, fibers, rubber, and detergents. This sudden change in the nature of our technology has had enormous effects–including serious pollution of the environment.

In agriculture, we have experienced a revolution in this country. The corn yield in the Corn Belt has increased about two and one-half fold in the last 25 or 30 years. This has had great social and economic consequences, including migration to the cities of rural residents who are no longer needed on the farms. Of course, there has been an environmental impact as well. One of the most important changes in agricultural technology, for example, has been in the use of nitrogen fertilizer. In the United States generally, since World War II, nitrogen fertilizer use has gone up 12 to 14 fold. What happens when this increase intrudes upon the nitrogen cycle? The nitrogen cycle goes like this: crops contain organic nitrogen; cattle eat the crops, converting the nitrogen in the corn or the grass into cattle nitrogen; manure, containing nitrogen, is delivered to the soil and there converted by indigenous microorganisms to soil humus, organic matter from which other microorganisms release inorganic nitrogen which then is taken up by the crop. This is a nice self-contained ecological cycle. But that's not the way it happens any more in the Midwest.

For example, Illinois has no cattle to speak of. It produces corn to be shipped to Iowa and Nebraska where cattle are collected in huge feedlots and fattened for the market; their manure is deposited right there, and the cycle is broken. Often manure washes into streams and pollutes them. Meanwhile back on the farm the nitrogen is not being returned to the soil; fertilizer is used instead, and, as a result, the humus content has gone down to half of what it was in 1880. Humus is responsible for the porosity of the soil, and this porosity is what lets oxygen reach the roots. Oxygen is needed to produce the metabolic energy which roots must use to work again the diffusion gradient and take nutrients into the plant. Hence, the result of losing humus is that fertilizer is taken up less and less efficiently. So we keep piling on more and more fertilizer, raising the crop production rate, but adding more and more nitrogen that is unused by the crop, but has to go somewhere.

In 1947 the United States used 11,000 pounds of nitrogen to produce one USDA crop unit (an index of crop production, the closest available measure of what we call the biomass, or the actual amount of organic matter). In 1968 it took 55,000 pounds of nitrogen to produce the same amount of crop. The efficiency with which we used fertilizer has gone down five fold. Where is the rest of the nitrogen? Most of it drains off into streams and lakes. One result is that in a town like Decatur, Illinois, every spring for the last five or six years, the nitrate levels have been at or over the Public Health Service limits. Why is there a Public Health Service limit for nitrate concentration in water? Nitrate is readily converted to nitrite, particularly in the digestive tract of infants. Nitrite is poisonous because it combines with hemoglobin and hinders it in carrying oxygen.

If we ask agronomists why these changes were made, they will often say that they were necessary in order to feed the hungry people of the world and of the United States. But has food production really increased that much? Are we all so much better off? The data in the *Statistical Abstract of the United States*[1] show that since 1947 there has been only about a 10 percent increase in the per capita production of food in the United States. We have been exporting only about 15 to 20 percent of our production. The growth of our production has just kept up with the growth of the population. One result is that we have retired land from agriculture helped by government inducements in the form of Land Bank payments.

Why did this all come about? Quite simply, it is because it is now impossible for a Midwestern farmer to break even economically without using so much nitrogen fertilizer that water pollution is inevitable. The yield of crop with increasing fertilizer tends to level off; so to achieve the last 10 to 20 bushels of corn per acre, it is necessary to double the nitrogen input. This is an efficient way to feed the plant, but that last 10 or 20 bushels is often the difference between profit and loss to the farmer. The tragic fact is that we have forced farmers into an economic position which requires that they assault the environment in order to survive. If you look at any environmental issue, and carry it back step by step to its beginning, you will discover that it originates in a very basic *economic* issue.

Another example is soap and detergents. Before World War II we all washed ourselves with soap. Now 70 to 80 percent of cleaners are detergents (synthetics) not soaps. Why did this come about? Detergent manufacturers say there isn't enough saponifiable fat available to produce soap. However, if we again turn to the *Statistical Abstract* we discover that we are now exporting enough saponifiable fat to make up the whole deficit. So that's not the cause.

Detergent manufacturers will also tell you that detergents are better for washing-machines. Detergents suspend the dirt, while soap tends to leave dirt in particulate form. These particulates can be washed away, but they are particulates. The difficulty here is the design of washing machines. The old washing machines, made when soap was used, very often had two basins. Clothes were washed in one, lifted out, and put in the other one to rinse, leaving the dirt particulates behind. In the modern washing machine the clothes are used as a filter for the dirty water in the rinse cycle. The clothes sink to the bottom or the sides, while the basket spins, and dirty water is pushed out through the clothes. That won't work if the dirt is in a particulate form, but is feasible if the dirt is solubilized. When detergents were invented, it was possible to redesign the washing machines so that now they are built to accommodate synthetic detergents rather than soap.

But, why detergents? Pound for pound, the profit derived from manufacturing detergents is nearly twice the profit derived from manufacturing soap. The development of detergents represented a forward economic step for the soap and detergent industry—it increased profits. Simultaneously, it reduced labor input because on-line production is more feasible with detergents than with soap. Soap is more amenable to a batch process method because, among other reasons, fat characteristics vary from batch to batch. Thus, soap needs closer watching. In a low-labor-input situation, detergents work out better.

But detergents are ecological idiocy! Let us look at their record. First, the manufacturers made non-degradable detergents. The molecules were branched, so the bacteria of decay that normally degrade organic materials in surface waters wouldn't break them down. Then, because of the resultant mounds of suds, manufacturers stopped making that kind of detergent and instead gave us a straight-chain detergent, still with a benzene ring on the end. Bacteria degrade detergents by lopping off carbons down the chain, ultimately leaving the benzene ring free. This may be oxidized in the water to become phenol, a toxic substance. There is some debate about how much phenol is formed; but however much it turns out to be, it still really doesn't make sense to put into the water something that *can* be converted into phenol. Phosphates, too, were put into detergents, and that story is well known.

Aside from all that, there is an ecological error in the use of any synthetic material to substitute for a natural one. One illustration of this is the use of energy. Energy is very difficult to come by. For example, fat, which is the base for soap, represents, so to speak, congealed solar energy. Solar energy is free. Taken up by the plants and the animals that eat them, it provides the raw materials for soap at low temperature with no smoke, no noise, and no depletion of fossil fuel resources. The synthetic detergent, on the other hand, must be prepared from a nonrenewable resource. It is processed at high temperatures at the expense of depleting fuel resources, and of air and water pollution. The fuel used to produce fat for soap is the sun, which comes up every day. There is a lot of talk now about dwindling fuel resources and about capturing solar energy. Soap is a natural scheme for capturing solar energy—and we have thrown it away in favor of burning petroleum to produce detergents. Similarly, cotton is a scheme for capturing solar energy that we neglect in favor of synthetic fabrics.

Throughout all of our productive activities, a series of technological transformations have taken place. Soap has been displaced by detergents; cotton and wool by synthetics; steel and lumber by aluminum; railroads by trucks; labor by automated machinery; land by fertilizer. Each one of these changes is driven by a very simple feature of our society, namely, that people manufacture or produce those things that maximize profits, by whatever method maximizes profits most. Each one of the new products or new technologies is more profitable than the one that it displaced. And in each case the new technology is much more of a threat to the environment than what it displaced. It would be a valuable exercise for high school students to trace such changes through data available in the *Statistical Abstract* and in the *Census of Manufacturers*.[2] A good topic is the truck-railroad displacement. What do we get out of freight? The delivery of something we want. It doesn't make any difference to us whether it comes by truck or rail—what we want is the ton-mile carried. But it takes six times as much fuel to move a ton-mile by intercity truck as it does by railroad. It takes four times as much energy to lay down the roadbed for a truck as it does for the railroad. The highway takes a 400-foot right of way, and the railroad a 100-foot right of way. It is ecologically insane to replace railroads with trucks, but we did it. Why? Because truck freight is more profitable. We are in ecological trouble because of our economic interest in raising or maintaining rates or profit.

We now come to the question of what to do about these issues—which, despite their scientific background, are clearly not scientific issues, but social ones. Let's consider some alternatives.

If in 1947 we had decided that we wanted to control pollution and keep it at the 1947 level, we could have embarked upon a campaign for a 30 percent decrease in the amount of pollutant emitted per unit good produced. Had we succeeded, we would now have the same general environmental situation that we had in 1947. Alternatively we could have decided to keep the pollution level constant by controlling the size of the population, rather than by improving the technology of production. Had we allowed our technology to change as it did—generally to become an order of magnitude worse in pollutant emission that it was in 1947—but reduced the United States population by 86 percent, we would also have now the same essential environmental situation than we had in 1947. In other words, the alternatives faced in 1947 would have been to achieve the same result with either an 86 percent reduction in population or a 30 percent improvement in technology in order to keep the levels of pollution unchanged.

But the improvement in technology would involve some important economic changes. The whole pollution issue represents an enormous debt to nature which we have been accumulating, and that someone is now going to have to pay. Here, one quickly comes to the realization that the environmental issues are issues of social justice—justice for workers who may be displaced if plants close down because it is uneconomical to run a non-polluting plant, justice for citizens in the polluted areas. An examination of environmental issues leads directly to fundamental political, social, and economic difficulties. These are the issues that we must face if we are to survive the environmental crisis.

On the other hand, we, as scientists, must not confuse scientific and political issues or try to convert one to the other. A case in point is the present discussion of population control in the world. The view of the population increase as an exponential growth phenomenon is highly simplistic. Furthermore, it is a view which fails to reflect what we know about the behavior of human populations. Just ask yourself: Where in nature is there an example of an ever-rising exponential curve? There isn't one. An exponential growth curve indicates a lack of coupling to the environment. Is the human population uncoupled to the environment? Of course not. People aren't stupid. In a primitive society where food is the limiting factor, people know that you die of starvation if there isn't enough food to go around; a system of taboos and other social practices evolve, resulting in the control of population growth. Demographers tell us that in every Western country, as the standard of living has increased, people have lost the motivation for having large families. Human beings translate a rising standard of living into a self-motivated control of their own fertility. This is even happening in the Third World today. The birth rate is still high, but in a number of places it is dropping. To extrapolate into the future you must look at both the direction of the curve and its slope.

The point I am making here is very simple. At the least, an objective scientific examination of the population question would hold that there are two alternate ways to regulate population growth. One is enforced population control. The other is raising the standard of living. These are both *scientific* statements. However, the choice between them is not at all a matter of science, but of morality, social justice, and politics. To pretend otherwise is to hide a political issue behind a scientific cloak.

A very interesting example in a similar area is the recent report on growth published by the Club of Rome.[3] What this represents is a computer analysis of the relationship between various factors—population, food, and so on—in the future. Past trends were used as a basis for extrapolation. If you look at the curves you will find that the authors accepted curves which can be changed by the stroke of a pen. For example, the relationship between pollution from feedlots and the production of beef is one that could be changed tomorrow if the government would abolish Grade A beef. Feedlots produce Grade A beef; if Grade A beef were no longer sold at a premium price, the feedlots would go. In *Limits to Growth* a hypothesis about growth has been put forward which excludes the alternative of solving the problems by social action. The result says: Horrors! if we don't reduce the population, all hell will break loose. The alternative of, for example, abolishing the profit system isn't mentioned. Yet that is an alternative which might allow us to develop ecologically sensible technologies rather than ecologically foolish, but profitable ones. The people have to decide among these alternatives. A scientific exercise can readily obscure the possibility of such a decision by wrapping it in a political assumption. Then the people get a finished product without knowing that they have a choice to make. The public has been deprived of the right of conscience.

The environmental crisis, carried to its origins, confronts us with longstanding questions of social justice. How can you discuss environmental issues in the classroom without raising the questions of racism, unemployment and profits, or the question of the war in Vietnam? If you start talking about herbicides, you end up with herbicidal warfare in Vietnam. If you talk about phosphate pollution, you will have to discuss the high rate of profit in the chemical industry.

This is a responsibility that we must face. The people who have to decide—your students and their parents, and society as a whole—simply can't get this kind of information unless you and I and the rest of the academic community help bring it to them. The ecological victories which have been won thus far have been achieved by getting the facts to the people, who have then understood that there *is* an issue. What impresses me about the recent history of the environmental issue is that the people of the United States and in most countries of the world have consciences that are ready to work on it. The people are ready to act. What they need are the facts. They don't need to be told what to do—to favor population control or improved living standards, to support the profit system or oppose it. They will be able to decide for themselves. As scientists and teachers we must be willing to educate the people and to have faith in their wisdom; to believe that the people, thus informed, will choose a humane course toward survival.

1. 1970 U.S. Department of Commerce, Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
2. U.S. Department of Commerce, Washington, D.C.
3. *Limits to Growth.* Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III. Potomac Associates, Inc., Washington, D.C. 1972. (The authors are researchers at Massachusetts Institute of Technology. The study was sponsored by the Club of Rome and the Volkswagen Foundation.)

NSTA - SUNOCO SCIENCE SEMINARS (ABSTRACTS)

EQUILIBRIA–WHAT THEY ARE, WHERE THEY COME FROM, AND HOW THEY TAME THE CHANGING WORLD

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The role of equilibrium in scientific explanations is reviewed. After identifying relatively slowly changing things and analyzing them into more permanent parts, the problem is to explain how the orderly patterns of change for wholes emerge from the motions of the parts. The cause of the behavior and the key to understanding it is equilibrium.

Various types of equilibria are described, starting with motion equilibrium. Flow and flow equilibrium are considered in some detail to see that equilibrium occurs periodically as a natural, mechanical event. If the equilibrium intervals are longer than the time between changes of external influences, then the fluid is kept on young parts of equilibrium intervals where its behavior is orderly, reproducible, and predictable. Probabilistic ideas can then be applied to explain equilibrium and to predict rates of forced withdrawal.

Heat equilibrium is explained in terms of molecular motions and collisions which lead molecular energy away from places where there is a high density of energy to places where the density is lower. The probabilistic argument is justified by the history of the fluid, i.e., the short stays on young parts of equilibrium intervals.

Evaporation, melting, dissolving, and chemical reactions are considered in terms of particle motions. Under the assurance of equilibrium randomization, each of the processes can be viewed as the net results of two opposing processes which have rates that vary with temperature and molecular concentrations. Equilibrium occurs at sharp, reproducible temperatures and concentrations where the rates of opposing processes are equal.

PATHO-BIOLOGY

E. Bernard Wagner, MD, Director of Laboratories, Beekman Downtown Hospital, New York, New York

Pathobiology is concerned with the changes in normal biological systems that occur in response to injury. Previously this area of biology was referred to as general pathology. However, with the rapid developments in cell biology, it is now possible to provide the student of biology with a more dynamic view of altered cell responses. The constant struggle of survival and adaptation by living systems in a hostile environment falls within the province of pathobiology. In effect, pathobiology has evolved as a new concept fusing the science of cell biology and classical pathology and encompassing the normal processes of growth, metabolism and biologic interaction and the effects of injuries on these processes. To understand pathology, we must appreciate the nature of the changes in structures and functions which occur in response to diverse injuries. Injurious agents, such as bacteria, viruses and radiation may determine the pathway that a reaction will take. But they are in many ways only triggering forces within the cell, tissue or organism leading to malfunction or disease.

Alterations in mitochondrial structure are as important as alterations in cardiac structure and interference with ATP is as crippling as interference with blood flow. Cancer and immunity may be regarded as parts of the general problem of biological control mechanisms. Which category of cellular processes determines the integrity of the cell in response to injury? Gene action, enzyme activity, endogenous regulators, exogenous factors all are factors in the ultimate expression of altered function.

Recent studies have indicated the importance of the extracellular matrix in control of cellular homeostasis. The connective tissue ground substance plays a vital role in transport of metabolic products and appears to have a regulatory function for cell growth and organ size. Studies in immunology and inherited disorders of metabolism have further elucidated the dynamic biological role of the connective tissue system. While experimental models are extremely useful in dissecting the multitude of responses to injury, spontaneously occurring diseases of animals are "natural" models. Such diverse conditions as Aleutian disease of mink and equine arteritis have provided new insights into virus-cell-host interactions.

The seminar considers the pathobiology of connective tissue, inflammation, immunological damage, cellular degenerations, and aging. From these common biological events a newer appreciation of concepts in teaching should emerge.

WATER SUPPLY MANAGEMENT

M. Gordon Wolman, Head, Department of Environmental Engineering, Johns Hopkins University, Baltimore, Maryland

Demands for increased water supply and improved water quality have strengthened concepts of water management. The range of alternatives available to water managers include not only new sources of supply, but also techniques of water re-use and economic manipulation to influence demand.

Growing interest in water and river quality have resulted in increasing requirements on appraising river quality and the development of biological and biochemical models of the behavior of the water system. Present evidence indicates that land use changes have most profoundly effected water quality in the eastern United States. Salt content has increased nearly 100 percent in some industrial regions, and more in rivers experiencing heavy return flows from irrigation. Thus far, radionuclides and pesticides indicate local concentrations and effective decay below point sources. Heavy investment in treatment works has permitted disolved oxygen levels to remain constant for several decades on the Hudson near New York and on the upper Mississippi; the Potomac at Washington, and others have declined in quality. Observations indicate a need for better descriptive parameters as well as continuing analysis of water and river quality. Public perception of necessary measures often does not correlate with scientific or engineering variables.

Models of stream behavior including biological, chemical, and hydrological relationships are essential water management tools. Thus far, such models emphasize primarily dissolved oxygen. Biological observations are being developed to provide more comprehensive description and prediction. The interacting effects of stream flow regulation, waste effluent treatment, and natural hydrologic behavior must be predicted if high cost water management schemes are to be effective. Political structures for internalizing benefits and damages as well as beneficiaries and contributors are required to realize such management.

Recognition of the requirements for treatment of wastes coupled with problems of distance and transport to new sources have made integrated systems combining prospects for water re-use with satisfactory supply and improved river quality. Known chemical processes are available for treatment of sewage wastes as are higher levels of bilogical treatment. Costs of wastewater reclamation estimated at 30 cents to 60 cents per thousand gallons begin to be competitive with other sources under special circumstances.

Problems of dependability as well as public acceptance remain. Integrated management of drainage basin systems must balance demands for improved water quality in streams with economic allocation of costs and equitable distribution of such costs.

CONTINENTAL DRIFT

Robert S. Dietz, Research Oceanographer, National Oceanic and Atmospheric Administration, Miami, Florida

Earth science is undergoing a modern revolution paced by plate tectonics and its corollary, continental drift. To the classical dimensions of geology (up, down, and time) there now has been added a fourth dimension—that of large, horizontal shifts of the earth's crust. Plate tectonics holds that the earth is divided into about eight major rigid, but shifting, 100 km-thick lithospheric plates in which the continents are embedded and drift along as passive passengers. We can visualize the ideal plate as rectangular, although only the Indian plate approximates this simplicity. Along one edge there is a subduction zone, usually marked by a trench, where the crustal plate dives steeply into the earth's mantle, attaining a depth of as much as 700 km before being fully reabsorbed. Opposing the subduction zone is a midocean rift, or pull-apart zone. As the rift opens, the gap is quickly healed by the inflow of liquid basalt and quasi-solid mantle rock. The other two antithetical sides, connecting the rifts to the trenches, are crust-piercing shears called transform faults. Thus, three types of plate boundaries are possible: (1) divergent junctures, the midocean rifts where new ocean crust is created; (2) shear junctures, the transform faults, where the plates slip laterally past one another so crust is conserved; and (3) convergent junctures—that is, trenches where two plates collide, with one being subducted and consumed.

A grand theme of plate tectonics is drifting continents, with any continent having a leading edge and a trailing edge—for North America, the Pacific coast leads while the Atlantic coast trails. The trailing margin is tectonically stable and, since the continental divide is near the mountainous Pacific rim, most sediments are dumped into the Atlantic Ocean (including the Gulf of Mexico). So it is along a trailing edge that the great geosynclinal prisms are deposited. The convergent junctures are of special interest for the geosyncline-mountain building cycle. There is a sedimentary prism may be collapsed into a mountain foldbelt accompanied by thrusting, crustal thickening, and isostatic uplift together with magmatism and metamorphism. Another theme is that ocean basins are not fixed in size or shape; instead, they are either opening or closing. Today the Atlantic Ocean is opening while the Pacific Ocean is closing.

This short course attempts to examine some of the basic principles of plate tectonics, review the breakup and drift dispersion of continents from the Triassic to the Recent, examine the role of plate tectonics in the geosyncline-mountain building cycle, and finally apply plate tectonics solutions to the evolution of selected regions around the world.

ELEMENTARY PHYSICS FOR ELEMENTARY SCHOOL TEACHERS

Malcolm H. Skolnick, Professor and Director of the Program in Biomedical Communications, The University of Texas Medical School, Houston

Our society is in transition from a state where most people were engaged in providing material goods to the present where the majority of working people provide non-material services. In short, we have moved from a base of industrial production to a new base requiring educated manpower—a "knowledge" society.

One component of this transition is the growing ecological awareness of the general public. The concern over the destruction of the environment and the depletion of our resources has saturated the media, enlarged the educational value structure and led to extremes such as anti-industrial vigilantism.

Unfortunately, increased sophistication about the complexity of the interactions between our needs, our technology and our environment has led to heightened frustration as the disparity between our dependence on technology and our inability to manage it becomes more clear.

The next set of people who will run our knowledge society are now being educated. They inherit the problems of the transition and the necessity for improved technical management with reduced margins for error. Their needs for developed knowledge-based problem solving skills places increased demands on the educational system.

Part of this demand evolves from a requirement that people become increasingly aware and knowledgeable about the consequences *to them* stemming from scientific and technical decisions. The informed populace must be able to test scientific expertise for honesty; it must resist intimidation by jargon; it must be secure enough in its knowledge to express temperate dissent from authority; it must be willing to learn when important decisions require it.

I feel that increased effort must be made to tap the richness in science education to address some of these demands. Beyond the mere skimming of the content of the existing disciplines, science education can be used to encourage the expression and development of attitudes about inquiry, about dissent, about pragmitism, about coupled opportunity and risk, and about choice.

One has only to open a teachers' guide written by any of the development groups such as ESS, SCIS, MINNEMAST, AAAS, etc., to note immediate concern and detailed attention given by the developers to the combination of content, styles for delivery and attitudes on the part of teachers and students. Repeated inferences indicate that attitudes children develop while learning science are as important as the content. The "way" it is learned is as important as "what" is learned. The necessity to provide some form of evaluation has led several of the groups to suggest that attitudinal as well as skill and content measures be incorporated.

I am disappointed that the lessons learned by the curriculum development groups resulting in the combination of the skills of basic scientists and teaching specialists have only infrequently been understood in teacher training institutions.

There are numerous examples of successes led by individual teachers using the experimentally-oriented materials produced by these groups which have shown that choice of content leads to a particular style of delivery that reinforces attitudes about inquiry, experimentation, and consequences of choice.

Increase in this kind of success can come if the structure supporting the processes of teacher preparation and science education can extend the fusion of people with complementary knowledge in scientific content and presentational style.

A training format for science teachers can reflect the dual concern that science teaching be used as a structure for examining values and stimulating attitudes as well as providing disciplinary content.

CYBERNETICS AND CYBERNATION

Alice M. Hilton, Institute for Cybercultural Research, New York, New York

I. The Re-unification of Knowledge
   1. Definitions: *Cybernetics*, ancient philosophy and modern science of the dynamic relationships within a system.
      Systems, components and the dynamic relationships distinguishing the system; systems may be open or closed, abstract or concrete, simple or complex, probabilistic or deterministic, large or small . . . .
      Cybernation, one—and only one—of the applications of cybernetics, namely the production method by means of machine systems under the direction and control of a computing machine.
   2. The Roots of Cybernetics: generalization and abstraction; logic and mathematics.
   3. The Basic Principles of Information Theory.

II. Computing Machines, the Product and Tool of Cybernetics and Cybernation
   1. Logic and Calculating Machines—from Lull to Babbage
   2. The Theory of Automata
   3. Logic and Mathematics as the Foundation: symbolic logic, Boolean algebra, truth tables, circuits, geometric diagrams and other symbols
   4. The Languages, Symbols, and Algebra of Logic

III. Modern Applications of the Science and Philosophy of Cybernetics—
   1. Its impact on the processes of learning, politics, and production
   2. Mathematical Models; the dynamic probabilities in the prognoses of future events.
   3. Mankind chooses the future of mankind: tools and alternatives.

ENERGY AND THE ENVIRONMENT

John M. Fowler, Visiting Professor of Physics, University of Maryland, Director, Commission on College Physics, College Park, Maryland

Three lectures encompass the dimensions, the underlying causes, and some of the possible cures of the "Energy Crisis." The three topics are: Energy—Where It Comes From and Where It Goes, Environmental Effects of Energy Use, and Possibilities for the Future.

The first lecture traces a historic trend involving a shift to more and more convenient forms of energy. At present about 96 percent of our energy comes from fossil fuels. Most of this energy goes through the intermdediate form of heat, and conversion from this form is inescapably inefficient. Electrical energy, because of its convenience, is increasing rapidly in importance, doubling about every 10 years.

Not only is our efficiency of energy use less than 50 percent but there are no immediate signs of increased efficiency and some evidence of decreased efficiency. There is also inequity in the worldwide picture, as exemplified by the United States, which uses 35 percent of the energy for 6 percent of the population. It is this inefficiency and inequity whose rationalization in the immediate future can exert a dominant influence on the energy picture.

The second lecture evaluates the impact on our environment: the scars on men and nature from mining, pollution of the land and air by the products of burning fuel and by the heat wasted in the process of conversion, and the wastage of heat and entropy in the "throw away" style of consumption. The contributants and the size and seriousness of their present impact can be quantitatively pictured at each stage, production, conversion, and consumption in the energy cycle of our industrial civilization; careful projections of the impact of the oncoming nuclear systems to which we are committed must be made.

Lecture three cites the challenge of the immediate future as undertaking the research and engineering development which will enable us to replace the non-renewable sources of energy with sources that are continuous or virtually unlimited. Of these the most important are solar energy, of which one thousand times our present daily use arrives daily, fusion energy for which the oceans' deuterium is a nearly limitless potential source, and geothermal energy whose extent and potential is largely unexplored. The problems of harnessing these various sources will provide scientific and engineering challenges for the next several decades. Success offers freedom from energy want but will itself reshape our future.

THE SKY ABOVE

Fred Hess, Professor of Physical Science, Maritime College of the State University of New York, Fort Schuyler

During the last ten years man's reach toward the sky above has yielded dramatic success in his attempt to know better the universe that surrounds his planet.

He has physically touched the moon four times. From samples of lunar rock brought back to earth and from data still being transmitted to earth from instruments he has placed on the lunar surface, he has exploded some theories regarding the moon and its origin, and has gathered new knowledge to feed afresh the thinking of theorists. He is beginning to read the history of the moon and the inner solar system which has been preserved on that unique museum—the moon.

He has lived in space between earth and moon, but not for long. He has remained there only long enough to reach the moon and return. He has discovered that living in space will require the solution of severe problems, only some of which he has yet identified.

Within these same ten years man has dispatched his instruments to Venus and to Mars, touching with them the surfaces of both of our neighboring planets. He has probed the atmosphere of Venus with his satellites, and has measured its contours with earth-based radar. He has photographed the face of Mars and has discovered earth-like and new landforms. He has measured the rotation of the inner planets and has discovered new knowledge of satellites of outer ones.

He has gathered radiant energy from the stars using new instruments to detect unseen wave lengths. He has added to the language terms like "quasar" and "pulsar", and has developed a new meaning for the "black hole". With radio receivers beneath the atmosphere and X-ray detectors above it he has found new objects in the universe. His orbiting satellites have discovered "polar caps" on the sun and hydrogen clouds surrounding comets.

For man it has been a decade of unparalleled acquisition of knowledge about his environment beyond earth.

HUMAN GENETICS

Orlando J. Miller, Professor, Human Genetics and Development, Columbia Presbyterian Medical Center, New York, New York

The first lecture, "Chromosomes and disease," deals with chromosomal abnormalities as causes of birth defects and mental retardation. The second lecture, "Single gene effects," considers the physiological and biochemical effects of mutation at a specific gene locus, and the diagnosis and treatment of genetic diseases. The third lecture, "Prevention of genetic disease," deals with genetic screening tests, prenatal diagnosis, and advanced research techniques which could introduce human genetic engineering. A consideration of the moral, social, and ethical implications of all such measures is included.

NSTA INVITED PANELS AND SYMPOSIA

NUTS AND BOLTS: Series A, B, and C

SESSION A-1

EDUCATIONAL TECHNOLOGY

Claude W. Gatewood, Professor and Director, Science Education, Cleveland State University, Cleveland, Ohio

I have entitled this paper, at least temporarily "Educational Technology?" for a variety of reasons. One is that I have never before had an occasion to use the English language's newest punctuation mark, the interrobang. It is a superimposed question mark and exclamation mark, and is properly used to denote incredulity. Some of the other reasons for my selecting the interrobang will become evident shortly.

First, let us consider a simple matter—defining the term "educational technology." A recent ERIC document[1] contains a description of a bibliography of educational technology that contains over a thousand entries. The descriptions assigned by ERIC should provide some clues as to what is meant by the term. The descriptors were: "Art education, audio-visual aids, bibliographies, curriculum methods, education equipment, educational facilities, educational games, educational research, educational technology, instructional materials, instructional television, language instruction, media selection, philosophy, programmed instruction, reading instruction, religion, resource allocation, science instruction, simulation, social studies instruction, systems approach, teaching materials." Although I was pleased to see "science instruction" included, I have yet to run across any ed-tech-assisted philosophy instruction in operation. *However*, as I delved further into the field, I began to feel that "philosophy" is certainly a crucial term when one considers educational technology.

Lawrence Grayson[2] in a recent article in *Science*, provides another definition. He states that educational technology is "a systems approach to instruction, incorporating specific measurable instructional objectives, diagnostic testing, criteria for student performance, and the repeated redesign of the curriculum materials until the criteria are achieved." The source he cites for this definition turns out to be another article by the same Lawrence Grayson. And here begins some of the "circularity" that one can detect in many reports on the status, use, success, failure, etc., of educational technology.

I sincerely do not intend derogating Mr. Grayson, but his article does provide other information that is worth noting. A footnote indicates that he is acting director of the Division of Technology Development with the U.S. Office of Education. The title of his article is "Costs, Benefits, Effectiveness: Challenge to Educational Technology."

Mr. Grayson's well-organized article starts with the statement that "Technology can and is affecting education today." With this, I agree. His first paragraph is an overview or statement of the purpose and function of the lengthy article. Briefly, the introductory paragraph states that this decade will witness tremendous growth with respect to ed-tech-assisted instruction, for two reasons. First, the present system isn't working very well because of such things as high cost, low productivity, etc. The second reason is:

". . . . recent advances and growth in the number of cable systems

. . . . the potential expansion of instructional television Fixed service for both video and nonvideo services

. . . . the appearance of new and specialized microwave common carrier systems

. . . . the development of domestic satellite communications

. . . . advances in film and tape cartridges

. . . . the emergence of mini-computers and computer time-sharing, and

. . . . the growing acceptance of microforms."

Only one source is cited for the above items in the article, and that is a publication by Bell Canada of Montreal, Canada. I can but assume that that is the Canadian version of our own "Ma Bell," an organization which I believe to be engaged commercially in every single item or development on the list. I most emphatically do not intend to imply that Mr. Grayson has deliberately slanted his article. What I do mean is that caveat emptor is beginning to apply more and more to the consumer of "knowledge," as well as the consumer of products.

On persuing the literature, I find that I am not alone in my wonderings. James A. Mecklenberger,[3] in an Ed-Tech series in the journal, *"Educational Technology,"* voices similar concerns. In this particular article, he is reviewing a report by the Rand Corporation on a $300,000 contract with HEW on the topic of performance contracting. Skipping over the fact that the Rand Corporation was the contractor rather than some educational institution, Mecklenberger says:

> "Volume I, (of the report) *Performance Contracting Concept in Education*, is signed by J.P. Stuckler and G.B. Hall. Elsewhere, I discovered that they are both PhD economists; no vita is given with the report. Since the report "should not be interpreted as representing the official opinion or policy of Rand or of HEW," presumably Stucker and Hall are solely responsible.
>
> How did they prepare the report? They don't say . . . Some passages suggest personal conversations with contractors. One can only guess whether Stucker and Hall immersed themselves in the topic, or merely surveyed the literature.
>
> "Errors in the report raise some question as to its authoritativeness. For example, Stucker and Hall do not know that there is no performance contract in Denver (Denver refused it, and it was hastily resurrected in a suburb)."
>
> "The report explains the rise of performance contracting as "Trends" that 'came together": a dash of taxpayer revolt, a pinch of dissatisfaction with city schools, an *ounce of frustration by educational technology companies unable to sell their wares* (emphasis Gatewood's), a catalyst from Department of Defense procurement policies, and bingo—performance contracts. While this is not untrue, this formulation is characteristic of the report—there are no

people in it, only abstractions.

"Their delineation is neat, like a PERT chart, but it scarcely reflects the gut-level reasons why companies and schoolmen have signed performance contracts.

"Since this report is "addressed to educational decisionmakers, particularly those guiding local school districts," it misses its mark.

I would maintain that Mecklenburger's concerns are *well-founded*, do *not* represent an isolated event, and reflect part of a broad trend whereby a barrage of "Madison Avenue" tactics are being employed against the educational enterprise.

Now don't get me wrong. Let me state here and now, unequivocably, that I belive in progress. I do *not* want to trade my Oldsmobile for a horse and buggy. I prefer penicillin to cow-dung poultices. I like typewriters and I own two television sets. In my science methods courses, I use transparencies, audio *and* video tape recorders, and even have my students do micro-teaching with real children. I even team teach some courses with a colleague.

But, I believe that anything can, and often is, taken too far. Remember that Mecklenburger's recipe called for an *ounce* of frustration by ed-tech companies unable to sell their wares, and only a *pinch* of dissatisfaction with city schools—and a *dash* of taxpayer revolt.

Remember when VTR's got to be cheap enough to be available to "average" schools? I have no idea how many were sold to schools complete with "wired" rooms and the like, and I am sure that many such systems are still in daily use, and making excellent contributions to education. On the other hand, I know of at least one school where the cables lie dormant, and the only use the VTR gets is when the superintendent uses it to tape his speeches and thus avoids having to attend his own teachers' meetings.

Twenty years ago, my prime "drive" in life had to do with the production of scientists for the future. I have since deserted this raft, and am now dedicated to the generation of a scientifically literate citizenry for the future. I made this change *not* because I didn't care about PhD scientists, but because adequate resources would have been directed toward that end whether Claude Gatewood lived or died.

Now (in a similar vein) with respect to educational technology, I do not reject its worth, but I believe that its impact and utilization will move ahead as inexorably as a glacier. I would like only to draw your attention to the possibility of a few flaws, and to urge that we guard against being swept up in an avalanche of "good things" lest their weight crush us.

First of all, I simply *must* find some way of working in a reference to an article that I felt compelled to have in my bibliography. James Evans[4] authored a chapter in a book titled *Technology and Innovation in Education.* The chapter is entitled "Behavioral Objectives are No Damn Good," and describes specific ways in which their utility can be misdirected or misinterpreted by teachers. I will cite only one example and recommend the entire chapter heartily.

A behavioral objective was stated as follows: "Without notes the student will use the quadratic formula from memory to solve quadratic equations." Beautiful, impeccable. But consider the correcponding criterion item: "Solve this equation with a quadratic formula: $x^2 + 5x + 6 = 0$. On the surface it seems to be a reasonable behavioral objective. However, I happen to know that 90% of the students in the validation group solved the equation by factoring. Ten percent solved it by completing the square. 100% of the students got 100% on the item, but not one student used the quadratic formula. The only one who got anything wrong was the writer of the behavioral objective who felt that the data established that the behavioral objective had indeed been reached.

Handy and Hussain[5] in a book on *Network Analysis for Educational Management*, discuss CPM (Critical Path Method), the two most prominent network analysis systems. The authors propose methods and examples of CPM/PERT applications in curriculum development and revision, as well as "management" functions ranging from repairing chalkboards to recruiting professional staff. Although detailed programs are *proposed*, there apparently were no examples to cite whereby these techniques had been successfully used to develop proven curriculum materials. This seems to me to be analagous to an obverse of the old idea that aerodynamics can *prove* that a bumblebee cannot fly.

bumblebee cannot fly.

A team in Michigan[6] is developing an English composition course in which student essays will be corrected by computer. On reading their report, I couldn't help but be reminded of the time I saw a copy of Lincoln's Gettysburg Address that had been attacked by a grammarian. It had been slashed to bits and given a grade of "C-."

A prestigous sounding group, the 1985 Committee of the National Conference of Educational Administrators[7], prepared a report entitled *Educational Futurism, 1985: Challenges for Schools and Their Administrators.* Rather than judge the book myself, and possibly be accused of bias, I will use the words of W. Timothy Weaver, who reviewed the book for the periodical *"Educational Technology."* Typical of Mr. Weaver's criticism of the report is the following quotation from his review:

> "There is some jargonese in this book that can only be described as simply awful. For example, this from the pen of Mr. Hack: 'Programmatic demands springing from an input change might include a modification in the school's custodial function, in that it might be required to diagnose, prescribe, and administer services and/or pharmaceuticals for learning stimulation or behavior modification!"

If you cannot understand *that* quote, you may agree with me that the "1985" in the book's title might more properly read "1984." But enough for now of picking at nits in the seemingly impenetrable hide of the establishment. Let me now try to set the stage for ending my conversation on this topic of educational technology. First, a look at the financial picture.

Brown and Norberg, in a book on *Administering Educational Media*[8], cite a 1954 NEA survey that most small cities did not even have centrally organized AV services. Additional evidence is given to present pre-Sputnik educational technology generally as being nothing but the usual "AV" support that had existed for years. Brown and from each of my teachers that commends itself to me as worthwhile and *not* be provided with a composite "model" that was predetermined—even programmed and administered by machines.

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SESSION A-3

PROJECT BIOTECH: AN ANSWER TO THE TECHNICIAN SHORTAGE

Carl Berkeley, Scientific Director, Foundation for Medical Technology, Great Notch, New Jersey

There is a worldwide shortage of adequately trained biologically-oriented technicians. Such technicians find employment in academia as teaching or research assistants; in industry as research assistants, in work in quality control testing and as process plant operators; in health care systems — in laboratories, in therapeutic situations, in the

Norberg do cite some examples of cooperative ventures to improve ed-tech types of assistance that originated years before Sputnik, but I maintain that exceptions to any "rule" could be identified. By and large, it was Sputnik I that scared the pants off the people in this country and led to an almost panic-level of spending to improve science education. (The move now is to scientifically improve all of education). The days when Uncle Sam would pay half the cost of a \$25.00 device, that may have been worth only \$7.50 are past. Hardly anyone bats an eye these days (except the victims) when they hear of another school closing because a levy or tax issue failed. We in science education have had our "Golden Decade," but it is now done. A dream of low-cost, automated education for all is, at best, just that—a dream. Oh, it can be made to sound extremely good by those whose specialty is profiting from such work. We have a good foundation, financed since Sputnik, on which to base future work and improvement. But my main concern is that we do not waste *any* of the finite and limited funds that will be available in the next few years, on "gimmicks."

In the past it was wasteful to see salt water aquariums in slum schools where children lacked supplies and lived in a world where only carp remained in their polluted ponds—tomorrow it should be a crime. If a private citizen chooses to buy a Cadillac to park in front of his hovel (while his children go hungry) that's *his* business. We who deal in public trust, however, cannot be so frivolous.

Now, while admitting that I have overstated the previous point in an attempt to assure your attention, let me set the stage for the final act and be done with it.

Robert MacNaughton[9] has divided educational technology into two "generations." First generation media are media used primarily as aids and supplements to teaching. He defines second generation media as media which alter the role of the teacher and *shape* instruction. Knirk and Childs[10] feel that in the past, AV materials were designed as "teaching adjuncts," but that they now have moved to a "mediated teacher format."

In closing, I will argue that educational technology can be proposed and used either as an adjunct *or* as an alternative to the teacher. If certain forces gain control of the limited resources available in these "cost cutting" days, it could be the latter. Educational technology can, and should be an adjunct to the teacher. As Gerald Torkelson said[11]: "Machines create automatons, not creative, thinking people."

In 1906[12] Ivan Pavlov wrote:

> "Mankind will possess incalcuable advantages and extraordinary control over human behavior when the scientific investigator will be able to subject his fellow man to the same external analysis as he would employ for any natural object, and when the human mind will contemplate itself, not from within, but from without."

And one last quote: a Norwegian named Henning Neerland said: "We are all born originals, but die as copies."[13]

I would argue that each student and teacher deserves to have some voice in the selection of what he wishes to become a copy *of.* I personally would rather copy that building and maintenance of health care equipment, in biomedical research, etc.; and in government — in research and inspection activities, in the Armed Services and in the Veterans Administration.

Biological technicians and biomedical technicians require extraordinarily diverse skills and training. If narrowly trained, they find that employment opportunities are limited. There is, however, a common pool of skills used by all life science technicians regardless of whether they are doing simple tasks or operating the increasingly complex equipment in modern technologically based procedures. It has been estimaed by the Technical Education Research Center that in the biomedical technology equipment area alone, there is an annual deficit in the United States of approximately 5,000 such technicians. The position as a technician can serve as an entering wedge to a science career for candidates for employment from underprivileged areas.

The BIOTECH Project, an undertaking of the Office of Biological Education of the American Institute of Biological Sciences in Washington, will train biological technicians in readily marketable skills through the development of BIOTECH modules which will be described in detail. Modules teach individual unit tasks. A task is described as the smallest unit of work that has as its work product something that is useful to another. The work product may be a tangible thing, a measurement, or a judgment.

A Biotech Teaching Module is a kit of teaching materials, available to the user as a single unit, covering only one task. It consists of a booklet, 32 pages or less, plus supportive audiovisual materials. The teaching module is designed to be used with the actual materials or equipment being studied. This project is being carried out under a grant by the National Science Foundation under the direction of John H. Busser, who is aided by a council who evaluates the various modules.

In order to obtain maximum implication of the biological community in defining and teaching the diverse tasks, modules are being developed through subcontracts with individual biological scientists who are most competent to teach specifically needed skills.

The need for trained technicians is a worldwide one. Modules developed under this program could, through the use of the identifiable visual materials and through the translation of the reading and audio materials, be very widely used in bringing the benefits of biological science to developing areas.

Typical BIOTECH Teaching Modules:

How to aspirate
How to use an autoclave
How to use a laboratory centrifuge
How to prepare common biological culture media
How to dilute liquids
How to make serial dilutions
How to use automatic and manual liquid dispensers
How to dry to constant weight
How to filter liquid suspension
Care and cleaning of common laboratory glassware
How to use volumetric glassware
How to read graphs
Mass, length, area, volume, units (metric)
How to use a compound light microscope
Prepare and check microscope wet amount
How to use a dissecting microscope
How to mix
How to observe quantitatively and record data
How to use a ph meter
How to pipette
How to pour plates
General laboratory safety
How to calculate and prepare percent solutions
How to use a common laboratory spectrophotometer
How to fill and empty a syringe
How to use a common laboratory thermometer
How to titrate using a burette
How to weigh (2 mg $\rightarrow$ 0.1 gm)
How to weigh ($>$0.1 gm)

CHEMTEC AFTER TWO YEARS OF CLASSROOM EXPERIENCE

Kenneth Chapman, Associate Project Director, Chemical Technician Curriculum Project, Lawrence Hall of Science, Berkeley, California

Seven hundred thousand dollars, fifteen professional man-years of effort, seventeen hundred pages of finished manuscript—these are some of the measures that can be applied to the Chemical Technician Curriculum Project (ChemTeC for short). Is this a legitimate investment for an educational program that has barely survived in many colleges and that attracts only two to three thousand new students per year? It is too early to provide an absolute answer for this question, but I would like to discuss some of the elements that have been observed in our evaluation thus far.

Chemical technology has long suffered with a Number 4 Syndrome. It is commonly the fourth technician program in the colleges that offer it. Its enrollment usually results in a Number 4 position in student numbers, faculty size, and budget. Many chemical technology programs have a history that shows outstanding demand for graduates, but the small number of students has always made the programs only marginally viable.

Beginning in 1963, committees of the American Chemical Society became concerned with chemical technicians and their education. Well-qualified technicians were few in number but their jobs had to be filled. The ACS committees found that the many jobs requiring technicians were filled in a variety of ways, ranging from employing professionals to elevating poorly prepared plant operators. As the committees continued their in-depth studies, it became apparent that crucial problems existed in addition to the obvious problem of student recruitment. Many chemical technology programs, particularly in the Northeast, had low percentages of graduates becoming technicians. Many faculty members judged their success by the number of graduates who transferred to science and engineering programs rather than by the number who became successful technicians. Nationally, the range in level of programs was very broad.

After carefully evaluting the problems of recruiting students, educating and training them in a two-year program, and getting them employed, the committees determined that the most promising point of attack was the curriculum itself. Among the reasons for this decision were:

1. Students in existing chemical technology programs generally did not enthusiastically endorse the program.
2. Faculty members had no reference mark for constructing chemical technology programs. They taught as they had been taught and very, very few had been trained in chemical technology.
3. Employers' expectations of chemical technicians were very broad and gave no sound basis for developing curricula.
4. Establishment of a sound, tested curriculum would give an identity to chemical technician education that would help a prospective student make a more informed decision, enable the teacher to more effectively design the instructional program, and give the potential employer a clearer perspective of the qualifications of a graduate chemical technician.

Thus, in 1967 and 1968, the American Chemical Society began the process that resulted in a 1969 grant that established the Chemical Technician Curriculum Project, or ChemTeC.

The principal goals of the ChemTeC Project were to clearly identify the curricular needs for chemical technology, including establishing a level of presentation, and to prepare actual instructional materials. The summers of 1970 and 1971 saw a 25-man writing team assemble to undertake the discussions and work to reach these goals. Industries, two-year colleges, and senior academic institutions were represented on the team. Additional industrial consultants were invited to work with the teams as well as to critique finished materials.

By fall 1970, a first version of ChemTeC materials was ready for classroom testing. Based upon classroom experiences in 1970-71 and 1971-72, a revised version of a text called *Modern Chemical Technology* will be made available for general use. The student materials will consist of about 1,700 pages of text. With the wealth of teaching aids available, ChemTeC has refrained from producing accessory materials until it can clearly justify such production. Thus, only one 16mm film has been made and it is principally an orientation-recruitment film.

The ChemTeC materials have some unique features:

1. Chemistry is not a prerequisite. Only one year of high school algebra is required.
2. The laboratory program is emphasized. To accentuate this, the laboratory experiments are an integral part of the text discussion.
3. The distinctions between subdisciplines in chemistry are drastically reduced.
4. No attempt has been made to impress colleagues with the technical ability of the writing team. Rather, we have tried to impress the students with a style that promotes the student's understanding while giving him confidence that he has been given a presentation that contains enough of the right material.
5. Although the concept of behavioral objectives could not be sold to the writing team in 1970, a 1971 compromise assures that each experiment is introduced with a New Ideas and New Techniques section.

Basically ChemTeC is concerned with three communities: (1) students, (2) employers and (3) faculty. As a result, our evaluation procedure has sought in-depth reviews from each of these groups. Twelve pilot colleges have provided us with student evaluators. Review copies of our materials have gone to hundreds of industrial representatives–technicians as well as supervisory and training personnel. Faculty comments have been solicited from individuals both inside and outside the ChemTeC structure.

The student class that began in 1970 has been interviewed on three occasions. Their response to the materials has been overwhelmingly favorable. At the same time, they have been very free with their criticism, and this has greatly strengthened the revised materials. For example, the early mathematical demands of the first version did not seem too great to the writing team. However, students felt differently and a critical review of later mathematical requirements showed that the first 6 to 10 weeks of the program were more demanding than what followed. Mathematics was obscuring chemistry and this approach could not reasonably articulate with the mathematics course structures that were conceivable. The revision reduced this problem to an acceptable level and gives a better overall result. Students have also been responsible for many less obvious changes and improvements. We have also received some rather interesting observations from students:

1. They see the program as a unique way of teaching chemistry that meets their needs and desires. The percentage of students that are dissatisfied is very small, and invariably these are students who think they should be in a professional program. Students are now taking pride in preparing to become chemical technicians and are less fearful of a second-class status which was always a concern of my previous students.
2. The first round of interviews found many students concerned with transferring to a *real college program*. By the third round of interviews, these same students decided they were in a *real college program* and interest in transferring dropped phenomenally.
3. Students are harshly critical of instructors who attempt to impose a more theoretical approach than is presented in the texts. The students are more concerned about understanding the presented material and gaining exposure to enough instrumentation than they are about learning more of the theoretical base of chemistry.
4. The students are genuinely enthusiastic about the educational value of the program. A number of students have volunteered to make recruiting visits to high schools. We are hoping that this enthusiasm gets partially transmitted to more prospective students.

Reactions from future employers are less voluminous than we would like. However, the response we have is very favorable. A few employers have questioned the amount of material presented but have commented favorably on the level and treatment given to the various topics. Several companies are using the materials in their own training programs. The research director of one company had written his own book for chemical technicians and was practically ready to publish it before he saw our materials. His company is now using our text as the basis for its training programs. Industrial advisory boards in both the U.S. and Canada have given their approval to the ChemTeC texts.

Faculty seem to be the most difficult to sell on the program, and even here there are very few that are completely turned off by the program. Some are very shocked that we would trust our students to use delicate microsyringes and gas chromatographs during the first week of school. Some point out that damage to microsyringes can be rather great. However, some of our pilot colleges have had very little damage to their equipment at this point. Many faculty members find it difficult to convert from their previous presentation style to a style that suitably works with the integrated lab-theory approach used by ChemTeC. Some teachers who have not taught the first semester ChemTeC have had difficulty in picking up classes in the second semester or second year because some topics normally taught very early in chemistry are placed very late or omitted altogether. They sometimes lapse into long lectures on pet concepts to find the students already knew much more about the subject than was anticipated.

Of the various concerned communities, we must admit that faculty will have the greatest problem acclimating to ChemTeC. They will frequently have their tried and loved presentation styles that may have to be changed. Many of them have great dedication but little experience in directing chemical instruction toward producing bona fide chemical technicians.

Students that are attracted to this type of program are generally already wanting a new approach to education. Many of our current students were overwhelmed or disappointed by their high school chemistry but have found chemistry to be dynamic and interesting as presented in ChemTeC. One of my most memorable encounters occurred when I asked one girl to contrast ChemTeC and the high school course she had taken two years earlier. She simply could not remain seated as she described the contrast by placing the ChemTeC approach and her high school course approach at opposite ends of a spectrum, describing interest and apparent value.

In closing, I can only say that ChemTeC has been very favorably received by its intended audiences. Students who belong in professional programs do not find this program to be particularly rewarding and exciting. The Project has set a fiducial mark for all those concerned with chemical technicians—employers and high school guidance counselors, college faculty and students. We hope that the Project and its products are breathing new life into an old and decrepit technology program. The test of what happens to chemical technology during the next five years should tell us if we did succeed.

SESSION B-3

SCIENCE EDUCATION VIEWED AS AN INDOCTRINATION PROCESS

Douglas A. Roberts, Department of Curriculum and Instruction, Ontario Institute for Studies in Education, Toronto, Canada

My remarks, like those of the other panelists, deal with limitations of "scientific literacy" as an overall objective, and therefore an organizing theme, for science teaching programs in elementary and secondary schools. As an objective, it suffers from the same weakness as a host of other objectives purporting to encapsulate thought processes, methods of investigation, and aspects of the nature of knowledge in science. Teaching programs based on such objectives implicitly present science as the best available way to explain events, to interpret experience, and to construe the world; they do so of necessity, because their objectives constrain them. If the program works well, pupils often learn a great deal about how science functions, but little (if anything) about who thinks it is "best" for explaining events, why it is thought to be so, and what events – if any – it will *not* prove best for.

Indeed, suppose we asked, "What is a scientific-way-to-explain *better than (or best of)*?" Other ways-to-explain, one assumes, and elsewhere I have given these the generic term "explanatory modes" (in *Main Currents*, Vol. 26, No. 5, 1970, pp. 131-139). Three radically different ways-to-explain (or "explanatory modes") can be discerned in human history: magical, religious, and scientific. These have given rise to impressive cultural institutions, but of chief interest here are the variations one finds in the purpose of explanation, the kinds of phenomena deemed appropriate to explain, basic assumptions about causation, what is admissible evidence, and the like. (Cf. Malinowski's *Magic, Science and Religion and Other Essays*, Doubleday, 1948.)

Of the three explanatory modes, science is the youngest. Man has used it with spectacular success *in a specified domain*, to account for particular kinds of phenomena. Why a "counter-culture," then? (Roszak: *The Making of a Counter Culture*, Doubleday, 1969). Why an "anti-science movement," also? (Dubos in *Daedalus*, 1965.) And, especially, why is it occurring among the *young*? And at a time when science curriculum was never better endowed, more researched, more tinkered with?

Elements of magical and religious explanation appear in young children's efforts to account for phenomena. (Piaget: *The Child's Conception of Physical Causality*, Littlefield Adams, Engl. tr., 1960.) These are quickly extinguished, by parents and teachers alike, and the effort obviously becomes more successful as our efforts at elementary science education become better. So a massive replacement process occurs in young children who begin to become "scientifically literate." One explanatory mode (science) replaces whatever hybrid of magical and religious explanatory modes the child had begun to develop. But does the child ever learn *why*, in the judgment of the adults involved, he is being told not to use the "explanatory ground rules" of magical and religious explanation – that somehow those are wrong, while these others are right?

The standard answer to that question is, more or less, that scientific explanations can be used to predict accurately, that they are consistent with certain kinds of logical rules, and so forth. Out of this success at prediction has come success at controlling an overwhelming variety of aspects of the natural environment and the human body. Yet it is scarcely safe to walk the streets, drink the water, or breathe the air. Are these rather straightforward human phenomena so *out* of control that such a spectacular success story as science cannot bring them back *into* control? Yes, they are. These are matters which require moral commitment *and* scientific know-how, and we can predict that moral commitment will not necessarily increase with increased "scientific literacy" in the population. (This is simply another way of saying that knowledge might be a necessary condition for action, but it is not a sufficient condition.)

Interestingly enough, the other two explanatory modes noted above – namely, magical and religious – carry with them a prescribed behavior code, which modern Western culture would regard as "excess baggage," no doubt. Stephen Toulmin stated the point well some twenty years ago. (His paper, "Contemporary Scientific Mythology," from 1951, appears as Part I of *Metaphysical Beliefs*, by Toulmin, Hepburn, and MacIntyre, published by SCM Press Ltd. in 1970, first published 1957. This passage is from page 6.) "In the main, it is because our contemporary myths are scientific ones that we fail to acknowledge them as being myths at all."

Now that we have more "fully baked" science to provide reliable explanations for an incredible diversity of phenomena, the "non-scientific motives" behind the particular brand of religious explanatory mode (pantheism), to which Toulmin refered, provide a means for characterizing the *limitations of science.* We find it quaint to think of explaining the sun's apparent rising and setting in terms of some sun god riding a chariot across the sky, especially if people who believe that garner some measure of security by offering sacrifices to this sun god. Yet here is an example of a "non-scientific motive" attendant to an explanatory mode – a way ("childish," to modern Western culture) by which to calm people's fears that the sun might not return, and thereby to avoid the chaos and interpersonal aggression which seem to attend gross survival anxiety.

To return to "scientific literacy," then. Robert Karplus probably has given as crisp and well-known a definition as anyone for it, in *JRST* Volume 2 (1964), page 296 (Issue 4).

> In other words, to be able to use information obtained by others, to benefit from the reading of textbooks and other references, the individual must have a conceptual structure and a means of communication that enables him to interpret the information as though he had obtained it himself. I shall call this functional understanding of science concepts "scientific literacy."

Clearly, there is no intention either explicit or implicit, in such a definition, to deal with limitations of science as an explanatory mode. The intention is to have the child become increasingly a "scientific thinker" – that is, to *use* the scientific explanatory mode more and more, better and better. We do so on the grounds that it is *better*, but we do not compare it with any other explanatory mode to give evidence to that effect, in any part of the elementary or secondary school science curriculum. By so doing, we in effect define for youngsters what they should want to control with their explanations: natural phenomena, but not gross survival anxiety. We do this very neatly, with a time-honored method. We don't show them how the alternatives work. That method is usually called indoctrination.

Courses in witchcraft won't help, and neither will astrology or world religions. Maybe it's time we looked at an objective I would term "*explanatory* literacy."

SCIENCE AND SOCIETY: SERIES A, B, AND C

SESSION A-5

PURPOSE, PERFORMANCE, ACCOUNTABILITY AND THE SCIENCE TEACHER

Jules Kolodny, Secretary, United Federation of Teachers, New York

Brief Outline

A. Accountability and Productivity:
   1. Origin of the terms as applied to education
   2. Motivations for the use of the terms:
      (a) Within the present structure - tenure, merit salaries, differentiated staffing
      (b) Development of alternative structures - performance contracting and educational vouchers
   3. The terms applied to the individual teacher
   4. Application of industrial terminology to education:
      (a) Industry deals with products
      (b) Education is concerned with a process

B. Teacher Evaluation:
   1. Research on teacher behavior
   2. Research on performance criteria
   3. Student evaluations of teachers
   4. Rating teachers by pupil achievement
   5. Evaluations by supervisors
   6. Evaluations by peers

C. Evaluations of Schools as a Totality:
   1. Purpose related to acquisition of knowledge and improvement of effectiveness
   2. The problem stated - joint and collective responsibilities
   3. The design described - Indices of school effectiveness
      (a) In-put
      (b) Educational Processes
      (c) Surrounding conditions
      (d) Output
   4. Complexities to be faced
      (a) Easy-to-change areas
      (b) Difficult-to-change areas
      (c) Mathematical and statistical procedures; series of regression analyses

D. Conclusions: Where do we go from here?

SESSION A-6

ENLARGING THE CHILD'S VIEW OF HIS COMMUNITY

Charles Wilson, Science Department Chairman, New Dorp High School, Staten Island, New York

If the Big Bang Theory of the origin of the universe is correct and we are moving farther apart astronomically, that same theory must also apply to us sociologically for we seem to be moving apart right here on this earth as well.

As science teachers, we have long taught of the "shrinking" earth with respect to travel and communication. Paradoxically, however, when we turn to politics and sociology, we find an earth that is expanding with increasing polarizations in every phase of our daily lives throughout the world.

The school as a mirror of society cannot help but reflect these polarizations. However, the school as an extension of society becomes a small funnel through which we may have some influence on the minds of future generations.

Today in American education, a very subtle though distinct change is taking place. It is a shift in emphasis from teaching to learning. If a radio station broadcasts to an English-speaking audience and refines its techniques of speech, grammar, vocabulary, and engineering, it will be an effective instrument. If non-English-speaking people begin to move into the area and eventually become a large percentage of the people within the area covered by this station, the effectiveness of the station is reduced and communication decreased even though the technology remains unchanged. That is why communication is an art. It defines an end result of a relationship between two persons; the transfer of understanding or feeling. And that is why teaching is an art as well.

And when we look at the end result of teaching–the learning of the child, we find a developing trend to accept alternative methods of "teaching" that can accomplish this learning as valid avenues of education.

That is our convention theme this year. Hopefully, we shall be able to shift our own emphasis in teaching if necessary from the technology of teaching to the art of teaching.

My topic is "Enlarging the Child's View of His Community." I sincerely believe that this is the goal of every step along the road to learning.

As a teacher, supervisor or administrator, how can we achieve this end? I would like to outline several essential steps:

First, and most important, get to know the child. Find out what he brings with him in his mind. Find out what he lives with in and out of school. Get to understand the child by getting to know the child's community, the ethnic, mental, spiritual, and physical community that the child is part of. I have known very few teachers that ever made a point of going out of their way to go through the neighborhood from which their students came.

Second, accept the child exactly as he is for now. This must be a concrete acceptance. Children are instinctively very sensitive and they immediately sense any pretenses.

Third, get to know the school community. The older the child the larger you draw the circle of community around the school. Know any and all resources that can be useful to you in your pupils' learning.

Fourth, have the child accept the school as part of his community. Next to home, the child spends more time in school than anywhere else. If he does not feel accepted and welcome there, all else is lost. This means that the school must make every effort to see that this takes place. It means that the school begins in your room. The largest national undertaking in education at the present time is probably the drive for integration. And we keep on using techniques of integration, but we haven't yet started the art. I wonder if we will ever develop the art of integration.

Fifth, introduce the specific community facets to the child through specific procedures within your classroom.

Sixth, let the child know what you'd like to see as his goal and help him develop his own goals.

SESSION A-7

COMMUNITIES AND THEIR SCHOOLS: FRIENDS OR FOES?

Daniel F. Connell, President, Satya Community School, Lincoln, Massachusetts

Most schools – public and private – are controlled, directed, funded, and staffed by individuals and groups from outside the communities they ostensibly serve. In fact, the schools seek to have the communities serve them and their interest, the interest of the social/political system for which they are designed to prepare, indoctrinate, and train their students. Since the community has no real control over its schools, it does not have the means to effect substantive change, and therefore, most attempts at reform are geared to changing the community's attitude toward the school rather than changing the school itself.

There have, however, been three kinds of experiments in recent years whose stated intent has been to create "community schools." One has been the large public venture which encompasses all or part of an existing school. Usually these experiments involve community boards, local teacher aids, relevant classes, etc. in an attempt to draw the community into the school. At the other extreme are the private "free schools" which reject the funding, forms, and content of public education. Usually these schools are more involved with creating their own community than in embracing an existing one. And finally there are the grass roots community schools – private, usually located in urban ghettos or ethnic concentrations of the poor and the oppressed – which serve to express the discontent, frustration, and hope for change of those who live in the community whether or not they have children in the school.

My teaching and administrative experience has been in the first two kinds of schools. My faith and hope for real change is in the third example. My presentation will briefly offer selected experiences from the schools I have worked with, particularly Satya Community School — a counter-culture free school — and a discussion of the third type. In closing, I will offer specific recommendations for establishing real connections between schools and their community for teachers in traditional schools.

COMMUNITIES AND THEIR SCHOOLS – FRIENDS OR FOES

Severo Gomez, Assistant Commissioner of Education, Texas Education Agency, Austin

For almost a decade now education has verbalized strongly its concern for the millions of school children in the country whose first language is not English and who have suffered in the educational process as a consequence of it. The reasons for its concern are numerous; some are educationally legitimate, but for the most part the concern has been motivated by political activities — civil rights, compensatory education, mobilization of minorities, and exposés of the situation. This does not mean that educators have not been interested in doing things differently for the culturally different children for a long time, but that they had little or no success in changing a philosophy of education which spoke to the melting-pot concept. Now there are some who subscribe to the idea that cultural differences of children must be considered in the educational process and that philosophically the change must be from the melting-pot idea to the concept of education in a confluence of cultures.

In spite of all the steps moving us forward in bilingual education, we are still in somewhat of a dilemma. This can develop certain pitfalls if it is not fully understood. Too many are only concerned with language and language development and forget that bilingual education might be a process which fully educates the child. The worst interpretation is that it is a means for getting to English through the first language of the child and then eliminating the first language as soon as English is learned. However, the most pressing problem is not in process, but in attitude of those responsible for education toward such a process. For many teachers and administrators it is a threat; for the former because of the change from the traditional, and the requirements of a second language, for the latter because of having to provide leadership in a process in which he cannot function.

I am speaking about my own state. I am quite sure that similar situations exist in other states, but each has its uniqueness. Our uniqueness is in the nature of the Mexican-American. We do have a half million native speakers of the Czech language and almost that many German speakers; plus those who speak French, Arabic, Russian, Swedish, Polish, natively and others, but it has been the Spanish speaker was has received the short end of the educational stick.

Over the years the dropout rate of the Mexican-American has been in the area of 80 percent. This figure was verified by the 1960 census and the Governor's Report on Education, a study in the middle sixties.

What does this imply? It implies that if this percentage of dropouts continues, 480,000 Mexican-American children of the 600,000 enrolled in school today in Texas would drop out. Can we afford to have this? What is being done to prevent this?

In 1968, the Texas Education Agency established the Office of Bilingual Education, a major department in its administrative structure. Its main purpose is to provide the leadership for establishing programs in bilingual education in the public schools. Technical assistance is given in staff development, curriculum development, and in program planning. This may sound encouraging but under the local autonomy philosophy, schools must want this service. A Bill enacted by the State Legislature in 1968 authorized bilingual education on an optional basis. Prior to this bill, classes could not be conducted in a language other than English except in foreign language classes.

Needless to say there has not been widespread implementation of bilingual education programs for several reasons. One is that it is a process that is different and requires great change. Mainly, it is because most educators don't understand bilingual education nor believe in it. A reason always given is that there are not sufficient numbers of adequately trained personnel. This is true, but many teachers who can teach bilingually are not being used in this way. We have in the state 600,000 Mexican-American children, but only about 8,000 Mexican-American teachers. Most are bilingual, but it must be taken into account that all have been through the same conditioning process that the monolingual English speaker has. They need some training also.

The breakthrough for motivation for bilingual education in Texas came in the form of Title VII, ESEA. It opened the door for an examination of the philosophy of education for non-English speakers and led to the development of a statewide design for bilingual education. The design will be described briefly later.

Let it not be overlooked that Title VII was politically motivated as an answer to the demands of the Spanish-speaking population of the nation. It was apparently appropriate for congressmen to favor it at least on a quasi-philosophical-altruistic basis. Congress didn't favor it with what it takes, however, dollars. The first year it appropriated 10 million dollars, the second 25, and the third 35. After three years less than 4 percent of the Spanish-speaking school population in our state has been touched by Title VII funds and we are constantly reminded that we are one of the more fortunate states. It is apparent then that the federal dollars will not be forthcoming in quantities to do the job that is necessary. The alternative is for state and local support.

May I remind you that although the need for money is imperative, it may not be the greatest deterrent to bilingual education. In the almost ten years of personal involvement in a state leadership role I have been able to observe that the greatest problems are engendered by the attitudes of teachers, administrators, and community leaders, each in his own way, constantly trying to prove its ineffectiveness. I have been able to recognize the threat of bilingual education and bilingualism to the monolingual teacher, administrator, and community leader. I worry about what will happen to the children. Can we afford to continue starting their intellectual growth by nurturing them with indigestible processes meant for someone else.

In an attempt to prevent this type of genocide, we have offered a program in bilingual education with six components; as far as we are concerned, if all six components are not implemented in the program, it is not bilingual education. English as a second language on its own is not bilingual education. Our program emphasizes the total development of a child in the ambiance of two languages using the second one, English, only when the child is ready for it. The six components are:

1. *The basic concepts initiating the child into the school environment are taught in the language he brings from home.*
   Orientation to the classroom code of behavior and patterns of social interaction with his peers are developed by drawing from the child's resource of experiences and concepts and language which he has already learned in his home environment.
2. *Language development is provided in the child's dominant language.*
   The sequential development of the four language skills, i.e., listening, speaking, reading, and writing, is continued in the language for which the child has already learned the sound system, structure, and vocabulary. This is exactly the same approach which has been used in the past. The only difference is the use of the dominant language of the child whose first language is not English. With this one change the child begins developing the skills with the use of his first language without having to wait until he learns his second language.
3. *Language development is provided in the child's second language.*
   By utilizing second language teaching methodology, i.e., teaching the listening and speaking skills by use of the audiolingual instructional techniques prior to teaching the reading and writing skills, the child immediately begins to learn a second language. For the English-speaking child this instruction is in the language of the other linguistic group involved in the program and, of course, English is taught to the child who comes from a non-English speaking environment. Unique about this component of the program is the fact that the child does not have to re-learn language skills. He has only to transfer these skills learned in his first language to the second language.
4. *Subject matter and concepts are taught in the child's dominant language.*
   Content areas which are considered to be critical to the intellectual and emotional development of the child and to his success in the school environment are initially taught through the use of the child's first language, thereby permitting and encouraging the child to enter immediately into the classroom activities, drawing from all his previous experiences as a basis for developing new ideas and concepts.
5. *Subject matter and concepts are taught in the second language of the child.*
   Since no language can be taught in a vacuum, content areas are also taught in the second language, providing the vocabulary and concepts which are needed for communication while the second language is being learned. Initially the number of ideas and concepts are necessarily few due to the limitations imposed by the amount of language the child controls. The teaching techniques are audiolingual in order to insure the development of listening and speaking skills. As the child's second language ability develops, more and more content is included and the other skills, reading and writing, are incorporated.
6. *Specific attention is given to develop in the child a positive identity with his cultural heritage, self-assurance, and confidence.*
   The historical contributions and cultural characteristics identified with the people of both languages involved are an integral part of the program. Both the conflict and the confluence of the two cultures are presented in the social development of the state and nation in order to create an understanding and appreciation of each in a positive rather than negative sense.
   By providing the opportunities for successful participation and achievement, the child is encouraged to develop acceptance of himself and of others through social interaction.

I consider the last component of this plan the most important and the most difficult to bring to realization. It is certainly the most relevant to the topic we discuss here. All the advanced methodology in one or more languages can be highly inefficacious if the self-perception of children is not considered. The main factor in effective teaching can easily be attributed to the differences between the culture of the teacher and that of the child, and the teacher not recognizing it. The teacher has been conditioned by a middle-class "American" process and hopes to impose the same on the students.

How can a child have a positive image of himself and his people when he is punished for speaking his first language? How can he have pride in himself when the history he reads excludes the contributions of his people to the development of his country. When he is taught American history, he hears of the "Black Legend" that tells of the exploitation of the Indians by his ancestors, the conquistadores; a term quite different from colonists, the term used for the pilgrims, etc. Yet we all know those so-called conquistadores christianized the hemisphere and assimilated the indigenous population to form a "new Raza." We also know what happened to the Indians in the northern region. And while on the subject of our Indian bloodline, we cannot overlook their contributions to mathematics, astronomy, engineering, and agriculture. Anthropologists tell us that the middle-America Indians scientifically developed about half of the staple foods eaten by mankind today—corn and other grains, the tomato groups, pumpkins and squash, the potato, etc. The children in the classroom do not hear of these things. When the children study about the Texas War for Independence from Mexico they hear mainly about Sam Houston and Stephen F. Austin. They never hear of the great numbers of heroes with Spanish surnames who were fighting for a republican form of government and against the dictatorship which existed in the 15-year-old country of Mexico. They read about disenchanted Tennesseean Crockett who came to Texas because he was looking for action and died at the Alamo as a hero shortly after arriving. They do not read about the men with Spanish surnames who also died at the Alamo and were fighting for the land they had developed for centuries, for their families, and for what they believed their country should become. The children do not read that the legal system of the state was copied from the Spanish, and that the architecture, cuisine, techniques in dry-land farming, and lifestyle of Texas and Texans is basically hispanic—the cattle process which has given Texas its notable lifestyle is hispanic from terminology to process. The southwesterner is culturally indo-hispanic no matter what language he speaks.

I can continue to cite items which are excluded from our texts and items that need to be included in order that children from minorities can develop a positive self-image, but let me point out here that it is rather futile if these activities are done in isolation. Those of us who belong to minority groups can verbalize about the contributions our people have made to the development of this country, but they mean very little here or in the classroom if the total society doesn't also recognize them. This implies that it is important that everybody get involved in these activities. This is what the concept of the confluence of cultures is all about. That this country is like a tapestry made of many different strands and colors each contributing to the beauty and magnificence of its totality. One cannot appreciate someone else's culture until it becomes part of him. The dynamics of cultures requires this. This is what happens in acculturation; where there is a giving and a taking to favor a new design in the "tapestry." For the most part this is not happening in the schools. And, until it does, the communities and the schools are foes to the children they hope to serve.

SESSION A-8

THE INTERRELATIONSHIPS OF SCIENCE AND SOCIETY

Herbert Priestly, Chairman, Science and Mathematics Departments, Knox College, Galesburg, Illinois

This presentation should be regarded as a Physical Review Letter, a report of work in progress. What I would like to do is to describe a developing activity at Knox College in the area of science and society, what I feel is good about it and what I feel needs improvement.

The interrelationships of science and society is a very popular subject these days. This is particularly true in terms of the environment. It would appear that the irrefutable position to adopt is to be for God and motherhood and against pollution. While pollution is a popular bandwagon, and certainly a valid area for developing a concern for one interrelationship of science and society, these interrelationships do in fact go much further and much deeper than just the environment. However, it does seem that these days to be an updated institution of higher education one must at least have one course in which environment appears in the title and, if the institution is really progressive and forward looking, then it has by now developed, in terms of at least a catalogue entry, a major in the environmental sciences.

Our approach at Knox College is broader than the environment and to a large degree anticipated the current furor of activity, all of which appears to be an attempt to make science "relevant." I started a course entitled "Science and Society" in the academic year 1967-68. It evolved out of a revision of graduation requirements, a revision which imposed as one requirement the passing of three courses in the area of science and mathematics. Note that there is no qualification to this requirement in the sense that one or more course must be a laboratory science. As you can imagine, when faced with this requirement, students elected a physics course only if all courses in biology, geology, and chemistry were full and their academic counselor insisted that they must take a science course in the up-coming term. There also loomed at this time a deep and spreading shadow of Vietnam which offered most college graduates a very limited choice in terms of their immediate post-graduate future. It was only natural that in the minds of these young people the specter of the industrial-military complex automatically linked science with war, and therefore made science quite distasteful. Physicists were the arch-villains. After all, they were the ones who had rubbed the nuclear lamp and released the genie of destructive atomic energy.

It was partly to meet these student concerns and partly to satisfy my own prejudices that I instituted the course in question. These personal prejudices reflected my concern that the desirability of dividing an institution into departments for administrative purposes has unfortunately similarly fractionated knowledge. As one consequence of this, students could find no obvious connection between science on the one hand and the non-science areas on the other. The course then was specifically designed for a clientele of junior and senior non-science majors. I elected to restrict admission to upperclass students because I wished to show among other things the relatedness of knowledge and this becomes more evident to the student the greater and broader knowledge he brings to the course.

It seems to me that this kind of program is even more important today when it appears that students in droves are being turned off by physics and chemistry. I feel there are several reasons for this. We may jokingly refer to these disciplines as the "hard sciences." Unfortunately, too many students accept a literal definition of the word "hard." After all, both disciplines, and physics in particular, do make use of mathematics. To me there is one other very fundamental problem with regard to the non-major's approach and outlook to the physical sciences. Particularly in physics, we tend to regard the ability to solve quantitative problems as the desirable goal of any course. The problems we ask students to solve are usually not of the real world; rather do they involve idealized situations which facilitate a solution to the problem. And because of the idealized conditions we presume, each problem can have and in fact does have one and only one right answer. Other answers are automatically incorrect. After a student has tried a problem, his almost reflex action is to look in the back of the book to see if the answer is right. And until recently, after a laboratory exercise he would then check a laboratory handbook for the right answer and determine his percentage error. As a result, the student has been left with little or no opportunity to express *his* opinion on the problem. And he also gets the impression that physicists are a special breed of cat who always know the right answer.

In talking with students, it also became clear to me that most of them, often including science majors, had no clear distinction in their minds of any differences that might exist between science and technology. The two were so synonymous that any technological failure or technology-created problem automatically became the fault of the scientist.

Most people today are still quite ignorant of the basic issues involved in many of the world's problems which have a technological base or orientation. As a result, they tend to be afraid and their approach is usually based on emotion, rather than reason and is therefore highly irrational. I think one can see this in the flagrant and highly-biased tirades of the so-called conservationists. I say so-called because in my judgment many people equate an antipathy to science-technology with being pro-conservationist.

Let me describe briefly what we are trying to do in the course I am talking about. Rather than concentrate on one particular topic, I have made the approach of trying to cover a broad area. This means of course that no one topic is dealt with in great depth. On the other hand it does help point out to the students that the environment should not be the only area of concern. As the course has evolved over the years I am now at the point when my basic thesis is that the world's technology-based problems arise from two facts: one, we have too many people and two, technology has been too successful. The first of these premises is I think quite obvious. With regard to the second, what I infer here is that problems arise not from the inability of technology to solve a specific problem. We have been quite successful in this respect. But in far too many instances the solution has brought with it unfortunate side-effects which turn out to be worse than the original problem. I am also concerned with the real and imagined threats of science-technology to the individual and his rights and privacy and with the fact that world conditions in general have a significant effect on the rate of growth or decline of science. A sequence of topics is therefore chosen to attempt to illustrate these several points. I also try to end by looking into the future. While my crystal ball is cloudy, this in itself is a valuable thing because of my personal philosophy that one function of an institution of higher education should be to prepare students as best we can to cope with the future. No one knows with certainty what its nature and content will be; but we can say with certainty that it will be different.

The mechanics of the course involve using one or two books as basic readers, supplemented by specific and relevant articles. Each topic is introduced by at least one lecture followed by smaller group discussions. Each student is given before the discussion period a brief list of questions or statements which I want him to think about and which hopefully will then form the basis for discussion. A substantial term paper is required. I suggest that wherever possible the student trys to select a topic which will relate to his major interest and to the concerns of this course. While this is not always possible, it does work out in the majority of cases. It is, I think, a valuable help to the student in increasing his awareness of the unity of knowledge.

There are weaknesses in the program. The most obvious is that it is a course *about* science rather than science. The student is never called upon to go into the laboratory and get his hands dirty. He only reads about how a scientist goes about his job and does not experience it first hand. The course would be much more meaningful were it preceded by a laboratory course. This is one of the areas which I am now exploring. My ideas at the moment are still in the formative stage but I hope that I may be on the right track.

A course like this has a clientele restricted to those who are in college. What about those who do not continue their education beyond high school, about 50 percent of all high school graduates? I am a sufficient believer in the fundamental concerns and philosophy of my program that I feel it is relevant to the high school as well as the college level. To this end, last summer I operated an NSF-sponsored institute of six weeks for high school teachers of biology, chemistry, or physics. The response to the announcement was very encouraging. It was not an easy task to select from the more than 200 applicants. It was particularly surprising to me to learn from their applications how many were already exploring at the high school level the interrelationships of science and society or who were about to initiate such a program with the 1971-72 school year. Because of this, I had no difficulty developing a participant list of highly interested and well-motivated individuals and the program was the most satisfying summer activity I have ever been associated with. The institute will again be offered this coming summer.

What I have described is only one way of tackling this significant and important problem. There are many others varying in degree of scientific orientation according to the scientific sophistication of the students to whom the course is directed. There are courses in the physics and chemistry of the environment, a variety of course offerings on the environment as a general topic. It is equally valid and certainly equally meaningful to place "relevance" topics in our regular courses. While here again environmental concerns are an obvious area, there are others such as the pros and cons of the space program. One which is particularly vital today is the clash of the conservationists with those who are attempting to meet our ever-increasing demands for energy in ways which involve minimum environmental destruction. Of particular concern here is the viability and the dangers, real or imagined, of the production of useful and usable energy from nuclear processes. This is a casebook example of a situation where a good scientific approach can be most valuable in recognizing the validities and invalidities of the arguments advanced by both sides and where there is a limited supply of valid experimental data. A sensible and logical discussion of this problem, recognizing the limitations of arguments on both sides, points up what I regard as one of the fundamental objectives of my own program. We do not seek to change minds, but rather to open them. It is our purpose to help them see both sides of the argument, and to point them in the direction of reaching meaningful and logical decisions.

TEACHING VALUES OF SCIENCE THROUGH AN INTERDISCIPLINARY APPROACH

Madeline P. Goodstein, Assistant Professor of Chemistry, Central Connecticut State College, New Britain

Several years ago, our faculty mandated itself to offer a college-wide series of single-section courses on the values inherent in the respective disciplines. Looking back, it seems that we were overly brave and confident; the task was difficult, and there was little to guide us. One problem at first was that many of us who undertook to teach values weren't even too sure what values were. In our discipline, moreover, we can really distinguish two kinds of values, those inherent in the PROCESS of science and those related to the PRODUCT of science. The values implicit in the process of science are such as honesty, precision, objectivity and open-mindedness, dedication, patience, curiosity, and enjoyment of intellectual pursuit. The other kind of value is the kind which science imposes on society by its theories and its products and which changes society and each member of it and which in turn change science. Some of us, myself included, are of the belief that this type of value in science is so significantly affecting each of us that no mature individual should have failed to become informed and to think about it. In the interdisciplinary course in science which I then developed, the interaction of science, society, and values became the central theme of the course.

What are values? I think of them as the internal standards by which an individual makes judgments. Can science affect the values of an individual, the internal standards by which he makes judgments? Toffler, widely known today for his book *Future Shock*, has elsewhere cited an example by Egbert de Vries, a Dutch sociologist. It concerns a community in Africa whose inhabitants had the interesting belief that it was necessary to start a new fire in the fireplace after each sexual act. As a result, someone had to go each time to a neighboring hut to bring back a burning brand with which to start a fresh fire. This meant that each sexual act became public knowledge with all the consequences thereof.

Then something happened to change all this, a simple bit of technology. Someone introduced matches. Now it was possible to light a new fire without public acknowledgment. Do you think that this created a shift in values?

Before we grin superciliously about this one, let's consider the increasing use of birth-control pills, a product of modern science. Has this changed the ideas of our youth on what's right and what's wrong? What about the effect of modern medicine on the size of the population? Is this not changing our ideas on the size of the ideal family?

Or consider the generation gap. In my grandmother's day, my grandmother had every expectation of finding the world she would live in as an adult to be the same as that of her parents. There would be changes, true, but they would be slow, and she could easily plan ahead for her entire lifetime. This is no more. The world is changing so rapidly that no one can look ahead very far. And what has caused it to change? I submit that science is the principal cause, science with its means of communication, transportation, laborsaving, medicine, chemistry, and so on. The world that I was brought up in is very different from the one that my children live in today. No wonder there is a generation gap! Their values must differ from mine, in big ways in some areas such as the nature of the family, and in very subtle but real ways in others. And is it not science which has changed the world and made it so different?

This is one thing that I want my students to face. The other is whether we want these changes. Do we want to control them? Can we control them? What principles must guide us? Here is the material for one course – for many, many courses in science. Students need to learn what science has done, how it has changed ideas in the past, what it may do in the future. They need convincing facts, and they need the stimulus, the opportunity, the setting, and the background to discuss them.

It does not really matter which topics of current import we elect to discuss nor which great past discovery in any or all of the sciences we choose to use to prove the impact of science on values and of values on science. Not only are textbooks and paperbacks food for the course, but so are newspapers, magazines, radio, TV, and graffiti.

I lean toward the interdisciplinary approach in science because I see the impact as coming in an interwoven net from all areas, so I try to weave in themes from the physical sciences, the biological sciences, anthropology, and history. There is a vast choice of topics–from the effect of the evolutionary theory on religion and politics, to the approaching prospect of eternal life, to the origins of the universe and man's tiny place in it, to all of the aspects of disturbing the ecology.

My own feeling is that much of the course should be substantive. We must have the facts to get to understand what has happened or may happen; and students must understand this and also understand that the foundation of science is itself substantive. Much of the course must be devoted to discussion, to the interaction of students with students, because this is the really effective way to open up the students' mind to thinking. This last is based on the well-accepted theory of learning that says that the student must play an active role in the process for significant learning to occur. Accordingly, I have adopted the approach that the teaching of values is most successful, deep-reaching, and democratic when it is developed as the result of informed discussion and debate.

The social scientists are far ahead of us in the use of group dynamics. They hold that the role of the instructor during controlled classroom interaction must require that the instructor be non-judgmental. He must not express his own opinions but must allow and make possible the

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situation where the students actively examine their own valuing. Mirror images of our own values are just no good; our students must, in as rational and informed a situation as possible, develop their own values. All too often, we scientists are not very good at leading discussions, and this is especially so when our required role is to be non-judgmental. Thus, we need to learn techniques to stimulate talk, to moderate discussions, to activate the individual reluctant to speak aloud, all without expressing our own opinions. We have much to gain by adapting the techniques of other disciplines to our own ends. The game we are playing—for rational understanding of the role of science in society—has very high stakes.

THE IMPACT OF CONTEMPORARY PHYSICS ON SOCIETY

Edwin J. Schillinger, Director of Program II, De Paul University, Chicago, Illinois

University physicists have, in the past generation, been singularly successful in educating the physicists which society has required for the spectacular growth of science and technology. The hidden price paid for this success has been the single-minded concentration on educating *only* future physicists. The average college student has turned from the highly sophisticated curricula developed during the past 25 years and from the intense competition encountered in physics courses.

Recent softening of support for physics and technology has driven home the necessity of extending some education in science to a large fraction of the college population. Since existing curricula are quite inaccessible, radically new and different courses and curricula must be developed. It is clear that these must virtually avoid mathematics and must sharply minimize the highly technical vocabulary of the discipline. Phenomenological physics must move to central stage at the expense of treating the field as if it were a branch of mathematics.

New programs should deal with the impact of physics and its technologies upon man and society and with the history, methodology, and philosophy of physics. If this is to appeal to students with only a general interest in the science, it must introduce phenomena of physics "as needed." It must face the reality that the overwhelming majority of students are not interested in physics, *per se,* but that they may well be interested in what physics does for (or to) them.

Programs such as this are truly part of the liberal arts tradition. As such, they are more interested in the student as a future citizen than as a future physicist.

Physicists' unwillingness to talk to people at their level of understanding during the past quarter decade has led to an aversion so complete that there is and will be difficulty in convincing a significant number of students to enroll in any physics course. Physics must be made palatable by talking to students at their level of understanding. This is a challenge that few university physicists are ready to meet – and too many are unwilling to try.

A common criticism of programs oriented to the general student body is their failure to prepare students for employment at the time of graduation. This argument is invalid if the student is made aware that these new courses and programs are not designed for professional training as a scientist. It is contended, however, that radically new programs, such as proposed, are better preparation for careers in peripheral fields than are the conventional curricula.

The Physics Department of De Paul University introduced, two years ago, a twelve-course program ("Program II") with the philosophy and orientation described in this paper. Recruitment difficulties were severe in the first year of operation (1970-71), but class size during the current year now averages about twenty. Enrolled students have expressed general interest in the course topics, or are preparing for careers in science journalism, patent law, teaching, paramedical positions, or in the other sciences.

Several of the Program II courses have different rationales. Two of them are quite specifically oriented to societal problems, exclusively. These are titled: "Nuclear Energy and/or Society" and "Contemporary Physics and Its Impact Upon Society."

The first of these attempts to bring some understanding of radiation and its interaction with human beings to the students. It describes the many benefits of radiation, it admits to the risks involved in using radiation, and tries to force students into the reasoning required in benefit/risk analysis. Class discussions center about selected speeches of Glenn T. Seaborg, a book, "The Careless Atom" (by Novick), and selected workbooks of the Scientists' Institute for Public Information.

The second of these two courses attempts to bring the student to a level of primitive policy formulation. It then describes current science and technology problems (ABM, siting power reactors, SST, the environment, space, etc.) and brings science considerations into the policy-making process. Current and future technology, are assessed and proposals to develop and/or limit growth are solicited from students.

Teaching problems encountered in this new departure are severe. All topics are interdisciplinary, and the disciplines involved are clearly not only scientific. There is no shortage of teaching materials: rather the problem is one of selection of good materials from a rather amorphous mass.

Rapid growth of programs such as this is heavily dependent upon sudden changes of attitude on the part of university physicists. Professors must come to the realization that they can teach physics at any level and that it is delightful to do so once mathematics is sacrificed in the interest of clarity.

SESSION B-4

EDUCATIONAL GOALS IN SCIENCE FOR THE 1970'S

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

The blast off of Russia's Sputnik in 1957 marked the beginning of a science curriculum reform in America. Its

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primary goal was to increase the supply of scientific and technical manpower in the United States. New curricula were prepared to display science in the classical sense. The emphasis in the new courses was upon the theories and constructs important for knowing "the structure" of a discipline and upon investigatory processes which characterize scientific research. In July 1969, Americans were the first to walk on the moon, thus ending the technological crisis, and with it much of the rationale for the "new" science.

Coinciding with this event was the emergence of the counter-culture, with youth not only questioning the American way of life but also expressing doubts about the "relevance" of their education. The issue to them was not how much better life is now than it used to be, but how bad society is today compared with what it could be. They view contemporary society as "sick," pointing out the seemingly endless piling of crises upon crises: economic, political, educational environmental, technological, and others; not to mention the tensions of everyday life, for example, war, loneliness, racism, and violence. In the span of only a few years the counter-culture moved from "acid" and overt revolution to drugs and a disturbing quiescence. Whether the revolution has failed or is seeking direction we have yet to learn; I suspect the latter. There is no doubt, however, but that the America of the 1970's is not the America of even five years ago.

Where do science and technology stand today? We find both are on trial: technology, which has maintained the strength of our economy for decades, is now regarded as an enemy of the natural environment and as a major force in the dehumanization of man. Scientists, who have enjoyed the isolation of the objective world for centuries, are now put upon by the general public to direct their research activities toward the common good and to add a dimension of social responsibility to the scientific enterprise. There exists a fear in our society of further technological developments without a prior assessment in terms of human values. Science is also on the defensive, characterized by an anti-science sentiment in students and the general public alike. Gerald Holton describes the educational change as a movement toward a "post-classical science" period.[1] The more pessimistic writers see approaching an end to continued progress and a slowdown in human achievement. These social changes and the fact that the very nature of the scientific enterprise is today different from the 1960's force the need to reassess the science teaching goals of the past decade.

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 must do this at the very time society is undergoing extensive cultural transformations and much soul searching in an effort to find itself. Albert Schweitzer described the situation several years ago with this comment: "The difficulty of our times is a difficulty of the human spirit." 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 this life.

Science, through its technologic applications, forms a delicately balanced system that influences in a major degree our economic and political life both nationally and internationally. These conditions have advanced to the point where they can no longer be considered separate from the social forces which determine the course of human activities and our manner of living. This means that the new goals for science teaching ought to be in the context of society and taught with a focus upon the welfare of mankind.

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 processes. It is technology with its application to agriculture and industry that provides meaning to whatever we describe as modern living, not only in material ways but in the very texture of our thinking. On one hand it provides us with more physical comforts than man has ever known before and on the other hand creates poverty. Better food and a healthier existence have not only resulted in a longer life but made overpopulation a problem. The continuing increase in available consumer goods is rapidly making the world a garbage dump and blighting our environment physically as well as aesthetically. Over the past decade a unity of science and technology has developed in a way that makes both essential to human welfare. Science and technology all the way from "pure" research to invention are on a continuum within which no meaningful lines of demarcation can be shown. A major goal for science teaching in the 1970's is to help people learn how to live in a modern technological society. I hasten to add, however, not in the terms technology was taught during the 1940's and early 1950's.

It is evident that science has become linked in various ways to nearly all aspects of human existence. There may be a question as to whether science is the servant of society or society the handmaiden of science, but there are no doubts that each depends upon the other for survival. 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. The natural, social and behavioral sciences need to be brought into a relationship and presented with a consideration for man's welfare. This will require that we take a more holistic view of curriculum goals than we have in the past. The problems that concern man most – disease, malnutrition, pollution, urban living, longevity, social disintegration, aggression, equality, and others – are not those that can be solved within the limits of isolated disciplines. Again it becomes evident that science should be taught in a social and humane context.

Much of the present crisis in science and in science teaching lies in the relationship between knowledge and values. The questions that greatly bother young people are these: What are the social responsibilities of science? Does science have a commitment to humanity or only to the advancement of a discipline? Can fact and value be separated at the practical level? Scientists and sociologists alike, have observed that a great deal of the conflict and turmoil we are experiencing in American life today results from a poverty of values, from too little we really care about, and from a paucity of social commitments. Is it not strange that in this period of history, when we have the knowledge and material resources to do about anything we wish, we are the most confused about what is worth doing? Values provide guidance and direction for the use of knowledge, but unfortunately, our present science curriculum is both value-free and anti-idealistic. Science teaching at present is mostly concerned with matters of fact, ignoring to what end. This leads me to suggest that if science is to be meaningful for developing a higher level of human responsibility and rationality, then the opportunities for students to develop worthy values must be given high priority. This does not mean that schools should seek to institutionalize a particular set of values, but that young people be allowed to participate in planning their own destiny. A science course in which a consideration of values is absent has only information to offer: there is no way a student can convert what he learns into wisdom.

Educational programs for centuries have been planned with the idea that tomorrow will not be much different from today. One result of this action is that today's problems are perpetuated. How we design the curriculum today and the goals we accept, so the morrow will be. Those who wish to leave the future to the future are defending the *status quo.* This generation of young people seek an education that has the possibility of developing a world in the direction of something better than already exists. The issue is complex, but the message is clear; young people want an education for that period of time in which they will be spending most of their adult life. They do not want an education that has the historical setting of their parents or even that of their teachers, for they will never live in those times. A science curriculum ought to prepare students to cope with a world of change by achieving "maximum adaptability" during periods of cultural transition. A science program which neglects man's future is an essay on history.

The process of education should do more than insure the acculturation of an individual; it should provide him with the skills and intellectual attitudes essential to understand the emerging world and to mediate the future. We are at a point in history where the future is spilling into the present. The entire issue of "environmental quality" and its attending problems is an example of what I mean. The future is the only period of time in our life over which we actually have any control. Our present mode of science teaching is on a collision course with the future because the student is permitted little opportunity to free himself of the present and to consider ways in which a more satisfying future for mankind might be planned. The educational problem is how best to teach and learn the future, how to reach from the *here* and *now* to the *there* and *then.* In planning curricula with a future orientation we do much to shape this future and minimize the possibility that man himself may become a victim of cultural lag.

We are moving into a period sometimes described as a "post-industrial" society in which learning and knowledge are likely to be the primary economic resources of the world. However, this will not be in the sense of a "knowledge explosion" like that of the past quarter of a century. For decades we have been content to simply add more and more knowledge to the stockpile we already have without much regard as to how it will be used. Consequently, a tremendous chasm has developed between the creation of knowledge and the use of knowledge. Today we have access by one means or another to nearly all the knowledge that ever existed. Individually and collectively we know more than any other society has ever known in the past, and a startling result of all these efforts is increased ignorance. We know less about how to solve contemporary problems of life and living than in the past; witness our ecological irresponsibility, our racial prejudice, our national disunity, the disenchantment of youth with existing societal goals, the "identity crisis," to mention a few. A new educational effort is needed to upgrade the quality of knowledge in science courses to the point where there is a reasonable chance that the complex science-social problems of the 1970's can be attacked by citizens. Michael Marien describes the image of the "ignorant society" as "a condition in which societal learning needs out-distance attainment."[2]

To achieve the proposed goals for science teaching in the 1970's will require a problem-centered curriculum with a man-societal bias. Human and cultural-based problems typically have roots not only in several sciences but also in nonscience fields; they are multidisciplinary in character. The fragmented knowledge of discrete disciplines is too limited for interpreting human experience. A greater interpenetration of subject matter between sciences and between the sciences and other fields of learning is needed. This is especially important if we expect the student to become a better citizen in the sense of being more informed, more concerned, and more competent to reach science-social decisions. The specialization of knowledge, which has brought us this far along the course of cultural revolution, is not adequate to deal with either today's science or social questions. There is need for a cohesiveness of knowledge and a plurality of approaches to problems. The most active fields of research in science are not in highly refined specialties but at the interface of such disciplines as biology and physics, chemistry and physics, and biochemistry. In a similar way the problems of life and living will not be resolved in separated disciplines, but through the integration of knowledge and interrelated modes of knowing.

Over the past decade there has been a great emphasis in science teaching on the development of inquiry and discovery processes, but for the most part these are not suitable procedures for solving science-based social problems. Rather, the need is for skills that help one to apply knowledge to problems for which there is conflicting data but for which decisions must be made. The problems students must deal with in "real life" are more task-oriented than experimental and data must be considered in qualitative as well as quantitative terms. They are problems which call for decisions and there are few conclusions. Decision-making is more a way of maximizing the meaning of information than simply interpreting data. During the 1960's in science teaching the emphasis was upon how data are obtained, for the 1970's the priority is how data are used. In another way this is the difference between *knowledge in being* and *knowledge in action.*

Here then, as I see it, are a few of the educational goals for the teaching of science in the 1970's. Progress is being made in translating these goals into curricula and appropriate teaching styles, but it will undoubtedly take a decade or more to move science teaching from "yesterday to tomorrow."

1 Gerald Holton. "Improving College Science Teaching: Lessons from Contemporary Science and the History of Science." *Journal of College Science Teaching.* 1:1:31 (October, 1971).
2 Michael Marien. "The Discovery and Decline of the Ignorant Society, 1965-1985" in *Educational Planning Perspective,* Thomas Green, Ed., Surrey, England: IPC Science and Technology Press, 1971.

SESSION B-8

MANPOWER AND EMPLOYMENT IN ASTRONOMY AND PHYSICS

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1. INTRODUCTION

Ironically, the topic regarding astronomers that has been the most carefully scrutinized at the highest levels has not been their education, but their number. Until recently these studies generally concluded that there was a shortage of astronomers in the United States, and that the shortage was expected to continue into the 1970's[1,2]; *e.g.* as recently as 1969 the U.S. Department of Labor[3] stated, "Employment opportunities for astronomers with the PhD degree are expected to be excellent through the 1970's. Well-qualified persons with only bachelor's or master's degrees in astronomy also will have good employment prospects . . ."
Today, however, the general consensus about astronomy, as for other sciences, is that an acute manpower problem exists and shows no signs of subsiding.[4,5]

This paper attempts to assess the following questions:

(a) What is the current supply of astronomers in the United States, and how has it been changing as a function of time, especially in comparison with other fields?

(b) What is the background and make-up today of astronomers in the United States?

(c) How have recent recipients of PhD degrees in astronomy or astrophysics obtained their first professional position?

(d) In fact, what is the current level of unemployment among U.S. astronomers, and how does it compare with rumors about the situation?

(e) What is the nature of the first professional position of such recent degree holders?

(f) How satisfied are such persons with their current employment?

(g) What conclusions and recommendations can be drawn from the above considerations?

Since manpower and unemployment are extraordinarily controversial and significant topics, it might be appropriate to note a few matters that this paper does *not* treat:

(a) International migration of scientists. It might be noted, nevertheless, that job shortages in astronomy exist elsewhere, although not always so acutely; *cf.*, Roeder and Kronberg.[6]

(b) Longitudinal study of migrations into and out of the field. Such an ambitious analysis is being made at the American Institute of Physics (A.I.P.) for physics, including astronomy.

(c) Projections. Although fascinating, projections are almost impossible to make accurately; nevertheless, they are being constructed for science in general.[7-10] To make accurate predictions for astronomy would require a detailed analysis of current and projected manpower needs and funding allocations, all of which are speculative.

2. SOURCES OF DATA

Most data sources for manpower in American astronomy have been discussed by Berendzen.[11] In this study, three sources were used:

(a) The National Register of Scientific and Technical Personnel of the National Science Foundation (NSF). The Register,[12] which is compiled biennially, collects information on the supply, utilization, and characteristics of scientists in the United States. NSF sends a questionnaire to members of U.S. professional scientific organizations. Typically the response rate for holders of PhD's is about 80 to 95%. Unfortunately, comparisons among the Register's data for various epochs are problematical, because NSF has made changes in its definitions of scientific fields and professional standing.

This study includes unpublished data from the Register that were provided by NSF, analyzed by computers at the A.I.P., and studied at Boston University.

(b) Information on enrollment for advanced degrees[13] and earned degrees awarded[14] from the U.S. Office of Education (Department of HEW). Since HEW collects these data annually from hundreds of graduate institutions, the information is not always consistent or complete, although it is nearly so.

(c) A questionnaire sent to recipients of PhD degrees in astronomy or astrophysics at U.S. institutions between 1967 and 1970. This form was sent in spring 1971 under the auspices of the Statistics Panel of the Astronomy Survey Committee of the National Academy of Sciences.

Eighty-two percent of the persons polled returned their forms, which is a substantial response rate considering the length and complexity of the questionnaire. Efforts were made to insure that all appropriate persons received questionaires by having the forms forwarded to them by their graduate institutions. No sampling bias was detected for the respondents either in their graduate institutions or in their year of award of PhD. It is possible that persons who received their degrees in astronomy but have since left the field would not have received the form or would not have responded to it. There was no indication in the replies, however, that this biased situation had occurred. The high response rate plus lack of detectable bias seem to indicate that the sample in this study is representative of recent recipients of astronomy doctorates in the U.S.

3. MANPOWER

3.1 *The Increasing Population*

One of the most perplexing problems in analyzing manpower in astronomy is to define who astronomers are. Astronomy's hybrid, multifaceted nature makes it difficult to distinguish uniquely from its sister disciplines of physics, geophysics, engineering, and the like. Two modern areas of research are especially problematic in this regard: space-and-planetary physics and relativistic astrophysics.

After carefully analyzing the manpower data in the National Register; the author of this paper concludes that both the total number of full-time-equivalent (FTE) persons employed in astronomy and the number with PhD's who are working in astronomy, irrespective of the field of their degree, have approximately tripled during the past decade.

One measure of the recent rapid growth of astronomy is the increase in the rate of awarding of doctorates in the field. From 1920 until 1960 the annual rate of growth of the number of astronomy doctorates was only about 4%, compared with a rate in other sciences of 7%. Beginning in about 1960, with the advent of the space era and the rise of modern astrophysics, astronomy's annual growth rate jumped to roughly 15 to 20%. Thus for the past decade astronomy has been expanding exceptionally fast, but over the broader time scale of the last 50 years, the recent surge has only brought the field into approximate equilibrium with the average in other sciences. Clearly, however, the recent expansion in astronomy could not be maintained indefinitely without draining proto-scientists from other fields and necessitation a realignment of the nation's priorities in science.

Not surprisingly, the number of departments that have awarded graduate degrees in astronomy have also risen during the past decade. While the number of institutions granting PhD's in the field remained nearly constant through the 1950's, it nearly tripled during the 1960's.

There is evidence, nevertheless, that the proliferation of astronomy degrees may have begun to subside. Apparently the relative influx into graduate programs in the field has begun to taper. If so, obviously the rate of production of graduate degrees in astronomy will lessen. But that effect alone will not cause a decline in the rate of production of astronomers, because of the enormous influx into astronomy from other fields.

3.2 *Influx From Physics*

The Register data indicate that approximately 700 new PhD holders have entered astronomy during the last decade. According to HEW reports[14], approximately half that number of PhD degrees were awarded by U.S. astronomy departments during the same period. Close examination of the Register data eliminates the possibility that massive immigration of foreign astronomers could have caused this discrepancy. A significant portion of the influx into astronomy must have been caused by a transfer of persons from other degree fields.

The Register data support this conclusion. Whereas in the early 1960's less than a quarter of the PhD holders employed in astronomy held their doctorates in physics, by 1970 the portion had risen to nearly half. During the 1960's, the percentage of doctorates working in astronomy who have PhD's in fields other than astronomy or physics has remained roughly constant at about 7%. Thus today over half of the PhD's employed in American astronomy hold doctorates in fields other than astronomy; among American astronomers approximately as many hold their PhD's in physics as in astronomy.

Such shifts in the graduate preparation of proto-astronomers have dramatic implications. From an educational standpoint, the early 1970's will mark a turning point in the development of modern American astronomy. In the mid-1960's, about 40% of the U.S. astronomers had obtained their undergraduate preparation in physics and 25% had obtained it in astronomy; on the other hand, a great majority of them held PhD's in astronomy.[16] Today the proportions from graduate programs in physics and in astronomy are nearly equal. And if the trend continues, henceforth the majority of American astronomers will hold all of their degrees in physics.

Of course, at many graduate institutions the programs in physics and in astronomy are virtually identical; clearly astronomy has become astrophysics. But the shift in the preparation of future astronomers has important educational implications:

(a) To meet the needs and interest of all physics graduate students, physics departments should have on their faculties persons who are knowledgeable in astronomy.

(b) To influence the graduate education of future astronomers, efforts should be placed at least as much in departments of physics as in departments of astronomy.

(c) To influence manpower and employment in astronomy, efforts should be placed at least as much in departments of physics as in departments of astronomy.

4. EMPLOYMENT

4.1 *The Search for Employment*

Because of concern over a shortage of jobs for well-prepared astronomers, a study was made of the issue in spring 1971, for the Astronomy Survey Committee of the National Academy of Sciences. Since the persons most directly affected by a job shortage are usually those who are at the beginning of their career, it was decided to survey recent recipients of PhD's in astronomy or astrophysics from U.S. institutions.

(Ideally the survey would have included PhD recipients in physics, but this was not attempted because the physics population is too large to reach efficiently and the findings for that group would virtually defy analysis. If they did not find employment in astronomy, what precisely would that mean? If astronomy PhD's failed to find jobs in their own field, the conclusions would be less vague.)

Although virtually all of the persons in the sample had found employment, apparently the difficulties in doing so have gotten progressively worse during the past four years. The portion receiving more than one job offer decreased from two-thirds for the 1967 graduates to roughly one-third for the 1970 graduates. Since some of the graduates might have received more job offers if they had not accepted an early one (perhaps out of fear of not receiving others), the data here reflect the lower limits of the potential job market. On the other hand, each year a higher percentage of the graduates sent out larger numbers of applications, yet an increasing fraction of those sending multiple letters received only one job offer. The percentage sending more than three letters rose from 24 for the 1967 graduates to 52 for the 1970 graduates; in only three years the fraction more than doubled.

During the same period, the way that the first job was found has also changed. The influence of faculty referral on job placement declined for the 1968 and 1969 classes compared with the 1967 class; concomitantly, the effects of previous employment and personal soliciting rose in influence. These changes further demonstrate the tightening of the market.

It should be noted, however, that the situation for the 1970 graduates began to return more towards the situation for the 1967 graduates. This reversal may indicate either a slightly improving market or a more job-wise faculty.

Interestingly, comparison of numerous variables in this study against the relative ranking of "Effectiveness of Doctoral Programs" by the American Council of Education (ACE)[17] shows that the only significant difference among the institutions in terms of employment of their graduates rose in the way by which they secured their first job. Graduates from the highest-ranked graduate programs were greatly aided in their job securement by their faculty, while those from the lowest-ranked programs had to rely more upon their own efforts.

4.2. *Unemployment*

According to data from the 1970 National Register,[22] unemployment was not a major problem among astronomers as a whole. Of the non-students in the field, 1.5% were unemployed and seeking employment, a figure that is identical to the average for all scientists listed in the Register. For PhD's in astronomy the percentage was 0.8, compared with the Register average of 0.9.

It should be emphasized, however, that the job market is constantly tightening. For the class of 1970 in astronomy, the numbers of jobs and of applicants were about equal, which suggests an extremely tight market; moreover, the recent trend indicates that the situation today must be worse, and unless conditions change, will be even more severe next year.

A follow-up survey by the NSF[18] in spring 1971 showed that unemployment among all scientists had risen since 1970 from 1.5% to 2.6% and for PhD's from 0.9% to 1.4%; however, for physicists it had risen to 3.9%. Specifically, that survey found that the age group under 30 had the highest unemployment, and that more than half of the nation's unemployed scientists were in either chemistry or physics.

The findings in this study for recent PhD's in astronomy indicate that even the ones under age 30 had a comparatively small problem with unemployment. Less than 1% of them were unemployed, in the sense that they could only obtain part-time work; however, half of this total 2% with employment problems had restricted their employment search to specific geographic locations.

In contrast, a report of the Physics Economic Concerns Committee, headed by Professor Lee Grodzins[19] at MIT, found for recent recipients of PhD's in physics the unemployment and unemployment levels to be about 4% and 2.5%, respectively.

4.3. *Field of Employment*

Even though 99% of the recent PhD's in astronomy are employed, not all of them found positions in astronomy. Twenty-four percent had looked for a position in other fields, usually physics, computer technology, or "teaching"; but only 9% of those employed today actually had taken a non-astronomical job, which is a natural migration rate in science.[20] The ones who had searched outside of astronomy reported that they had done so primarily because of job scarcity in astronomy or because of their greater interest in another field. Half of the 9% who are employed in other fields had made the change by choice, and a third of the 9% said that they had sought but had been unable to find a position in astronomy. These statistics, like those in section 4.2, indicate that the current demand for astronomers is essentially equal to the supply, but not in excess of it.

The situation for young physics PhD's is strikingly worse: about 30% of those who sought employment in traditional sectors of physics in this country failed to obtain such jobs.[19]

The percentage of astronomy PhD's seeking employment outside the field is an indicator of the fear of job scarcity in astronomy. While 13% of the 1967 graduates looked outside astronomy, 40% of the class of 1970 did so.

(Moreover, many of the graduates did not seek regular employment immediately after receiving their doctorates; instead 31% obtained post-doctoral appointments. Only a tenth of these appointments were for less than one year, and no increase in a "holding pattern," or short-term tiding-over period prior to employment was evident.[9,21] Each year from 1967 to 1970, approximately the same fraction of the graduates who applied for post-doctoral fellowships received them – about 2/3. But during that period the fraction who applied for such appointments rose.)

4.4. *Nature of the Employment*

In 1970, according to the National Register,[22] about 50% of all astronomers were employed by educational institutions, 20% by the government, 10% by non-governmental research centers, and 10% by industry. For PhD's working in the field, the pattern was different, with 65% being employed by educational institutions.

In terms of FTE percentages, the main types of employment were, in decreasing order: research on-campus at educational institutions, teaching on-campus at educational institutions, research at government facilities, and research off-campus at educational institutions. Those four endeavors account for over 3/4 of the total working time of the recent astronomy doctorates.

Note that even though 4/7's of them are employed on-campus at educational institutions, the new PhD's devote over twice as much of their working time to research than to teaching.

The nature of the employment of the new PhD's has changed drastically during the past few years. Employment at on-campus educational institutions plummeted from 80% for the 1967 graduates to 37% for the 1970 graduates. And naturally there was a simultaneous rise in the relative levels of employment in non-academic positions.

As could be expected, the nature of the work activities also shifted. The principal work activities of the 1967 graduates in their first job were divided approximately: research and development, 48%; teaching, 41%. In contrast, the principal activities of the 1970 graduates were: research and development, 81%; teaching, 13%.

This shift may have risen because traditional teaching positions have now become saturated, a situation forecast years ago by Cartter[23] and recently reiterated by him.[9] Or perhaps the recent graduating classes have preferred new forms of employment. Considering the lack of job choice today, and the apparent slowing of the expansion of astronomy departments, the first hypothesis is more likely.

The shift in employment patterns may also have been one of the reasons, besides actual job scarcity, that recent graduates have found it necessary to send increasingly large numbers of job applications. From their knowledge of past employment patterns, they likely have sought jobs at the traditional employer of astronomy doctorates, namely educational institutions. But apparently that market is nearly filled, at least in comparison with non-academic employers.

4.5. *Employment Satisfaction*

Even though virtually all of the recent doctorates obtained employment, it is possible (indeed, widely believed) that many of them are severely dissatisfied with their jobs, having accepted the only positions they could find. It is rumored that graduates today are often forced to accept positions that will not allow adequate time for research, and that what research time they do have available cannot be spent as they would like.

Although 62% of the recent doctorates in this study said that their research was restricted in some way, their most prevalent complaint was a "lack of assistants," followed by a shortage of computer facilities. Teaching and administrative demands were listed as relatively minor interferences. Similarly, lack of available observing time was not a major problem, except for a few astronomers who used optical telescopes.

(Unfortunately, no similar study is available from "better" times; if one were, it could calibrate these replies. No one knows what percentage of PhD's are dissatisfied even under excellent working conditions.)

The astronomers' ideal and present distributions of time and research were remarkably homogeneous. Among the respondents who spent more than half their time in research, almost 95% were able to devote at least 3/4 of their research time exactly as they would like; in fact, only 7% of the total research time of the entire set of recent astronomy doctorates was spent in sub-fields that the individuals ideally would not pursue.

This study also attempted to assess employment disappointments by asking the respondents specifically for their complaints. Surprisingly perhaps, the most frequently mentioned problem was not too much teaching, stated by only 10% of the sample, but "lack of intellectual stimulation," mentioned by 25%. Another 25% of the sample reported no disappointments. Other frequently mentioned problems were "isolation" and the lack of miscellaneous support, such as assistants, travel funds, and secretaries.

Another rumor holds that many young astronomers are forced to choose between teaching at remote, undesirable sites or taking mundane jobs, below their technical competency. In fact, this study found that they have not (at least in appreciable numbers) been forced into the latter situation, even though that has happened in physics;[19] nevertheless, the rumored geographic effect has occurred in astronomy, albeit not so severely as some believe. There were not enough jobs in the Southwest to meet the demand, and some astronomers had to accept employment in the South and Midwest, contrary to their preference. But on the whole, the situation could not be described as bleak, for half of the persons in the study with a preference had obtained a job in the state of their first choice and three-fourths of them secured a position in one of their first three states of preference. Even though securement in one of the top choice states does not insure that the site was desirable, only 18% mentioned any disappointment with their location, and often not for professional reasons.

5. CONCLUSIONS AND COMMENTS

Starting in about 1960, manpower in American astronomy began to increase at a phenomenally large rate. From the perspective of the last 50 years, the surge during the past decade has only brought astronomy's overall rate of growth roughly into line with that of other sciences. But the magnitude of its recent expansion, especially when compared with its funding, has in the last few years almost exactly brought the supply of astronomers into balance with the demand. That situation is dramatically different from that obtained in astronomy in the early 1960's, the era of the employees' market. And, of course, if the recent trend should continue, the supply would substantially exceed the demand.

How critical is the job problem in astronomy? The answer can only be given in relative terms. This study shows that the availability of jobs in the field today is severely limited compared with five years ago, but it is not so limited in astronomy as it is in many other sciences. And undoubtedly one of the major factors that has exacerbated the job problem in astronomy has been the migration into the field of scientists from other disciplines, especially physics, where the job situation is even more difficult. Even though the nation as a whole has been in a recession, astronomy has survived comparatively well.

Overall, employment levels in American astronomy are high, and despite anecdotal stories to the contrary, most of the recent astronomy doctorates seem fairly satisfied with their jobs. On the other hand, many of them have had to seek employment outside the traditional academic environment and away from their ideal geographic location; moreover, even then job securement has often been difficult. And the situation seems to be rapidly worsening.

How could the job market in astronomy be improved? As in any problem of supply and demand, there are two related remedies: decrease the supply or increase the demand. The latter alternative implies increased funding for astronomy,[24] particularly on a per capita basis. Since that nettlesome issue is outside the scope of this paper, it will not be discussed here.

But what about decreasing the supply; *i.e.*, reducing the number of astronomers? Two-thirds of the PhD's in this study said that relative to funding, there are too many astronomers in the U.S. today, and over 80% of them recommended having graduate astronomy departments train fewer people. In manpower parlance, that tactic implies "negative recruiting."

The authors of this paper believe that it would be prudent if the recent proliferation of graduate programs in astronomy would cease, and if the size of existing departments would hold constant or slightly decrease. (Such recommendations are frequently made today about the output of doctorates in most fields.[25,26]) Extreme measures of negative recruiting might have catastrophic effects for the future, however, as has been cautioned by NSF.[27] In this regard, a well-known senior astronomer recently remarked that he was glad no one had enforced negative recruitment in his graduate years, which came during the Depression of the 1930's. Considering the number of remarkably productive astronomers from that era, his observation seems highly sage. (Numerous alternatives have been discussed in the literature.[9,10,28])

While a tightening of graduate astronomy departments would help to taper the supply, by itself it would be inadequate; indeed, it would not be aimed at the heart of the problem. Since over half of the future astronomers in the United States will receive doctorates in physics rather than astronomy, the curtailment of physics departments would be more effective. Furthermore, considering the relatively tight job market in physics, the recent massive influx of physicists into astronomy may have been caused not only by the enormous latent interest of the field but also by superior job opportunities in it. Whatever the current manpower problem may be in astronomy, it has been caused more by departments of physics than of astronomy.

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Several hundred recent astronomy PhD recipients who responded to the questionnaire in this study.

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SESSION C-3

LET'S HUMANIZE SCIENCE EDUCATION!

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Many times critics of scientific endeavors or technological advances point to science as the cause of our societal ills.

BRIEF SUMMARY:

Teachers in science education have or should have the difficult task of teaching a moral science to their students. This becomes difficult too many times when science is blamed for the ills of society. They should be faced with the problem of at what point does scientific knowledge, which is in great demand, become disastrous. Our world is constantly clamoring for new methods to make life more profitable and enjoyable. Consequently our systems become increasingly complex. In many scientific projects, i.e., the space program, the automobile and aerospace industries, etc.; science is placed at fault too frequently.

The scientific architects of our society may have not given enough consideration to national problems. As students perhaps, these architects did not receive moral humanist values. I would suggest to science teachers to teach their students to understand the possible effects on humanity of technological advances. It is the duty of the teacher to create a sense of humanity in the student for the sake of a wholesome society.

Therefore, one might possibly conclude that science is not to blame for societal ills. These ills are brought about by the human element in the application of science. With the stress of the moral sciences to students perhaps an awareness can be instilled which will reverse our present course of disaster.

SESSION C-5

TREATING THE SOCIAL IMPLICATION OF SCIENCE IN THE SCIENCE CLASSROOM

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This is a time of general disenchantment with science and technology, particularly on the part of our young persons. There is a feeling in the land that science has been misused and that the technology that science has spawned has been allowed to desecrate our environment, and has led to the plunder of our resources. To be sure, some of this general anti-scientific malaise can be attributed to a depressed economy and the high material, social, and moral costs of a disastrous Asian war. Nevertheless, it is clear that even if the economy were to recover, and the war to end tomorrow, a substantial amount of dissatisfaction with the scientific enterprise would still be felt by a large proportion of our citizenry. It is time to acknowledge that, in large measure, we have earned this reaction by virtue of our failure as scientists and educators to be sufficiently sensitive to the need of our students and the society as a whole to learn to view science as a human activity with which they can identify. It was all simple for us in the 1960's, when research budgets were soaring and when school science courses were often viewed primarily as the first rungs on a ladder leading to social prestige and financial success. It was easy for us to look away from the problems of teaching science to those in our society who would not go on to college or to scientific and technical careers. It was satisfying to focus our attention upon the development of courses that reflected the basic structure of our respective disciplines in ways that would be esthetically pleasing to those who practiced and taught them. Of course, it was good that those courses were created. Those years produced many curriculum advances that were to have much influence upon science education, not only in schools but in colleges as well. However, taking physics as an example, the hard facts were still gravely in evidence: Only 20% of our high school students ever saw the inside of a physics classroom. The message was clear even then but we chose to ignore it. Now we are faced with the harsh consequences. Astrologers appear to outnumber astronomers by several orders of magnitude and a dismayingly large fraction of our young persons recoil from technology and science as they would from bearers of the plague. Efforts to reverse the pattern, such as Harvard Project Physics, are still too new for us to tell whether they are successful.

The Defensive Response

In view of the general disenchantment and economic depression resulting from employment problems within the scientific professions and academic communities, it is only natural for us to react defensively. At the very highest level, the President has proclaimed a program of "technological Initiatives" designed to restore trade balances and increase employment in the technical community, while the National Science Foundation devotes a substantial share of its resources to a program in Research Applied to National Needs (RANN). On all sides, we see attempts made to emphasize the positive applications of science to problems of the human condition. Of course, it is appropriate that this be done. When basic human needs are not being met, it is appropriate and right that we turn our attention to them; we know that the more sophisticated needs of the human spirit are not likely to develop and emerge as long as significant numbers of basic needs are unfulfilled. Particularly on a world-wide scale, problems associated with basic human needs continue to be extraordinarily acute. Most of the world's citizens are impoverished; one-third of the world's population cannot read or write; one-half of its school-age children are denied classrooms. Certainly it is right that scientific energy and research be channelled to meet those needs; certainly it is right that our educational institutions, in particular, request public support for applied science in the name of the public interest. However, at a time when basic needs are greatest and when resources are in shortest supply, it is essential that those of us concerned with science education for citizens never lose sight of the fact that the intellectual, ethical, and other positive human values associated with the scientific enterprise provide a social return that, in the long run, is just as important to the development of a flourishing human society as the more immediate technological applications of advances in scientific research.

This is particularly true at a time when research in some areas of basic science is being curtailed so that work directed to more immediate applications can be supported. It is difficult for some politicians and other non-scientists to understand why problems in basic science are not always amenable to quick solution. Men with shortened perspectives who look for immediate returns on scientific investments are not likely to be able to make wise judgments about the long-term support of basic science. Nor is it likely that they will understand or be sympathetic to educational programs which stress those less-obvious, but equally vital, contributions of science – scientific values – to human society unless we provide leadership and direction. It is precisely for this reason that those of us concerned with general education and science for citizens must make every effort to develop programs and strategies which emphasize those contributions.

How Can We Begin?

How can we ensure that our students learn how important ethical values are in the scientific enterprise? Can this be done within the framework provided by our traditional science courses? Are these matters too tenuous to stand up to rigorous classroom examination? Is it proper for science teachers to divert time from more traditional concerns to deal with these matters in the classroom? If these themes are sufficiently overarching to justify our attention, what materials are available? How do we begin?

In partial response to the first question, I suggest that all good teachers have always known that, even if clear goals are specified for their courses, it is not always possible to define precisely the route by which these goals are to be achieved. Just as different persons may make different interpretations of a work of literature because they view the work in contexts influenced by their own interest and lives, students in our science courses deserve to be able to make similar interpretations when questions of scientific values and social implications are discussed. Definitions and interpretations of values, unlike scientific models, are not easily tested experimentally. Consequently, there is no programmed method which can guarantee success. Those of us who are used to the less ambiguous domain of the laboratory will have to learn to be tolerant and to listen more.

It is perfectly proper for a science teacher to concern himself with matters of scientific values and their relationship to other human affairs. I assert that the character of our times demands nothing less. Most of us have always known that scientific developments do not take place in a vacuum. The "scientific method" always was a myth that did a disservice to the diversity of styles that can be observed in any school or laboratory. Scientific models are created by humans as much for esthetic reasons as for any other. Seeking simplicity, we strive to create explanations which serve to link events which would otherwise be unrelated. Seeking to test these explanations, others create new experience in the laboratory. To the extent that questions of taste and style are highly personal, so it is with the working approaches of contemporary scientists. But, it may be argued, "ultimately our models must describe experimental results." Fortunately, some of our most visionary scientists who work at the frontiers have provided us with the deep insight that if our theoretical models are sufficiently beautiful, but do not agree with experiment, the experiment is likely to be incomplete or wrong. "Ultimately" may be a long time away. In other words, I am suggesting that science has an esthetic and ethical value structure, and that its practitioners are sensitive to it. If we accept this, then it is clear that ethical values in science, and their social implications, can be discussed in the same interpretative and subjective manner that we discuss other human activities.

Some Available Materials

Fortunately, those who wish to set forth in these directions need not begin without resources. Because visionary men of science and science teachers have always been conscious of the ethical character of science and its relationship to other fundamental human concerns, scientific and educational associations such as the American Association for the Advancement of Science, the American Chemical Society, the American Physical Society, and the National Science Teachers Association (as evidenced by its sponsorship of this session) are beginning to provide their encouragement and support. As a specific example of available materials, I would like to call attention to the magnificent bibliography "Science and Society" prepared by John A. Moore for the American Association for the Advancement of Science. Available from AAAS for only $1, it contains, under a variety of subheadings, references to more than 4,000 articles, books, and periodicals commenting on various aspects of the interaction between science and society. Ranging from discussions of problems caused by technological advance on the one hand to the ethical implications of various aspects of contemporary science on the other, a careful reading of this bibliography will provide thoughtful teachers with numerous ideas about potential themes to be pursued.

Many teachers will also be interested in the audio tapes prepared by the American Association for the Advancement of Science in conjunction with its annual meeting. Many sessions of these meetings deal with the social implications of science and include extremely valuable discussions of pressing contemporary problems. Even though most of our students will not be able to attend such sessions in person, some may be interested in listening to the tapes to ascertain for themselves how seriously many contemporary scientists consider these matters. Catalogs and price lists for tapes may be obtained from the AAAS.

The Importance of Student-Initiated Studies

A teacher who wanted to broaden his science course by enlarging its scope to include examples of the interaction between science and society could begin by making copies of this bibliography available to students, who would be asked to identify the papers that seemed to be most appropriate and interesting for individual reading and class discussion. Library searches could be conducted and resource materials assembled to provide the basis for student-arranged seminars and discussion groups. It would seem that this course of action has several advantages. By being invited to choose the subject for discussion themselves, students will be more likely to have a vested interest in the productivity of these discussions. Second, the teacher sponsoring these activities will not be suspected of selecting particular topics to advance social objectives or ethical judgments which may not be shared by everyone.

Another advantage of student-designed seminars and forums is that many students who find that they are left without anything to say in our standard science courses because they feel that they do not have sufficient knowledge (unlike courses in the humanities where questions of values and morals are routinely discussed and in which students are not afraid to voice opinions) may be encouraged and willing to participate. In this way, they may discover for themselves that one cannot make judgments about these matters without possessing some scientific and technological insight. In other words, a case study approach to problems of science and society can be used to motivate students to learn more of the basic scientific principles that underlie the particular issue. By taking part in these activities, students can experience for themselves the style of discussion that we all strive for in our scientific and educational activities (even though we may not always achieve it) in which ideas can be freely exchanged and in which arguments are judged on their merits. This, after all, is the most precious aspect of our profession. If we believe that the ethical values implicit in the exchange of information and opinions among men who are free to speak their minds, record their experiences, and test their theoretical models against their experiments are important, then we must encourage our students to engage in these activities wherever possible.

Long-Range Goals

It is certainly appropriate for scientific administrators associated with our great national institutions to encourage the building of bridges between the various components of the nations research and development enterprise in the hope that ways may be found to overcome informational, technological, and marketing barriers to the application of research and development to the satisfaction of human needs. As teachers of science, we cannot afford to let our society forget that the course of civilization is determined by the quality and character of learning pursued in our educational institutions. Since science has continually shaped the character of learning in our schools and universities, the ethical values of science should be at least partially reflected in all areas of human life. In turn, we must strive to incorporate into our sciences those universal values of truth, and human dignity which are held in high regard by all peoples.

Perhaps it is appropriate to end by considering a question from Ecclesiastes that asks "And the days of eternity, who shall number? The height of the heaven, and the breadth of the earth, and the deep, and wisdom, who shall search them out?" Wise men have always wondered about the mysterious and unknown expanses of time and distance. The answers to these questions are now beginning to take shape. But who shall find wisdom? How shall those human values which we treasure be woven into the tapestry of our teaching? How can the ethical values of science from which we derive so much satisfaction and pleasure be shared with our fellow men? These are the challenging questions of our times which we all must confront with humility and courage.

THE HIDDEN CURRICULUM IN SCIENCE TEACHING MATERIALS

Jonathan Beckwith, Professor of Microbiology and Molecular Genetics, Harvard University Medical School, Cambridge, Massachusetts

There is a crisis among scientists and science students today. Many are beginning to see the social, political and ethical implications of their work. This awakening results from an increased awareness that science and technology are being used more for destructive than for beneficial ends. Consequently, science students and others are turning away from science or even becoming anti-science. Others who are presently scientists or heading toward scientific careers are trying to develop ways of doing science which will benefit those people who are suffering most under our present political-economic system.

Science education works against a society in which the potential benefits of science are distributed to all people equally. First, the education of future scientists trains them to ignore the social and political implications of their work. Second, non-scientists are presented a mystification of science and of the scientist which robs people of the ability to deal with the science and technology permeating everyday living. A paasive population is created which receives each new development and product with fear or gratitude. No questioning of the goals of our technological society is permitted.

Present science curricula track students into these anticipated roles in several ways. Myths of the neutrality, objectivity and infallibility of science and the scientific method are presented. Further, a hidden curriculum with many social and political messages exists in all presently used teaching materials. Some of the most oppressive features of our society — sexism, racism, elitism and the competitive ethic — are subtly or not so subtly propagated by these hidden curricula. The Science for the People — Science Teaching Group is attempting to reverse this negative role of science education. Examples of concrete ways in which we can counteract these pernicious features of science teaching will be presented.

SESSION C-6

THE CHALLENGE TO SCIENCE EDUCATION DURING A PERIOD OF ANTI-SCIENCE

Clarence J. Goodnight, Head, Department of Biology, Western Michigan University, Kalamazoo

There seems to be little doubt that this is a period of anti-science. The general public, looking over the whole area of technology is at once struck by the idea that there is something here that isn't entirely satisfactory to them. Something that isn't quite what the public wants, and yet no one is very clear as to what it is that they really do want.

One of the problems of the general student or the proverbial "man on the street" is that he somehow is suspicious of the very technology that he has worshipped so long. For long years, most laymen have considered technology to be the highest form of activity of Western man. They recognized technology as the source of many of the comforts which they loved so well: the large automobile, the washing machine, automatic heating. Now all these things that have seemed a part of the "good life" have suddenly come under suspicion. With the increased interest in environmental problems, many of the technologies which were producing the machines and the soaps and the gasolines and all the other things that we associate with the good life are now the objects of suspicion. The manufacturing processes are polluting the waters and air, causing sickness, endangering lives, both the lives of adults and children. So a general striking out against technology seems to be the modern approach.

Since man was not willing to give up all these comforts: comforts of increased electricity, comforts of air-conditioning, big automobiles, fast transportation, large airplanes, he had to blame somebody. So he began to blame technology, the same technology that he felt before he could not live long without. He demanded more energy and to get more energy he found that there had to be either more fossil fuel plants to pollute the air or more nuclear power plants had to be developed. These latter had the suspicion of thermal pollution, radio-nuclide release possibilities, and possibly other undesirable effects.

Thus, technology became the object of man's anger and frustrations. Along with this, most laymen were not able to distinguish between science and technology. They could not see science as an area basically concerned with discovering basic principles of how the universe operates, of discovering relationships. They also could not see technology as only the application of the information gained by scientific investigation. Instead of focusing his anger on only the technologists, the applied scientist, it broadened to all areas of science. Some began to suspect that maybe we would be better off without any more science. Because all that science was doing was discovering ways to endanger man's environment, lower the quality of life; and somehow all these annoyances were implicated with what he saw as the frustrations of modern living.

It is no wonder that as our "average citizen" looked at the schools from elementary to graduate, he would complain first at science and the science educators. He thought of these latter as training people in not only the understanding of science, but in the possibility of developing new science. This unrest manifested itself in the general downgrading of the school systems, the general refusal to increase money for laboratory supplies, equipment, assistants, and all the other details that seem so necessary if the educator is to do the job as he thinks it should be done.

Another very basic fear of many people is the increasing cost of operating school systems at all levels. Whether it be the tuition which they are paying for their child, or the property tax which goes to operate local school systems or the state taxes that may make possible the large state universities, they are worried. How could citizens afford to continue paying these bills? What was wrong with society? Children were coming from schools and colleges, threatening authority, and advocating all the other things that worried the adults in their recognition of a society in change.

Somehow people were having more than a vague suspicion that this change would not necessarily increase man's comfort, his well-being, and might well be changing his entire mode of life. That is always difficult for anyone. Frustrations in all these ways manifested themselves in what we might call an anti-intellectual movement especially focused on the science areas and the science educator. The scientist, the science educator, were no longer the respected men, men who were going to save us from all our diseases, were going to provide us with a life so comfortable that we would need do nothing but enjoy things that we liked, and provide us with all the great technologies that were going to make the marvels of the 21st century. Somehow all of this glory evaporated in a fog of disillusion. So for a period, which I feel we are still in, we are in an era of anti-science. We are in the period where people think that money should not be focused on new research, new equipment, new ways of approaching science, new science instruction.

This all leaves the science educator in very much of a predicament. The science educator could sit back and say, "What can I do?" But at this time, he cannot afford to do that. He, individually and in cooperation with organizations such as the NSTA and other groups, must plan his strategy very carefully so that again he can go back to his real purpose of educating our students, our adults, our whole population in some general understanding of science and scientific methods. He must devise ways of distinguishing for the students who are coming through his classes the difference between science and technology, and perhaps inspire those few students who will go on to become scientists.

At one time, it was enough for the science educator to use the traditional approach in his teaching. He, perhaps

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depending on the level he was teaching, could teach some classical work in physics or chemistry, or some in biology. Much of this could be descriptive and simple. If some of the students were bored, he could look at it as if it were their fault. This material was inherently interesting, after all, he was interested in it, and he should know, and then for years, great minds had been interested in it. It was up to the students, with the help of the textbook, to understand it. The rest did not matter.

This attitude is no longer sufficient. Students, at all levels, are no longer willing to sit back and accept that this is it. You understand it, or if you don't, it is your fault. Students want to know: is this relevant for me, what does it mean, so I'm never going to be a scientist. Why am I taking this science? What do I want to know from it? What good is it going to do me? Will I remember anything from it except that I had a course in chemistry? So, in a sense, what should the science educator do? Should he feel simply beaten, insecure, and go on dragging out his days until this period may be over?

I think, in a way, this period of questioning, this period of anti-science is actually quite a challenge and will probably end up in the science educator's developing new methods and becoming a much more effective teacher and individual. In the long run, this period may be one of the best things that has ever happened to science. The end result may be a new understanding by most students and many adults, as to what science is about and what are some of the excitements associated with it. Although most students will not be scientists, they may understand its value in our culture. It could be an understanding far greater than the technology involved in producing a better smelling perfume. At its best, it may be a better understanding of the universe and its beauty. Even if we go beyond basic science, the technology it spawns may well be the techniques that will help us in overcoming some of the past problems that inappropriate technologies have caused. Perhaps our students will grow to see this.

We do see science educators everywhere experimenting with different techniques: audio-tutorial systems, different types of visual aids, community involvement, the many things you are well acquainted with. I think that we can see in this type of teaching a new way for a holistic approach. We will not study segments of biology, or segments of chemistry, or segments of geology, but we will try to integrate as a problem-solving mechanism all these areas. The great social and physical problems that face our culture, things that we keep hearing about that we must solve if we are going to survive, may be the raw material for meaningful investigations. The educator can focus his science on some particular problem in his community. The student then may see that all science may be integrated in problem solving: the water pollution problems, the air pollution problems, the economics of manufacturing, the cultural relationships, the sociology of different city areas. The educator can use facets of what used to be many separate disciplines. If the student cannot arrive at a solution to a problem, at least he may be able to ask more intelligent questions and see the integration of all science.

This is also where I think the science educator can cooperate with the humanities man, the social sciences person, etc., to give a new type of integrative approach to solving problems. Well, to most students, this proves to be exciting. The student may live near a stream which is heavily polluted, he breathes air which makes his eyes water in an urban situation; so he is interested. He gets involved, he checks the chemistry, the biology of the polluted water. He does some air sampling. He traces the pollution down to the manufacturer. He may get involved with the factory and find out how many people are working in these plants that may produce necessary products, but whose by-products are causing him some of the discomfitures. He gets involved in economics; he also gets concerned about the social arrangement and ecology of his community.

We can thus see an imaginative, integrative approach which can be developed. I feel that if once the student can see this holistic approach, he will see that learning how to analyze the oxygen in water or being able to identify some of the bottom fauna of the stream is not just a simple exercise to keep him busy, but has some real meaning in his adult life. He will then have a true appreciation of the role of science in his own life. Along with the teaching of the course, perhaps some local figures—politicians, scientists—could appear either in person or in recorded interviews made by the students.

We know that this is not going to work with every student, but it may well work with enough that we can have a new excitement in teaching science. We may find that the textbooks go by the board and that we use syllabi which we develop ourselves, or paperbacks, or magazine articles. While the amount of work involved in this may be great, we may well find the challenge and the success that comes along with it, worth the trouble. This period of anti-science, in this sense, becomes not a debilitating effect on science education programs, but actually a stimulus to them.

Another thing that the science educator may be able to do in this interim period is to incorporate many things into his program that he might not have been willing or able to do in the more traditional times. He might incorporate many controversial areas. Many areas which are not proven, but look to the future for either confirmation or denial, problems like the unexpected responses of plants to different environmental stimuli. These may interest students tremendously. What is wrong with taking some of these ideas, for example, ideas related to ESP and experimenting with them? The students certainly will find them interesting, an excellent exercise, and at least they will know more of what the scientific method is all about.

The teacher can also bring a challenge to the students to consider what science has done in our cultural heritage. Too often, I think, students think of science only as a cold, impersonal subject, which may have tremendous implications so far as the development of new products is concerned, some understanding of how things operate, but little more. The interested students now look to other areas for the cultural background.

The dependence of progress on technology can be explored: We could not have learned much about the cell until the microscope was developed. Certain aspects of cellular chemistry could not be understood until microchemical techniques were better developed. So, in all, perhaps if the science educator can do nothing more than present a picture of the beauty of science, the beauty of the regularity and the relationships of the universe, he shall have done a great deal for the student.

Perhaps we have talked more about the ideas that are going to come from years of work. In the meantime, the science educator has to meet his classes, has to develop his techniques, has to continue his career. So what should he do while he is developing techniques or while groups of educators are developing some of these approaches that we are talking about?

I think we must always struggle to perfect our techniques, to develop our ideas, modify them with the times, incorporate new discoveries. I think the educator can, at present, experiment with many different types of techniques, some of which are not expensive. He can try many devices related to the holistic approach. While he may not feel completely competent at first, he can begin to develop his expertise in increasing the student's understanding, interest, and involvement in the role of science in society, the way science affects his every day life and its bearing on the cultural heritage that most groups are rightly so proud of.

SCIENCE AND HUMAN-VALUED RELATIONS

LaMoine L. Motz, Director of Science Education, Oakland Schools, Pontiac, Michigan

Science is a process in which observations and their interpretations are utilized to construct new concepts, to extend our understandings of our world, and to probe new areas for exploration and to predict the future based upon past observations and experiences.

Science is a human endeavor with the capability of improving the quality of life. Paradoxically, science is a human endeavor with the capability of destroying the quality of life.

The knowledge and methodologies of science are of little value if there is no disposition to use them appropriately. Science and scientific methodology are not infallible or impersonal objective guides to certain improvements in the quality of human life. Scientific methodology is not some great machine into which we just input data at one end, analyze it, and come out with inevitable human improvements and quality of life for all. Science is a human enterprise and must be used by human beings. What science produces at its best, can be converted into the worst by man. Science and human values must transcend the field of science alone and take into account the fundamental characteristics of the individual and an appreciation for him as a person of worth.

Science is *a* way of knowing, not the *only* way. Science is a way of knowing based upon one's own interpretation. Every conclusion in science is the product of human thinking, based upon both objective and subjective reasoning. Thus, science can be considered partially the result of subjective influences or stimuli. Also, science is a way of knowing based upon one's own interpretation of facts. Facts never interpret themselves. The findings, the experiments, the theoretical searches, the models and patterns of interpretation are basically guided by previous experiences or presuppositions, by the nature of times, and by the scientific climate of the world at that particular moment. But, science, furthermore, is a way of perceiving and knowing based upon the interpretation of data derived by our sense contacts with the natural and human world. If science cannot be seen, heard, felt, smelled, or tasted, then it isn't really science.

Students of science need to experience science in real, vital, and meaningful ways. As science teachers we cannot be content with simply presenting digested facts to our students. Our students will be seriously deprived—plus our society will be deprived if our students believe that 1) through scientific methodology we can only gain truth; 2) scientific methodology infallibly delivers us from the subjective interpretations of human beings; 3) scientifically accumulated data provide their own interpretation and do not need to be interpreted by human beings; or 4) scientific methodology is capable of informing us of everything of value or reality in life.

The scientific method or even science is the only reliable way to truth and if a scientific description of a given event can be given, no other kind of description is valid or even necessary. This is one of the most pernicious falsehoods accepted by a culture which propounds science in this way. We are living in a day when reaction to this falsehood and to other misrepresentation of science's abilities is sweeping all before it in a massive wave of anti-intellectualism. The conservative is becoming more anti-intellectual because he sees the university as an institution of intellectual activity leading to a hotbed of radical dissent. The radical feels that intellectualism in the past has given us the present impersonal rationalistic establishment. From both viewpoints, the reaction to rationalistic approaches to life is becoming an important factor today.

The need for our students today is to develop a concept, a feeling, and an applicable understanding of science. The best place to reverse trends is in the minds of our young people; we teachers need to be not only aware of the needs of our students, but to provide them with exciting, stimulating, and successful experiences during the times they are entrusted to us.

For more than a quarter of a century science has been exalted. It helped us win the last war. The influence of Sputnik ignited massive science education curricula development after it was realized that little effort was being exerted to bring science to the daily lives of our students. But now, this seems to have changed abruptly, to a lack of a scientific prestige. Government support is decreasing, jobs are on the decline, and scientists and engineers are out of work, by reasons of an economic and political nature.

I would like to suggest some other basic roots I feel are causes for the loss of scientific prestige or an anti-science attitude.

One cause for an anti-science attitude is that science has become identified in the popular mind with the destruction of religious meaning in life, and thus with the loss of hope and the inevitability of despair. Science shows that man is a complex mechanism. If science is our only

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guide to truth, then it follows that man is abandoned, an impersonal association of matter, subject to the fates of a heartless universe beyond his powers. When science is all, there *are no* human values. But I feel that men *are* men and that this dictum will not be accepted in total. Men know that they love, hate, decide, respond and relate to other people in meaningful ways.

Another cause for an anti-science attitude is that the ethical impotence of science and scientists *per se* is increasingly evident. We seem to be living in a day, a paradoxical day, where moral choices are highly valued, and even if those who call for moral choices appear to be engaged in immoral activities. Science does not provide any basis within itself to distinguish from right and wrong, or even to define these words in a moral or ethical sense. In science, to be right, means to be actively involved to work. Scientific truth is that perspective that works today. Science cannot solve all of life's problems. Students need to conceptualize and exercise this attitude--science is a limited body of knowledge.

Our students of science, furthermore, need to understand that if science is forced to provide from within its own discipline some guidance of a value nature, it is forced into a deduction without basis: what *is* defines what *ought* to be. "Is" is transformed into "ought" without a glimmer of scientific support. If it happens, it is good. If 45% of young women have premarital intercourse, this must be something reasonably good for young women to do; if 75% of them do it, then it ought to be recommended for all. Pragmatic criteria replace moral ones.

Science has been claimed the modem savior for the ills of mankind--but this appears now to be more of an illusion. Here science *per se* is shown to be relatively powerless; the human factor dominates. Scientific and technological advances have produced tremendous possibilities for improving the quality of human life in travel, communication, conveniences, etc. But these advances have also brought with them pollution of the land, air, and water--and threaten destruction of our natural and human environment.

Every good that science produces can also be used for evil. We cannot stop destructive science without stopping *all* science. We cannot limit the dangers of destructive knowledge without stopping the acquisition of all knowledge. Science must continue, but what we need is for humans to exercise their values, and define them in a different realm, a realm that takes full account of the inputs from science, but which is empowered by the kind of "ought" decisions that are demanded, which science cannot make for itself.

In conclusion, what is it then that science *can* do, and that we, as science educators, *ought* to foster and strengthen? I feel that this can be achieved in terms of the kinds of attitudes and values that students in science classes should develop.

1. Students should come to realize that science is *a* or *one* way of knowing, *a* or *one* way of learning, with a particular method which is both its strength and its limitation. Along with science we must strengthen the experience of the interpersonal relationships between teachers and students, students and parents, teachers and parents, and school with community. As teachers we should make it clear to our students that appreciating, respecting, loving, are more than scientific experiences, that in the relationships between people more transpires than can be described by scientific methodology. When such relationships have been described physically, biologically, psychologically and sociologically they still are not understood and appreciated completely until they are seen in their full perspective of their place in the totality of the created universe.
2. There are many basic and ultimate questions in human values which science can never answer. It is often said that science can tell the "how?" but can never touch the "why?" This is true, in that scientific study does not provide the foundation for establishing the basic whys of existence, or of determining the purpose and meaning of such personal existence.
3. Rational and scientific perspectives on life are an important antidote to irrational excesses and anti-intellectual subjectivism. Science emphasizes the sense of law, of objective structure and unity in the universe. Science teaches us the objective reality of the law of gravity: that no matter how sincere or devoted the disbeliever in gravity is, his jumping off a ten-story building will show him the falsity of his position. Science can also help one to appreciate the existence of a related moral structure of the universe. The science student should know how to relate his rationality with his emotions, his subjective feelings.
4. A career in science is an opportunity to serve. The development of science is a necessary response to the existence of need in the world. Service to mankind should be a positive response to man's interrelationships with man.

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:

1. Help young people make free choices whenever possible in the whole range of living.
2. Help them search for alternatives.
3. Help them examine the consequences of the alternatives.
4. Help them consider what they prize and cherish.
5. Help them affirm those things and experiences they value.
6. Help them do something about their choices.
7. Help them consider and strengthen the patterns in their own lives.

The development of several attitudes are the force for development of values. Values dictate behavior. What do I believe? What guides my behavior?

SESSION C-8

MAN AND ENVIRONMENT: A NEW PROGRAM IN GENERAL EDUCATION

Virginia Gentle, Program Coordinator, Miami-Dade Junior College, Miami, Florida

Environmental solutions depend largely on citizens capable of making decisions that are environmentally sound—in the voting booth and in their life styles.

Recognizing that citizen awareness is CRITICAL, Miami-Dade Junior College elected to reach the largest number of citizens possible through a mass-media approach to environmental education. The series is called *Man and Environment*—a 3-credit, general education college course. Students can mail in registration and are required to come to campus only twice—once for midterm and once for final examinations.

Information is exchanged between students and TV College faculty through the use of a learning system composed of (1) open-circuit television—one-half hour, two times a week; (2) a textbook; (3) a study guide containing specific suggestions for citizen involvement—lists of organizations, problems pending, names and phone numbers, etc.; (4) a radio phone-in show—one hour each week; and (5) individualized learning prescriptions based on a computer analysis of study questions mailed to TV College by the student.

The presentation includes a resumé of course content, film clips from the TV documentaries and TV panel discussions, and excerpts from the radio phone-in show. Each component of the learning system as well as the curriculum grid will be explained, including the computer-assisted individualization for mass enrollments.

SESSION C-12

BSCS AND THE MIDDLE SCHOOL

Paul DeHart Hurd, Chairman, Human Science Project, Biological Sciences Curriculum Study; Professor of Education Emeritus, Stanford University, California

Human Sciences for the Middle Schools of America begins a venture in curriculum design and organization especially suited to the emerging adolescent. The project is an outgrowth from a series of conferences involving middle school teachers and administrators, as well as representatives from a variety of biological, social, and behavioral sciences. Months have also been spent by conferees and BSCS staff members listening to adolescents, the questions they ask and how they view events and themselves. The shifts occurring in our culture have been closely studied, particularly those related to the "quality of life" and what appears to be a search for new values in our social structure.

A preliminary step in designing a new curriculum requires learning as much as possible about the students for whom the program is intended. Although there is not as much information on the emerging adolescent as one might expect, we were able to find data on the physical, cognitive, political, moral, and social phases of development. A profile of the emerging adolescent is being organized from research studies to go along with personal observations made by the staff, teachers, and writers.

Currently there is a plethora of books being published critizing the organization and management of schools and the way children are taught. These books have become best sellers because parents have bought them in large numbers. There are commonalities in these books that should be taken seriously in planning a new curriculum, such as the need to recognize young people as individuals, the importance of an education in harmony with the realities of modern life, a demand for a greater rnage of learning options in the curriculum, just to mention a few. Our plan is not only to improve the subject matter selection that goes into the curriculum but also to enhance its learnability and use.

The Middle School is in itself a new organizational unit in the American system of education. Typically, it includes grades 6, 7, and 8; however, there are four-year middle schools and some two years long, generally called intermediate schools. No combinations of grades known as a "middle school" include grade 9. Currently, approximately 2,000 schools have the 6, 7, 8 combination of grades. The "middle school" exists to meet the special social, psychological, and biological needs of the emerging adolescent. Puberty now comes at an earlier age than it did in the past, which means childhood ends earlier and adolescence arrives sooner. The new school organization provides an arrangement whereby it is possible to work directly with the problems of the pre-adolescent at his own level of development; not as a child nor as an adult. A suitable curriculum, therefore, would not be like that of the elementary school, nor should it be like that of the high school.

The BSCS recognizes the complexity of the educational challenge it has to meet. We found no science programs we felt were entirely suited to this age range either in terms of goals or subject matter. We are, therefore, starting *de novo*, creating a science-oriented curriculum that does not at present have a counterpart in rationale in schools. The program takes direction from the conflicts and tensions now apparent in the American culture; the biological and social characteristics of the emerging adolescent; the public criticisms of schooling; the changing perspectives about the place of science in society; and the educational philosophy underlying the middle school movement.

To accomplish these broadly conceived purposes will certainly demand a mix of subject matters not now found in the school curriculum. It will also require a major restructuring of the curriculum and new notions about teaching. We know more now than a few years ago about curriculum designing and it should be possible to invent a new organization. We do not envisage a science course that is completely discipline oriented, nor do we want to treat topics superficially. We want to broadly integrate science into the cultural history, the social and economic conditions of today, and to consider the place of science and technology in the future of man. We do not seek to keep biology "pure" but to examine it in terms of its meaning for man and his welfare, personally and in relation to his fellow beings. Hopefully, we can make it possible for the pre-adolescent to learn about himself: What is he like? Where did he come from? How is he getting along today?

What kinds of futures are available to him? And how can he get there with dignity? We also hope we can help him to understand himself as a person and how as a social being he relates to his fellow men and to the biologic and social world. We are as much interested in the emerging adolescent's social, cultural and affective development as we are with his cognitive growth. Throughout the entire program the student is the object of his own study; he is also the "type animal" for laboratory purposes.

We have given as much consideration to pedagogical considerations as we have to the rationale and substance of the curriculum. We are concerned, for example, with the life uses of education — this suggests the need to include both *inquiry* and *decision making* skills in the program. It also means working in a problem context with problems that involve the individual as well as the community. The student will have opportunities to work both as an individual and in cooperative efforts.

Over the past decade curriculum developments in the sciences have been either confined to a single discipline or a combination of several closely related sciences. We have found the life sciences as disciplines too restrictive for dealing either with the kinds of questions children raise or the problems and issues which beset society. Our solution has been to move to a curriculum organization based upon the *human sciences:* anthropology, biology, psychology, sociology, geography, political science, and others. Our workshop conferences are always some mix of people from diverse disciplines, in other words, they are multidisciplinary in character.

To find the relevant subject matter for a human sciences program we worked with specialists who sought to identify concepts that lie at the interface between two or more disciplines and to identify where logical "bridges" between disciplines exist. In each instance the concepts selected have meaning in a biological science and connections in a non-biological science. For example, the evolution of man has a dimension in biology as well as in cultural anthropology. If we are to consider the impact of tools on man's cultural evolution and the influence of technology upon economic development, the story cannot be completed within a single discipline. The same is true in studying the cause and control of disease; the problem is not only a biological one but also has economic and social dimensions.

Three integrative themes have been isolated to serve as guides in designing the human sciences curriculum. These are: continuity and change; conflict, accommodation, and cooperation; and equality and inequality. It appears these themes will allow us to present the life sciences in a bio-social context and furnish a means for relating the course in the human sciences to other subjects in the middle school curriculum. Furthermore, these themes not only allow a focus on problems pre-adolescents face today, but provide action directives for long-range problems extending into the future.

Goal statements for the program are now being formulated from the curriculum rationale we have conceived. In curriculum designing, however, goals are in part a product of the effort and are likely to be restrictive if firmed too early. We do expect students, however, to acquire an understanding and appreciation of such concept materials as:

- roles and function of organisms within a community
- interactions and interrelationships of living things
- nature of conflict, aggression, accommodation and cooperation in social groups
- adaptive behavior as a product of learning and cultural norms
- change within natural and social systems, the continuity of change and man's potential for directing change.

In terms of process competencies we want students to understand and appreciate alternative inquiry and explanatory systems in the natural and social sciences, such as:

- different ways of inquiring and knowing about man's place in the universe (for example, anthropologists, biologists, psychologists, archeologists, sociologists, geographers, humanists, and medical scientists all study man but in different ways, with different perceptions, and with different interpretations for their observations).
- various coping behaviors for arriving at interpretations and decisions (here we view concepts as having an inquiry role and recognize the need to reduce the fact-value dichotomy in applying knowledge).

These goals serve to integrate the Human Sciences Curriculum from one grade level to the next. For each grade or maturity sequence, specific objectives are being defined; for example, the goal—"roles and functions of organisms within a community"—is treated in:

Phase I — as the identification and description of organisms in a community

Phase II — as a pattern representing a division of labor

Phase III — as a comparison of roles and functions within a community.

Two interpretations may be gleaned from this phase sequence: (1) there is a conceptual hierarchy representing a higher degree of intellectual sophistication from one grade level to the next; and (2) the mental operations at each phase correspond with Piaget's research on intellectual development. In Phase I mental operations are at the concrete level; Phase II is transitional, requiring a more systematic behavior than Phase I; and Phase III is at the level of formal-operational thought in which hypothetical situations are considered and a system of reasoning is required.

At each of these levels the plan is to engage students in a variety of information-getting and data-using activities. The work will not be limited to the class or laboratory in the usual sense but will include the actual or simulated community. The entire human sciences program is focused upon engaging the student in a wide range of situations requiring him to cope with problems and issues in a variety of "real life" contexts. He will need to make decisions that go beyond empirical data and include moral and ethical judgments, cultural norms, societal values, personal preferences, aesthetic feelings and other means of managing data *qualitatively*. We want young people to recognize that controversy is a product of differing value systems but that there are rational means for dealing with controversial issues. Problems of life and living are complex and rarely have simplistic answers based upon knowledge derived solely from research.

The curriculum task we have laid out is difficult, but one which we believe can be developed. A framework has been evolved by which we can relate abstract subject-matter themes to the specific questions asked by students, preserving on one hand the authenticity of science and social concepts and on the other a respect for the questions children ask.

The first writing conference for the BSCS Human Sciences Curriculum will be held during the summer of this year, 1972. We expect to produce only one module at this time, followed by a "try-out" of the material in middle schools throughout the school year 1972-73. A sample module for general use should be available for the fall term of 1973.

BREAKING DOWN THE WALLS: SERIES A AND B

SESSION A-11

INDEPENDENT STUDY – FREEDOM AND RESPONSIBILITY

N. Jean Enochs, Assistant Professor of Biological Science, Michigan State University, East Lansing, Michigan

"The problem is that half my life was over before I realized that it is a do-it-yourself job." This quotation that I saw with some ESCP material grounds the need for independent study in our classrooms, and it suggests a model for education that sees students as questioners and question answerers, teachers as motivators and supporters of questioning and question answering, and administrators as facilitators of the student-teacher interactions. As science teachers, we have the advantage of being in an area in which a stated goal is having students learn methods for finding answers to questions. There are two perversions of the educational model that are easy to slip into, the first in which the teacher becomes the questioner and question answerer while the student has little freedom to question, and a second in which neither student nor teacher questions as we search for student freedom. Somehow we need to provide simultaneously maximal freedom and maximal help for students at different points along the road toward independence.

Biological Science 202 is a General Biology course for pre-service elementary school teachers in which we have been experimenting with different ways of doing this. Among the various tactics we have used are: distributed behavioral objectives, individualized study, small group interactions, weekly oral quizzing, assigned projects, role playing, bonus points, unorthodox texts and attractive room decor.

We have endeavored to motivate students to take the opportunity for both freedom and responsibility, freedom *for* learning rather than simply freedom *from* domination. Data from course evaluations of students and teachers indicate that some of these methods allow students to develop confidence in their ability to think scientifically and to develop enthusiasm for independent study and action.

SESSION A-19

SANDY HOOK – GATEWAY TO THE NATION

Richard C. Cole, Chief Naturalist, Sandy Hook State Park; Associate Professor of Oceanography, Brookdale Community College, Lincroft, New Jersey

If you should ever drive to the top of the scenic Highlands in Monmouth County, New Jersey, you would see what many men have looked upon through the years with approval. On September 2, 1609, Robert Juet, a ship's officer on Henry Hudson's ship the "Half Moon," recorded the following description of the Sandy Hook area – "This is a very good land to fall with, and a very pleasant land to see." You would probably, on viewing this same area, agree with this early statement. The Sandy Hook area was probably the first close view of America enjoyed by the many weary immigrants entering New York harbor. To these people Sandy Hook must have appeared as a gateway to the nation.

Sandy Hook is located 16 miles due south of Manhattan, and 15 miles east-southeast of Perth Amboy. It is the most northerly section of New Jersey's ocean front. The 1,634 acre "Hook" is attached to the mainland just south of the Highlands and extends nearly six miles into the sea. This peninsula reaches across Lower New York Bay, almost halfway to Brooklyn. To the east of the "Hook" lies the open Atlantic Ocean. Sandy Hook's jutting position into the strategic New York Bay region has given it a prime position in history. This attribute explains the many historical articles and books written about the rich military involvement in the Sandy Hook area. This presentation approaches the area from a naturalist-educator's viewpoint with a concern for the future preservation of the natural areas.

Due to its long seclusion from the public as a military installation, Sandy Hook still retains the wilderness qualities usually found only in more remote areas. Sandy Hook abounds with wildlife. It has long been an attraction to those who are interested in the study of nature within its proper setting. On warm summer days the osprey, or fish hawk, wheels in majestic flight above the protected coves. This bird often disappears in a cloud of spray while capturing an elusive fish. Hungry young osprey scream with impatience from stick nests that would outsize an economy-type car. American holly trees, nearly as old as the state of New Jersey, tower above a forest canopy of green brier and Virginia creeper. The many curved branches extending above the tree line, on closer observation, prove to be the extended necks of the great blue herons. These birds nest in the more remote forested portions of the peninsula. Part of this precious wilderness trust was transferred from federal to state control and is now known as Sandy Hook State Park. The park consists of acres of dunes, forest, and marshland on the southern portion of the land area. More recent developments indicate that this area may soon become an important part of the "Gateway" Project which is a huge recreation area planned to incorporate several land areas in the New York Bay area.

An explanation of the natural features of Sandy Hook is far more comprehensive if we understand the forces of nature involved in the molding of this unique area. Shoreline areas are undergoing continual change; ours at Sandy Hook is no exception. The area is described by geologists as a compound shoreline. This type of shoreline consists of land features of submergence and emergence. A few miles to the north is a submerged river valley that forms the Hudson River channel. Standing proudly above the sea, a mile to the southwest, is a ridge of land called the Highlands. This area emerged from the sea millions of years ago and resisted erosion because the upper layers are composed of an ironized gravel cap.

Many of us visit the beach each summer, but few pause to reflect as to the origin of all those sand grains along the shore. Most would say that sand "comes from the sea." If the person questioned happened to be a geologist, his reply might sound like this – "Sand is composed of a loose incoherent mass of minerals in a granular condition. Most sands are of rock or mineral origin but others may consist almost wholly of fragmented organisms such as coral or shell." The materials of any beach vary with the parent rock and the quantity of shell found in the area. Quartz is generally the prime constituent of beach sands. This mineral is formed during the latter stages of cooling during igneous rock formation. Imprisoned through the ages, the quartz is finally exposed at the surface as the parent rock breaks down as chemical and mechanical disintegration occurs. The quartz and other minerals, when weathered free of the parent rock, begin their journey to the sea via streams and rivers. The crystals are angular at the beginning, but become rounded and small through abrasion. In this reduced state the grains are almost indestructible, often lasting millions of years. Incorporated into rock, repeatedly released and then recaptured in newly forming rock, sand presents many forms during its long existence on earth.

Beach sands are modified and distributed by water forces along the shore. Wave action exerts the greatest force in the movement of beach sand. Waves are nearly all wind-generated. The friction of air across the ocean surface generates a series of wave swells that follow one another to the shores of the continents. Upon reaching shallow water, these wheels of energy are pulled apart by the forces of gravity and crash as breakers against the beach. Along the northern New Jersey shoreline, the waves generally strike the shore from the southeast. Like a billiard ball bouncing from the cushion of a billiard table, the resulting water flow off the beach face is deflected in a northerly direction. This persistent energy flow causes the *longshore current* which flows northward along the shoreline of Sandy Hook. From the eroding shoreline to the south, the sand drifts northward in this current to be deposited in a new location.

Several thousand years ago, sand moving northward produced a spit formation that slowly projected itself into the present Sandy Hook Bay area. This formation developed to the northeast of the present town of Highlands, New Jersey. Early studies indicated that this land extension grew at the rate of thirty to forty feet per year. As the spit progressed into the bay area, the refraction of the waves curved the tip to the west in a hook-like formation. Geologists call this a recurved spit or *hook*. As the initial hook formation developed, new additions of sand on the north end of the tip caused additional land development. At the tip of this land mass a new curvature was produced. A repetition of these events has left us with a reminder of their passing. Plum Island, the north shorelines of Spermaceti and Horseshoe Coves, and the present curved tip of Sandy Hook, are all vestigial evidences of old curvature tips found on the west shore of this peninsula. The "Hook" has been an island twice in its history, due to storms breaking through the "Hook's" narrow neck. Further incursions have been prevented by a rock jetty wall that was erected along the ocean shoreline in 1921. During the 18th century, the Navesink and Shrewsbury Rivers reached the sea through an estuary at the base of Sandy Hook. The sand deposits of the longshore drift sealed this opening and forced the river water to travel around the inside of the "Hook" through a new estuary to reach the open sea. The town of Sea Bright now stands near the site of the old river mouth.

The newly deposited sands on the ocean shoreline, exposed by low tide, are drifted by the wind. As the sand grains move across the beach, the wind is often slowed by obstructions such as driftwood, shells, and other debris. The sand begins to accumulate in mounds around these objects and becomes the heart of a new dune area. Seeds that are water borne, air carried, or bird dropped, germinate and anchor the drifting sand. A botanical sequence of events is now set in motion, producing what is called *plant succession*. Plants themselves modify their environment. They anchor the soil, enrich it, and prepare it for other plants better suited to the new environment which is continually being created. This progress of plants in succession, going from pioneer types to more established vegetation, finally produces a vegetative *climax*. This is the termination of the botanical chain of events. The type of climax vegetation is controlled by environmental factors. Since nature is never static, a change in the environment produces a new type of vegetation. Due to the sandy soil, and a temperature modified by the sea, Sandy Hook is well suited for its American holly climax forest. In a different environment, just a few miles away, the Highlands' slopes are covered with an oak-hickory climax forest.

SESSION B-8

A NEW APPROACH TO THE TRAINING OF CHEMISTRY/PHYSICS TEACHERS

Kenneth E. Borst, Associate Professor of Chemistry, Rhode Island College, Providence

Obviously, the title of this session allows for a great deal of speculation as to the scope and depth of the topic to be discussed. I will therefore limit my remarks to what I believe must be the role of the college in preparing physical science teachers for our secondary schools, and, to be even more specific, to the role of the college in preparing teachers of chemistry/physics. Although critics may wish to condemn this presentation from the very start, by observing that the preparation of such teachers is not in keeping with the development of "unified science" courses, I contend that the creation of such supermen is not possible in four or five years of college training.

The approach to the problem of training chemistry/physics teachers that we took at Rhode Island College was dictated by an awareness of (a) the impact that "discovery approach" methods are having on science teaching; (b) the current and future job market in teaching, one that on one hand indicates that no shortage of science teachers will exist in a few years but on the other hand indicates that a large number of unqualified teachers hold science teaching positions, will be open to only the highly qualified; (c) the antiscience and antitechnology attitudes that seem to be held by young people today; and (d) most importantly, the availability of a pilot program in which we could take part.

The pilot program is the creation of the Physical Science Group, under the direction of Uri Haber-Schaim, at Newton College of the Sacred Heart in Newton, Massachusetts. This program is unique in a number of ways, and it offers an opportunity for us to graduate a chemistry/physics teacher who is not only up to date in his knowledge of, and command of, materials and methods being used in the secondary schools, but one who is flexible enough to meet the competition of an unfavorable job market. The teacher that we will graduate will be a true professional and one who will not likely stray to the ranks of administration or guidance.

Among the things that our pilot program does that other programs are not designed to do are: (a) It draws upon students who are interested in science and education, as compared to programs which feature the same courses and methods used in the preparation of physicists and chemists. We are not interested in "drop-outs" from such programs. (b) It combines subject matter and methodology in every course, beginning in the freshman year. "Pre" and "post" labs, for example, are done by freshmen during the first semester, and our "practicum" experiences extend over all semesters prior to the actual student teaching. (c) Many of the courses are college counterparts of the innovative (IPS, PS II, PSSC, etc.) NSF-sponsored secondary level courses, making institute retraining unnecessary in those cases. (4) It provides the potential science teacher with ancilliary courses in mathematics, shop, and English. These courses, also designed and created by the Physical Science Group, have made the teaching of the science courses much easier and much more meaningful.

SESSION B-13

ALTERNATIVES IN THE TEACHING OF CHEMISTRY AND PHYSICS

Richard J. Mihm, Physics Teacher, Glastonbury High School, Connecticut

The past 15 years show considerable evidence for a minor revolution in the teaching of physics and chemistry. Our jargon is now filled with new phraseology: multi-media, multi-level courses; behavioral objectives; discovery approach; phenomenological physics; laboratory-oriented; self-paced instruction. We seem to have collected a lexicon of acronyms identifying new courses and their educational philosophies: PSSC; CHEM; IPS; CBA; HPP; ECCP; etc. Even with all of this educational activity, the golden age of physics-chemistry teaching still eludes us; that much remains to be done is certainly suggested by the theme of this panel discussion.

The last 15 years have also continued to reveal substantial evidence that our past and present science courses have not been the successes that were anticipated. The very fact that several of these new programs were designed to correct some of the shortcomings of a predecessor should not noted. There is almost universal agreement that the nature of science and scientists is poorly understood by a large segment of the American culture, even after these people have presumably profited from one of our academic offerings. While it must be admitted that scientific reasoning is not the only way to approach a solution to a problem, considerable evidence is appearing that our young people, beset by the complexities of our highly technological age, are abandoning or ignoring rational thought as a process by which problems may be solved, or at least reduced in complexity. Instead, visceral feeling at best, or the occult, at worse, has taken the place of reason.

Some blame for the failure of our science courses may be found in several flaws that permeate nearly all of our teaching, be it derived from a textbook or from one of those acronyms.

The disproportionate share of what students learn in their introductory, and usually only, physics and chemistry course is of a verbal nature; they can speak the in-words of the science. This language literacy is equated by many teachers to scientific literacy. This is similar to calling the dictionary a masterpiece of the English language. A short conversation with nearly all of these jargon regurgitators reveals the shallowness of their understanding of the science behind these words. The true nature of science is not reflected by a walking dictionary.

Someone replies: "With the students that we get, this is all one can hope to achieve." All too many teachers perpetuate the concept that chemistry and physics are much too difficult to be truly understood by the average person. Even if students of all abilities are accepted, our insidious and condescending methods of science teaching reinforce the belief that science is a discipline with methods much too difficult to be understood. Teachers strengthen the misconception that scientists really do a form of magic, abetted by enormously complex machines, and expressed in that strange language called mathematics. Science is something that only a genius can do.

Some teacher is sure to protest: "What makes the subject so difficult is the amount of material that must be covered." Why is the specific content of our introductory courses so important? Consider the entire school population. No more than five percent will have jobs that will use the material that is covered on a regular basis. Those that use it irregularly, forget it anyway. To the rest, the content of a physics or chemistry course is a useless fixture on their educational landscape. Someone protests: "Students must be prepared for the next course in physics and chemistry." However, the majority never take another course in physics or chemistry; those that do are spread over so many institutions that the next instructor repeats the entire course anyway. Our love for our course content appears to be the crutch that gives physics and chemistry teaching its being, forgetting that there are other reasons for education than this narrow goal.

The final criticism concerns another aspect of content: our pedagogical technique invariably equates the teaching of science with the telling of the facts that comprise our present state of understanding. Gone completely is any kind of first-hand experience with the tortuous process that was followed in reaching our present state of understanding. Science is viewed through the wrong end of the telscope. To be sure, there are courses that examine the historical development of some scientific concept. However, these seem to become history courses, full of personages, dates, and facts, and squeezed dry of the intellectual ferment that actually went on. History is viewed as the only way to explore the process that is science.

For the past decade, a physics program, which attempts to avoid these flaws and to put physics teaching within a different frame of reference, has been evolving at Glastonbury High School. This evolution has produced a two-year sequence of laboratory investigation into the processes of physics. The program has resulted in changes in both the role of the teacher and the student, in the general objectives of an education in science, and in the methods of exploring the science of physics.

Education is change that involves the student. Education necessitates the activity of the student, and not the traditional docility where ideas are placed into the mind like garbage into a trash can. Students must have direct, personal, and concrete involvement with the concepts under investigation. They must have the freedom to discuss their findings with their colleagues, for more often than not, ideas are born in intellectual interaction. Accordingly, the mode that will achieve these goals is an open classroom where students engage in laboratory work.

Teaching is not telling! Learning is finding out something for yourself. The only printed material supplied to the student is the laboratory guide, which tells next-to-nothing and asks countless questions. The only expository material in the guide directs the student's attention to the particular scientific area to be studied and describes the general technique of investigation. For example, in a unit on the RC circuit, the Tektronic 503 oscilloscope is used extensively. The first lab in this sequence does not describe the oscilloscope, but rather has the student determine the purpose of each dial and knob through experimentation. A number of batteries are used in a detailed study of the horizontal and vertical channels and the deflection of the spot on the CRT. The students are instructed to try the batteries in all combinations and permutations until they feel that they know what is going on, and can predict what will happen for any arrangement of batteries connected to the horizontal and/or vertical inputs. Similarly, the sweep settings are studied by actually timing the motion of the spot on the CRT and graphing the results. Then, since science is not isolated fact, questions are raised about how the sweep is associated with the results from the battery experiments. This is an example of the nature of the lab guide, which presently covers some eleven different units, with four additional ones in the planning stage.

Teaching is still not telling! One of the instructor's roles is to amplify and interpret the written instructions. The written word can be misunderstood and occasionally the student becomes misdirected. In this case, the instructor supplements the lab guide. However, the instructor has a much more positive role than just interpreter; here, the physicist, Ernest Rutherford, is our model. Gentle questioning, pleasant rapport, probing and delving conversation, encouraging comments and general affection were the qualities that he exhibited and we try to emulate with our students. In this role, the instructor deals with each student as an individual. However, the teacher is not the classroom authority nor the source of information; information comes from the experiments. The teacher is not the Oracle at Delphi, but rather the yeast that goes into the intellectual cauldron of the classroom.

Since the covering of some particular fact of physics is not a goal, our laboratory investigations differ markedly from more traditional exercises. There is no desire to prove that some formula found in a textbook is approximately correct in the lab. Instead, the investigation involves the science that lies beyond the equation. The largest part of the unit on RC circuits consists of an investigation of changes in the decay times when using different combinations of capacitors. Accordingly, the students study groups of differing numbers of both like and unlike elements arranged in simple and complex series and parallel circuits. The guide suggests that an orderly procedure be followed through this maze; first like elements in simple series and parallel patterns, then in combinations of series and parallel, finally the unlikes in the same order. Naturally, the resulting effects on the decay times become more and more unpredictable and difficult to understand.

However, science is that process by which we attempt to understand the physical universe, even if our understanding is only partial. The students are asked to develop methods by which they can predict or approximately predict the decay times for the combinations just from the decay times of the individual elements. Straight series are easy and so are identical parallel, but all combinations are beset with problems. This analysis, so common to all science, is similar to determining the shape and form of an iceberg. There are the visible parts, the understood parts, that project above the surface. But these are merely extensions of the unseen part. The combinations of capacitors that are predictable, and thus understood, are like the projections above the sufrace. However, what is the nature of the underlying order that makes sense of the whole iceberg, the whole phenomenon? This is the search that the students make, and it has occurred repeatedly in the history of physics. It is not necessary that they be totally successful, and many times they are not. In place of the answer as we know it, students have suggested series approximations and correction factors determined from the design of the circuit. In fact, the actual answer has become unimportant as the student gropes with the true nature of physics and science. Even with all the educational activity of the past 15 years, there still are alternatives in the teaching of science.

SESSION B-14

HIGH SCHOOL BIOLOGY: LEARNING THROUGH LABORATORY ONLY

Patricia Fleming, Biology Teacher, Millburn High School, Millburn, New Jersey

In the spring of 1970, the head of the science department at Millburn High School, Millburn, New Jersey, Leonard Blessing, discussed with me the possibility of offering a course in biology which would involve laboratory work exclusively. During the past several years at Millburn High School innovative programs in the teaching of science have been developed and introduced, and the aim of the department has been to expand and increase the laboratory offerings included in each course. It has been my experience, and it is the expressed opinion of many other science teachers, that most students enjoy laboratory work, apply themselves during laboratory sessions, and generally retain much of the knowledge they acquire during lab. One often hears about the educational efficacy of "learning by doing." Children are initiated into a world of "touch, taste, hear, smell, see." They learn by experimentation in their preschool days as any parent knows who has watched his child gnaw and grasp and gurgle. What they learn stays with them and forms the foundation for sensory and motor skills.

Taking as my own, James Bryant Conant's definition of science, "Science is an inter-connected series of concepts and conceptual schemes that have developed as a result of experimentation and observations and are fruitful of further experimentation and observation," I launched into a full-scale laboratory course in high school biology. I hoped to awaken and make use of those experimental instincts that presumably have been dormant in my students since they were young children.

Many theories in education are being tested in a laboratory course in high school biology. Is a curriculum which is "relevant" also an educationally sound curriculum? Are labs the most effective means of learning biology? Should the emphasis be placed on verification of previously established facts or principles? Or rather, should the emphasis be placed on student discovery? Is detailed factual information only of value if it is illustrative of a biological concept? Can a student assume some measure of responsibility for his own learning? Fully recognizing the principles I would be testing, I determined to set up a course which would be sufficiently flexible to allow myself to introduce new objectives or techniques should I find that the old ones were not working, or vice versa.

Millburn High School adopted a system of modular scheduling during the academic year 1969-70. The flexibility offered by the modular system is ideal for the scheduling of laboratory classes and it was determined that I should conduct one biology class exclusively in laboratory work on an experimental basis during 1970-71. The class involved was scheduled at random. That is, the students did not elect this course over the usual biology offering. The class was grouped homogeneously and was in the middle of all classes in terms of ability grouping. In other words, they were average students. There were 26 students in the class, the maximum number which can be handled ideally with our facilities. The class met three days each week. Each meeting was for a period of 69 minutes or a total meeting time of 207 minutes per week.

The experiment was deemed successful enough to warrant its being continued this year. It has been implemented more fully. I am presently teaching five laboratory classes. Due to scheduling difficulties the meeting time has been reduced to 66 minutes per session or a total of 198 minutes per week.[1] I see each class approximately 100 times during the year. Of those meetings approximately ten would be eliminated from so-called "lab" time due to the administering of tests. During the remainder of the meetings labs are done with the exception of possibly three lectures during the unit on genetics. For clarification, I am considering as lab time the administering of directions, demonstration of techniques, and post-lab discussions or pooling of data as well as the actual laboratory work. Excluding testing days, I would estimate the time spent in laboratory or lab related activities as between 85 and 95 percent of the class meeting time per year.

In oder to prepare the program I spent part of a summer vacation searching through a variety of laboratory manuals choosing appropriate labs. I decided to follow the topical format of the text the students would be using,[2] and to use as many supplementary labs as possible to illustrate the major concepts in each unit. Aside from the lab manual accompanying the students' texts, *Biology Investigations*, I frequently used BSCS Yellow and Green version laboratory exercises as sources of labs. Back issues of *The American Biology Teacher* also served as sources of ideas. The areas covered in brief unit outline are:

I. Biochemistry
II. Cell Biology
III. Genetics and Natural Selection
IV. Organisms
  A. Microbiology
  B. Zoology
  C. Botany
V. Ecology and Field Biology

One of the objectives of the course is to illustrate the thread of continuity running through all aspects of biology and to stress the unity and organization in the world of life. The levels of organization in the living world provide a systematic and logical approach to an understanding of biological concepts: atoms, molecules, cells, tissues, organs, organ systems, organisms, populations, biotic community, ecosystem, bioshpere. Each of the levels is studied in depth in the appropriate unit. For example, atoms and molecules are introduced in the biochemistry unit when investigating the nature of organic compounds, the behavior of enzymes, and the properties of suspensions, colloids, and solutions. The study of populations in an ecosystem is done during the unit on ecology and field biology when a trip is made to a nearby arboretum and bird sanctuary.

I. Introduction to scientific method and attitude of inquiry
   - Observations of a living grasshopper
   - Observing living things

II. Biochemistry: atoms, molecules, elements, compounds, solutions, suspensions, colloids, organic compounds
   - Investigating properties of solutions, colloids, suspensions
   - Identification of organic nutrients
   - Action of salivary enzyme

III. Cells: structure, reproduction, photosynthesis, respiration, diffusion, protein synthesis
   - Variation in cell structure
   - Diffusion through membranes
   - Osmosis demonstration
   - Paper chromatography
   - Goldfish respiration
   - Human respiration
   - Protein synthesis: constructing models of DNA
   - Mitosis: preparing smears of onion root tips

IV. Genetics: Mendelian laws, human genetics, natural selection, (usually involves 3 lectures and 1 problem-solving session)
   - Classification of human genetic traits
   - Blood typing and blood smear preparation
   - Natural selection
   - Natural variation

V. Organisms
   A. Microbiology:
      - Inoculation and transfer procedures in bacteriology
      - Hanging drop preparations
      - Simple staining
      - Gram's differential staining
      - Termites — intestinal protozoa (extraction)
      - A garden of microorganisms

   B. Animals: dissections and/or wherever possible observations of living animals including sponge, hydra, planaria, earthworm (response to stimuli by living earthworms), crayfish, grasshopper, frog

   C. Plants: roots, stems, leaves, plant growth and reproduction by examination of specimens and prepared slides in lab; by examination of living specimens on campus and use of keys in identification of species.

VI. Ecology: population biology, ecological relationships
   - Field study: arboretum trip
   - Succession in a jar

These labs have been selected for a number of reasons. Some were desirable because they are contained in the student's lab workbook. Others were chosen because of the investigative nature of the lab, because they filled a gap left by the traditional lab manual, or because they introduced specific laboratory techniques. Others have been improvised by me from recollections of things I have done, through I have long since forgotten the source. In setting up a course of this nature, one must keep in mind the adaptability, the complete license one has to arrange and re-arrange as one progresses through the years to suit one's own needs and talents, student interests, and facilities and equipment available.

At the beginning of each unit, the students are assigned reading material in their texts and are instructed as to which labs they will be doing. Most of the labs I modify and re-type for distribution to the class. I do this so that I may include in the directions a general discussion of the hows and whys of the lab. Any necessary background information is also included. Before each lab I demonstrate any techniques which are to be encountered for the first time and, of course, verbally caution the students about any potential hazards.

Student response to the course has been favorable. They genuinely enjoy doing laboratory work and to quote more than one, "labs are fun" They are pleased with themselves when they discover that what they do in class really does apply to their world. One student informed me that she understood each step in blood testing that was done in order to diagnose her case of mononucleosis because she had previously examined and identified her white blood cells in a smear preparation. Another explained that she fully followed the streaking and culturing technique done by a nurse in order to diagnose her throat infection. She understood what was being done and why because she had completed a series of bacteriology labs. Of course, parents are delighted to discover that their children are so "well-informed."

My observations thus far are almost entirely subjective. The students work well in groups as well as individually and, significantly, the groups are interchangeable. That is, they are interested enough in what they are doing to be minimally concerned with working with a friend. On occasion they move to another lab table and reproach a classmate if they consider him distracting or not seriously engaged in his work. Alternately, they criticize one another for not following directions explicitly, and help one another by checking on techniques. They are learning the discipline of following directions because they are given a carefully limited amount of verbal instruction.

It is important, however, to emphasize that a program of this nature is by no means a satisfactory alternative for the so-called problem student. For some students with limited academic interest or with little self-discipline the course is unsuccessful. They respond to the more exciting labs but they do not follow through with text readings or laboratory reports. They absorb a limited amount of factual material but probably experience no significant change in attitude toward science or toward academics. With a course of this nature, it is essential that a student be interested and disciplined or, lacking those characteristics, he must be open-minded enough to permit himself to be motivated in those directions.

In setting up a program involving extensive laboratory work, one might encounter problems with facilities, equipment, money for supplies, scheduling time, teacher preparation time, and so on. Millburn High School is fortunate to be more than adequately provided with equipment and supplies. Perhaps, some degree of the success of this experimental program can be attributed to the fact that it is being conducted in very favorable conditions. However, I strongly feel that supplies or facilities should not be seriously considered as a deterrent to introducing a full laboratory biology program. The course can be made entirely flexible, and nearly all labs can be carried out with a greater or lesser degree of variation so as to be completely adaptable to all classroom situations. The most important factor which can predetermine success or failure is that of teacher commitment. Enthusiasm is certainly contagious. If one communicates an attitude of respect for, enjoyment of, and involvement in what one is requiring of one's students, the students nearly all reciprocate in turn.

Student performance is judged in several ways. They are required to keep laboratory notebooks which are graded carefully with many written comments and suggestions. Tests are a combination objective-essay approach. Test questions are based on the readings in their text which they do on their own and some factual information they acquire in carrying out labs. Essay questions are designed to present an opportunity for the student to show his understanding of concepts in biology. I find that on objective questions they do as well as my more traditional classes have in the past. The significant difference in achievement lies in their expression of "what, how and why" each lab was done. They show general understanding of concepts and are quite capable of making relationships between past and present labs.

A statistical study is being done to evaluate student achievement in this course. During 1970-71, all my biology classes were administered the Cooperative Biology Test of the Educational Testing Service at the beginning of the year. In June, the same test was again administered to all the students. Students in the experimental class will be compared to control students with the same IQ. The study, which is part of a much larger statistical analysis being done by the science department at Millburn High School, has not been completed and data are not yet available. Accordingly, I would again stress that the nature of this paper is subjective and based on observation and opinion.

One of the key advantages of this type of approach is the uniqueness of the relationship between student and teacher. Barriers are dissolved as everyone in the room becomes involved in discovery. The close personal contact which occurs daily between each student and me has helped to establish an atmosphere of mutual respect.

The most important achievement I have noted has been regarding attitude. These students have truly discovered that science is challenging, rewarding, and fun. Too many of our students enter high school science courses with an attitude of skepticism about science and technology. A curriculum which burdens them with isolated facts serves only to widen the rift between their immediate concerns and the world of science and academics. I have tried to improve students' attutides toward science by showing them that biology is vital and stimulating and that an understanding of basic biological concepts is within virtually everyone's grasp. A full laboratory approach to biology is timely. For the majority of students, the accumulation of a body of factual knowledge may or may not be significant. To have achieved the behavioral objectives of independence, self-discipline, inquiry, and objectivity is educationally significant. This course accomplishes some of the former and, I believe, all of the latter.

1 For the academic year 1972-73, the meeting time will be increased to four 66-minute sessions or a total of 264 minutes per week.

2 James H. Otto and Albert Towle, *Modern Biology* (New York, 1965). A new text adoption has been made and in the future the student text will be: BSCS Green Version, *High School Biology* (Chicago, 1968).

THE EXCITEMENT OF A FLEXIBLE SCHEDULE

Sister Elizabeth Ann Stock, Head of the Science Department, Monongahela Valley Catholic High School, Pennsylvania

Flexibility in the scheduling of a secondary school is an exciting educational innovation which by a domino effect alters all aspects of instruction. In order to investigate whether this indeed takes place, it is necessary to define terms, cite objectives, clarify misconceptions, enumerate effects on students, teachers, and administrators, and, if possible, provide documentation of how a flexible schedule has altered the teaching of a particular area of the high school curriculum, namely biology.

What is a flexible schedule? J. Lloyd Trump defines it in terms of freedom – freedom in the use of time, space, and numbers of persons, as well as the content of instruction. He speaks of the schedule as a reflection of the current educational philosophy of the school, since the time arrangement in the schedule enhances or inhibits curriculum improvement. Time manipulations are capable of encouraging students to a considerable depth of study, and he sees such variations as incentives for teachers to plan and develop curriculum so as to provide for stimulating variety. A rigid schedule, he notes, can stifle students from caring deeply about any area of study and even can limit their exposure to a wide spectrum of intriguing subjects. The energy of teachers is sapped as a direct result of being locked into such a schedule with the students.[1]

The goal of flexibility in regard to students involves such areas as productivity, responsibility, progression, and independence. Eugene Howard, Director of Innovation Dissemination for the Kettering Foundation Project (I.D.E.A.) says, "Learning how to learn responsibly, progressively, and more and more independently becomes a major objective."[2] The schedule provides freedom for the student to become as productive as he knows how to be. Howard does caution, however, that the freedom given to students to make responsible decisions should not extend beyond the level of their compentency.

Many misconceptions have arisen, even among educators, about the atmosphere inculcated by flexible scheduling. Some have equated the freedom engendered in the system to be a total lack of structure and a chaotic happening, unforseeable and unprepared for. A flexible school is indeed a school in which people are free enough to make important decisions effecting the quality of their work and mature enough to assume the responsibility for their decisions. But the flexible schedule is not necessarily less structured than a block schedule. Its structure is made up of different building materials which encourage rather than discourage responsible decision making. The blueprint of such a structure calls for more rather than less careful planning so as to make maximum use of the varied time units provided. The availability of audiovisual materials cannot be left to chance, for example. Discriminate planning of lectures is vital. An efficient use of this mode of instruction is of utmost importance. Well-defined areas for independent study must be established. These things do not just happen, in some haphazard fashion. They must be the result of considearable forsight.

How do teachers adapt to flexibility? First of all, it is important that teachers know the rationale behind the change from the more traditional system. They must see it as answering the need to individualizing instruction. They must see the slow-learner being benefitted while the academic student is being guided toward independent study. Kenneth Fish notes that the switch toward flexibility is predicated upon a faculty made up of professionally alert people who communicate well with each other. This type of faculty is one which makes maximum use of experienced teachers who have the fundamentals of teaching well under control, but one which must also include some young teachers who are eager to practice the theories they have learned in college. The faculty which chooses a modular or flexible schedule must be composed of teachers who are not afraid of hard work.[3]

What effects are felt by the students? How do they respond to a free-er atmosphere? Charles Wood comments that since secondary students come in all sizes, shapes, and abilities . . . and since some subjects are more effectively taught in variable time periods, it is only natural that a schedule which allows such variability could more effectively meet the needs of the students.[4] In what ways? Flexible scheduling, with its concomitant reduction in class meetings per week and with varied time periods allowed in such a program, can provide many opportunities for the more motivated students to opt for classes otherwise unavailable to them. It may also provide them with untold possibilities for independent study. It is here where mature decision making is fostered. The less motivated students' needs are met by the program in terms of the individual attention each receives. His schedule may reveal more scheduled class time rather than less in a particular area. His unstructured time may be directed to a resource center, library, or conference area. He will find himself succeeding for the first time in his life as a direct result of the interest shown to him by a teacher. It is of utmost importance that there be a climate in which a student is motivated to become involved in his own education.[5]

Flexibility alters all aspects of instruction. Teachers are stimulated to vary their teaching methods to allow for the fewer hours of formal instruction assigned them. Students are challenged by problems requiring independent study and are gratified by their personal achievements. The interaction between student and teacher grows rather than diminishes. The atmosphere becomes charged with activity. Education, at last, is seen as a dynamic process rather than the routine-ridden vehicle by which "children were educated." But, you may ask, what has this to do with innovations in the teaching of biology? Of what particular value is flexibility to such a science class?

Before I describe my experience with such a schedule, I would like to mention that I feel that education has a built-in mechanism for innovation in the living, breathing, unique human beings who daily excite the minds of unsuspecting students with a wide variety of mysteries, ranging from the monumental to the trivial. In the area of biology, the mysterious and fascinating world of ever-changing, ever-stimulating, great unknowns provides a wide range of possibilities for the creative teacher. But, too often, the schedule shackles the potential innovative teacher and locks him into a time slot which severely limits, if it does not completely destroy his initiative. The freedom built into the flexible schedule allows room for breathing, for growing, for investigating, for discovering. The excitement of science education is here . . . where the student finds dynamism in the most unlikely of places . . . the school.

Have you ever noticed how a student enters your class? Does he look pained, distraught, apathetic? Does he just come . . . a typical student to a typical classroom, where a typical class will be taught? Is he just another young person on a treadmill who hops off with the appropriate Pavlovian response at your classroom at a given period each day? Imagine if you can a school where students spend different time periods each day in a class, where the time of the day they come changes from day to day, where a six-day cycle of schedules requires a high degree of alertness, here there is NO typical student, where each is unique and knows it, where expectations are high because just about anything can happen. That is my school. These are my students. Believe me, it is stimulating! It is impossible for them to be apathetic. They just might not arrive at the class if they are not conscious of the day, the time, the mod. Their instincts just won't set their feet on that treadmill which will carry them day after day to the laboratory. If you think students have difficulties adjusting to such variability, imagine the problems a teacher has in such a system. Young people are pliable by nature and thrive on change, but we, of varying ages and dispositions, must not only alter our biological clocks, so to speak, but we must also alter a style of teaching which we may have found effective in the past. (I might add that our effectiveness may have been more hypothetical than real.) It is not easy to shift our mental classes. Those vague goals which served us well in the teacher-centered past just won't satisfy in an atmosphere where student-student interaction is every bit as important as "our" teaching. We must learn to trust our students with their own education. We must concretize for them the goals they are moving toward. We must allow them to do what they can do without our direct guidance. This is not easy. It requires that a teacher reevaluate his own part in the educative process.

Before I describe how such a schedule enhances a biology class, it is important that you understand how our schedule is set up. Our school day consists of 17 23-minute modules which are variously combined to meet individual class needs. We follow a rotating 6-day cycle. In each cycle, for example, my Biology I students meet for 3 double-mod lectures in a large group; in 2 single-mod groups of 10 to 15 for discussion; and in one double-mod laboratory group of 10 to 12. Students who elect to take a second year of biology in their junior or senior year, after a year of chemistry, meet for 12 mods per cycle in 2 or 3 mod segments.

It is the effect of the flexible schedule on this second year group which I would like to share with you. I believe the innovative potentials of the flexible schedule in such a course are limitless. The philosophy of the second level BSCS text provides the backdrop for these experiences. I use the word "experiences" rather than "course" because "course" still connotes to many educators a long-standing irrelevance in the high school curriculum. This class is anything but that. It is a going, doing, investigating activity, and, it surely is. The objective is to provide opportunities for the students to experience scientific inquiry, to meet problems head-on, to search for possible explanations, to share, to discuss, and even to defend, if necessary, the many aspects of the reality which is science. Student independence is a defined goal, but one which implies student acceptance of responsibility and the degree of self-discipline required to keep the laboratory functional. I have used the second level BSCS, Interaction of Experiments and Ideas, as the springboard from which the class moves, but this is by no means the entire course. The first section of the text develops the how and why of biological investigation by a thorough discussion of alcoholic fermentation of molasses by yeast. It concerns itself with the many variables involved in the process and directs investigation of them in a methodical way. The investigations move from the very explicit experiments to the devised experiments of the students, based on the discovered inaccuracies or inadequacies of interpretations. It is here that the teacher role becomes defined, almost by default, you might say. He must move out of the position of the answer-giver. He must become the initiator, sometimes even an instigator in the whole process. He must never again fall into the trap of being the last word, the all-knowing, infallible possessor of all knowledge.

As the students move through the experiments, they discover the need to examine the data of others. The collection and interpretation of the data become a rap-session of exchanges, possible explanations, challenges, and counter-challenges. When the group reaches a stalemate, I may have to make my presence known by interjecting some question which may move the discussion another direction. The problem I find is not in knowing all the answers, but in formulating the right questions.

The flexibility of the schedule provides much time for student movement from the library to the laboratory to the resource center, to the teacher. In this second-year course, as the students become more independent, they recognize their individual potentials for investigative study. They are aware of the teacher as a resouce person, even as a devil's advocate, in some instances. They have many opportunities for conferences with him both inside of class and outside of it. At such times, the teacher must guide, direct, and stimulate, but he must always stress that there are *no* pat answers to complex scientific problems. Can learning take place? Does it take place? I'm convinced it does.

Last year I asked the class to anonymously evaluate the program. Here are just a few of their comments. Judge for yourself:

> "There were times when I really enjoyed learning. The class taught me responsibility, and to have determination . . ."
>
> "This course sneakily succeeded not only in conveying the required material, but taught me invaluable knowledge about people and life . . ."
>
> "The breakdown of this teacher-student idea was, in my opinion, a step toward making our school into what an educational experience should be. I did discover a degree of irresponsibility in doing work, but I did discipline myself into not only doing the work, but LEARNING something from it."

Some of the areas we investigated throughout the year were outgrowths of the BSCS text, the section on the Biological Abstracts and the Statistics section, for example. But we also did work on Animal Behavior, Psychology, and Environmental Problems. Even though each quarter emphasized a different area of study, the basic idea of inquiry and independent investigation were maintained throughout.

You may be wondering how such a free-wheeling situation which allows of such student excursions in different directions could possibly be evaluated for such necessary evils as report cards. I have made use of the contract method as the means of evaluation. The students are provided each quarter with a list of expected outcomes consonant with each letter grade. Each one chooses the level on which he expects to perform. The competitive nature of society today so affects the good students that often they become nervous wrecks in their efforts to achieve. The contract system permits them to set realistic goals and achieve them without competition, and the freedom of the scheduling makes it much more likely that they will meet the requirements of a certain grade without undergoing the attendant pressures. Both quantity and quality are required.

The school environment becomes dynamic with a flexible schedule. Imposed silent-study periods become independent-study mods. Teachers are often consulted during these "free" periods. If the teacher happens to be involved in another teaching situation when the student needs him, the student must be creative in finding other avenues to solve his problem.

"Dynamism" best describes what is constantly occurring. Students are coming and going: consulting the teacher, using the library, viewing single concept films or filmstrips, using programmed learning materials. "When are you free? I want to talk to you." "Will you be here after school?" "How can I determine the amount of solution to inject into my eggs? Someone suggested doing a serial dilution. What do YOU think?" Stimulating! Indeed it is! Students come to class eagerly. (They seem to have some feeling of achievement from even knowing where their next class is!) Even the poorer students are thriving on the attention they receive from the teacher and their fellow students. It is not a bit unusual to have a student stop a teacher in the hall and ask a question that may keep that teacher from his lunch or his only free mod that day. But such a student's acceptance of the responsibility for his own learning is not to be sloughed off with "I'm on my way to lunch!" The nonverbal clues or the breathless arrival of a student to the classroom or a student experimenter sitting Indian-style on the floor listening intently as a teacher questions his reasoning about his own personally-initialed investigation: these things add up to education. Motivation is high. Goals are attainable. Here is excitement in education. What greater compliment can be paid to a flexible schedule.

FOOTNOTES

1 J. Lloyd Trump and Delmas F. Miller, *Secondary School Curriculum Improvement*, (Boston: Allyn and Bacon, Inc., 1968), p. 307.

2 Eugene R. Howard, "How to be Serious about Innovating," *Nations Schools*, 79;88, pp. 130-131.

3 Charles L. Wood, "Modular Scheduling? Yes, but....," *Journal of Secondary Education*, January, 1970, p. 42.

4 Kenneth L. Fish, "Adopting a Modular Schedule," *The Bulletin of the National Association of Secondary School Principals*, September, 1968, p. 63.

5 Wood, *op. cit.*. p. 42.

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1. Fish, Kenneth L. "Adopting a Modular Schedule." *The Bulletin of the National Association of Secondary School Principals*, 52: 329: (September, 1958) pp. 62-70.
2. Howard, Eugene R. "How to be Serious about Innovating." *Nations Schools*, 79:88, pp. 130-131.
3. Trump, J. Lloyd, and Miller, Delmas F. *Secondary School Curriculum Improvement*. Boston: Allyn and Bacon, Inc., 1968.

SESSION B-16

UNESCO'S ROLE IN ISRAELI ELEMENTARY SCIENCE EDUCATION

Eugene Kaplan, Professor of Biology, Hofstra University, Hempstead, New York

There has come into existence in the past ten years a substantial armamentarium of child-oriented, "hands on" elementary science curricula. They represent the culmination of an evolutionary process which, although catalyzed by Sputnik, was inevitable, for the innovations are less in the realm of new scientific content than they are in mode of presentation to the children. The idea of supplying challenging objects and situations from which the child is expected to evolve his own problems and solutions was taken from the realm of philosophy and placed into actual classroom practice only when curriculum developers had good insights into the capacities of the children. This information has been provided by Piaget and his colleagues and represents the cornerstone of modern curriculum development.

This natural evolution occurred in a very few highly sophisticated, relatively prosperous nations. The vast majority of developing nations have been more concerned with building schools than with constructing sophisticated curricula. Colonial legacies left autocratic native teachers whose absolute rule in the classroom is reinforced by sharp tongue or, commonly, the rod. In many emerging nations inadequate facilities and poorly trained faculty at the teachers' training colleges have left the elementary school teacher in ignorance and fear of science. In other nations, science at the elementary level is synonymous with nature study and "love of homeland," so that it has political connotations which act towards perpetuating the status quo. Curricular innovation in elementary science, then, conflicts with the teacher's system of values and satisfactions in that it forces her to give up the security of her autocracy. It challenges the fiscal resources of the often impoverished Ministry of Education in that relatively vast quantities of materials are needed by child-centered programs where the pupils are expected to "do" science. It forces reform at the teachers' college level. It demands an infra-structure of competent administrators to oversee the implementation of the new curricula. It requires teams of curriculum developers who are knowledgeable both in science and in the intellectual and physical capacities of children. These conditions and stresses invariably overwhelm the resources of the emerging nation.

Unesco's section on science teaching is attempting to augment the efforts of those nations which have reached the stage permitting curricular reform. Assistance is provided primarily in two areas: supplying technical aid through the services of long and short-term consultants, and providing equipment for the construction of prototype kits, audiovisual materials (such as cameras for locally produced teaching films), etc. The client nation must supply the manpower to staff the writing teams, to train the teachers, to manufacture the kits of equipment. Most important, there must be sufficient awareness of the problem in the Ministry of Education to initiate a request for aid.

There is another method of approach which has had a substantial impact on elementary science education in Africa. The African Primary Science Project (EDC), supported by several foundations (including NSF) has experimented with the adaptation of American programs to the needs of underdeveloped nations. The philosophy and some of the ideas of the Elementary Science Study have been applied to the African milieu. The result has been an interesting and substantially successful program which is bearing less and less resemblance to its parent. Both the goals and the modes of achieving them have been "Africanized" so that while some units (such as *Ask the Ant Lion* and *Powders*) show some "genetic identification" with ESS units, others have lost their resemblance to the parent program and, indeed, are exclusively the products of the several African science teaching centers which appeared as a by-product of the program.

The Philippine Elementary Science Project began as an adaptation of the AAAS-Science A Process Approach. Again, its later evolution shows a tendency towards fundamental changes induced by the endemic educational milieu.

A few nations are experimenting with direct translations of American programs. Sweden is trying out SCIS units. This approach appears to be limited to countries of comparable social, educational and economic status to that of the nation producing the innovation. These conditions preclude widespread use of the "straight-translation" technique. Reading the interesting and creative Science 5/13 Program (Bristol, England) or its predecessor, Nuffield Junior Science, reveals how specific a program can be to its own educational environment. In England the teachers are highly trained and their professional prerogatives to determine the elements of their own classroom curriculum are jealously guarded. The resulting program, relying as it does on the teacher choosing from a series of "suggestions" in her teacher's guidebook is no more applicable to the needs of Portugal or Ethiopia or Peru than the supersophisticated and highly structured AAAS-Science A Process Approach program.

It appears that the most feasible approach towards modernizing the curricula in developing countries is to provide a selection of programs and technical assistance in their interpretation and application. The development of programs and units must evolve from the educational environment of the developing nation and must incorporate the attitudes, goals and directions of its people.

The history of the Israel Elementary Science Project relfects this conclusion. In 1967, A.M. Feuchtwanger, instructor of physics and physics education at the University of Tel Aviv received a commitment from the U.S. Office of Education to "explore the feasibility of adapting American elementary science curricula to the needs of Israel's schools." One SCIS unit, *Measurement* and an ESS unit *Growing Seeds* were tried out in six classes. It was apparent that the American programs were not applicable to Israel's needs in direct translation.[1] The teachers, although coached on a one-to-one basis throughout the course of the experiment, understood neither the scientific nor behavioral goals of the programs, nor were they able to deal with the children on the informal child-oriented level so necessary for creative thinking in the classroom.

As the result of this experience, it was decided to organize a team which would adapt the essentials of modern science programs to the already existing infra-structure of elementary science education in Israel. The author was invited to participate in the establishment of this team. It was difficult to find qualified personnel. As finally constituted the group responsible for the development of the new curriculum comprised several high school science teachers, several teachers' college instructors and some university scientists. None of these people had had any experience in elementary school teaching. After an exhaustive search, one elementary school teacher who had *independently* evolved a philosophy of teaching amenable to modern pedagogical practices was found. She was to serve as the main resource person for the writing team for several years.

Because of the inexperience of the writers, it was decided to pattern the new program after a highly structured model. The format of AAAS-Science A Process Approach was adopted, with minor modifications. A curriculum committee was set up to determine a sequence of topics which integrated with the junior and senior high school curricula. This turned out to be a conventional series of topics with pragmatic and nature-study overtones. Such subjects as "hygiene," "light" and "electricity" were handed down by the committee of the Ministry of Education to the project. Efforts were made to adhere to the directives as much as possible, especially when conditions made their inclusion functionally desirable. In this context a unit on "hygiene" was eventually constructed, although there are virtually no precedents for such a unit in modern elementary curricula.

In 1969, Unesco became interested in the program because it represented a "stepping-stone" between the needs of the underdeveloped nations and the highly sophisticated offerings of the innovator-countries.

A Unesco-sponsored mini-conference was appended to the Fifth Rehovoth Conference on Education in Developing Nations. A number of experts on science teaching offered advice and perspective to the Israeli team during and after the conference. The result was an accleration of the philosophical and didactic development of the team and the subsequent rejection of the AAAS-SAPA model as inappropriate to the newly evolved goals of the project. It was now possible to use the resource of the fine library established at the onset of the project. Many "first" and "second" generation programs were available, including ESS, SCIS, AAAS-SAPA, Minnemast, Nuffield Junior Science, Science 5/13, African Primary Science Project, Philippine Elementary Science Project and others.

It became apparent, however, that progress would be limited until an "Israeli Approach" to elementary science education would be formulated. This problem has remained the focus of controversy and a leavening agent throughout the five years of the existence of the project.

At present, programs for kindergarten and grades 1-3 are nearing completion. The units are "written in the classroom." That is, ideas for activities are tried out in experimental classes even before they are written down. The two writing groups, one specializing in physical science units and the other with a biological orientation, have access to ancillary resource people, such as teacher-advisors and a developmental psychologist. These consultants take an active role in unit construction, visiting experimental classes and participating in even the earliest planning phases of the units. One of their main contributions is to help the writers determine their behavioral and cognitive goals and to pinpoint the physical and intellectual limitations of the children who make up the population of the target grade. It is anticipated that implementation of grades K-3 will begin in fall, 1972.

Many problems remain unresolved. The cost of kits is comparable to that of their American counterparts. A kit-producing industry is not yet established, although the nucleus of a living organisms production and distribution center has been established, as well as several incipient industrial affiliations which show promise.

Most important is the huge gap between the require-

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ments for teacher-behavior inherent in modern elementary science programs and the nature of the Israeli teacher. American-style teacher-training courses have been tried on the in-service and pre-service levels and have been unsuccessful. It is simply not adequate to provide Israeli teachers with the opportunity to manipulate equipment and repeat experiments designed to be done by children without attempting to change their value systems, concepts of achievement and classroom management procedures. Micro-teaching, analysis of video-tapes and most important, "attitude changing sessions" resembling training groups are showing promise. A series of fifteen teacher-training films are being produced to provide a visual model for the teachers to emulate. Teacher-training still remains one of the major problems to be overcome.

The Israel experience provides the world with the insight that relatively poor nations can use the ideas of modern science programs as the foundation for their own indigenous curricula. "Home-made" programs are in tune with national aspirations and integrated into the total national educational scheme. Unesco and other interested agencies can provide training for leadership personnel and fellowships for members of writing teams so that the abundant resources available in American and British elementary science programs can be used to modernize teaching methods and curricula in the emerging nations. If our knowledge of how to encourage creativity and problem solving abilities in young children is withheld from the underdeveloped nations, the gap between achievement and hope will be lengthened.

* Formerly, Unesco expert in elementary science, Tel Aviv, Israel.

** The opinions in this paper do not necessarily represent those of Unesco.

1 Feuchtwanger, A.M., Progress Report, 1968, Tel Aviv Elementary Science Project, submitted to the U.S.

KINDERGARTEN SCIENCE IN ISRAEL

Yaakov Reshef, Co-Director General, Neot Kedumim, New York

I. The use of Science Curriculum Improvement Study (SCIS) methods in Israel in teacher-training programs for kindergarten teachers and the practical applications of these methods in the classroom situation.
   A. Modifications of the SCIS program to fit the early childhood education scene in Israel.

II. Adaptation of some SCIS methods and activities for the introduction of special material to teacher-training courses and kindergarten classes in Israel.
   A. Examples of kindergarten class activities dealing with the relationship of the Land of Israel to several Jewish holidays.

ABSTRACTS OF CONTRIBUTED PAPERS

Groups A — 0, 3:30 to 5 p.m., April 9
Groups P — Z, 9 to 10:30 a.m., April 10

GROUP A

ELEMENTARY SCHOOL SCIENCE: PROVIDING NECESSARY SUPPORT TO ELEMENTARY TEACHERS WHO IMPLEMENT CURRICULA

A-1. WHAT VARIABLES DO INNOVATING TEACHERS AND CURRICULUM CONSULTANTS IDENTIFY AS IMPEDIMENTS TO CURRICULUM CHANGE?

Robert E. Ziegler, Associate Professor of Science Education, Elizabethtown College, Elizabethtown, Pennsylvania

No abstract submitted.

A-2. HOW CAN THE PRINCIPAL BEST SUPPORT TEACHERS WHO ARE IMPLEMENTING A NEW SCIENCE CURRICULUM?

Robert A. Bernoff, Associate Professor, The Pennsylvania State University, Ogontz Campus, Abington, and James M. Mahan, Director, Field Implementation Center, School of Education, Indiana University, Bloomington.

If the principal is to be the curriculum leader in an elementary school, he should take an active part in implementing a new science curriculum. However, many principals remain unaware of the philosophy of new science programs and the problems in implementing them.

In a 1968-69 Colorado study of implementation of elementary science programs, the author states, "Principals were often only marginally involved." "The principals' central role in solving the equipment problems is but one illustration of the importance of having the support of a knowledgeable principal."

The Eastern Regional Institute for Education (ERIE), in a 1969-70 study of the implementation of *Science – A Process Approach* in 53 schools, found that the principals played only a marginal role in administrating the consultant support for the program in over 70 percent of the schools.

This paper outlines a number of specific ways a principal can make significant contributions to the selection, installation, implementation, and evaluation of an elementary school science program.

A-3. IN WHAT SPECIFIC WAYS DO INNOVATING TEACHERS UTILIZE THE TIME AND EXPERTISE OF EXTERNAL SCIENCE CONSULTANTS?

William B. McIlwaine, Associate Professor, Millersville State College, Millersville, Pennsylvania.

Science consultants internal to the school district and science consultants external to the school district are interested in the major demands that will be made upon their consulting time. Consultant schedules can be constructed and consultant skills developed, that best enable the science consultant to invest his energies in activities that teachers find most supportive. Teachers, in turn, can discover how their peers have effectively subdivided the consultant day into acts that facilitate the systematic introduction of an innovative, process-oriented science curriculum.

This presentation, based on a survey of the amount of time each of 43 professor-consultants spent in 20 consulting activities during 129 full days of consulting to 43 schools, describes the field performances that seem to constitute the consultant role. The emphasis given by the cadre of consultants to such activities as demonstration teaching, observation of teaching, co-teaching, follow-up conferences, equipment procurement and assembly, inservice faculty meetings, progress conferences, competency measure administration, etc. is discussed. Implications for clarifying the role of the science consultant, for charting classroom consulting behaviors, and for maximizing consultant assistance to elementary teachers engaged in science curriculum change are examined.

A-4. CENTRAL OFFICE PERSONNEL: HOW CAN THEY BETTER SUPPORT TEACHER IMPLEMENTATORS?

Frederick Brown, Assistant Superintendent of Schools, Peekskill School District, Peekskill, New York

No abstract submitted.

A-5. REDUCING THE DISCREPANCIES BETWEEN TEACHER AND ADMINISTRATOR PERCEPTIONS OF THE REALITY OF CURRICULUM CHANGE SUPPORTS: A SERIES OF RESEARCH-BASED RECOMMENDATIONS

James M. Mahan, Director, Field Implementation Center, School of Education, Indiana University, Bloomington, and David Williams, Associate Professor of Elementary Education, University of Maryland, College Park.

As a result of extensive experience in engineering systematic science curriculum change in elementary schools of diverse characteristics, pragmatic guidelines for curriculum installation have been postulated. These guidelines, in the form of generalizations accompanied by recommendations, emerged from a case-study approach to curriculum installation and the necessary observations, reports, and evaluations emanating from hundreds of involved personnel.

Science curriculum change efforts have been subdivided into the following eight stages: (1) establishing governing conditions, (2) selecting the innovative curriculum, (3) preparing for the introduction of the curriculum, (4) providing assistance mechanisms to implementing teachers, (5) implementing the innovation in the classroom, (6) assessing the progress and the quality of the implementation, (7) maintaining the curriculum when it is no longer an innovation, and (8) demonstrating and diffusing the curriculum to other schools.

Guidelines relevant to each stage have been prepared. Teachers and administrators have made Likert-type responses to each guideline, signifying the degree to which they agree or disagree with each one. Similarly, the same teachers and administrators have indicated the degree to which the guidelines are, or are not, practiced in their school district. This presentation is concerned with widespread practitioner support for the guidelines, serious limitations in the field implementation of the guidelines, and recommendations for narrowing the gap between supports desired by curriculum implementers and supports actually received.

GROUP AA

ELEMENTARY SCHOOL SCIENCE: SOME EVALUATIVE STUDIES

AA-1. THE IDEAL ELEMENTARY SCIENCE TEACHER

Rodger Bybee, TTT Project, New York University, New York.

The idea of an "ideal elementary science teacher" is an intriguing one, often discussed by elementary teachers and science educators. These discussions usually center on components of the teaching-learning interaction: subject matter, new curriculum planning, and working with people. To avoid biases and personal prejudices this study attempted to establish a hierachy of the various components included in teaching elementary science. Utilizing Third Force psychology, which explains behavior as a function of perceptions and expectations, the profiles of the "ideal elementary science teacher" were established. Responses were from three primary populations: elementary children, preservice teachers and inservice teachers.
inservice teachers.

The survey established a preferential order of characteristics, stated in a positive manner, that might be demonstrated by an elementary science teacher. The categories were: (1) knowledge and organization of science subject matter, (2) adequacy of relations with students in science class, (3) adequacy of plans and procedures in science class, (4) enthusiasm in working with students in science, and (5) adequacy of science teaching methods. A 50-item Q-sort with 10 items keyed to each of the 5 categories listed above was used to collect data.

All groups examined rated *adequacy of relations with students in science class* and *enthusiasm in work with students in science class* as the top two items, occasionally reversing their order. *Knowledge of subject matter, plans and procedures,* and *teaching methods* varied in order as the less preferential items.

The implications should aid teachers, curriculum developers, and educators in designing science programs. It is now our duty to establish a higher correlation between our behavior as science educators and the perceptions of those groups with whom we interact.

AA-2. A STUDY OF THE ELEMENTARY SCIENCE STUDY PROGRAM: ITS IMPLEMENTATION ON A SYSTEM-WIDE BASIS

John H. Turner, Elementary Science Coordinator, Kennedy School, Mishawaka, Indiana and H. Prentice Baptiste, Jr., Assistant Professor of Education, Indiana University, South Bend.

The purpose of this study was to analyze the implementation on a system-wide basis of the Elementary Science Study program in grades one through six of the Penn-Harris-Madison School Corporation located in St. Joseph County, Indiana.

Suggestions include methodology for adoption committees and techniques for solving problems which arise from selection procedures.

Identification of the procedures recommended for implementation in the form of guidelines for grade, building, and system-wide application are presented.

Analyses of problems encountered during the implementation period are included in the study. Identification of and possible solutions to these problems through the use of inservice interaction sessions, evaluative instruments specifically developed for this project, and direct communication with teachers involved in implementation are presented in the study.

The investigators also present recommendations for individualizing science instruction through the use of Elementary Science Study materials, development of audiovisual supportive programs, construction of behavioral objectives for selected units, and evaluation of student performance.

AA-3. TEACHING SCIENCE IN THE ELEMENTARY SCHOOL: A TIME ANALYSIS (DESIGN OF THE STUDY)

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

If elementary teachers are to teach science as part of their elementary school curriculum offerings, time periods must be allocated for science instruction during the school day. In addition, if we expect the Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS) and Science – A Process Approach (S-APA) materials to be used; extended periods of time may be needed for the students to become involved in laboratory investigations. Yet, many demands are placed upon he elementary teacher to teach reading, language, arts, social studies, etc. each day. How much time does an elementary teacher devote to science each day? Is additional time needed for teaching the laboratory-oriented elementary science programs? What reasons do teachers state for not teaching science or for a lack of science activities? Do teachers in a self-contained classroom teach more science than those in content area classrooms? Do intermediate teachers spend more time teaching science than do primary teachers? These major questions, as well as many others, are explored in an attempt to identify the time factors needed for the successful teaching of science in the elementary school.

Harry F. Fulton, Olivet Nazarene College, Kankakee, Illinois; Richard Gates, Director of Teacher Education, St. Bonaventure University, St. Bonaventure, New York; and Gerald H. Krockover, Purdue University, Lafayette, Indiana; have developed an instrument for the purpose of conducting a survey of more than 500 elementary teachers in Illinois, Indiana, New York, and Pennsylvania with regard to the above questions. Their responses are being tabulated along with identifiable time factors. An individual analysis of the four states involved in the study will also be reported. In addition, the investigators will conduct a discussion of their results and their implications for the future.

AA-4. TEACHING SCIENCE IN THE ELEMENTARY SCHOOL: A TIME ANALYSIS (DATA ANALYSIS OF THE STUDY)

Harry F. Fulton, Assistant Professor of Biology and Science Education, Olivet Nazarene College, Kankakee, Illinois

No abstract submitted.

AA-5. TEACHING SCIENCE IN THE ELEMENTARY SCHOOL: A TIME ANALYSIS (IMPLICATIONS FOR THE FUTURE)

Richard W. Gates, Assistant Professor of Education and Director of Teacher Education, St. Bonaventure University, St. Bonaventure, New York

No abstract submitted.

GROUP B

ELEMENTARY SCHOOL SCIENCE: ALTERNATIVES IN SCIENCE! OR ALTERNATIVES TO SCIENCE?

B-1. ALTERNATIVES IN MAKING DECISIONS CONCERNING A NEW ELEMENTARY SCHOOL SCIENCE PROGRAM: SHOULD PROGRAM SELECTION BE MADE AT THE DISTRICT, BUILDING, OR CLASSROOM LEVEL?

Theodore Bredderman, The State University of New York at Stony Brook

No Abstract submitted.

B-2. WHAT ARE SOME ALTERNATIVES FOR WORKING WITHIN A REGIONALLY ADOPTED FRAMEWORK, DRAWING UPON DEMONSTRABLY EFFECTIVE PROJECT MATERIALS?

Victor A. Perkes, University of California, Davis

No abstract submitted.

B-3. ENVIRONMENTAL ACTIVITIES AS ALTERNATIVES WITHIN AN ADOPTED ELEMENTARY SCIENCE CURRICULUM

Conrad Laflamme, Cass Park Educational Center, Woonsocket, Rhode Island

No abstract submitted.

B-4. INDIVIDUALIZATION OF SCIENCE: A PROCESS APPROACH AS AN ALTERNATIVE TO GROUP INSTRUCTION OF SCIENCE IN THE UPPER ELEMENTARY GRADES

Ronald Osborn, Jesville-DeWitt Central Schools, DeWitt, New York

No abstract submitted.

B-5. COMPETENCY-BASED EDUCATION: AN ALTERNATIVE MODEL FOR AN ELEMENTARY SCHOOL SCIENCE CURRICULUM

Paul T. Richman, San Diego State College, San Diego, California

No abstract submitted.

GROUP BB

ELEMENTARY SCHOOL SCIENCE: A LOOK AT PROGRAMS IN PRACTICE

BB-1. THE A B C's IN ELEMENTARY SCIENCE

Sam S. Blanc, Associate Professor of Elementary Education, San Diego State College, San Diego, California

Teachers and administrators concerned with revitalizing the science curriculum at the elementary level must reexamine their premises about the place of science in the general education of the child. This will require an evaluation of the needs of children in our science-oriented, technological society. We find that an effective science curriculum is one that supports the desired learning endeavors, is valid in terms of science, and is in harmony with society—which must itself be supportive of the learner's efforts. The curriculum should, therefore, be designed so as to bring every child to his maximum potential. Thus, if the science curriculum is to promote intellectual achievement, it needs to be organized and sequenced in terms of the growth and developmental characteristics of children. The learning goals in such a program can be grouped under the general headings of *Attitudes, Behaviors,* and *Competencies* – The A B C's of elementary science.

Scientific attitudes must emphasize disciplined, rational, ordered learnings. The children must be taught to accept examination and criticism of their fellows, and to maintain an open mind when assessing their own data. Scientific behaviors involve processes, such as hypothesizing, drawing inferences, and formulating theories. Science learning becomes an ongoing enterprise. New theoretical models evolve from the observations and experiences of the children. Finally, the children should learn how to find information through experimenting, observing, discussing, and reading, developing skills in recording, graphing, comparing, and organizing data. For consistency with changes in cultural values, the needs of the children, and the nature and structure of science itself, the A B C's of science learning must be continually reassessed.

BB-2. ROSEVILLE'S APPROACH TO "PROCESS" SCIENCE: CHOICE, IMPLEMENTATION, EVALUATION

David H. Siegel, Science Resource Teacher (K-6), Roseville Area Schools; Mary Jean Ekman, Third Grade Teacher, Lauderdale School, Roseville, Minnesota; and Roger T. Johnson, Jr., Assistant Professor, College of Education, University of Minnesota, Minneapolis.

Roseville's approach to "Process" science is unique for several reasons: (1) choice through pilot school plan, (2) collaboration with the University of Minnesota and the Minnesota Department of Education, (3) model used for implementation, (4) aspects of the central supply system, and (5) type of evaluation.

A pilot project began in 1968-69 with a two-school investigation of four "Process" science programs, Science – A Process Approach (S-APA), Science Curriculum Improvement Study (SCIS), Elementary Science Study (ESS), and Minnesota Mathematics and Science Teaching Project (MINNEMAST), to determine which program or programs would fulfill district needs. Although originally directed by the two school principals, the 1969-70 program expanded from SCIS and ESS to include two interested teachers from each elementary school, who attended an intensive three-week summer workshop sponsored by the State Department of Education. Additional discussion, revision, and evaluation resulted in an intermingling of two programs, (ESS and SCIS).

Stage I implementation 1970-71 committed district support for teacher participation to an intensive two-and-one-half week workshop sponsored by the University of Minnesota, the State Department of Education, and the district. To centralize the storing, supplying, cataloging, and distributing of materials, a Science Materials Center was created. In spring 1971, teachers evaluated the program by grade-level meetings and revised the scope and sequence. One third of the district's teachers were then involved.

Forty-eight teachers enrolled for the Stage II 1971 summer workshop, and our science resource teacher became full time with two-thirds of the teachers involved. A Stage III 1972 workshop is planned, also.

For Stage III 1972-73 student, teacher, parent, and administrator questionnaires as well as video and audio tape recordings of actual class involvement are planned. Evaluation is informal, based on the reactions and observations of students actually "sciencing."

Program strengths include slow "back-door" infiltration over a five-year period; consideration allowed for teacher interest, choice, and involvement; and the student interest as observed by themselves, teachers, parents, and school administrators.

BB-3. MAN AND THE ENVIRONMENT: A RESEARCH AND DEVELOPMENT PROGRAM IN ENVIRONMENTAL EDUCATION

Alan M. Voelker, Assistant Professor of Curriculum and Instruction, and Research and Development, University of Wisconsin, Madison.

The major outcome of this research and development program is quality-verified environmental education materials for elementary children.

The materials, produced as instructional packages, include readers, activities booklets, and audiovisual materials. Related assessment and teacher inservice materials facilitate their use. The major foci of each package are concept attainment and decision-making and problem-solving skills which together enable children to become aware of the complexities of environmental problems. Each component is prepared for use in programs of individually guided education in a variety of classroom settings. Such materials make provision for accommodating differential knowledge levels, learning modes, and varying learning abilities.

The underlying philosophy is that this nation's future decision makers, i.e., elementary school children, must better understand man's interaction with and responsibility to the environment. Therefore, they need to recognize the multidimensionality of environmental issues.

The program emphasizes the interaction between science and social studies, and decision-making and problem-solving techniques. Each package has the children following problem-solving procedures so that they progress from a stage of awareness through one of recognizing impact, to one, ultimately, of being responsible problem-solvers and decision-makers. Consideration is given to problem identification; identification of causes rather than symptoms; and postulation of alternative solutions considering relative consequences, risks, and limitations.

Children are introduced to concepts such as democracy and government through their applications in realistic situations rather than to idealized concepts. Citizen action in alleviating environmental problems is heavily emphasized.

Materials development proceeds from reader to activities booklet to audiovisual materials, providing a data base for determining the nature of each subsequent component.

Related basic and development-oriented research efforts include concept attainment, awareness and recognition of environmental problems, approaches to decision-making and problem-solving, beliefs, attitudes, values, and prediction.

A progress report indicating the rate and direction of additional product development is presented.

BB-4. SCIENCE AT SUTEC: TRAINING TEACHERS AT P.S. 76, A MULTI-RACIAL, INNER-CITY ELEMENTARY SCHOOL IN NEW YORK CITY

Wesley Miller, Lecturer, Queens College of the City University of New York, Flushing.

For both children and teacher trainees, science is big at SUTEC (School University Teacher Education Center). This program trains elementary teachers for service in multi-racial, inner-city schools. Most significant is that this training is taking place in such a school as P.S. 76, located in Long Island City, just across the East River from Manhattan. Teacher trainees spend two semesters taking methods courses, and a third in student teaching at P.S. 76. Throughout the program they work with children in classrooms. SUTEC is operated by Queens College and has [illegible] instructors serving 120 teacher trainees under a format that is flexible – no set schedules, no bells.

Since sensorimotor experiences are effective with inner-city children, a science program with heavy emphasis on process activities plays an important role. The approach is ecletic (if it works, use it!), yet has definite aims. For the children science is both an end in itself and a vehicle for instruction in other curricular areas. For teacher trainees science provides opportunities to interact with children in learning that utilizes concrete objects.

The best activities for inner-city children (1) provide for manipulation of objects by individual pupils, (2) have a prescribed procedure but permit variations, and (3) progress toward attainable, short-term ends while retaining opportunities for continuation.

Every effort is made to expand science activities into learning experiences in other curricular areas. If an activity generates numbers, e.g., data from the swings of a pendulum, these numbers are used for math; further, language experiences are provided by writing and talking about science activities.

After five years SUTEC has gained experience in providing a science program that meets the special needs of inner-city children and assists teacher trainees in becoming effective inner-city teachers.

GROUP C

ELEMENTARY SCHOOL SCIENCE: SOURCES OF FREE AND INEXPENSIVE HARDWARE FOR IMPLEMENTING MATERIALS-CENTERED ELEMENTARY SCHOOL SCIENCE PROGRAMS

C-1. HANDS OFF OR HANDS ON?

Verne N. Rockcastle, Professor of Science Education, Cornell University, Ithaca, New York.

When science materials and objects are costly, fragile, or mysterious, they often are "hands off" for curious children. But when materials and objects are inexpensive, sturdy, and commonplace, there is little to discourage discovery, at school or at home.

Classroom experiments often are merely for verification, or they are teacher-directed, because the problem is teacher-selected. At home, however, the application of science concepts to unexpected problems is real. When commonplace materials are used to solve real problems, creativity and understanding are enhanced.

Calibration is not a consideration with commercial apparatus for children, yet a child needs a standard for calibration when he rolls a stick balance to poise. He learns that weighing is comparing, and he understands the standard for comparison.

A broken ruler makes an acceptable measuring device. But a child who uses one cannot take the left-hand index for granted; he must examine it. So he learns that linear measurement involves two comparisons – a left-hand one and a right-hand one.

When there is not enough material to eke out what a child needs to make, he learns to estimate, to substitute, and to splice. By using free or inexpensive materials, he seizes opportunities to "transform things, and to find the structure of his own actions of the objects," which Piaget says "is necessary for intellectual development." Thus, for the child, a shoe box becomes a spider cage, and a milk carton a periscope. Such transformations would probably not have occurred with commercial equipment.

Using free and inexpensive materials does not obviate the need for things that are costly, fragile, or mysterious. However, inexpensive materials do help to provide real understanding of the principles on which science operates, because they encourage "hands on" exploration for the children. With such encouragement comes added incentive to learn.

C-2. ESS CHEAP!

Bruce Whitmore, Science Coordinator, Lincoln Public Schools, Lincoln, Massachusetts

The paper *ESS Cheap* provides detailed information on how to cut costs when using the Elementary Science Study program. Teachers and coordinators should find many helpful and practical suggestions in this presentation.

Information on how to construct special apparatus and hints on where to look for some of those hard-to-find items, much of which is feedback from teachers presently using ESS, highlight the talk.

A list of the 20 most commonly used items in the ESS program is also available.

C-3. GUIDELINES AND HELPFUL HINTS FOR THE PROCUREMENT OF HARDWARE FOR SCHOOL SYSTEMS ADOPTING PUBLISHED SCIENCE PROGRAMS

Jerry F. Durand, Science Consultant, Greece Central School System No. 1, Rochester, New York

The adoption of innovative education programs is usually hampered by the high cost of commercial hardware. This paper sets guidelines to aid school personnel in obtaining hardware at greatly reduced costs.

The author has seven years of experience in designing and purchasing materials for the Greece Central School System. The entire elementary division is equipped with classroom hardware for the Elementary Science Studies program. All of this material is supplied and refurbished at a central material processing center. The author has procured hardware for various other programs such as Time, Space and Matter, for junior high; areas of elementary social studies; and motor perception in physical education.

Topics to be elaborated on in the presentation include: (1) the importance of becoming familiar with the role of each hardware item in the program, (2) identifying hardware items that can be substituted for material in commercially supplied hardware, (3) criteria for detemining quantities, (4) aids for locating sources, (5) getting the vendor to work for you, (6) the advantages and disadvantages of large and small vendors, (7) reworking purchased items, (8) containerization, (9) build it better yourself: you may already have a factory, (10) simplified record keeping, and (11) budget estimating for replacement and refurbishing.

C-4. PRODUCING ELEMENTARY SCHOOL MATERIALS THROUGH COMMUNITY INDUSTRY

Douglas M. Lapp, Director, Elementary Science Study (ESS) Project, Fairfax County Public Schools, Bailey's Crossroads, Virginia

During the past ten years, the Elementary Science Study has developed "discovery" science units for the elementary grades. However, the problem of providing the large quantities of materials necessary for these science activities at a cost within the reach of a school system is often a roadblock in the implementation of ESS and other science curricula centered on student investigations. In addition, the sheer size of the logistical operation required to keep thousands of elementary school teachers adequately supplied with equipment in good repair and a multitude of expendable items presents a problem.

During the past two years, the Fairfax County Public School System has demonstrated a way to overcome these obstacles effectively by developing a new kind of school service organization, the Instructional Materials Processing Center. At this Center, community workers are currently manufacturing scientific apparatus and packaging materials sufficient to supply over two thousand elementary school classrooms with a continuous flow of ESS kits.

Originally conceived and piloted in the Greece, New York school system, the idea for the I.M.P. Center was brought to Fairfax County in 1969 by the late Superintendent of Schools, Lawrence M. Watts. Located in a low-income community, the Center draws upon 30 Neighborhood Youth Corps student workers and 15 adult workers. The creation of the I.M.P. Center thus represents a meshing of two needs: the need of the school system for elementary science materials and the need of the local community for a source of employment.

C-5. ELEMENTARY SCHOOL SCIENCE ON A SHOE-STRING

Carl F. Berger, Science Education Director, Detroit Edison, Edison Center, Detroit, Michigan

The presentation focuses on discovery and high student involvement using inexpensive or free materials commonly available in the home or classroom. Emphasis is on the unusual use and unexpected results obtained with everyday materials.

C-6. 103 USES FOR FREE FILM CANS

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

Small metal film cans in which 35mm rolls of Kodachrome or Ektachrome are packaged are available *free*, worldwide. Large quantities of these cans accumulate in a relatively short time and are appropriate for sets of "sense cans," weight surprises, variable pendulum bobs, "mini-black boxes," insect and soil sample containers and energy transfer investigations.

Film cans may often be substituted for costly items in units on *Peas and Particles, Primary Balancing, Senior Balancing, Mystery Powders, Pendulums, Material Objects (Science Curriculum Improvement Study, SCIS)*, and *Energy Sources* (SCIS). Many other applications are possible.

GROUP CC

ELEMENTARY SCHOOL SCIENCE: SUGGESTED CONSIDERATIONS

CC-1. SCIENCE: A HUMAN ENDEAVOR

Judith S. Klein, Lecturer in Education, Queens College of the City University of New York, Flushing

"Man makes himself through enlightened choices that enhance his humanness."[1] With this brief statement one has the means to test the relevance of science as a part of knowledge worthy of study in our schools. However, its unique relevance derives not from its content *per se*, but rather from science as personal involvement. With its opportunities for engagement of the student, with the chances it offers him to raise and answer questions of meaning to him, in systems of his own design, science is ideally suited not only to produce effective cognitive learning, but also to emphasize the vital lessons of the affective domain.

Within the context of science teaching rests a perfect opportunity to cause learners to relinquish their poses of docility, passivity, and dependency on the teacher. We must abandon the reinforcement of those behaviors which not only produce little cognitive growth, but also ignore all personal (affective) learning. Using science in the elementary schools more as a vehicle to self-knowledge, and less as an unalterable body of knowledge will stress learning in which a student's entire being is involved. Thus, science in the schools can have a rightful place; it can be made relevant to those learners whom we call humans.

[1]Dubos, Rene. *So Human an Animal.* Charles Scribner's Sons, New York. 1968. P. xii.

CC-2. INDIVIDUALIZING ELEMENTARY SCIENCE ACCORDING TO AN INSTRUCTIONAL PROGRAMMING MODEL

Juanita Sorenson, Assistant Professor, Department of Elementary Education, Wisconsin State University, Eau Claire

The Instructional Programming Model (IPM) can individualize elementary science in relation to concepts commonly found in elementary science texts (i.e., solid, liquid, gas).

The sequence of the model illustrates how an elementary teacher can utilize the text(s) and supplementary materials presently available in a school and adapt them to a meaningful and in-depth individualized program. The steps of the IPM in the perspective of the science program are: (1) set long-range objectives for the group of children in a given area of the science program; (2) set specific objectives relative to specific concepts (i.e., solid, liquid, gas) according to a comprehensive schema that includes test items for a concept on attributes, examples and nonexamples, definitions, supraordinate, coordinate, and subordinate concepts, and at the highest level, principle-type relationships between the concept being considered and other concepts; (3) assess students on the concepts in terms of the objectives listed in (2); (4) set objectives for individual children based on assessment results by grouping children for study in a variety of independent, one-to-one, small-group, medium-group and large-group modes; (5) design learning programs for individuals and groups of children according to their needs, staff, and materials resources; (6) post-assess to ascertain attainment of objectives.

Utilizing the IPM for individualization also includes suggestions for efficient and practical processing of data for individualized decision making.

CC-3. TEACHING SCIENCE READING THROUGH INQUIRY-DISCOVERY PROGRAMS

Phillip A. Heath, Assistant Professor of Education, Central State University, Edmond, Oklahoma

The role of reading in the new contemporary elementary science programs and projects is in a process of change. As a result of the emphasis on the processes of discovery and inquiry the formal classroom time devoted to the development of reading skills in these programs has become nearly nonexistent. Authorities in elementary reading point out that in order for a child to be able to read successfully in science, opportunities for the development of reading skill must be provided in the science class. Concurrently, reading-based abilities such as problem solving, critical thinking, and development of conceptual understandings are objectives of the new instructional methodologies.

Organizational schemes of the new programs and projects include experiential background which provides the foundation for development of practical reading skills and abilities. As these programs are providing opportunities for students to encounter and assimilate a wide variety of meaningful first-hand experiences, they are also providing the most essential and fundamental foundation for development of science reading abilities.

The kind of classroom organization and instructional methodology employed permits students to apply the reading abilities learned in language arts classes to the reading for problem-solving tasks in science. More specifically, the provision for opportunities for basic experiences related to the content and processes of science enable students to more readily gain insight into the application of reading skills and abilities. This in turn, stimulates the development of science vocabulary, conceptual understandings of science, and styles of thinking and reasoning involved in comprehending scientific literature.

CC-4. EVALUATION OF A K-3 SCIENCE PROGRAM THROUGH THE USE OF STUDENT INTERVIEWS

Lynn W. Glass, Consultant, Science Education, Department of Public Instruction, Des Moines, Iowa

Each year the Department of Public Instruction is requested to evaluate the educational programs of selected public school districts in the State of Iowa. In past years these evaluation reports consisted of an inventory of educational materials and a collection of stated teacher philosophies and practices.

A questionnaire was developed to elicit the child's attitude towards the formal study of science. Each questionnaire item was administered orally by an independent observer to one child at a time. Data were collected from students using elementary science programs sponsored by the National Science Foundation and from students using other elementary science programs.

Student responses were analyzed in relation to stated teacher philosophy, teacher background, and nature of science course in each grade level, kindergarten through grade three.

GROUP D

ELEMENTARY SCHOOL SCIENCE: MOSTLY FOR THE PRIMARY LEVEL

D-1. SONGS ABOUT THE SENSES: PRIMARY AND INTERMEDIATE SCIENCE

Isabel S. Abrams, Biology Teacher, Wilmette Public Schools, Wilmette, Illinois

In a second grade, Wilmette, Illinois, classroom, this song introduced a discussion of the kinesthetic sense:

"Am I floating out in space right now?
Am I floating out in space right now?
How do I know where I am?
How do I know where I am?
Am I floating out in space right now?"*

Songs about hearing, seeing, smelling, touching, and tasting introduced the other senses. The rhythm and rhyme of the lyrics enabled the children to grasp difficult vocabulary. The rhythm of a word such as "stimulus," made it easier to pronounce. The rhyme of words like "vibration" and "sensation" made them easier to learn. Furthermore, when words rhymed, the children sang along so that they easily memorized these words.

Songs were also useful for teaching complex concepts and for reinforcing them. Ideas were developed in the verses. Step by step, a function was described. Or, perhaps, an amusing example was presented.

e.g., "A stimulus is a change.
Something new or strange . . ."*

The chorus gave the listener a chance to digest the verse. And the chorus emphasized the main concept.

e.g., "I'm excited. I'm excited.
Let me tell you why.
Many things excite me.
They're known as stimuli."*

Because of the rhythms and rhymes, concepts could be repeated without seeming repetitious.

After the songs were discussed, some of the children added their own verses. Others drew pictures of things that they had seen, tasted, heard, or smelled. Because the students enjoyed the songs, they were very willing to listen and find out what ears hear and what "Your Nose Knows."

D-2. AN EARTH SCIENCE PROGRAM FOR THE PRIMARY GRADES

Irwin L. Slesnick, Professor of Biology, and Maurice L. Schwartz, Department of Geology, Western Washington State College, Bellingham

Noting that the interests of primary school age children (grades K-3) heavily emphasized such topics as rocks, dinosaurs, volcanoes, weather, moon, and stars; and further noting that the new elementary school curricula as developed for the primary level make relatively little use of earth science content, we attempt to identify appropriate experiences in the earth sciences for children. The program incorporates science educational processes applicable to the primary grades, pre-operational and concrete-operational Piagetian child development considerations, sequentially planned activities, and varied strategies. The program covers four general topics: landforms, fossils, weather, and moon. Activities have been classroom tested. The format for each topic includes a teachers guide, student sourcebook, and the necessary materials. The dinosaur study under the topic of fossils is demonstrated.

D-3. MANIPULATIVE EXPERIENCE AND THE ATTAINMENT OF PROCESS SKILLS IN ELEMENTARY SCIENCE: A RESEARCH STUDY

Douglas R. Macbeth, Science Curriculum Coordinator, Lewisburg Area School District, Lewisburg, Pennsylvania

Rationale for the Study

Although for several decades educators and psychologists have generally agreed that direct manipulative experiences by young children are important to the child in certain learning situations, experimental research is scanty. Authors of the newer elementary school science curricula incorporate direct manipulative experiences into their programs without sufficient evidence of their value. This study was designed to test the importance of this manipulative experience in the attainment of science process skills for kindergarten and third grade students.

Experimental Procedures

Exercises chosen from the *Science–A Process Approach* program were taught in kindergarten and third grade classrooms. During the teaching of the exercises, certain pupils were allowed to manipulate the science materials while others were not. Following the teaching of each exercise, a competency measure was administered to assess the pupils' achievement of certain tasks. Using a method of alternating subject treatment condition with exercise, an experimental design was constructed that placed each student into both the manipulator and non-manipulator roles. Mean scores on the exercise competency measures for each treatment condition were computed and tested for significant differences using the t-test for related measures.

Results and Conclusions

The data collected from the kindergarten and third grade experiments suggest two basic conclusions: (1) kindergarten children (ages 5-6) directly manipulating science materials attain process skills better than children not manipulating these materials, and (2) the attainment of science process skills by third grade children (ages 8-9) directly manipulating science materials is not significantly ($\alpha = .05$) better than the attainment by children not manipulating these materials.

D-4. SIMPLE AND INEXPENSIVE FIELD DEVICES

Carolyn H. Hampton, Associate Professor, and Carol D. Hampton, Associate Professor, Science Education Department, East Carolina University, Greenville, North Carolina

Many elementary school teachers have begun to include environmental science topics or units in their regular science curriculum. Most of the teachers are at a loss about approaches to pollution and other environmental topics. They are hesitant to conduct field studies because of the lack of funds for equipment. In recent months, the market has been flooded with environmental science kits. Some of the kits are excellent but are overly expensive for teacher use. Others are of poor quality, and vague educational value; some are even potentially harmful.

Teachers and students can make many simple, inexpensive, and easily constructed devices to provide more interesting and meaningful field studies in environmental science. These might include: (1) a sampling device for population density studies; (2) a plankton net for collecting and concentrating small aquatic organisms; (3) a height meter for measuring the height of trees and other objects; (4) a soil sampling device for collecting and studying soil profiles; and (5) a burlese funnel for collecting and concentrating small soil organisms.

GROUP E

JUNIOR HIGH SCHOOL: INDIVIDUALIZED TEACHING APPROACHES

E-1. PLANNING FOR INDEPENDENT PROGRESS PROGRAMS

Allan Crowe, Teacher, Ninth-Grade Science, Waverly Junior-Senior High School, Waverly, New York

The changes in science teaching which occurred when students in all ability levels were involved in the gradual development of an Independent Progress Approach in the ninth-grade science program at Waverly indicates that planned evolution may be a sound approach. This approach evades many of the problems which often arise with the immediate adoption of a large program.

Detailed descriptions of careful and thorough planning; student, administration, and parental support; and demonstrable proof of success are provided. The presentation deals primarily with the three forms of the program, with stress on what conditions led to the program's inception; what problems arose in each case and how they were solved; and how each program produced student pressure for further change.

The first program consolidated a small group of the best students into an independent study unit, creating a greater challenge for the best students and allowing greater amounts of class time for instructor contact with the other students.

The success of this project led to total class involvement in completing a basic core of material and in choosing from a wide range of options within a unit. Normal class routines disappeared as students, working at their own pace, made startling gains in achievement.

Program evolution continued as students requested a choice of units as well as choice within a unit. Less time being devoted to lecture preparation paved the way for the current program, which allows student choice from three basic units every five weeks; the most popular units being offered more than once to facilitate scheduling.

In total, programs have considerably lessened the problems of a drastic change from regular classroom routines. Because each form of the program is a distinct entity, any structural changes may be motivated by a desire for improvement rather than by necessity.

E-2. TEACHER TRAINING IN INDIVIDUALIZED INSTRUCTION

Charles E. Doebler, Earth Science Teacher, Redland Junior High School, Rockville, Maryland

The outgrowth of an individualized instructional program in earth science led to the proposal of a teacher training program using these methods. The course, *Multi-Media Approach to Individualized Instruction,* is financed by Montgomery County Public Schools and is accredited by the Maryland State Board of Education. Two 3-week sessions were completed last summer. A set of performance objectives were designed for the teachers. The objectives were divided into two major categories; the psychological factors in individualized instruction and developing programs in areas of speciality. The teachers were required to develop evaluation procedures for their area of interest.

The entire program was evaluated by having the teachers rate each of the performance objectives. A follow-up questionnaire attempted to determine to what extent the teachers are individualizing instruction in the classroom.

E-3. DEVELOPMENT AND PROGRESS OF THE A-V-T APPROACH TO INDIVIDUALIZING HIGH SCHOOL EARTH SCIENCE

Jerrold Kline, Earth Science Instructor, Walter Johnson High School, Bethesda, Maryland

In order to more fully personalize learning for high school students in earth science, the classroom lecture was replaced with an audio-tape package, utilizing cassette tapes and recorders. Much of the content of the various units of study is covered on these cassettes. In addition, 35mm slides, overhead transparencies, 16mm films, videotapes, 8mm film loops, laboratory activities, field trips, and guest speakers are a part of the course.

These changes in the teaching-learning strategy were designed to involve the individual student in curricular decisions and to encourage and enable him to take a more active role in assuming the responsibility for learning.

In its fourth year of operation the Earth Science Project has expanded to include four schools, eight instructors, and over one thousand students. This year we added two instructors at the junior high level which involves over three hundred students.

A further outgrowth is the use of the multimedia aspect of the facility by the high school aviation classes. A summer course for teacher preparation, dealing with the utilization of individualized instructional methods, was presented last year and will be expanded next summer.

E-4. STUDENT EVALUATION IN INDIVIDUALIZED INSTRUCTION

Arthur J. Kramer, Earth Science Instructor, Montgomery Blair High School, Silver Spring, Maryland

The author has been involved in a team-teaching situation in earth science for the past three years, in which students have been evaluated in an individualized auto-tutorial program. Evaluation techniques which evolved proved to be effective and successful.

The earth science course is basically laboratory-oriented. Students can work individually or in groups of two or three. Like the student, the instructor spends the majority of his time in the laboratory, where he is continually involved in guiding, assisting, and questioning. Although the four different schools involved in this program in Montgomery County utilize a variety of evaluation techniques and procedures, the majority of a student's evaluation is determined through individual verbal questioning by the instructor.

Upon completion of a laboratory exercise the student presents the exercise to the instructor. The instructor then questions the student and discusses the exercise with him at his level of comprehension. If the instructor feels that the student has satisfactorily completed the exercise, using as a guide an adapted check list from *Bloom's Taxonomy*, this is recorded on the student's record. If the exercise is unacceptable, it is returned to the student. He continues working on it until it is accepted by the instructor.

A student may not finish the course, which means he will not receive full credit for the course – but he cannot fail. He fails only in the sense that he failed to fulfill the minimum requirements. Anyone who does not meet the minimum requirements can receive full credit upon the completion of the requirements. Students are not required to repeat another full year. They receive credit for what they have accomplished and receive full course credit when they complete the minimum course requirements.

E-5. SCHEDULING AND CREDIT OPTIONS IN INDIVIDUALIZED INSTRUCTION

Charles Showalter, Earth Science Instructor, Walt Whitman High School, Bethesda, Maryland

Schools are under continuous pressure to increase the options available to students. Usually providing such options is a serious additional expense, often requiring another teacher with unique skills. In science, particularly, the cost of materials and equipment for a science room is nearly prohibitive. However, the audio-tutorial method of presenting earth science, as described here, provides options in scheduling at no increase in cost.

The key to these options is that the total content of the course is larger than a pupil can be reasonably expected to complete in a school year. The requirements for completion in the reference program are six of ten units. The object is to provide student otpions within the classroom, and the concept is that each unit may be undertaken without prerequisites. If this were not so arranged, serious problems would arise, requiring more physical resources and defeating the self-selected curriculum concept.

However, if six independent units are satisfactory for one credit, then three should be acceptable for one-half credit, and nine should be acceptable for one and one-half credits; and as the teacher's time and capabilities permit, other units could and should be added; (slide rule, air pollution, water pollution, ecology, etc.) Further no-cost high-visibility options are available in permitting double scheduling by the students; thus one credit may be earned in one semester by scheduling two classes of earth science in a day.

GROUP F

JUNIOR HIGH SCHOOL: ADAPTATIONS TO LEARNERS

F-1. PHYSICAL SCIENCE II IN A SUBURBAN JUNIOR HIGH SCHOOL

F. Reed Cutting, Physical Science Teacher, Marblehead Junior High School, Marblehead, Massachusetts

Marblehead Junior High School serves an upper middle class suburban community on the seacoast north of Boston. The school has an enrollment of 1,200 students in grades seven to nine. All students are encouraged to complete two years of science prior to entrance into the senior high school. The science offerings at the junior high include laboratory courses in the life, earth, and physical sciences.

Following the introduction of pilot classes of Time, Space, and Matter, and Introductory Physical Science in 1965, the science department began to offer different sequences for the various junior high school science courses. Inclusion of Physical Science II as an additional elective three years ago resulted in several new alternatives. This paper focuses on how these alternatives developed and how students utilize them as a foundation for different options in the senior high school.

The IPS/PS II course combinations are offered in several ways. Students may elect to study these two courses over a period of two school years, including a grade eight to nine combination or a grade nine to ten combination. A third alternative is a special section of grade nine physical science which utilizes both IPS and PS II in a one-year course. These students enroll for a "double credit" in science and are scheduled for seven periods a week with two or three of these periods back to back. In addition, they have one "independent study period" per week which is allocated to the science. Students enrolled in this special section become involved in their science work and have done very well. Upon entrance into senior high approximately 80 percent have elected chemistry, which is normally taught in grade eleven. The special twelfth-grade biology class for students who have completed chemistry is the next course in the sequence for these students.

F-2. PHYSICAL SCIENCE II IN A RURAL HIGH SCHOOL

George E. Hall, Physical Science Teacher, Harwood Union High School, Moretown, Vermont

The Harwood Union High School serves a region of seven rural towns in north central Vermont. The high school population of approximately 800 students in grades 7-12 includes interests and abilities from pre-college to terminal education.

Since introducing Introductory Physical Science and Physical Science II several years ago, the science department has experimented with a variety of curriculum plans designed to meet the needs of the varied student population. This paper reports the results of our efforts in utilizing PS II as an option for junior high students who are interested in expanding their experience in science.

The key features of this curriculum plan are: (1) all students take IPS as the physical science requirement in either grade 8 or 9; (2) two classes of eighth-grade IPS are offered each year; (3) PS II is offered as an elective for ninth-grade students who have completed IPS; and (4) IPS is a prerequisite for the senior high science courses in biology, chemistry, and physics. The biology teachers report that the PS II students' abilities, interests, and attitudes have caused a significant shift to an individualized, independent project mode of instruction in these classes.

We feel that the program will expand, resulting in changes in all of the senior high science courses.

F-3. PHYSICAL SCIENCE II IN AN INNER-CITY JUNIOR HIGH SCHOOL

Merle M. Bush, Physical Science Teacher, Backus Junior High School, Washington, D.C.

For the last three years the Washington, D.C. School District Science Department has utilized the materials of several of the curriculum projects as a basis for introducing laboratory programs in the junior high school. Students are offered the option of enrolling in a sequence of general science courses or selecting one or more of the laboratory science courses.

This paper focuses on the science options available at Backus Junior High School and, in particular, shows how PS II has been used to broaden the science background for students who normally would not have elected science.

The physical science laboratory courses offered at Backus include: Time, Space, and Matter; Introductory Physical Science; and Physical Science II. It is possible for a student to enroll in all three courses in grades seven, eight, and nine, respectively. Since these courses are offered as electives, the only prerequisite is interest. The classes therefore include a mixture of ability levels in math, reading, etc.

This year the first class of students completed the IPS/PS II sequence and moved on to the senior high school. A check of enrollment indicates that the majority of these students enrolled in chemistry as tenth-graders. A report of a series of interviews with these 24 students is included in this presentation.

F-4. PHYSICAL SCIENCE II IN A SUBURBAN HIGH SCHOOL

Paul A. Dittmer, Physical Science Teacher, North High School, Naperville, Illinois

The Naperville Senior High School district serves approximately 3,000 students in grades 9-12 at two campus locations. Following the 1968 adoption of IPS as the principal science course for grade eight, the high school science faculty and curriculum personnel launched an effort to provide more alternatives in the curricula. The only ninth-grade science courses available were biology, and IPS, for those students who had not studied the course in grade eight.

In the fall of 1970, the ninth-grade students were offered a choice of one of the following: biology, Earth Science Curriculum Project, Introductory Physical Science, and Physical Science II. Dramatic shifts in enrollment accompanied these changes. The ninth-grade biology program of 26 sections seemed to evaporate in the rush to enroll in the alternate courses. When school started, there were three sections of biology, five sections of IPS, six sections of PS II and twelve sections of ESCP.

This fall the enrollment pattern showed an increase in both the ESCP and PS II classes, since more students in the feeder schools completed grade eight IPS.

The initial feeling that our earth science and physical science electives would hurt the biology has proved false. The marked drop in biology enrollment in the 1969-70 school year was temporary, for it appears that the students are enrolling in grade ten biology in significant numbers. It is our expectation that the biology course work will improve as a result of the students additional year's work in ninth-grade physical science.

GROUP FF

MORE ADAPTATIONS TO LEARNERS

FF-1. IDEA-CENTERED LABORATORY SCIENCE AND THE SLOW LEARNER

Sharon E. Kitchel, Delton-Kellogg Intermediate School, Delton, Michigan, and W.C. VanDeventer, Professor of Biology, Science Education, Western Michigan University, Kalamazoo

The science programs in many intermediate schools are directed toward the "average" student. Activities are generally provided for the "bright" student and sometimes for the "slow" student. Actually, however, the "slow" student struggles to achieve and often fails. So far as the writers know there are few programs that are adaptable for all levels of ability.

Idea-Centered Laboratory Science (I-CLS) can be adapted to a program for slow learners. By using I-CLS methods for teaching and testing, the student may arrive at a better understanding of himself and his relationship to his world. If the child succeeds with the I-CLS program he may develop an incentive to succeed in other disciplines.

The slow learner continually fails tests. Testing should be a tool to further a student's ability to solve problems and identify relationships. Subject matter should be introduced only in connection with laboratory experiences, and is important only in its contribution to ideas and understandings. The slow learner may have more success in "fact-learning-understanding" situations if only limited factual recall is required of him. Such teaching situations are provided by I-CLS.

I-CLS is based on student-oriented, open-ended laboratory experiences. Students learn by doing and by asking questions. The program utilizes a type of evaluation which gives evidence of effectively determining the extent and quality of students' thinking in relation to an idea. The results of this evaluation are coordinated with results of standardized tests.

FF-2. INDIVIDUALIZED RESEARCH – A SPRING ALTERNATIVE

Maureen K. Beringer, Farth Science Teacher, Lincoln-Sudbury Regional High School, Sudbury, Massachusetts

Demands for relevance and attention to preservation of physical surroundings characterize the student values of the seventies. Tailoring courses on all levels to develop student ability in seeing relationships between himself and his environment helps to answer these demands. An individual outdoor spring project heightens the success of this approach.

At Lincoln-Sudbury Regional High School, a four-year school of almost 2,000 students, two earth science teachers have designed such a course for freshmen. Advance planning for the project begins as soon as special student interests become discemible. A basic Earth Science Curriculum Project (ESCP) course is modified to emphasize an understanding of the earth as the environment of man. Students choose areas of interest from a wide selection, asking and attempting to answer questions concerning the physical world. By spring, students recognize the importance of using time wisely and of shouldering much of the responsibility in an "open lab" system. By late April, all other course requirements are completed, a project proposal has been approved, and equipment needs have been evaluated.

Students ask "a simple question of nature," and record, analyze, and report pertinent observations. Any aspects of the physical environment–pollution studies, soil analysis, microclimate studies, and limnology investigations, etc., are appropriate. During this time, formal class meetings are replaced by field work, analysis, attendance at one seminar a week, and a weekly conference with a teacher-advisor.

Evaluation of this program reveals that: (1) in-depth study allows student testing of skills and understanding in an area of special interest; (2) researching techniques are better understood by the students; (3) student involvement increases growth, achievement, and self-satisfaction; and (4) students recognize that responsibility in education must be shared.

FF-3. THE "OPEN LAB"–A BETTER WAY

James F. Moir, Earth Science Teacher, Lincoln-Sudbury Regional High School, Sudbury, Massachusetts

The "open lab" offers limitless possibilities as a new and effective approach to laboratory courses, because it is adaptable to any discipline and invaluable for upgrading existing programs. This sytem departs from the traditional pattern which offers a group of students one activity at a specific time. The "open lab" increases student responsibility, and makes optimum use of time, allowing greater flexibility in the scope of a course. Student achievement and self-satisfaction flourish with increased involvement.

At Lincoln-Sudbury Regional High School two earth science teachers have found the "open lab" successful under both traditional and flexible scheduling for stretching facilities and equipment in a rapidly growing suburban high school, and for developing an individualized freshman science program.

In the "open-lab" system formal classes meet less frequently, thus freeing students, teachers, rooms, and equipment for extended periods of time. Ideally, it becomes an all-day laboratory period offering a variety of laboratory equipment, investigations and activities, audio-visual and library materials, and the resources of one or several teachers. Students may work during scheduled or free time. Attendance is taken on a sign-in basis. Guidelines for required and optional work are carefully "pre-labbed" at the beginning of each learning unit. Key concepts are presented and "post-labs" shared during the very active discussion of scheduled class meetings.

The advantages of this informal environment are many: students often teach students; the varying rates of student performance are recognized; students with make-up work have greater flexibility; students now compete with themselves; teachers know students better and can evaluate them more personally; everyone benefits from the varied talents of the teaching team.

FF-4. AN INNOVATIVE SCIENCE CENTER PROJECT AND ASSOCIATED PROGRAMS

J. Bruce Holmquist, Director, and Jack Head, Science Education Specialist, Omaha Suburban Area Council of Schools Science Center, Gretna, Nebraska

The Omaha Suburban Area Council of Schools Science Center is a Nebraska ESEA Title III Project serving seven school districts including 40,000 students. A slide-tape presentation outlines the projects objectives and activities.

The avowed purpose of this project is to upgrade science education (K-12) within these schools through emphasis on teacher in-service training, student activities, and a materials bank.

Program development has been tied to all activities to provide outlines of various aspects of this project for outside educators in order that adaptations of these programs might be considered in other school systems.

FF-5. THE MULTI-PURPOSE SLIDE/TAPE SERIES

Gary W. Brown, Science Education Specialist, Omaha Suburban Area Council of Schools Science Center, Gretna, Nebraska

OSACS Science Center has developed a slide-tape series concerning relevant topics of science education. The series provides a multi-use audiovisual supplement to science curriculums and may be used by the instructor to introduce a topic and stimulate interest, clarify a point, or summarize a discussion. The tapes may be equally valuable when used by the student for individual instruction.

The slide-tape series offers a maximum of instructional material through a minimum of effort on the part of the person using the material.

35mm color slides are arranged in a carousel tray for ease in projection and the taped narrations are recorded on an audio cassette. The prerecorded narration is timed so as to notify the user as to when to change the slide. The cassette is recorded on both sides so that the user simply turns the cassette over to replay and rewind.

The slide-tape series offers versatility in that it may be used as planned, or altered to fit the class circumstance. For example–the complete series may be used to introduce a topic and later segments (selected slides) used separately as review points, individual study helps, and even as exam questions.

GROUP G

JUNIOR HIGH SCHOOL: ATTITUDES, PERCEPTIONS, CONCEPTS

G-1. A PROGRAM FOR DEVELOPING BASIC SKILLS IN SCIENCE

Ruth Lofgren, Associate Professor of Science Education, Brooklyn College of the City University of New York

As students proceed through school, they face increasingly severe handicaps when they come from backgrounds that do not reinforce academic skills. These young people are repeatedly denied the rewards of social approval and the delights of learning that draw successful students ahead. Many of the students who fall behind academically impress their teachers as being sensitive, energetic, and intelligent.

During the past five years, several general science teachers have been working out a series of classroom and field activities that provide opportunities for seventh-grade students to build their self-respect and confidence through the development of basic skills in science, and, in the process, to begin to understand some of the important scientific information they will need if they are to cope effectively with the world.

Our program has four aspects: the *teachers' guide*, providing the rationale for the selection of activities and background information for each content area; the *basic information* for the students for each of the activities; the *worksheets*, giving sufficient directions, space for data collection, etc.; the *review* for reinforcement of past learnings and self-evaluation.

Some of the topics covered by the students are: organizing a science notebook, what do scientists do, using scientific instruments, the nature of matter, physical changes of matter, chemical reactions in the world around us, atoms and molecules, the differences between living and non-living things, the needs of living things, etc.

The activities are planned so that students who do not know how to use a ruler, for instance, have repeated opportunities to measure distances accurately. Many students who have a particular skill, or who catch on quickly, enjoy teaching the slower ones when sufficient time is available.

G-2. THE SCIENCE AND SCIENTISTS ATTITUDE INVENTORY (SASAI): THE DEVELOPMENT OF AN INSTRUMENT TO EVALUATE SIXTH AND NINTH GRADE STUDENTS' ATTITUDES TOWARD SCIENCE AND SCIENTISTS

LaMoine L. Motz, Director of Science Education, Oakland Schools, Pontiac, Michigan

This study attempted to develop a valid and reliable instrument for determining the attitudes of 981 male and female sixth- and ninth-grade rural, urban, and suburban students (as a representative group) toward science and scientists. Based upon a grid of key statements about science and scientists, Part I of the instrument consisted of statements about science; Part II about scientists. School geographic area, sex, grade, socioeconomic backgrounds, and intelligence quotients of the students were also studied.

Ideas and statements about science and scientists were obtained by questioning 525 elementary, secondary, and college students, plus scientists and science educators. The final form of the instrument resulted after extensive trial administrations for readability and understanding, and validation by a panel of 20 professional scientists and science educators.

General findings include: (1) sixth-grade suburban and ninth-grade rural and suburban students scored significantly higher on their attitudes toward science than did sixth-grade rural and urban students while ninth-grade urban students, as a group, scored significantly lower than did ninth-grade rural and suburban students, but significantly higher than either the rural or urban sixth-grade students; (2) overall, ninth-grade students showed a more positive attitude toward science and scientists than did the sixth-grade students when compared to the responses of the professional science and science educator control group; (3) male and females were not significantly different in their attitudes toward science and scientists; (4) students from higher socioeconomic backgrounds showed a more positive attitude toward science and scientists as compared to agreement with the control group; and (5) students of higher intelligence quotients showed a more positive attitude toward science and scientists when compared to the control group.

Contrary to expectations, this study did not reveal a drop in the attitudes toward science and scientists from the sixth to the ninth grade. Suburban students, as a group, at the sixth- and ninth-grade levels, possessed a more positive attitude toward science and scientists than did the rural and urban groups. The study indicated that science education curriculum materials should be developed to include information about the development and practice of scientific attitudes.

G-3. COGNITIVE STYLES OF CHILDREN'S PERCEPTION OF BIOLOGICAL PHENOMENA

Max Berzofsky, Science Department Chairman, Loch Raven High School, Towson, Maryland

This study explores three cognitive style dimensions exhibited by third, sixth, and ninth-grade children as they viewed, categorized, and organized biological phenomena. Sub-problems were related to the effects of the independent variables of grade, sex, and IQ on these dimensions.

Each respondent made 15 matches of pictures chosen to represent five biological levels of organization—cell, organ, individual, species, and ecosystem. This picture-interview technique was based on validation by 3 panels of judges, and findings resulting from a pilot study involving 22 children.

The three cognitive style dimensions were: (1) *perception,* the selection of a part or the whole picture for matching; (2) *explanation,* conceptual categories of biological structure, function, or history, and (3) *classification,* the biological level of organization.

Several other variables were coded: (1) response latency; (2) validity, the congruence of respondents' classification with judges' classification; and (3) deviation, a measure of the degree of variation from on-level matches.

The major findings of the study were that: (1) the perception of *wholes* was evidenced to a much greater degree than perception of *parts;* (2) there was a linear pattern of relationships between structure, function, and history explanations, with the greatest proportion of matches made on the basis of structural explanations and the least on the basis of historical explanations; (3) there was a linear and quadratic pattern of relationships between classification on the five biological levels of organization, with the greatest percentage of matches made at the *individual* level of organization and the least on the *cell* and *ecosystem* levels of organization; and (4) lower biological levels of organization were related ($p < .01$) with structural explanations and higher levels of organization were related ($p < .01$) with functional explanations. There were no significant main effects or interactions of grade, sex, and IQ on the pattern of classification on the patterns of perception or on the individual perception variables, on the patterns of explanations, or on biological levels of organization in findings (1), (2), and (3) respectively.

G-4. ACCURACY AND/OR TEACHABILITY OF TEXTS

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

There are many reasons for the amazing amount of errors and misleading statements that one finds in instructional material. The examples given can perhaps be classified as: (1) carelessness in terminology, which may lead to real misconceptions; (2) misconceptions by the author, which could be reduced by choosing authors who are equally competent both in subject matter and educational theory; and (3) oversimplication in order to make the situation more comprehensible to the reader with limited background, which often results in illogical presentation.

GROUP H

SENIOR HIGH SCHOOL: BIOLOGY

H-1. INDIVIDUALIZED CURRICULUM MATERIALS IN BIOLOGY

Donald W. McCurdy, Associate Professor, Secondary Education, University of Nebraska, Lincoln

For the past three years, scientists at the University of Nebraska and public school teachers have been preparing sequential individualized learning modules for biology, chemistry, and physics. The chemistry-physics materials were prepared with the aid of a grant from the National Science Foundation. The biology materials were produced in a writing conference supported by the University. These materials include behavioral objectives, instructional activities drawn from the new curricula (i.e., Biological Sciences Curriculum Study, BSCS; Chemical Education Materials Study, CHEMS; Physical Science Study Committee Physics, PSSC; Harvard Project Physics, HPP; etc.), plus a wide variety of other sources – supplemental study guides and a complete testing program, and a teachers guide.

The materials are designed for use in an individualized continuous progress setting with many options available to the students and to the teacher. Students choices are based on their interests and needs.

Upon completion of the biology materials in summer 1972, it will be possible to structure a completely integrated and individualized three-year program in the three disciplines. Other schools may then utilize the products of this curriculum development effort.

The role of the teacher in schools now using these materials has changed from that of a lecturer to that of a tutor, discussion leader, and inquiry instigator. The student's role has changed from that of a passive listener with no choices to that of an active participant with many decisions on what he wants to do and how he should accomplish the goals of the program. A common "core" and optional "branch" arrangement of the learning modules help to provide this flexibility and freedom.

H-2. SELF-INSTRUCTIONAL MATERIALS FOR BIOLOGY

Albert Kaskel, Biology Teacher, Evanston Township High School, Evanston, Illinois

Teacher-constructed packets for student self-instruction are rapidly becoming valuable assets to a complete and meaningful biology program. Concepts often considered too difficult for average high school biology students can now be easily mastered through auto-tutorial materials. Although materials of this nature are already available in a "programmed" format, I have developed tutorial materials which require that students assume a more active role during each lesson. Requiring that students construct and manipulate paper molecular models to extract desired information, or measuring and recording data from pictures or graphs, provide methods for direct student involvement in self-instructional activity. Some representative types of activities and information gained by students are listed below.

Concepts dealing with chemistry of fats, proteins, and carbohydrates are handled on a one-to-one basis with students, as paper molecule models illustrate the meaning of synthesis, hydrolysis, structural formulas, molecular formulas, and isomerism.

ATP, ADP, glycolysis, high and low energy bonds, conversion to ATP and ADP with subsequent energy gains and losses are difficult concepts. Again, paper molecule models serve as the strategy for guiding students through these areas.

Pictures of animal chromosomes allow students to measure and record data on chromosome length. Concepts of chromosomal pairing, diploid and haploid numbers, sex chromosomes, autosomes, or mitosis and meiosis, can then evolve from student collected data.

An EKG tracing allows students to teach themselves about heartbeat sequence, heart sounds, heartbeat time intervals and pressure changes associated with contracting and relaxing of muscle tissue.

Paper models again allow students to construct and evaluate similarities and differences between DNA and RNA molecules; tRNA, mRNA, mutation, and protein synthesis concepts are mastered.

H-3. HUMANIZING THE SECOND YEAR BIOLOGY COURSE

Susan S. Plati, Biology Teacher, Wellesley Senior High School, Wellesley, Massachusetts

The natural excitement of science, felt by practically everyone in "The Age of Sputnik," has dissipated as sociology and concern for man's social problems have achieved elevated positions in academic circles. Scientists have usually seen objective knowledge of their subject as being of considerable value in evaluating man's social problems, but high school students often fail to see the connection. Disillusionment with advanced placement programs which prepare a student for college biology, and second-year courses which instruct would-be technicians in clinical procedures, led to a second-year course designed to capitalize on the relationship of biology to other academic disciplines, and at the same time, teach the student, through actual participation, some of the unique aspects of scientific research.

Four units—behavior, ecology, biochemistry, and an independent research project designed and executed by the student comprise the course. Class discussions focus on the biological basis of social problems including war, love, social behavior, communication, pollution, population, race, radiation and drugs. The course is laboratory oriented, with well over 50 percent of the time spent in laboratory investigation of problems which are new to the students, and in some cases new to the scientific community itself. For maximum opportunity in individual and small group experimentation on problems which are of specific interest to a student, a choice of experiments which becomes greater with each succeeding unit, culminates with the independent research project. Labs are varied and include a film study of baboon bahavior followed by field experience at the New England Regional Primate Center; study of behavior of lower vertebrates and invertebrates; ecological work with pesticides, pollutants, and population growth; a human crowding experiment in which the class spends a weekend in one room; and paper and thin-layer chromatography for analysis of amino acids in various organisms.

H-4. A BIOLOGY COURSE THAT MEETS THE NEEDS OF THE INNER-CITY STUDENT

Eleanor R. Fabiano, Biology Teacher, Barringer High School, Newark, New Jersey, and Eunice S. Liberson, Professor of Biology, Middlesex County College, Edison, New Jersey

Descriptions of a laboratory-centered course in biology for tenth-grade students and examples of the 67 laboratory lessons that have been designed for the non-academic inner-city students that attend Barringer High School in Newark are detailed.

The typical inner-city student has many problems that he brings into the school building with him. He has limited math skills and is far behind in his reading level. He has come to expect and to accept failure in school and may attend school infrequently.

To capture the interest and the imagination of a class of these students, we start the course with familiar material—his own environment in the fall, and then move to the unfamiliar. Laboratory lessons give each student the opportunity to handle materials, collect data, draw conclusions, plan experiments, and to keep records. He is encouraged to follow directions and to think for himself, rather than to be fed "right answers."

The classes are informal and are free from pressure for completing a prescribed amount of work. The students set their own pace and extra "research" work is provided for the more able or the more interested students.

The material for this course is inexpensive and readily available. It is familiar to the student and relevant to his environment and his needs. He learns biology as he handles the material; he also learns some reading, some self-expression, some grammar, and some responsibility to his group and to himself.

H-5. AN EXPERIMENTAL EVALUATION OF THE EFFECTIVENESS OF THE BSCS SPECIAL MATERIALS APPROACH TO TEACHING BIOLOGY TO THE SLOW LEARNER

John Mack Welford, Assistant Professor of Education, and Director of Secondary Teacher Training, Roanoke College, Salem, Virginia

This study attempted to evaluate the effectiveness of instruction in high school biology in a conventional course and the Special Materials course for underachievers in terms of achievement and interest of the underachiever.

Students were pretested in January 1969 and posttested in late May 1969. Experimental and control groups were selected according to whether the students were making use of the Biological Sciences Curriculum Study (BSCS) Special Materials or some other curriculum materials for the slow learner in biology. The Lorge-Thorndike Intelligence Test and the Iowa Test of Educational Development, No. 6, were used for students to obtain a measure of IQ and reading ability in the natural sciences, and were checked to see if differences existed between the two groups. Students were posttested with the Nelson Biology Test and the Biological Science: Patterns and Processes Final Examination and compared for differences in achievement. Pretests and posttests with two short science-related interest questionnaires determined changed interest in science.

Data analysis revealed no significant difference in IQ or in reading ability between the experimental and control groups. No difference was found between the two groups in either achievement or science-related interest. There was no difference between boys and girls in achievement or in science-related interest.

It was concluded that students achieve equally well whether using BSCS or non-BSCS materials when measured by a traditional biology test and when measured by the BSCS examinations. Boys and girls achieve equally well. The experimental and control groups, and boys and girls, when compared, exhibit no difference in science-related interests. These conclusions were drawn with consideration of the limitations of this study.

GROUP I

SENIOR HIGH SCHOOL: EVALUATIVE STUDIES

I-1. STUDENT-TEACHER REACTION TO AN INDIVIDUALIZED PROGRAM IN CHEMISTRY

Donald P. Altieri, Paul A. Becht, and W. Wooten, Instructors, Science Department, P.K. Yonge Laboratory School, University of Florida, Gainesville

This paper discusses the reaction of students and teachers involved in a locally developed individualized chemistry program, which has been in operation for almost three years, beginning in a laboratory school setting, then moving to a limited field testing, and now to a more extensive field testing program.

In addition to the cognitive instruments used, several affective measures were utilized in order to gain a more complete picture of how students function and react to a program of an individualized nature. Specifically, an attitude scale and a questionnaire were administered to students. Teachers were also asked to complete a questionnaire.

The program consists of units which represent major concepts in chemistry. These units are further divided into smaller sections called guide sheets. The guide sheet provides the directions for the study of one or two related concepts, and provides basic and optional experiences for the student. It is self-pacing with help and direction from the teacher with evaluation primarily based upon laboratory work, and classwork and guide sheet quizzes predominately used by the student for *self*-evaluation.

The program was designed to encourage the teachers to change or modify the program to fit their particular needs and situation and to provide feedback to the writers about problem areas in the program. Student feedback is also an important criterion in curriculum development.

Such issues as how one handles grades in such a system, or the problems that the student faced when this was the only individualized class are but two examples of problems faced by the students and teachers involved in an individualized chemistry course.

From the data gathered, we can begin to identify students who thrive as well as those who suffer under a program of this nature. The implications of these findings are discussed.

I-2. A CASE FOR TAKE-HOME EXAMS IN PHYSICS

John W. Milton, CSV, Science Department Chairman, St. Viator High School, Arlington Heights, Illinois

The increased attention paid to the needs of the individual student, the shift in emphasis from detailed content to principles and process in science teaching and learning, and the search for means to diminish some of the more distasteful aspects of doing high school physics, all lend credence to the value of take-home exams in a high school physics course.

An underlying assumption is that an examination should be a learning experience, and that most physics students, even after two or three years' exposure to high school science teaching and testing, are not really able to adequately meet the demands of substantial "in-class" physics exams. It is also assumed that a high school physics program capable of meeting a greater variety of student needs must depart drastically from traditional techniques of evaluation.

Examples of take-home exams coupled to an open laboratory course which allows for a measure of independent study, and the relation of these exams to other evaluation devices used in the course are included. Follow-up studies of student performance in college level science courses are also summarized.

I-3-5. A MODEL FOR STUDYING PHYSICS TEACHING

J.W. George Ivany, Associate Professor; Richard Mullaney, Research Associate; and Douglas Huegel, Research Associate; Teachers College, Columbia University, New York, New York

The three papers arise from different facets of a large-scale survey which deals with the status of physics teaching in high schools in 12 states in the Northeast. The study is funded by the National Science Foundation, sponsored by the American Institute of Physics and directed by J.W. George Ivany of Teachers College, Columbia University. The study has been underway since February 1971. The topics for the three presentations are drawn from three of the major facets of the study including: (1) "A Model for Studying Physics Teaching;" (2) "Physics Teaching Objectives: Real and Perceived;" and (3) "A Comparison of Attitudes Towards Science Among Physics and Social Studies Students."

GROUP J

COLLEGE SCIENCE TEACHING

J-1. NON-MAJOR BIOLOGY RELEVANCY USING THE MULTI-MEDIA APPROACH

Mary E. Lynch, Assistant Professor of Biology, Manhattan College, Bronx, New York

During the past two years a completely redesigned biology course for non-majors was inaugurated. The format originally consisted of two hours of lecture and four hours of lab per week, with emphasis on man in the biosphere.

During the second term of the first year, audio-tutorial lab instruction was tried experimentally, with such gratifying results that the audio-tutorial approach was expanded to include all laboratory classes in the second year. Small discussion groups are held before each lab period. A new feature is the optional lab exercises, where students may elect to participate in a regulation lab period, to take a field trip, to do a project, or to write a paper. Attendance is mandatory at about half of the labs, which are concerned with basic scientific data.

Biweekly formal lectures, audiovisual presentations, and a series of symposia on topics of general interest form the backbone of the course. These symposia are held twice each term, and feature special guest lecturers, panel discussions, and exhibits.

During two years of operation, with about 200 students per year, the course has been extremely well received. The students enjoy the audio-tutorial labs, finding a choice of lab work very desirable. Special lectures are always well attended, and readings are done so that student participation is very high.

The program is still developing. We look to videotapes, more individualiziation, and more use of audiovisual materials.

J-2. COMPUTER ASSISTED INSTRUCTION (CAI) IN AN INTRODUCTORY CHEMISTRY COURSE

Charles E. Coffey, Assistant Professor (on leave), General Motors Institute, Flint, Michigan; College Teaching Fellow, Syracuse University, Syracuse, New York; and Daniel J. Macero, Associate Professor of Chemistry, Syracuse University, Syracuse, New York

The availability of an on-line IBM 2741 Communications Terminal for use with the University's IBM APL/360 system prompted us to use computer-assisted instruction in "Introductory Chemistry," a course designed for undergraduate non-science majors at Syracuse University.

The computer offers a one-to-one relationship with the student and serves as a patient, tireless tutor. At the same time, the CAI approach can tailor a given sequence of material to the responses of individual students by programming a series of pretests designed to ascertain the student's awareness and ability in a specific area of chemistry or science, i.e., the metric system, basic mathematics, equation solving, etc. By constant scrutiny of the responses to these questions, the computer decides whether the student needs further assistance or needs to skip a unit entirely. Once the student's level of accomplishment is established, the computer starts him on the main CAI program. A modified tutorial approach is followed, i.e., the computer involves the student in drills, sequential in design, which are prearranged by the programmer. The modification occurs by allowing the student to "control" the actual material he is to use.

Student control of the program is exercised with where to begin the program; how many chances at the correct answer he is to have; whether to skip a given program or unit, and where to end the material. In the course of the program, he can ask for further clarification, for an additional example, or, to a limited extent, ask questions.

A record of the student's performance is kept and stored for later analysis. Such items as the time required to answer each question; the performance on the pretests, and the actual sequence of material are recorded and stored.

Programs on the chemical elements, the metric system, significant digits and scientific notation, and a simulated laboratory experiment are now complete and in use.

J-3. BREAKING DOWN THE WALLS WITH MINI-COURSES

James D. Russell, Minicourse Project Coordinator, Purdue University, Lafayette, Indiana

A new approach in higher education, offering additional educational opportunities to millions of students, is the concept of "colleges without walls." Many of the programs offer an "external degree" for college courses completed off campus. Modular units of instruction or minicourses constitute one learning approach which has proved successful in this country and abroad.

The paper traces the success of these "exportable" packages at Macquaire University in Sydney, Australia, and the potential for their use in study clubs, home study courses, and off-campus instruction, even behind prison walls.

Factors such as implementation patterns, evaluation procedures, and cost are included in the discussion. The challenge facing science educators today is to provide equivalent "courses" for both "internal" (resident) and "external" (non-resident) students. Regardless of the approach, each student should have equal opportunities for learning.

J-4. A HELICAL APPROACH TO TEACHING PHYSICS

John W. Hamilton, Chairman, Natural Science Division, Brunswick Junior College, Brunswick, Georgia

A helical approach to the teaching of physics has been developed for a small physics faculty. A single series of four introductory courses meets the needs of students pursuing a wide variety of fields of study. The various areas of physics can be introduced in the first course at a relatively unsophisticated level and returned to at a higher level in succeeding courses.

Students are given a set of minimum learning goals for each topic and are provided with questions with which they may determine their knowledge of the topic.

This approach, called FLIPS, has been used at 18 colleges throughout the United States for the past three years with a great deal of success.

The advantages and problems of using this approach in a small junior college are presented.

J-5. THE SIMULATED FIELD TRIP: INDIVIDUALIZING GEOLOGICAL CONCEPTS FOR THE SECONDARY AND COLLEGE STUDENT

George T. Ladd, Assistant Professor of Education, Geology and Geophysics, Boston College, Chestnut Hill, Massachusetts

Among the trends apparent in science education today are the movement toward individualization and the increasing attempts to direct science curricula toward the real environment. But how does one accomplish individualization when teaching budgets, classroom space, and material allocations remain unchanged? How does one involve students with the environment when monies for field trips are being drastically cut or, in some cases, totally eliminated? These are questions which science educators must face at a time when more and more students are being "turned off" by science as it has been traditionally taught.

The Boston College Department of Geology and Geophysics has developed and experimentally tested (at both the secondary and college level) an audiovisual tutorial program based on the concept of simulated field trips. Each weekly trip involves the student in observing and interpreting various worldwide processes and phenomena related to a fundamental geologic concept or principle. The program is composed of specimens, slides, audio tapes (complete with sound effects), film loops, and a wide variety of activities. The simulated trips form the basis for subsequent, small (10-12 students), student-initiated seminars and periodic, optional lectures on related topics.

From all available experimental and observational evidence, the program has been most successful in providing: (1) individualized and self-paced instruction; (2) a more realistic setting in which to study geology; (3) more interest in knowledge acquisition; (4) the potential development of a "bank" of field trips from which a student can select those which he is interested in pursuing; (5) significant changes in student attitude toward geology and science in general; and (6) the solution to a number of logistic, monetary, and staffing problems.

J-6. A GEOLOGY FIELD TRIP TO THE BOSTON MUSEUM OF FINE ARTS: RESULTS OF A TEST

L.N. Morgenstern, Assistant Professor, Department of Earth Science, Northeastern University, Boston, Massachusetts

A visit to the Museum of Fine Arts, Boston, Massachusetts, can solve a winter weather problem for elementary geology students. Basalt, granite, marble, limestone, sandstone, and jade, from pollution-free parts of the world, are among the exhibits. Twenty-foot statues of granite and basalt, which are thousands of years old, exhibit zoned feldspars, femic rims, and plagioclase laths. Carved marble and limestone, not yet exposed to a polluted atmosphere, are unharmed inside of the museum, whereas, steps, walls, and statues are pitted and gnawed just outside of the museum door.

The non-science major can benefit from exposure to something more than just plain old rocks. Once non-motivated students, especially the young ladies, now put in extra-curricular hours to bring back sketches, polaroid snaps, and "treasure maps" of rock and mineral specimens which they have discovered. The corroded appearance of unprotected rocks sent one newly motivated group to one of Boston's older burial grounds to compare time and environmental effects on slate, marble, iron, sandstone, limestone, and granite headstones. Conclusion? They would rather be granite than limestone. For the incoming class they left a question-answer guided tour booklet of their favorite pieces.

In my trip-abroad diary I find two incriminating notes that: (1) there are at least 28 magnificent and different types of marble in the Palace at Versailles; and (2) I'm glad they moved Michelangelo's David inside, away from the elements of atmospheric decay.

There are actually very few public buildings, museums, cornerstones, or curbs where one cannot find at least some geology for a field trip. Even the genuine blackboard of the classroom and the top of a pool table are now fair game.

GROUP JJ

MORE ON COLLEGE SCIENCE TEACHING

JJ-1. AN ENVIRONMENTAL SCIENCE EDUCATION PROGRAM FOR TEACHERS OF SCIENCE AT THE SECONDARY LEVEL

Harold J. McKenna, Instructor, School of Education, The City College of New York

Problem: To design and implement a graduate program for teachers of science at the secondary level in environmental education.

Purpose: Environmental science education is aimed at producing a citzenry that is knowledgeable about the environment and its associated problems and motivated to work toward their solution. This program gives science teachers the opportunity to gain content in the area, to acquire techniques and skills for teaching basic concepts, and to become actively involved in a project in the school or home community.

Procedure: Development of a 30-credit master's program in this area, using the interdisciplinary approach, both within each course as well as throughout the program, will meet the needs of school systems and districts wishing to create programs and courses in environmental education. As a model, this researcher is offering a course, Human Ecology, at the City College of New York. Social sciences are integrated with the natural and physical sciences to give the students insights into the many facets of interdisciplinary action.

1. Some 60 colleges, with schools of education, were surveyed to ascertain which, if any, offered comparable programs for teachers at this level. To date, none has such a program.
2. A program which incorporates 30 graduate credits of an interdisciplinary nature and allows credit allotment for each course at registration on a sliding scale of one credit to a maximum of three is planned. Thus, students may select credits for courses on the basis of gaining only content or gaining both content and research.
3. Courses will emphasize the three goals—content matter, methodology, and action involvement. Behavioral objectives are being established for each course in the program.
4. Courses under this program will be titled ESE (Environmental Science Education).
5. Evaluation of the model course is being undertaken through various pretest and posttest procedures.

JJ-2. FEEDBACK AS A PERVASIVE PRINCIPLE IN SCIENCE TEACHING

John H. Marean, Assistant Professor, Department of Curriculum and Instruction, The University of Calgary, Alberta, Canada

The feedback principle is an increasingly valuable analytical tool for studying systems in many disciplines. Applying the principle to familiar systems in introductory science teaching as an alternate approach to more familiar and traditional explanations is quite successful.

Examples are taken from mechanical, chemical, and physiological systems. Equilibrium and stability within these systems are considered. These early learnings and explorations can be extended usefully into more complex systems, leading to the development of an increased ability to apply this and alternate analytical schemes to new systems.

Science teaching which is oriented around comprehensive concepts or such pervasive principles as feedback has value in facilitating interdisciplinary learning and problem-solving, as in environmental studies.

JJ-3. ENVIRONMENTAL CLASS IN 3-P DIMENSION: PROJECTS, PARTICIPATION, PERSONAL INVOLVEMENT

Sister Elizabeth Staudt, HM, Instructor, Biology Department, Youngstown State University, Youngstown, Ohio

Convinced that Emerson was right when he said, "The true scholar grudges every opportunity of action passed by, as a loss of power," yet realizing with the Harvard philosopher, William E. Hocking, "there's many a horse which does not know it is thirsty which when led to water finds it wants to drink," we made an attempt to substitute for the traditional three R's of learning a new 3-P dimension: projects, participation, and personal involvement.

Whether this type of student involvement accomplishes the desired objectives can be judged from colleague comments, from requests for class-admit slips, and from students' anonymous evaluations. Students speak favorably for projects, participation, and personal involvement with:

"A fantastic and inspirational experience."

"I found the activity aspect of class most rewarding; the approach to learning through idea-exchange, discussions, and audiovisuals is the best possible. We worked more, but so did you: slides, tapes, movies, environmental organizations, handouts. I always felt that if something became enjoyable, learning would occur. Our course has substantiated that."

"Satire, beauty, what is worth conserving: the projects appealed to me because they demanded thought and creativity."

"I appreciated the group friendliness and informal atmosphere. One of the biggest things is that I made new friends; that never happened to me in a class before."

"I can see what Rousseau meant when he said that personal experience was a better way to learn. Projects got us all involved. I understand now that when you do something on your own and really care, you learn, and have a sense of satisfaction."

"There are few classes where group participation and teacher enthusiasm are so evident: this has to rank above all others in making learning an enjoyable process."

"Music – I never realized what a powerful force it is in conveying ideas; even on pollution."

"The class began as a 'science requirement', but it ended my stay at YSU on a very happy note."

JJ-4. MORGAN STATE COLLEGE PHYSICAL SCIENCE EXPERIMENT

Andrew Stevenson, Associate Professor of Science Education, Morgan State College, Baltimore, Maryland

Throughout the nation there is an increasing awareness of the need for liberal arts colleges to present a different type of science program to their students who are not planning to concentrate in the science or science-related areas. The number of scientific facts is increasing at such a rapid rate that it is difficult for scientists to keep up, let alone the average person. As a result, more colleges are now offering physical science courses for nonscience majors with an emphasis on understanding the scientific enterprise and the role scientists play in society, rather than presenting a large body of facts and theories which may or may not be useful 10 or 20 years from now.

The faculty at Morgan State College, responsible for the physical science course, decided in spring 1970 to see whether a program of this nature could meet the needs of the College. It was hoped that the students would develop the ability to: (1) analyze and solve problems; (2) take and support a position using specific evidence; (3) recognize limitations on information, including the understanding of experimental errors; and (4) manipulate basic equipment and have an understanding of the scientific enterprise.

In the 1971 spring semester 4 of the 20 sections of physical science were designated for the experiment. Although there was insufficient time to complete the program, it was decided to use the College Introductory Physical Science (CIPS) program and adapt it to fit the course objectives. Morgan State College uses an unlimited-cut policy, but absences were significantly reduced by the new program. The response to the experimental course by the students was gratifying.

JJ-5. OPEN ENROLLMENT AND ITS RELATION TO THE TEACHING OF BIOLOGY IN THE HEALTH AREAS IN THE COMMUNITY COLLEGE

Henry F. White, Dean of Allied Health Areas, Bronx Community College of the City University of New York

Since the City University of New York announced the policy of open enrollment, the college enrollments have increased sharply, for every graduate of a city high school, both public and private, is admitted tuition-free to either a two-year or a four-year college. In fall 1970, 34,000 students were admitted to the 16 units and in fall 1971, 41,000 students were admitted. The enrollment in the health areas increased, too, as nursing students numbered nearly 1,200 with 96 departmental faculty members.

Necessary program modifications included: (1) placement examinations for all new students in English, reading and writing, mathematics, speech, modern language, and chemistry (in late April) to determine which students lack the required science and need compensatory courses and which students score below the minimum in reading and writing and, therefore, should not elect science courses; (2) advisors interviews by department of student personnel who aid students in developing programs appropriate to their high school background; (3) instructor-scheduled exams given within the first two weeks, and face-to-face interviews in which instructors discuss results with students and recommend action; (4) free tutoring services offered to students at faculty and peer levels; (5) mimeographed outlines of course contents and requirements, a glossary, and topics for term papers or projects; (6) a comprehensive explanation of the grading system; and (7) specially-designed lab experiments to encourage maximum student participation.

JJ-6. TWO DECADES OF SCIENCE CARTOONS FROM *THE NEW YORKER*

James W. Cox, Associate Professor of Chemistry and Education, University of Montana, Missoula

No abstract submitted.

GROUP K

TEACHER EDUCATION: ELEMENTARY SCHOOL LEVEL

K-1. EXPERIENCE IN ELEMENTARY SCHOOL CLASSROOMS DURING METHODS COURSES AS A MEANS OF INCREASING UNDERSTANDING OF ROLE EXPECTATIONS

Darrel W. Fyffe, Instructor, Department of Education, Bowling Green State University, Bowling Green, Ohio

In Spring 1969 the Bowling Green State University Department of Education began the operation of the Methods Experience Project in one school. The project now includes four elementary schools and approximately 100 students per quarter.

Elementary education majors enroll in 16 hours of methods courses (science, mathematics, social studies, and reading and language arts) during one quarter. The project assigns students to an elementary classroom for three days per week, while two days are spent on campus in class. Transportation to the schools is handled by the university, and observation of the students is conducted by faculty members.

Duties of students in the classrooms include observation of the teacher, presentation of lessons in all subjects, preparation of educational aids for the classroom, and individual assistance to students. In the classes on campus the following activities are emphasized: discussion of nature and scope of science, presentation of information related to teaching elementary science, overviews of content areas and resource materials, and frank discussion of experiences.

Some recent staff research indicates that students who volunteer for the Methods Experience Project differ little from those selecting the normal sequence of on-campus methods courses, in the areas of experience, attitudes, or expectations, initially. However, after the experience a noticeable difference exists in the conflict in role expectations.

Students who volunteer for the project seem to exhibit a greater degree of interest in certain other projects, within the Department of Education, which involves classoom experience.

Possibly, the increased conflict in role expectation, caused by the varied activities and situations of the project, will produce students who attain a deeper understanding of the teaching-learning situation. The experience of accommodating the conflict with prior concepts of the role may result not only in better understanding, but also in more successful student teaching.

K-2. A STUDY OF THE EFFECTS OF PRESENTING THE PROCESS OF MEASURING TO PRE-SERVICE ELEMENTARY SCHOOL SCIENCE TEACHERS BY ABSTRACT AND APPLIED MODES OF INSTRUCTION

Doris K. Mouser, Assistant Professor of Education, Murray State University, Murray, Kentucky; and Leo G. Mahoney, Associate Professor of Education, University of Houston, Houston, Texas

This study investigated the effects of presenting the process of measuring to 102 preservice elementary school science teachers by the abstract and applied modes of instruction. Comparisons of the gains made by students receiving the abstract mode of instruction with those receiving the applied mode were of primary concern, but student gains according to area of interest were also compared.

Materials of the measuring presentation from the elementary science program, *Science–A Process Approach*, were used as the basic testing and teaching elements, by permission of the Xerox Corporation. A performance test, consisting of the individual competency measures the process of measuring from *Science–A Process Approach*, was given. An abstract mode of instruction was used on half of the subjects and an applied mode on the other half. Pretests were administered initially; following the teaching period, posttests were given to determine competency gains.

An analysis of variance, using the Completely Randomized Factorial Design, provided a simultaneous evaluation of method, classification, and interest on the basis of 12 treatment combinations. Four interactions were evaluated from the three-treatment design, and the categories of the interest level were examined by the Tukey test of Honestly Significant Difference.

A significant difference existed between the two modes of instruction. In examining the two-way interactions, a significant difference was found for method and classification and for method and interest; but not for classification and interest. The analysis of variance indicated no significant difference for the three-way interaction of method, classification, and interest.

K-3. SELLING OUTDOOR EDUCATION TO PRE-SERVICE ELEMENTARY SCHOOL TEACHERS

Ronald C. Wise, Assistant Professor of Education, Baldwin-Wallace College, Berea, Ohio

The purpose of this project was to give preservice elementary teachers direct experience in working with children in an outdoor setting. In science methods courses, educators often discuss the benefits to be derived from outdoor education; however, actual involvement with developing and conducting a program with elementary school children illustrates these benefits.

Eighteen preservice teachers volunteered to plan and conduct a five-day program with two sixth-grade classes. An initial meeting with the elementary students indicated that the interests of the children coincided with the five following areas: map and compass study, pond ecology, soil study, forest ecology, and animals and their habitats. Each college student then chose an area of interest and was assigned to a particular group of elementary children.

The first meeting with the interest groups concerned getting acquainted—backgrounds, expectations, etc. In subsequent meetings at the school, various lead-up activities were conducted in each group.

Four children were elected by their peers to travel with the teachers and college students to a rented lodge for the purpose of taking slides of the area and to present the slides at the next meeting to the remaining class members. Based upon the slides and student comments, rules were established for the week's experience.

During the five days other activities included night hikes, whittling, foot races, a nature hunt, fishing, camp fire songs and stories, dramatizations, athletic events, astronomy, arts and crafts, fire building, outdoor cooking, conservation activities, and weather forecasting.

Both elementary and college student feedback indicated that the experience was highly successful.

K-4. METHODS TEACHER AS MODEL: A DEMONSTRATION-PARTICIPATION EXPERIENCE FOR PRESERVICE TEACHERS IN ELEMENTARY SCHOOL SCIENCE

Lloyd M. Richardson, Assistant Professor of Education, Aurora College, Aurora, Illinois

Teacher education should provide models and experience which enable the prospective teacher to become a successful inservice teacher. This concern for appropriate models is essential if attitudes and skills are to be compatible with future role expectation. While the transition from college student to professional teacher is highly personal, there is considerable evidence to suggest that a significant impact is made upon the prospective teacher by the "model" his own training affords. It is incongruous for a methods professor to lecture on the importance of self-discovery, inquiry, and student involvement in the learning process. Only as the preservice teacher experiences meaningful encounters in his own learning is he likely to assimilate and internalize the ideas central to a given methodology of instruction.

The preservice training project described is a cooperative program between Aurora College and Gates School, East Aurora School District, Aurora, Illinois. The project components are: (1) an on-campus segment in which the preservice teacher is confronted with a series of activities in which he experiences firsthand, at his level of sophistication, the inquiry method of learning science; (2) an extensive demonstration situation in the public school setting in which the methods instructor employs process-centered inquiry techniques with a class of youngsters; (3) a teaching unit developed by each preservice teacher and reviewed by the methods instructor and the classroom teacher; (4) each prospective teacher directs the inquiry unit, which developed, with a classroom of children at the grade level of his choice.

This program is an effective way to indoctrinate teachers in training in a particular methodology, is beneficial to the school children involved, and is beneficial as an inservice training tool.

K-5. SCIENCE ATTITUDE OF PRESERVICE ELEMENTARY SCHOOL TEACHERS

Robert L. Shrigley, Assistant Professor in Elementary Education, The Pennsylvania State University, University Park

No abstract submitted.

K-6. A SCALE FOR MEASURING SCIENCE ATTITUDE OF INSERVICE ELEMENTARY SCHOOL TEACHERS

Theodore M. Johnson, Director, Curriculum Materials Center, The Pennsylvania State University, University Park

No abstract submitted.

GROUP L

TEACHER EDUCATION: SECONDARY SCHOOL LEVEL

L-1. AN EXPERIMENTAL PROGRAM FOR THE PREPARATION OF SCIENCE AND MATHEMATICS TEACHERS: A PROGRESS REPORT

Robert R. Donaldson, Professor of Physics, Plattsburgh State University, Plattsburgh, New York

No abstract submitted.

L-2. PROJECT POINT: AN EXPERIMENTAL PROGRAM IN SECONDARY SCHOOL TEACHER EDUCATION

Dale E. Ingmanson, Assistant Professor of Physical Science, San Diego State College, San Diego, California

Project POINT is an experimental program for the preparation, orientation, and induction of new teachers into the teaching profession. The POINT program is conducted by a regional consortium consisting of San Diego State College, San Diego County Department of Education, and several other cooperating local school districts.

POINT is a five-year program designed to combine preservice education and the first years of inservice education into a single, integrated system planned and conducted by representatives of local school districts, San Diego State School of Education, and selected academic departments.

Initially, POINT will include only students majoring in English and physical science. During the student's senior year, a special course will be taught jointly by faculty of the English and physical science departments. All students will meet in class together for a course which attempts to integrate the humanities and sciences.

Preservice education includes paid employment as a teacher aide and diversified experiences in exemplary teaching techniques. Inservice education includes a paid internship and work toward an MA degree in the chosen field of the student.

At the end of POINT, a participant should have AB and MA degrees, a state credential, three years of time accrued toward tenure and retirement, and a step on the local salary schedule appropriate for three years of employment.

L-3. A COMPETENCY-BASED METHODS COURSE IN SECONDARY SCHOOL SCIENCE TEACHER EDUCATION

Van E. Neie, Assistant Professor of Physics and Education, Department of Physics, Purdue University, Lafayette, Indiana

The science education faculty of Purdue University stresses competency-based certification of teachers in the secondary science teacher preparation program. The first phase began in fall 1971 and is continuing through spring 1972. Teacher competencies have been identified and objectives written as vehicles for implementation. Teacher candidates in the physics-chemistry program are given the objectives, the list of competencies, and the available resources to attain these objectives. Resources include the instructor, individual and group programmed learning packages that contain audio and visual aids, and frequent group meetings for exchange of ideas. The chemistry and physics departments also maintain teacher education centers where the students may use a wide variety of curricular materials, including laboratory equipment and audiovisual aids.

The format is essentially one of self-pacing, interspersed with small-group activities. Pretests are available for all learning segments to allow for individuals who have attained objectives prior to instruction. Evaluation, which determines written as well as demonstrated competency of the teacher candidate, is based on the posttests that accompany each instructional segment and on conferences with the instructor.

Administratively, the Department of Education requires a letter grade, but efforts are under way to implement a pass-fail evaluation scheme. Presently grades are reported as A or Incomplete. The list of competencies is placed on file with the Teacher Placement Office as part of the student's credentials.

Although the program is individualized, the requirements encourage some experience with classroom observation and necessitate demonstration of teaching ability in peer-group teaching sessions. Role-playing and micro-teaching are the most effective techniques in this area.

L-4. COMPETENCY-BASED PREPARATION OF SCIENCE TEACHERS FOR THE PEACE CORPS/TEACHER CORPS

Joyce Swartney, Assistant Professor, and Francis T. Siemankowski, Professor, Department of General Science, State University College at Buffalo, Buffalo, New York

This program is an experiment in interdivisional planning at the State University College at Buffalo. The project involved the Teacher Corps/Peace Corps experimental program faculty, housed in the faculty of professional studies, and the science education branch of the department of general science in the faculty of arts and sciences.

Teacher Corps prerequisites of interdisciplinary cooperation, modification of collegiate instructional methods, and a competency-based teacher educational program; sparked a reappraisal of college teaching practices, and the analysis of skills and competencies required in teaching and supervision of science in an inner-city school and in an underdeveloped country. Discussions involved personnel from the Teacher Corps, the general science department, Lackawanna Public Schools, and the Peace Corps, as well as a cross-cultural representative from Afghanistan.

An initial scarcity of instructional materials, appropriate for an individualized performance-based learning laboratory, was resolved through the assembling of an extensive library of tapes, filmstrips, motion pictures, transparencies, journals, books, reprints, monographs, etc., with the cooperation of the college community. These resources were incorporated into a series of module clusters, based on the skills required by the interns, for serving ultimately as science supervisors in Afghanistan. The teaching technique is best described as self-directed, with professors serving as consultants. The interns were aware of the desired performance objectives, but choices of materials and methods were largely open to the individual. Videotaping and microteaching were frequently used for evaluation purposes.

There are now seven competency-based module clusters which utilize a multimedia approach. Modules were evaluated by the students and staff, and modifications are planned before their next use.

GROUP M

THE MUSEUM'S ROLE IN SCIENCE EDUCATION

M-1. WHAT MUSEUMS HAVE DONE TO PROMOTE AND DEVELOP SCIENCE PROGRAMS AT THEIR INSTITUTIONS

Kyron McGrath, Director, American Association of Museums, Washington, D.C.

No abstract submitted.

M-2. WHAT INNOVATIVE SCIENCE PROGRAMS ARE BEING GIVEN TODAY AT MUSEUMS

Michael Spock, Director, The Children's Museum, Boston, Massachusetts

No abstract submitted.

M-3. HOW MAY ORGANIZATIONS SUCH AS NSTA COOPERATE AND HELP DEVELOP SCIENCE PROGRAMS IN MUSEUMS

J. Darrell Barnard, Professor of Science Education

and Associate Director of COPES, New York University

No abstract submitted.

M-4. THE MUSEUM AS A TEACHING RESOURCE

Glenn McGlathery, Associate Professor, Denver Center, University of Colorado

This paper deals with the museum as a teaching resource for elementary teachers. Teachers are advised to develop plans for using the time at the museum effectively, enabling them to do more than simply "read the label" on the various exhibits. The paper is based on experiences gained from "The Museum As A Teaching Resource," a course conducted in August 1971. Although the Denver Museum of Natural History is used as a reference, the concepts and principles are applicable to other museums.

GROUP N

ENVIRONMENTAL EDUCATION

N-1. THE ENVIRONMENTAL SCIENCE CENTER: A MODEL EDUCATIONAL RESEARCH AND DEVELOPMENT ORGANIZATION

Barbara B. Clark and Michael J. Naylon, Staff Associates, Minnesota Environmental Sciences Foundation, Incorporated, Minneapolis

No abstract submitted.

GROUP O

SOME ALTERNATIVES BEING TRIED

O-1. A K-12 UNIFIED SCIENCE PROGRAM

Neal V. Fertitta, Chairman of Science Task Force, Science Implementation Center, Odenton Elementary School, Odenton, Maryland

During the 1970-71 school year, eight science teachers released from classroom responsibility, worked full time to develop a K-12 science program for Anne Arundel County.

Recognizing the statement by NSTA in *Theory into Action,* the work of those in FUSE (Federation for Unified Science Education), and the need to actively involve students in science rather than in its component disciplines, the team developed a unified science program which emphasizes the interrelationships between science disciplines. Five major unifying concepts, supported by subconcepts which are in turn supported by measurable educational objectives, combine to cut across discipline boundaries. The program emphasizes individualization of learning styles by supplying students with a variety of materials and activities coded for each educational objective. Thus the bright student is challenged while the slow learner is given assistance. Learning, in terms of continuous progress between grade levels, is achieved by placing the concept blocks in a continuum from K to 10 and by giving students material from the next grade level before the traditional September date. Thus eleventh and twelth grades offer a unique opportunity for learning, since these grades consist of semester courses designed to: (1) allow students to continue unified science; (2) study within a selected discipline; or (3) select learning from a variety of course offerings designed to extend prior learning and to meet the interest of students.

The role of the teacher becomes one of a diagnostician of individual needs, a prescriber of appropriate learning materials and activities, and a facilitator of an optimum learning environment. Classroom teachers were prepared for program implementation during summer 1971. Also, teachers received support during the 1971-72 year from the original writing team, who served for a second year, in order to implement the program.

O-2. THE INDIANA PLAN FOR IMPROVING SCIENCE PROGRAMS: A MODEL FOR EFFECTING CHANGE

Jerry M. Colglazier, State Science Consultant, Department of Public Instruction, Indianapolis, Indiana

In early 1968, a Science Advisory Committee was appointed by the Indiana State Superintendent of Public Instruction to develop a plan for improving the quality science instruction in Indiana schools, under the direction of the Science Consultant.

The committee recognized immediately that it must establish a philosophical base around which to organize its efforts. After developing a statement of goals for school science programs, the committee undertook the development of guidelines for achieving these goals, culminating in *Guidelines for Indiana School Science Programs, K-12.*

The ideas contained in the guidelines were borrowed from nearly every science curriculum project of the last one and a half decades and from many other educators. Ideas are organized to converge on the problems of developing relevant science programs.

The guidelines do not mandate, and only to a limited extent prescribe, a curriculum. It is suggestive, and the committee admits that the objective sequence and many of the suggested relationships to processes, conceptual schemes, and values and attitudes are only inferred. The teachers are challenged to become actively involved in sciencing by testing these inferences.

The core of the guidelines is a set of about 900 "performance" objectives arranged in parallel sequential strands. In parallel columns with the objectives are listed: (1) the processes which the student should use in accomplishing each objective; (2) the conceptual schemes into which the cognitive achievement of each objective may eventually be synthesized by the student; and (3) the values and attitudes which the achievement of each objective can nourish.

The committee does not view the guidelines as an end product but as a beginning focus from which relevant science programs may begin to radiate.

O-3. SCIENCE ON WHEELS

Maxine L. Savitz, Professor of Chemistry, Federal City College, Washington, D.C.; and Thomas W. Black, Project Director (on leave from District of Columbia Public Schools), Federal City College, Washington, D.C.; and Shirley A. Law, Student Intern, Federal City College, Washington, D.C.

This program, which is supported by the National Science Foundation, is directed toward demonstrating the relevance of science to community problems. As a means of bringing enriched science programs to students, and bringing problems which scientists are currently studying to the community; a 50-foot mobile home has been outfitted and equipped as a laboratory, containing scientific experiments and demonstrations in biology, chemistry, physics, mathematics, and applied science. During the past summer, the lab traveled to selected neighborhoods in the District of Columbia and is currently spending two weeks at each of the District's 11 public high schools.

The first experiments have dealt with the effects of air and water pollution on urban life, including the effect of noise and the existence of lead in house paint. At each location the students in the high schools and/or people in the community enter the lab and actively participate in the experiments. Under faculty guidance, Federal City College students have devised experiments to show the relationship of modem science and technology to the urban environment. Twenty-five students, five from each of the major science study areas, are working with the project and do the actual teaching in the lab.

The project has a three-fold application which; (1) provides a practicum for science majors at Federal City College; (2) lends enrichment to the existing science curriculum in the District of Columbia Public School System; and (3) develops an interest and appreciation among urban residents and students of the ability of science to solve everyday problems. The above-mentioned applications, in addition to the organization, types of experiments, and benefits of the program to the student interns and participants are discussed.

O-4. INTERDISCIPLINARY ENVIRONMENTAL ACTION PROGRAMS IN EDUCATION

John T. Hershey and Alan D. Sexton, Environmental Specialists, Project CARE, Montgomery County Intermediate Unit, Blue Bell, Pennsylvania

Interdisciplinary environmental action programs in education have probably been going on for several decades under isolated circumstances. Now that environmental education has become timely, a rare opportunity for learning may be more readily instituted into the educational process.

Interdisciplinary aspects of study, problem solving, and the role of the educational institution must be considered in order to understand the value of this educational approach.

The boundaries separating established disciplines often prevent study from a holistic point of view. By allowing a study to develop through an interdisciplinary approach relationships among disciplines are revealed. Environmental problems provide an interdisciplinary basis of study and students are aware of their environment because of the present problems. Teachers and students must cooperate to determine areas of study, and they must be prepared to learn together. Departments must develop working relationships which allow students to transcend or modify "traditional barriers" inherent in the role of the educational institution.

O-5. A MODEL FOR THE EVALUATION OF UNIFIED SCIENCE PROGRAMS

Thomas Gadsden, Jr., Assistant Professor, P.K. Yonge Laboratory School, University of Florida, Gainesville

Unified science is one of the most promising developments in science teaching today, by virtue of being unique in curriculum content and approach, being the result of local needs, and representing the efforts of small-scale local projects.

Promise, however, is not sufficient. Although careful evaluation of developing curricula is essential, it has often been either absent or not adequately productive. Constraints of time, money, politics, and the lack of evaluation guidelines are contributing factors. For small-scale curriculum development projects, having local concerns and unique purposes, evaluation is especially difficult.

Experience in the development of the P.K. Yonge Integrated Science Program and a study of the process of evaluation, resulted in a flow-chart model of evaluation designed to aid unified science projects in developing evaluations suitable to their specific needs. The purpose of evaluation in this model is to obtain and provide information for use in decision-making relative to a project.

The model includes eight major components of the evaluation process: identification of criteria, identification of constraints, optimization, design development, implementation, analysis, reporting, and decision-making. This paper examines the first three components in detail with a discussion of decision-makers and their possible effects on the project, alternative purposes for evaluation, constraining and mitigating factors affecting the evaluation, and the process of optimizing a project's evaluation. The remaining five components are discussed briefly.

GROUP P

ECOLOGICAL EDUCATION ACTIVITIES

P-1. AN INTERDISCIPLINARY TREASURE HUNT

Eleanor McKeeman, and Helen Heron, Teachers, Cunningham Elementary School, Denver, Colorado

Students of all ages love solving clues to find a treasure. Ideas incorporating all areas of the curriculum can be woven into the clues. The complexity of the clues is limited only by the abilities of the children who participate. Such a treasure hunt can consume an hour's time, or several days.

Appropriate clues for primary children include: Walk ten steps. Turn left. Walk as many steps as a tricycle has wheels. Look for the next clue.

Older students may use clues such as:

> How many legs has a spider?
> Add to that the number of days between January 4th and February 27th.
> Subtract the number of baseball teams in the National League.
> Walk that many meters in the direction geese fly in the fall.

Secondary students may need research to answer clues requiring:

> The population of Walnut Creek, California, in the 1960 Census.
> Conversion of centimeters to meters.
> Data based on a certain pendulum length and the number of swings it makes in 20 seconds.

Foreign language, scrambled words, kryptogram exercises, or messages using letters on a musical staff could provide material for challenging clues.

Students who complete the hunt should be rewarded with a treasure, possibly in the form of time to do a creative project, or opportunity to choose a new game, book, or puzzle which would be available in the classroom or library.

Clues should be left intact, so that other teams can compete to set a new record for completion of the hunt. Results of the timed contest could be graphed, average time needed could be computed, and, hopefully, students would be motivated to write some clues of their own.

P-2. THE WHITE MOUNTAINS OF NEW HAMPSHIRE AS AN OUTDOOR EDUCATION RESOURCE

Robert E. Kilburn, Science Coordinator, Newton Public Schools, Newton, Massachusetts; and John B. Nutter, Coordinator for Environmental Education, Appalachian Mountain Club, Pinkham Notch Camp, Gorham, New Hampshire

The Presidential Range of the White Mountains (New Hampshire) is within a day's ride of 80,000,000 citizens of the United States and Canada. No other region in the northeastern United States offers the ecological and geological variety, combined with rugged beauty and a sense of adventure. In addition, the region has a number of rustic hotels, or "huts", each a day's walk apart, high up in the mountains, which are unused during the school year, but can be utilized by school groups. For these reasons, this area offers an ideal locale for significant outdoor education experiences for secondary school students and teachers. Such experiences can contribute significantly, not only to academic growth, but to physical and psychological growth as well.

This paper describes the three-year-old program of three-and four-day hiking and study trips conducted by junior high teachers and students, and a new three-day teacher training workshop, conducted by the Appalachian Mountain Club, to assist teachers in utilizing this region.

Mr. Kilburn describes the hiking program which has been developed in Newton in terms of objectives, experiences, cost breakdowns and evaluation. Mr. Nutter describes the teacher-training workshops which are open to interested teachers who want to improve their expertise in biological and geological field study of this region, as well as in hiking trip leadership.

P-3. WATER POLLUTION CHEMICAL ANALYSIS TECHNIQUES FOR JUNIOR AND SENIOR HIGH SCHOOL LEVELS

James E. Murphy, Research Assistant, Science Education Center, University of Iowa, Iowa City

This paper, which is directed to teachers of physical science, life science, and chemistry, presents a short general introduction of chemical characteristics of water, with tests for the following water characteristics: dissolved O_2 and CO_2, pH, alkalinity, salinity, and content of phosphates and of nitrates. Techniques for collecting water samples are also included.

For each of the chemical analyses, the importance of the test, the physical and chemical materials required (as well as preparation of solutions), the directions for carrying out the test, and the calibration and interpretation of results are discussed.

All tests involve common chemicals available to junior and senior high school teachers. The procedures are straightforward enough to be followed by the average student and will yield data which are meaningful to the student.

P-4. AN INTRODUCTION TO WATER POLLUTION: A MULTIMEDIA APPROACH

Thomas J. Plati, Chemistry Teacher, Dover-Sherborn High School, Dover, Massachusetts

The pollution theme permeates our everday life to such an extent that a teacher must dramatize the naïveté of the students about the pollution problem to justify the inclusion of a pollution unit. An introductory lesson accomplished the above objective through a synchronized slide presentation of local sites to the accompaniment of Tom Paxton's song, "Whose Garden Was This?" The words of the song reveal today's beauty as well as today's ugliness, and student discussion stimulated by this presentation calls attention to the possible problems that might arise in studying the environment.

Upon completion of this discussion, the class is asked to examine two samples of water—one, a murky-bluish color and one, clear. Students quickly point out that the murky-bluish sample must be from a nearby polluted river, whereas the clear sample is obviously tap water. At this point, the teacher drinks the "polluted water" (chocolate and food coloring) and adds a piece of metal to the "tap water" (sulfuric acid).

The need for establishing a more quantitative test procedure thus asserted, the students are presented with a sample of river water with instructions to make an analysis, using any materials available in the science area. Students attempt various testing procedures, only to be thwarted in many cases by their own ignorance. At this juncture a prepared data bank is supplied to the student, but even when presented with test results, students can only make a superficial analysis of possible pollution problems.

Although frustrated, students become desirous of learning more about different test procedures and methods of interpreting results. Classroom resource material, a few simple testing kits, and teacher expertise are the only remaining prerequisites for implementing a local water-pollution survey.

GROUP Q

ESP AND OTHER THINGS

Q-1. SECONDARY TEACHING UNITS INVESTIGATING THE PURSUIT AND PRACTICE OF ESP

Charlotta I. Mary, Chairman, Science Department, Palm Springs Junior High School, Hialeah, Florida

There is much to be taught using ESP units in he classroom. A few of the behaviors that are easily reached are: (1) mathematical and statistical usage; (2) scientific objectivity; (3) observation; (4) motivation; and (5) the desire to read and research.

We have a broad scope when all psychic phenomena are considered as ESP; and there is a temendous amount of resource material available which is written scientifically, autobiographically, biographically, and as historio-fiction. ESP tests used at Duke University are good instruments to begin with because statistical analysis is part of the package. Hobby shop games should be used only at the end of the course or not at all because of the great demand on the individual's credibility.

Q-2. ESP IN HIGH SCHOOL

John M. Davison, Science Department Chairman, Ceres High School, Ceres, California

Extra sensory perception is an undeveloped frontier of science.

Capturing student interest in ego-centered activities enhances the scientific approach and using the mind to study the mind challenges all of us. The questions developed include: What realistic goals can be established? Are objectives measureable? Is parapsychology a natural for using scientific ways? Are scientific methods likely to fail? How do pupil-teacher relationships change? Can there be a generation bridging expected? Data are available.

Q-3. THE SCIENTIFIC STATUS OF ESP

R.A. McConnell, Research Professor of Biophysics, University of Pittsburgh, Pittsburgh, Pennsylvania

What is the possible importance of extrasensory perception? Could it offer a future means for improved communication in the classroom and elsewhere? To what extent does it deserve our attention?

Has it been scientifically proved to occur? What is the meaning of "scientific proof"? How does one set about evaluating the evidence for himself? What skills are needed in the investigation?

To what extent has ESP been accepted by the scientific world? Who speaks with authority on controversial matters in science? In general, what are the signs of acceptance of a new phenomenon? Are these signs yet present in the case of ESP?

These questions are examined in a brief discussion of the available pathways by which the intelligent layman might reach a judgment as to the reality of this controversial phenomenon.

Q-4. THE USE OF THE UNUSUAL FOR THE TEACHER OF SCIENCE

Ray L. Birdwhistell, Professor of Communications, Annenberg School of Communications, University of Pennsylvania, Philadelphia

The role of the scientist, and more specifically, that of the science teacher, necessitates the attempt to deal with nature in a manner which stands apart from political, religious, and economic considerations. Obviously, this is easiest when the phenomena studied or taught to others are removed by structure or distance from such matters. On the other hand, if the teacher's task is to excite others to learn about or to learn to practice science, he needs to find objects for study within the ken of his students.

In the past, issues such as evolution, the shape of the universe, sexual reproduction, food chemistry, and nuclear energy have seemed of immediate importance to students. In their own period each of these subjects has been considered a heterodox object for scientific curiosity. For many of our present students these issues seem distant, already settled, or trivial.

As educators we have long realized that we need to get the student's attention. We can use the particular phenomenon as a window into a way of thinking. Perhaps we need to look at more of the things students, innocently anti-intellectual and avowedly anti-scientific, are concerned with today. Such matters as hypnotism, extrasensory perception, "vibrations," and even, perhaps, astrology, of great interest to many students, are appropriate subjects for examination by carefully trained teachers. Such matters can be used as exemplary phenomena without sacrificing scientific and academic integrity.

Discussion of a single case of what appeared to be extrasensory communication, but which under analysis turned out to be extra-verbal rather than extra-natural illustrates this point.

GROUP R

EVALUATIVE STUDIES

R-1. THE DOMAINS OF INQUIRY SKILLS

Henry P. Cole, Associate Professor, Department of Educational Psychology and Counselling, University of Kentucky, Lexington

This paper utilizes a four-year study by the author to define categories of skills essential to productive living which can be operationally incorporated into curriculum and instructional designs. Justifications for developing clusters of inquiry skills or process categories through instruction and suggestions for evaluating the clusters, when implemented, are offered.

Inquiry is defined as the process of creating meaning from one's own actions and experience and the accumulated experience of the culture in the form of knowledge. A paradigm defines and relates the terms "inquiry-processes," "skills," "meaning-making," "knowledge," "problem-solving," "learning," and "education." Known characteristics of inquiry skills as determined by recent research are examined.

A comprehensive set of dimensions of skills upon which inquiry activity depends, based on the classical learning processes such as attending and orienting behavior, memory, and motivation, include: (1) dimensions of inquiry skills related to the scientific discipline and analytic problem-solving; (2) generalized skills of perceptual, affective, and cognitive fluency and flexibility which relate to all aspects of living and being; and (3) dimensions concerned with the skills of interpersonal relations, belongingness, esteem, self-actualization, and expressive-creative behavior.

The skill clusters or dimensions were identified from the work of Gagné concerning the conditions for learning and domains of the learning process; Guilford's model of the intellect; Torrance's work on fluency and flexibility, in relation to creative production and problem-solving; Lippitt's, Fox's, and Schmuck's work in interpersonal skill for more efficient group and individual problem solving; as well as Roger's, Maslow's, and Ruben's work in relation to skills of personal being, competence, and fulfillment. Particular emphasis is on concrete embodiment of curriculum approaches which collectively emphasize a wide array of these dimensions of inquiry behavior.

R-2. EVALUATION OF EDUCATIONAL OUTCOMES OF PROCESS EDUCATION BY VIDEO TAPE

Richard E. Ripple, Professor of Education Psychology, Cornell University, Ithaca, New York

This report attempts to document certain aspects of small-group work and their relationships with process education. Particular attention was given to such student characteristics as ability levels, quality of group performance, and attitudes toward problem solving.

Small groups of students were videotaped while working on curricula identified as process-oriented. Videotaped protocols were also recorded on the same groups while they were involved in non-process activities. Comparisons were made between several measures of group performance taken before, during, and after exposure to process curricula. In addition, attitude and personality inventories were administered both before and after the use of process curricula.

Process-oriented activities seemed to mitigate the relationship between students' ability levels and performance. The emphasis on conceptual activity in process curricula is discussed as a possible explanation of this finding. Attitudes favorable to problem solving were also found to increase after exposure to process curricula. Greater increases in favorable attitudes were found in students who had used highly structured curricula.

R-3. EVALUATION OF EDUCATIONAL OUTCOMES OF PROCESS EDUCATION BY OBJECTIVE TEST

Marjorie W. Geesaman, Assistant Editor, CTB/McGraw-Hill, Del Monte Research Park, Monterey, California

Process skills (as opposed to knowledge) can be acquired in both inquiry and conventional content curricula. In fact, such skills are a requisite for success in either curriculum, although rote learning may receive more emphasis in the content curriculum.

Therefore, it is appropriate to test students in either curriculum with an instrument that measures their process skills. It is even possible that a process-oriented instrument can provide a better evaluation in a given discipline than a test designed to measure factual knowledge: Often a test of reasonable length cannot cover adequately the factual information contained in so vast a discipline as science.

A process-oriented test is constructed so that its content causes the evaluation to have reference to a particular discipline, such as science. However, the content serves only as the framework in which a skill is tested, without reference to knowledge.

To develop a process-oriented test, one first identifies the skills which are to be evaluated. Then he decides on the content which will form the framework for testing the skill and on the criterion of success by which the student is judged. Finally, items are written to comply with these established specifications. Each item provides a stimulus which enables the student to demonstrate the specified skill, even if he is unfamiliar with the content area. Therefore, a process-oriented science test which measures skills through various content frameworks is appropriate for evaluating all science students, even those who have been exposed to only one subject area within the discipline of science.

R-4. THE PROGRESS AND FUTURE OF PROCESS EDUCATION

Eugene Wheetley, Senior Editor for Science, McGraw-Hill, Incorporated, New York, New York

This paper addresses itself to: how well accepted process education is in the schools; whether there is a real trend toward implementation of process education, or whether it is primarily accepted only on the theoretical level; and how the trend is affecting the content of educational materials.

GROUP RR

MORE EVALUATIVE STUDIES

RR-1. ARE THE NATIONAL CURRICULUM PROJECTS REALLY BETTER?

Robert F. Champlin, Assistant Professor, Science Education Department, East Carolina University, Greenville, North Carolina

Recently this author read and studied 72 research reports dealing with the effectiveness of the Biological Sciences Curriculum Study (BSCS), the Earth Science Curriculum Project (ESCP), and Chemical Education Materials Study (CHEMS). Analysis revealed little to support the notion that these curricula are superior to other courses in influencing student cognitive and affective outcomes. The majority of these studies were of a comparative nature, comparing student achievement in one of the "new" curricula to achievement in a "traditional" course. Whether there is anything further to be gained from such studies is questionable. Efforts could be better spent by focusing on how best to utilize these curricula in the classroom.

The teacher, not the curriculum materials, is revealed as the critical variable in causing student learning. Furthermore, a number of studies indicate that certain types of teachers are more suited, by temperament, to teach the "new" curricula than are other teachers. Therefore, it may be wise to match teachers with appropriate curricula rather than arbitrarily assigning them.

Several studies examined the teaching act in detail, especially pupil-teacher interaction. The findings of these studies reveal some interesting behavior patterns and point the way for some potentially meaningful research. Findings dramatically support the long-held notion that the teacher dominates the so-called learning process, using intuitive rather than carefully planned approaches. Another interesting finding is that there is some disparity between what a teacher thinks is occurring in class and what is actually going on, even where he is faithfully attempting to abide by the prescribed "new" curriculum philosophy.

RR-2. ATTITUDES AND OPINIONS OF PRINCIPALS AND TEACHERS INVOLVED IN AN EXPERIMENTAL EARTH SCIENCE PROGRAM IN NEW YORK STATE

Barbara Krahm, Science Teacher, Jericho Senior High School, Jericho, New York

This study attempted to determine the attitudes of 89 principals and 105 teachers who participated in the 18 statewide Experimental Earth Science Try-Out Centers in New York during the 1968-69 school year. However, only 44 principals and 63 teachers offered appropriate responses relative to their (1) open and closed belief systems, (2) science commitment levels, and opinions as to the extent of agreement or disagreement regarding the adoption and implementation of the Regents Experimental Earth Science Curriculum. What relationships, if any, existed between these attitudes, opinions, and the control variables: (1) cost per pupil in the school district; and (2) program success ratings were also sought. The APP Theory (Attitudes, Perceptions, and Process) served as a conceptualized research framework.

Data were obtained through the *Opinionnaire*, a three-part instrument which measured the respondent's belief system, level of science commitment, and appraisal of the experimental earth science program. The Rokeach *Dogmatism Scale, Form E*, measured the belief system, while the Schwirian *Science Support Scale* measured science commitment. Part three appraised the factors involved in the: (1) adoption ease; (2) adoption influences; (3) nature of the program; (4) student learning; (5) parent reaction; (6) principal support; and (7) teacher qualifications of the experimental program.

Statistical procedures included the median, the *t* test for uncorrelated means, nonpooled variance, and the Pearson product-moment coefficient of correlation.

Findings indicate that compared to teachers, the principals: (1) were more open according to the Dogmatism Scale and scored higher on science commitment as measured by the Science Support Scale. (These differences were not significant); (2) related their perceived belief systems positively to their appraisal of the nature of the experimental program, student learning, and teacher qualifications; and (3) related their perceived level of science commitment to their appraisal of student learning, while teachers related their perceived level of commitment to their evaluation of the nature of the experimental program.

RR-3. TEACHING BY INQUIRY

Carl Hoagland, Assistant Director, Education Department, Museum of Science and Hayden Planetarium, Science Park, Boston, Massachusetts

Methods of inquiry seem to vary from situation to situation, posing a problem in the strategy or methodology used by a teacher to bring about inquiry. The sequence of steps used to bring about inquiry has not been specified, other than instances where steps in the process have been delineated, exemplified by the often referred to scientific method.

This proposal attempts to present a comprehensively documented methodology used in the selection process – a first step to teaching by the inquiry method — and to present the evaluation from the developer's perspective. Inquiry is here defined as a self-directed mode of learning in which the learner selects and organizes unique attitudes, activities, and processes for the attainment of a goal.

The methodology for the first step of teaching by inquiry – the selection process – delineates an intervention strategy for the teacher. This strategy helps learners determine their goals, break them down into operable components, and evaluate their effectiveness.

The empirical model used for the selection process incorporates: phase one to involve the stating of the methodology for the selection process; phase two to field test the methodology in the science methods course; phase three to evaluate the field test according to the developer's perspective, and phase four to make substantive modifications to the methodology based on the evaluation phase. Successive iterations through these four phases provides potential for systematic development of a methodology that will accomplish its objectives through empirical measurement control.

GROUP S

INTERESTING APPROACHES AND CONSIDERATIONS

S-1. INFORMAL METHODS OF SCIENCE INSTRUCTION IN THE PEOPLES REPUBLIC OF CHINA

Frank Swetz, Coordinator of Mathematics and Education, The Capitol Campus, Pennsylvania State University, Middletown

Educators in the Peoples Republic of China are employing a variety of formal and informal methods to instill a technological competence in their charges, particularly in their young children. Devices and schemes such as popular science-oriented children's books and required agricultural and industrial student participation supplement formal school instruction in the sciences and orient China's young to the country's national goals. The recent cultural revolution was especially directed toward increasing this type of informal education.

Results of such educational efforts indicate that the Chinese are developing a society where almost all individuals are exposed to a basic, practical science education and appreciate its application. Other developing nations and even some highly developed ones might profitably examine the Chinese experience.

S-2. SCIENCE TEACHERS AND SI

John M. Flowers, Director, Project for Metric Research, Department of Science Education, University of Southern Mississippi, Hattiesburg

The modernized metric system is a simplified and rationalized version of the system of weights and measures which science teachers have used for years. The meaning of some familiar terms and concepts has changed while others have been discarded entirely. The International System of Units, *le Système International d'Unités*, is known as SI in all languages. The basic concepts of SI will be introduced, and some of the reasons for modifying the concepts of the "old" metric system discussed.

Current research projects in teaching the metric system at various educational levels are summarized.

S-3. TELEVISED SCIENCE INSTRUCTION

Lawrence Edward Crum, Television Teacher/Field Coordinator, The Hampton Roads Educational Television Association, Norfolk, Virginia

To determine what is being taught via television, a survey was compiled in the spring of 1971. Of more than 200 television teachers who responded, approximately one out of five presents science instruction.

Twenty-nine teachers representing 18 states or territories, instruct elementary science series. Twelve teach secondary science; only four present college level courses.

While elementary science is taught more frequently on ETV, it is difficult to categorize by science field. However, secondary science breaks down as follows: five life science, four earth science, three physical science, and two general science, series. On the college level, three geology courses are offered; only one in chemistry.

As an area, science is well represented. Only social studies compares in the number of presentations, while music, mathematics and art trail in respective numbers.

S-4. SCIENCE TEACHERS AND SCIENTISTS (RESEARCHERS) WRITE SCIENCE STUDY AIDS

Henry J. Bindel, Jr., Associate Professor of Education, George Mason College of the University of Virginia, Fairfax

Four years ago the Agricultural Research Service (ARS), U.S. Department of Agriculture, Beltsville, Maryland initiated a program to involve science teachers in working with research scientists, during the summer, in writing resource materials for students. At the end of the fourth summer, when an average of 15 teachers had worked each summer with research scientists, the program was attracting national recognition.

As the coordinator of the ARS program, my prime responsibility was to have more of the materials printed and in the hands of fellow teachers and students. The actual research publications are called Science Study Aids (SSA's).

The materials are of great help to students and teachers. When it comes to distributing the materials, people are getting a return on their tax dollars. The materials are free.

Seven SSA's are now complete, and four of them will be appearing in science journals this fall.

Along with the completion of these SSA's three fellow teachers are sending in contributed papers (on specific subject areas), helping with the ARS workshop at the NSTA National Convention, and excited about their work and association activities.

S-5. MOBILE FIELD INVESTIGATION PROGRAM

Larry A. Hardt, Science Chairman, Valley View Junior High School, Omaha, Nebraska

The Mobile Field Investigation Program is a unique successful summer science course for several hundred junior high and middle school students of the Omaha Suburban Area Council of Schools. OSACS, a group of seven public and private school districts, has partially funded the program for the past three years, the balance of the cost being met by student participants.

Each morning, for one week, a bus transports approximately 20 youngsters to a site which has been carefully chosen to demonstrate some aspect of Great Plains ecology. During any given day the students may visit and study two or three different sites within a 25-mile radius. Each student is required to make certain environmental observations and record those observations in his databook. Conclusions drawn from the materials in the databooks serve as the basis for later discussions.

Noonday meals are served from the "chuckwagon," a part of the mobile laboratory which contains all of the paraphernalia needed for adequate experimentation and observation of the environment.

The program is designed to provide a wholesome balance between outdoor recreation and science education, and to do it in such a way so as to be both enjoyable and stimulating to the junior high school student. Although the major emphasis of the program is on ecology, the interrelationships between all sciences are developed as the total environment is explored. Supervision and direction of the course is provided by a staff of qualified teachers and student assistants.

GROUP SS

MORE INTERESTING APPROACHES AND CONSIDERATIONS: K-12

SS-1. EVERYTHING YOU ALWAYS WANTED TO KNOW ABOUT THE BALTIMORE COUNTY SCIENCE PROGRAM—AND WERE AFRAID TO ASK

presented by the staff of the Board of Education of Baltimore County and teachers of Baltimore County, Maryland

This multimedia report presents information about the various science programs in the Baltimore County Public Schools, how these programs evolved, ways in which they are supported by materials and services, and how they are implemented.

Slides, film loops, and tapes tell the story of children and young people at all levels of the school system working with science materials and commenting as they interact. This overview is followed by a brief description of the school system. Next is a survey of the Board of Education of Baltimore County (BEBCO) science programs and the various options available at the different levels. Major attention is given to the process of curriculum development, both during the year and in the annual summer workshops, as well as to inservice programs and other means of implementation. Described also is the way the science programs are supported by the Office of Instructional Materials, the services of laboratory aides, and by a variety of provisions for obtaining science equipment and supplies, including local school centers for special materials, a central facility for local fabrication and distribution, annual ordering and petty cash funds. The services rendered by the science department chairmen, special elementary science teachers, and the supervisors, specialist, and coordinator in the Office of Science are also depicted.

GROUP T

COLLEGE SCIENCE TEACHING

T-1. TECHNIQUES, TRAUMAS, AND TRIUMPHS IN A COURSE OF SCIENCE AND VALUES

Madeline P. Goodstein, Assistant Professor of Chemistry, Central Connecticut State College

A new general education program, initiated at Central Connecticut State College, sparked the construction of an interdisciplinary science course around the central theme of content and values of evolution as it appears in biology, anthropology, the history of science, astronomy, and science in the future.

The course itself undergoes a process of evolution during the semester from a teacher-dominated approach to a largely student-directed effort; from subject-matter lectures to student presentations and discussions. Open-ended procedures with emphasis on student participation and interaction in topic choice, discussions, debates, and oral reports stresses the process by which students develop their values as well as the values themselves. The teacher acts as a guide or resource person to help students learn to accept and to act effectively in such self-directed learning.

Evaluation is based on term papers and a midterm examination. Feedback at the end of each semester has been favorable and sometimes enthusiastic for this interdisciplinary approach.

T-2. WHAT PEOPLE EAT: AN INTRODUCTORY COURSE IN BIOCHEMISTRY

John N. Vournakis, Research Associate, Department of Biology and Education Research Center, Massachusetts Institute of Technology, Cambridge

What People Eat is a new approach to the teaching of the natural sciences, particularly chemistry, biology, and biochemistry, for the late high school and early college years. Students are introduced to: (1) some of the basic principles and techniques of science in a project-style learning situation; (2) the excitement of scientific discovery; and (3) to exigencies of planning and the conduct of independent research in a flexibly structured multidisciplinary natural science program. The study of food provides interesting and important topical issues such as the search for trace elements which render foods unfit for consumption.

To help new students begin their study of food, a common exercise provides some simple techniques and gives a preview of the type of problem to expect in the course. The Duplicate Meal Analysis experiment, in which all students determine the simple composition of one day's worth of their own food is used.

The study program is arranged in a group of 13 study units; each comprised of a collection of study guides which focus on some particular issue related to food analysis. Each unit includes such items as experiments, lab techniques, research problems, films, designs for inexpensive laboratory equipment, and textual materials. Some representative units are: visual inspection of food, caloric content of food, and microbiological analysis of food. For example, contents of the visual inspection unit include the examination of food samples by the naked eye, the light microscope, and the electron microscope; histological examination of food and other tissues; and the identification of animal and vegetable tissues, cell structure, and microorganisms.

T-3. A CONTROLLED RESEARCH APPROACH TO GENERAL BIOCHEMISTRY LABORATORY

Joyce A. Morrissey, Assistant Professor of Chemistry, Framingham State College, Framingham, Massachusetts

Most college laboratory courses do not acquaint the student with the realities of working as a practicing scientist. Whereas a complete research approach has been used by some schools to remedy this situation, this is often difficult to implement in a school with only limited facilities and technical assistance. A controlled research approach offers an alternative.

At Framingham State College biochemistry is offered at the junior-senior level to students with a background in inorganic and organic chemistry. With two years of rather classical laboratory experience behind them the students are ready to encounter a new approach.

The laboratory portion of the course stresses problem solving in the four to five experiments offered in the course of the semester. The experiments involve the application of well-developed techniques to untried systems. Each student is presented with an experimental objective sheet containing a statement of objective, a series of reading assignments on background information, and an overview of the entire experiment to help in organization of the work. In addition, the student is given a portfolio of necessary procedures, which expose the student to a cross section of biochemical techniques and allow for adaptability to any new experimental objectives.

This approach provides a transition experience between the rather classical laboratory experience of the introductory course and the full research experience often expected of the students in their senior year. Although students cannot give full rein to scientific curiosity, they are well prepared for such an experience.

T-4. A SURVEY OF THE USE AND RECOGNITION OF SCIENTIFIC SYMBOLS AND OTHER PROPOSED SYMBOLS

Gerald C. Llewellyn, Assistant Professor of Biology and Education, Virginia Commonwealth University, Richmond

This study attempted to identify proposed and commonly used science related symbols, particularly safety symbols, and to evaluate the recognition and meaning of such symbols and their potential use in the science laboratory and/or classroom. Few symbols are in use, and the availability of such symbols or proposed symbols is limited. Of the symbols presently used, most are designed primarily to attract attention rather than to portray their concept with or without accompanying words.

Currently there are several proposed but not widely accepted safety symbols with a potential for scientific use which include: "Biohazard," "Warning-Explosive," "Caustic Material," "Caution-Combustible Material," and words such as "Volatile," and "Flammable."

The commercially available "Biohazard" symbol presents some cautionary effect, but is often interpreted as a radar installation sign.

A flame enclosed in a triangle, cautioning against combustion or indicating the presence of combustible material could be radically improved by retaining the flame, deleting the triangle, and placing an "X" over the flame; meaning no sparks, no open fires, and no flames (flammable material present.)

The symbol which warns of explosive material, a ball-like device which is fragmenting, conveys its meaning well but is not really designed for laboratory use.

Words such as "Caution" and "Volatile" are normally printed in bold letters without an accompanying symbol on chemical or household containers. A symbol on the container front would indicate danger at a glance as, for example, the proposed symbol for caustic material conveys the idea of caustic contents by showing the bones of the hand partially submerged in a beaker containing a red liquid.

Although the skull and crossbones, indicating a deadly poison or toxin, is in limited use, it is a reliable symbol, even without any accompanying words.

The most common scientific safety symbol, the federally regulated "Radiation" sign, lacks a meaningful design, but is familiar to the public through extensive use. The fallout shelter symbol also ranks high in recognition, but a symbol which designates an environmental study area and is used by the national park system is often mistaken to mean protection against radioactive fallout.

While some proposed symbols may be clearly understood, others such as warnings of caution for ultraviolet light, ultrasonic waves, dry ice, mercury, high voltage, and microwaves require further delineation.

T-5. SUNSPOT SCIENTISTS

Kenneth C. Wardell, Research Professors Institute, Cohoes, New York

Astrophysics began with a mathematical concept by Galileo about satellites of Jupiter, the discovery of sunspots (1610), and the libration of the moon (1637). Contributions by sunspot scientists from the time of Galileo through the present contributions of today's astronauts are detailed.

GROUP U

SENIOR HIGH SCHOOL: THE PHYSICAL SCIENCES

U-1. STUDENT STEREOCHEMISTRY EXPERIMENTS UTILIZING INEXPENSIVE COLORED MOLDED POLYSTYRENE

Douglas A. Halsted, Chemistry Teacher, Evanston Township High School, Evanston, Illinois

A series of model-making experiments were used in order to make the study of atomic and molecular structure a part of laboratory chemistry. Chemical Education Materials Study (CHEMS) students "discovered" the efficiency of arranging electrons tetrahedrally in CBA Experiment 16. CHEMS students then did an experiment based on L. Carroll King's "Molecular Architecture," using white spheres with axial holes. Using yellow or lavender small and large teardrops, large truncated teardrops, and white partial spheres (all shapes molded with axial holes), connected by rubber bands or by using three different shaped axis and plastic tubes, each student constructed orbital and hybridized orbital models of HF, H_2O, NH_3, CH_4, CF_4, BF_3, BeH_2, BeF_2, F_2, O_2, N_2, C_2H_6, C_2H_4, C_2H_2, C_3H_8, C_6H_6, C_6H_{12}, and related compounds. Other experiments which employed model-making techniques were also used.

CHEMS students balanced their first equations with space-filling models.

In each experiment except CBA 16, the teacher inspected each model assembled by the student and initiated a check sheet. Thus a topic which is typically a "teacher talk" unit, becomes an opportunity for individualizing instruction.

These CHEMS students had a good three-dimensional feeling for what they read in the chemical literature as well.

U-2. CHEMISTRY FOR CHANGING TIMES: A NON-TRADITIONAL COURSE FOR THE NON-SCIENCE STUDENT

John W. Hill, Professor and Chairman, Department of Chemistry, Wisconsin State University, River Falls

Introductory chemistry courses have moved ever nearer to physical chemistry and to physics. The course content has become at the same time more rigorous and more asbstract. This trend has extended even into the texts for nonscience students. Concomitant with these trends there has been a decrease in the number of chemistry majors, a decline in enrollment in most chemistry courses, and a rise of "antiscience" among many students of the humanities and social sciences. While these developments have not been simple cause and effect, the author believes that they are not unrelated.

Several groups and individuals have called for new chemistry courses for nonscience students. The author has had a successful course of this nature in operation for two years. It is designed to: (1) extend chemical education to a wider audience by attracting more students; (2) involve them in working through just enough cases so that they will incorporate in their life style a sense of how a chemist approaches and solves problems; (3) induce them to relate chemical problems to their own life and living and to understand the significance to these problems; and to (4) excite students to an interest in the subject which is completely open-ended in content—as they take the course and, in time, as they leave the course to live the rest of their lives.

Course enrollment has doubled over a two-year period. That student interest continues after the course is evident from the fact that students have enrolled in additional chemistry courses, joined environmental action groups, collected samples for monitoring of air and water quality, and have helped form and man a "hot line" telephone service for helping other students with drug problems.

U-3. AN ALTERNATIVE IN HIGH SCHOOL PHYSICS

John E. Euller, Science Department Chairman, and James E. Smith, Physics Teacher, Eastridge High School, Rochester, New York

At Eastridge High School a physics program that is highly adaptable to a variety of student needs and interests has replaced former organization (four classes of New York Regents physics and one class of Physical Science Study Committee, PSSC, physics) with only a single course, designated as "physics." The internal organization of this course enables a student to follow stream 1 which is PSSC physics third edition; stream 2 which is New York Regents physics, and stream 3 which is Project Physics. Individualized materials are available for all streams and all proceed simultaneously.

The traditional lecture-demonstration has been abandoned, as well as the fixed laboratory period, and test day. Within a six-week grading period students work individually at their own pace, only being required to complete all basic assignments within that period.

The role of pupil has changed from passive receiver of information to active participant in the planning and process of his own learning, while the role of the teacher has changed from dispenser of information to planner and organizer of learning activities.

Aside from these fundamental changes we have observed that the physics room has become a workshop where you "do" physics instead of just hearing about it. Student morale is high and discipline problems have disappeared, one-to-one conferences between teacher and pupil average about one per week, and group learning under controlled conditions is now extended to all parts of the course. In two years enrollment has increased approximately 20 percent, many of the new students being girls in the upper ability levels. Students perform better on our own tests, but we do not yet have enough data from external achievement tests for comparison.

U-4. THE ENVIRONMENTAL IMPACT OF NUCLEAR POWER: A MINI-COURSE

John J. McDermott, Science Education Adviser, State Department of Education, Harrisburg, Pennsylvania

The Environmental Impact of Nuclear Power (EINP) course, prepared by the Divison of Science and Mathematics, Pennsylvania Department of Education, under contract to the U.S. Atomic Energy Commission presents a study of the need for increased electrical generating capacity and of the resulting environmental effects of meeting this need in an informative, unbiased manner, allowing the student to gather pertinent information and draw his own conclusions.

The committee responsible for developing this study included educators, nuclear engineers, geologists, ecologists, fisheries biologists, physicians specializing in nuclear medicine, conservationists, and health physicists.

Traditional methods of power production including such examples as mine mouth operations and construction of plants with increased generating capacity cannot control the environmental damage or compensate for the rising costs and decreased availability of fossil fuels. The related problems of thermal pollution, radioactive gas discharges, disposal of radioactive wastes, and the possibility of accidental exposure to radiation increase with the rapid increase in nuclear generating capacity effected to meet power needs.

Opposition to nuclear stations among the informed and uninformed has increased, but the average citizen is not equipped to decide upon the benefit-to-risk ratio associated with nuclear generating stations. He is beset by opposing reports from conflicting interest groups.

Since an informed public is vital to any solution of this problem, this course provides a view of the need for increased power and the environmental price which we must be willing (or unwilling) to pay.

A minicourse of this type may be inserted into currently existing science or social studies courses, thus reaching a great number of students in a relatively short time. It could also be offered as a short independent course to interested students or to adults as part of an evening school program. It is hoped that this course will have a lasting impact in producing a well-informed citizenry who can and will use its democratic franchise wisely.

U-5. NUCLEONICS IN HIGH SCHOOL

Arnold Friedman, Teacher, Physical Science Department, Bayside High School, Bayside, New York

A one-semester, comprehensive course in nuclear science at Bayside High School, Queens, is described. Topics examined are: (1) radioactive decay and transmutation; (2) decay schemes for all modes; (3) mathematics of decay-rate (activity), decay constant, half-life determinations, and problem-solving techniques; (4) radiation and matter interactions—energies of emissions, ranges, penetrating and ionizing power, pertinent mathematical considerations, and problem-solving techniques; (5) artificial transmutation—equations, accelerators, and fundamental particles; (6) nuclear energy—fission and fusion; (7) radiation biology—doses and effects; and (8) radioisotope utilization.

In addition, the laboratory work includes operation of detection instruments, factors in Geiger counting, half-life determination, absorption, and radioisotope utilization.

Materials, methods, teaching aids, and time considerations in teaching are also discussed.

GROUP UU

SENIOR HIGH SCHOOL: CHEMISTRY

UU-1. MINI-COURSES, MINI-EXPERIMENTS, AND MODULES: INSTRUCTIONAL CHARACTERISTICS OF THE INTERDISCIPLINARY APPROACHES TO CHEMISTRY (IAC) PROGRAM

Marjorie Gardner, Professor, Chemistry Department, University of Maryland, College Park

Upon the request of chemistry teachers and science supervisors in the metropolitan Washington-Baltimore area, chemistry professors and high school teachers began the Interdisciplinary Approaches to Chemistry (IAC) program in spring 1970. This program consists of eight interchangeable, instructional modules: *Reactions and Reason:* An Introductory Chemistry Module; *Diversity and Periodicity:* An Inorganic Chemistry Module; *Form and Function:* An Organic Chemistry Module; *Molecules in Living Systems:* A Biochemistry Module; *The Heart of the Matter:* A Nuclear Chemistry Module; *Earth and Its Neighbors:* A Geochemistry Module; *The Delicate Balance:* An Environmental Chemistry Module; and *Communities of Molecules:* A Physical Chemistry Module.

The instructional characteristics of the program were carefully defined in advance through the interaction of classroom teachers and university professors. The IAC program, which seeks to popularize chemistry study at the high school and introductory college levels, requires flexibility in decision-making on the part of the teacher and school systems for adapting to local audiences and environments; a strong emphasis on relevance, interdisciplinary themes, and investigative skills with at least 50 percent of the student's time spent in the laboratory; and more enjoyable student activities in a program easily modified for conventional classroom use or for self-pacing. The program operates on the principle that motivated students who enjoy chemistry will also learn more of the important concepts and retain them longer. Expected student performances have been stated in behavioral terms. Major concepts of chemistry have been identified for each module, and each major concept is presented from different points of view in several modules. The testing of the program in the schools is being carefully monitored for student and teacher response in all domains of learning.

UU-2. DEVELOPMENTAL EVALUATION IN THE IAC PROGRAM

Harry Gemberling, Teacher, Duval High School, Lanham, Maryland

Preliminary elements, mainly laboratory investigations, for the IAC (Interdisciplinary Approaches to Chemistry) program for high school chemistry were taught by module authors to a 1970-71 inservice institute of area teachers. These participants were invited to evaluate the appropriateness of the developing IAC materials as an integral part of their course assignments. Evaluative feedback from this institute provided guidance for the first draft development of each module for test teaching to two 1971 pilot summer classes of high school students. Based on pilot student and classroom teacher evaluation, revision by local teacher teams continued on each module during the summer. Second draft modules were completed and are now being taught to approximately 800 high school and community college students in the Baltimore-Washington area.

While students have been carefully monitored on their relative success in meeting the behaviorally stated cognitive and psychomotor objectives for each module, the broader (and often overlooked) area of possible student interest and attitude changes toward science-related concepts has received strong attention. Changes in both student knowledge and interest are being continuously compared with control groups. Innovative and effective ways of evaluating both the IAC program and its students are in the formative stages of development.

UU-3. HIGH SCHOOL CHEMISTRY: CAN IT BE INTERESTING AND INFORMATIVE TOO?

James E. Huheey, Associate Professor of Inorganic Chemistry, University of Maryland, College Park

The IAC program currently being developed in the chemistry department, University of Maryland is an attempt to make chemistry more interesting and attractive to the average high school student. The Interdisciplinary Approaches to Chemistry (IAC) program stresses the unity of science and the unifying multidisciplinary areas of chemistry: biochemistry, environmental chemistry and geochemistry; while keeping the traditional areas of study: inorganic, organic, nuclear, and physical chemistry as basic building blocks for departure to interdisciplinary areas. However, even these conventional areas have novel subject matter: the chemistry of hemoglobin and metalloenzymes in the inorganic module, the chemistry of sex attractants and chemical warfare by insects in the organic module, and various aspects of the chemistry of an automobile in the physical module.

Unifying themes of the program are that (1) chemistry is an experimental science; (2) chemistry is a quantitative science; and (3) chemistry is a developing science which is new, relevant, and applicable to the problems of today.

UU-4. LABORATORY EXPERIMENTS IN THE IAC PROGRAM

David L. Martin, Assistant Professor of Biochemistry, University of Maryland, College Park

The IAC program is activity oriented. Laboratory experiments are incorporated directly into the text to provide maximum support for the concepts as they are developed. The laboratory program includes short (15 minute) nonquantitative "mini-experiments," longer experiments requiring a full class period, and some experiments which take place over a period of days. The experiments frequently deal with materials common to the students' everyday experience such as soaps and detergents, meat tenderizers, nylon, and automobiles. The laboratory deals not only with the reaction of individual molecules but also with the structure of macromolecules and interaction among molecules. While the thrust of the experiments is directed toward supporting and developing the students' grasp of chemical concepts, the experiments also develop a number of skills such as various kinds of measurement techniques (weighing, titration, pipetting) and presentation and analysis of data by graphing.

GROUP V

SENIOR HIGH SCHOOL: LIFE SCIENCES AND ECOLOGY

V-1. THE CLOSED ECOSYSTEM: AN ATTEMPT TO INDIVIDUALIZE COGNITIVE AND AFFECTIVE INSTRUCTION IN THE LIFE SCIENCES

David C. Brummett, Doctoral Candidate in Science Education, University of Virginia, Charlottesville

The construction and observation of a closed ecosystem (microcosm) provides a setting for the individualization of cognitive and affective instruction in the life sciences. This system can be a prime instrument for developing understanding and concern for the delicacy of the balance and interaction between organisms in natural communities.

The ecosystem, composed of aquatic plants and animals placed in a one-gallon glass jar, is developed from organisms collected from local ponds by the students. The environment is arranged to resemble a pond including all elements considered necessary to produce a balanced system.

The excitement of the students during the sealing and early observation of the closed ecosystems stimulates student interest in experimentation to investigation in small groups and in independent research which may lead toward class understanding and appreciation of the biological world.

Possible cognitive objectives include the understanding of (1) the fragility of community relationships; (2) the cyclic nature of the ecosystem and the planet earth; (3) the relationships between the closed ecosystem, natural communities, and the entire planet; (4) the behavior of organisms and their adaptation to the environment; and (5) cause-effect relationships.

Possible affective outcomes include awareness of personal worth and accomplishment, appreciation of the delicacy of the natural world, ego-involvement in the study of biology, and increased respect for individuals of different abilities and life styles.

V-2. AN ENVIRONMENTAL ODYSSEY

Felicia E. West, Assistant Professor of Education, P.K. Yonge Laboratory School, University of Florida, Gainesville

This paper describes how a series of field activities are being utilized in an environmental study program at the University of Florida laboratory school. The primary goal is not to develop environmental awareness alone, but to actively involve students (grades 9-12) as they study environmental problems in Alachua County, Florida. The paper describes the development and implementation necessary for utilizing field studies as a source for laboratory investigations so that students can develop needed skills. Emphasis on better utilization of the county's human resources has progressed concomitantly with the emphasis on field activities. Individualization is also stressed as each student chooses a particular environmental problem and proceeds at his own pace.

Activities available for student involvement are illustrated through slides of (1) field studies of two wooded areas, a pond, and a creek on the campus; (2) field trips to the east and west coasts of Florida; (3) a field trip to an offshore island in north Florida; (4) an aerial overview of the county; (5) open laboratory situations in which the student conducts indoor investigations of the campus areas; and (6) large group meetings devoted to films and lectures.

The culminating activity requires each student to apply his newly learned skills in studying a specific problem of his own choice during the last six or seven weeks of school. Hopefully, this will be a problem of Alachua County, but students may elect to study problems of nearby areas in the state. A brief summary of student reactions to the program is presented.

V-3. BIOTELEMETRY AND BIORHYTHMS IN THE HIGH SCHOOL

Lewis E. Love, Great Neck North Senior High School, Great Neck, New York

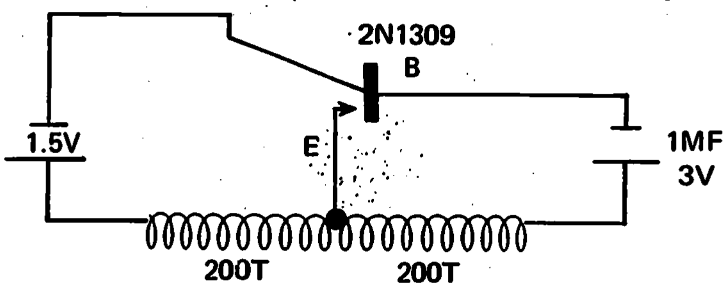
A temperature-sensing device based on a McKay-type radio frequency transmitter was constructed. The basic components of the transmitter were: (1) a germanium type PNP transistor 2N1309; (2) 1.5 volt Union Carbide cell, type 301; (3) 1 micro farad capacitor (1mfd) with a 3 volt rating; and (4) a hand wound coil from No. 39 copper wire that is shellacked for insulation. The signals produced by the transmitter can be detected by any commercial transistor pocket radio.

The transmitter was tested on two rats and a rooster.

It is placed inside the animal. The rhythm to be studied was deep body temperature on a light-dark schedule of L12:D12 (12 hours light, 12 hours dark).

The device can be built by most students and is easily prepared to withstand the rigors of remaining in the internal environment of a vertebrate animal. It can be calibrated and is accurate enough for a student to demonstrate the periodicity of deep body temperature. The device is not harmful to the animal and will give continuous signals as the animal moves freely in the cage.

The experiment is valuable in its melding of basic physics and electronic ideas with those of biology. Students gain experience in making and calibrating a measurement device, conducting an interesting experiment, and gaining some understanding of an important circadian rhythm. Calibration charts can be made. Below is a circuit diagram.



V-4. MARINE ECOLOGY FOR THE SECONDARY SCHOOL

Richard A. Leavitt, Chairman, Science Department, Northfield Mount Hermon School, Mount Hermon, Massachusetts

This paper describes the program in marine biology offered in March 1972. The recent interest in marine biology among the secondary school science students throughout the century should make this brief but intensive study valuable. Evaluations of goals, scientific value to the students, and the overall problems concerned with such an undertaking are presented.

V-5. THE CHARLES DARWIN STATION ON THE GALAPAGOS ISLANDS

John H. Rosengren, Professor of Biology, William Paterson College, Wayne, New Jersey

No abstract submitted.

GROUP W

JUNIOR HIGH SCHOOL: TEACHING STRATEGIES

W-1. THE SENSES AS DATA COLLECTORS: AN ENGLISH-SCIENCE INTERDISCIPLINARY APPROACH

John D. Loosman, Science Teacher, Wellwood Junior High School, Fayetteville, New York

As part of an interdisciplinary teaching team (English, science, mathematics, social studies) it is a constant objective to look for meaningful interactions between science and the other disciplines.

Activities which incorporate sensory observations into accurate descriptive writing techniques are excellent situations for English-science interaction.

Focusing on students' senses as data collectors provided for skill development in both subjects, along with an increased awareness of the stimuli that are constantly flooding their senses.

Sixty seventh-grade students, scheduled for a 90-minute time block with their English and science teachers, worked through a series of activities designed to emphasize the ability of each of their five senses for conveying data to them about various objects.

Physical characteristics of rocks and minerals are introduced, along with properties of liquids, during activities centered on sight and touch.

Cassette recorders are used for sounds in the school environment. While one group was recording sounds, the others, in English class, used recorded sounds as ideas for composition writing.

Experiences with the sense of smell and taste and how they are related completed the activities for the individual senses. In English, emphasis was placed on poetry and descriptive writing by people who are handicapped, and therefore, must rely on other senses for their interpretation of objects.

A hike through meadow and forest communities encouraged the utilization of all senses to collect observations for descriptive writing exercises and also encouraged ecology understandings.

Additional field experiences throughout the year provided opportunities to describe seasonal changes in the forest and meadow communities, and unlimited topics for English writing assignments with plant and animal descriptions a la Thoreau.

W-2. INSTRUCTIONAL EFFICIENCY IN AN IDENTIFICATION KEYING TASK

John E. Lutz, Associate Professor, The Campus School, State University College, Oswego, New York

This study was designed to investigate the communication and problem-solving efficiencies of three instructional strategies with fifth-, sixth-, and seventh-grade learners. The experimental task was an identification keying problem and required an instructional medium of three-dimensional objects. The purposes of the study were to find support for Snyder's (1968) prototheory of tutor-learner efficiency, to clarify previous related research (Lutz, 1970), and to provide information on how one instructional medium might be used effectively and efficiently.

Allometric Scores were calculated from common mental ability and achievement test scores for all fifth-, sixth-, and seventh-grade students in The Campus School of the State University of New York College at Oswego. One hundred and eight students from three grade levels and four aptitude levels (defined by Allometric Score ranges) were assigned to three treatment groups.

The treatment groups were defined by the degree of structure of the instructional strategy presented by audiotape to the learner. The unstructured instructional strategy offered only an overview of the task to the learner; the semi-structured strategy included the overview and an operational rule for the keying task; the structured strategy consisted of the overview and rule, plus specific directions for successful completion of the task.

Preliminary findings have shown that certain learners, identified by an Allometric Score, were able to complete the task with greater verbal efficiency than were other learners; the probability of solving the problem was different for learners at different aptitude levels with different amounts of tutor-learner verbal interaction; and learners who were more efficient in verbal interaction with the tutor also initiated more of the interaction than did other learners. A trend suggested by the preliminary findings was that the unstructured strategy was the most verbally efficient, followed by the semistructured, and then the structured instructional strategy.

W-3. A LEARNING ACTIVITY PACKAGE APPROACH TO JUNIOR HIGH SCHOOL SCIENCE

Jerry Cunningham and Ross Iverson, Science Teachers, B. R. Miller Junior High School, Marshalltown, Iowa

Due to the promotion of science in the late 50's and 60's through new and better equipment and better trained teachers, there were many changes in the junior high school science programs. New approaches for a laboratory-oriented teaching method, such as recognizing the individual students, and attempting to meet the needs of students as well as those of society, represent some of these changes. While the new materials and methods are very good, they are not appropriate to all situations.

The Learning Activity Packages developed in our program grow out of a philosophy and procedure. The philosophy had two main points: Every student has the right to a successful and satisfying experience; and while some experiences have value for all and can be held in common, other experiences do not have value for all. As a result the Learning Activity Packages have a basic core of required activities and a set of supplemental activities. The procedure evolved from the traditional and complete continuous progress approaches. The modified continuous progress features much laboratory activity, immediate feedback, appropriate group activities, a set of deadlines, a chance to accelerate, and an opportunity for personal success for every student.

A learning activity package includes everything needed for a unit of study: all books, pamphlets, periodicals, visual aids, live and preserved material, and evaluation devices. The packet which the student receives is a set of instructions which includes: required activities, both soft and hard lab; supplemental activities, both soft and hard lab; grade requirements, audiovisual materials; behavioral objectives, important facts and concepts, and special instructions for activities not satisfactorily covered in an available text.

W-4. KINDLING THE UNDERMOTIVATED STUDENT

Kenneth Bobrowsky, Board of Education of the City of New York

During five successive summers, groups of students from the "inner city" of New York participated successfully as junior scientists in National Science Foundation sponsored programs, conducted at the Wave Hill Environmental Center and at the Bank Street College of Education.

The hypothesis was that underachievers from disadvantaged areas, with innate ability, could succeed when their interest was kindled and when initial experiences were drawn from the realm of the learner.

Students traveled by bus for one hour each way to and from the learning centers. Of the 14-23 youngsters in each year's group, few were absent or tardy, and there were no dropouts.

From interviews and evaluations concluded at the end of each summer, all participants indicated that they hoped to attend college and over 80 percent indicated an interest to pursue science or a science-related career. Each student indicated a readiness to repeat the experience if given the opportunity in another year.

Many of the successful learning techniques and firsthand science experiences gained from extended association with "inner-city" learners are now incorporated in a course of study.

GROUP WW

JUNIOR HIGH SCHOOL: INDIVIDUALIZED INSTRUCTION

WW-1. AN OVERVIEW OF THE INTERMEDIATE SCIENCE CURRICULUM STUDY (ISCS)

Stewart P. Darrow, Field Trial Coordinator, Intermediate Science Curriculum Study, Florida State University, Tallahassee

The Intermediate Science Curriculum Study (ISCS) program, developed under the college of education at Florida State University, is aimed at students in the middle grades of seven, eight, and nine. It consists of texts, laboratory equipment, self-evaluation materials, student response books, teacher guides, and test resource booklets.

The ISCS plan is based on the belief that science instruction in these important middle years should aim at general education to give the student a taste of the structure of science and the way scientific knowledge is gained and to give him skills and concepts that will help him interpret everyday events in the world around him. The three-year sequence directs the student's attention first to a wide variety of fundamental phenomena. He learns to relate these situations to each other and to develop tools for solving the problems that are posed. After developing skills and concepts with the simpler ideas, he tries to apply them to the more complex situations outside of the classroom.

Fundamental to the ISCS method of instruction is the concept of individualization. The materials are designed for student pacing and for choice of different pathways as the student moves through the sequence. He investigates phenomena, as far as is practical, in a "hands-on" laboratory environment and responds to direct questions on the basis of his own discoveries.

The role of both student and teacher is thus changed. No longer is the teacher simply a purveyor of knowledge, nor is the student forced into a lockstep with other members of the class. Instead, the teacher is free to interact with independently working students, giving clues, answering questions, and serving as an indispensable resource when difficulties arise.

WW-2. WHAT ARE THE PREPARATION NEEDS OF A PRACTICING ISCS TEACHER?

Charles E. Richardson, Head of Science Department, Belzer Junior High School, Lawrence, Indiana

Can we effectively change our model of science teaching from the teacher-directed, teacher-managed, teacher-centered science program? Can we have students doing different activities at different rates at different times with different equipment requirements? Can we implement a prepackaged science curriculum developed by someone else and salvage enough ego satisfaction from teaching to remain sane? In short, can we shatter "tradition" and still maintain a reasonable sense of mental balance?

Yes, but the skill and the teaching strategy are different, and the training needs of the practicing ISCS teacher are different. This paper deals with the needs for training and/or retraining of practicing teachers for more effective teaching of ISCS.

WW-3. A CLOSE LOOK AT AN ISCS INDIVIDUALIZED TEACHER PREPARATION MODULE

George Dawson, Assistant Professor, Department of Science Education, Florida State University, Tallahassee

This paper focuses on one module of the ISCS Individualized Teacher Preparation Modules to illustrate specifically how a module is used. The module, Classroom Organization, is described as illustrative of the modular program. The format of the modules, which is similar to the student materials, with core and excursion, is explained. The explanation includes examples of how a teacher can vary the scope and sequence of the content of any module studied.

"Hands-on" experience with an activity from the Classroom Organization is a component part of this presentation.

WW-4. INDIVIDUALIZED TEACHER PREPARATION PROGRAM

William R. Snyder, Co-Director, Intermediate Science Curriculum Study, Florida State University, Tallahassee

This presentation describes efforts by the Intermediate Science Curriculum Project to produce individualized instructional materials for the training of ISCS teachers. A set of nine modules composing what is formally known as the Individualized Teacher Preparation Program are designed to be used in preservice and inservice training of teachers where the rationale, teaching strategies, and the required content of the ISCS program are being considered. This paper briefly reviews some problems of teacher education and discusses how the Individualized Teacher Preparation modules can make a contribution in resolving some of those problems. Use of the modules by teacher educators is recommended for a variety of settings.

GROUP X

UTILIZING THE COMPUTER

X-1. USING THE COMPUTER-BASED RESOURCE UNIT AS AN AID TO INDIVIDUALIZED SCIENCE EXPERIENCES

Herbert G. Koenig, Chairman, Mathematics-Science Department, Royalton-Hartland Central School, Middleport, New York

The basic concept of the computer-based resource unit (CBRU) was developed by Robert S. Harnack at the State University of New York, Buffalo, in 1963. In 1965, BOCES #1 of Erie County became involved and the first six units were constructed and placed on computer tape for later retrieval. Thirty-one units were developed by expert teachers from every area of the curriculum.

Through the resource guide, which is generated from the computerized unit, unit teaching, individualized instruction, and pupil-teacher planning are encouraged. This presentation describes one instance where the CBRU was used as a research technique in the area of individualizing science instruction.

The study required 28 fifth-grade teachers from separate rural schools in western New York to be assigned randomly to four treatments. All teachers used a resource guide generated from the computer based resource unit *Solar System and Beyond* to plan a teaching unit. Guides for Treatment One provided no help for individualizing instruction; Treatment Two guides fostered individualized science activities; Treatment Three guides stressed individualized reading activities; and Treatment Four combined individualized reading and science activities. A pretest, posttest, and questionnaire were administered to 856 students. Teachers maintained time and activity logs and completed a questionnaire.

Three main conclusions which emerge from an analysis of the data and subsequent findings are: (1) Individualized reading and science activities incorporated in a teaching unit did not significantly affect students' science achievement (at the 0.05 level of confidence) when measured with the instrument used in this study, although students and teachers alike rate achievement as satisfactory, or as being positively affected by individualized reading and science activities. (2) Reading activities should be included in a science-oriented teaching unit. (3) The implementation of unit teaching and individualized instruction seems to be aided by the use of a computer-based resource unit.

X-2. COMPUTER-EXTENDED LEARNING IN THE PHOENIX UNION HIGH SCHOOL SYSTEM

Norbert J. Konzal, Science Supervisor, Phoenix Union High School System, Phoenix, Arizona

A system owned time-sharing computer system is used exclusively in mathematics and science instruction in 10 high schools in the Phoenix Union High School district.

Computer-extended learning is defined as that experience afforded by the computer above normal science instruction. District teachers and students have access to the computer via remote teletypewriters located in each of the school's science departments. Students program problems in chemistry, biology, physics, and earth science using Basic language. Simulations and games in chemistry and biology and a special remedial mathematics program are also available for students.

The system has additional modes of operation, Fortran, using keypunched cards, and educational Basic, using mark sensed cards. Students program problems on cards in either language and send them to the computer center where they are processed at night by a college student operator and returned to the student the next morning.

Applications of computer-extended learning are illustrated and discussed. Typical teacher and student developed programs are presented.

X-3. AUTOMATED ANALYSIS IN YOUR COMMUNITY HIGH SCHOOL

R.F. Comte, Coordinator of Continuing Education, Technicon Corporation, Tarrytown, New York; C. Carl Buessow, Assistant Headmaster, Hackley School, Tarrytown, New York; and James F. Melville, Jr., Dean of Mercy College, Tarrytown, New York

This paper offers a unique concept for teaching automated analysis in the high school curriculum, initiated in fall 1972 at Hackley School in Tarrytown, New York. It is a joint project between industry, high school, and college.

The program encompasses eight hours of automated analysis techniques concerning principles and concepts, plus an additional two hours–one hour of medical profiling, and one hour of environmental applications to automated analysis.

Upon completion of the classroom theory of principles and concepts, the students attend classes at Mercy College in Dobbs Ferry, New York. Here, the students have an opportunity to adjust to college atmosphere, a new learning experience, and at the same time, apply practically the theories they have learned during the classroom exercises.

At the college the students are taught environmental methods for evaluating the data which they obtain. The AutoAnalyzer is used to run the test samples. Since Mercy College borders on the Hudson River, water samples from the river are analyzed by the students for amounts of nitrate and nitrite. From January to May 1972 Hackley students took samples and actually ran and analyzed their samples on the AutoAnalyzer.

It is hoped that the exposure of potential scientists of this country to automation, college life, and the environment will better prepare them for their future.

GROUP Y

ELEMENTARY SCHOOL SCIENCE: THEORY INTO PRACTICE

Y-1. CANCELLED

Y-2. THE PROCESS APPROACH AND THE ADVANTAGED CHILD

Jerry B. Ayers, Associate Professor of Education, and Geraldine S. Connor, Instructor, Tennessee Technological University, Cookeville

Though much attention has been given to the acquisition of science process skills by disadvantaged children, few studies have given emphasis to children who came from "advantaged backgrounds" (children who came from families with above-average incomes and are achieving satisfactorily in school). The study attempted to investigate the effectiveness of the use of the AAAS *Science – A Process Approach* (S-APA) in a school attended largely by children from advantaged backgrounds.

S-APA was adopted as the science program in grades K-2 of the Tech Campus School in fall 1969. Over 90 percent of the children in attendance at this school came from homes that were classified (according to the *Hollingshead Two Factor Index of Social Position*) as advantaged. Classroom teachers taught the program during the 1970-71 school year in the normal manner and a random sample of 60 children (total N=143) was chosen for detailed evaluation, utilizing the competency measures designed for S-APA. The relationships of S-APA achievement to age, sex, standarized test scores, and length of time in the program were studied.

Results of the study indicated that there were no significant differences in the level of achievement by boys and girls; there were no significant differences in the attainment of objectives for students in the first grade for those who had, and those who had not been, exposed to the program in kindergarten; the children as a group were achieving at a level comparable to those who studied the Third Experimental Edition of S-APA; and there were significant positive relationships between level of achievement in S-APA and readiness scores, IQ, and arithmetic achievement. S-APA appears to be a versatile science program that is satisfactory for both advantaged and disadvantaged children.

Y-3. THE INSTRUCTIONAL AND THE EXPERIMENTAL APPROACHES TO ELEMENTARY SCHOOL SCIENCE

John F. Newport, Associate Professor of Education, Southwest Missouri State College, Springfield

The different philosophies in science education today mainly concern whether the teacher or pupils structure and pace educational ends and means. The structuring of ends and means by the teacher leads to a certain approach to science education (instructional), and the structuring of ends and means by pupils lends to an entirely different approach (experiential). The major differences are readily apparent if one contrasts the two approaches item by item.

In the instructional approach: (1) the teacher sees students as a product of external events to be molded and directed; (2) the teacher sets up an image of what children should be like and then, with reinforcement techniques, molds them to become that image; (3) the ultimate purpose is the acquisition and storage of knowledge and skills, and their subsequent retrieval and use; (4) children are primarily consumers of information; (5) products and processes of science are ends of education; (6) the structure of the subject matter, the unifying themes, is taught; (7) children respond to the teacher or to programmed materials; (8) the learning environment leads to efficient mastery of specific objectives; (9) the teacher perceives the helping task as a matter of controlling, manipulating, coercing, blocking, and inhibiting; and (10) children are expected to master certain objectives before moving on to the next set.

In the experiential approach: (1) the teacher sees students and their behavior as essentially developing from within; (2) the teacher lets children choose their own ends, but helps them to become the best choice-makers possible; (3) the ultimate purpose is the development of children's intellectual, language, and social potential; (4) children are primarily producers of information; (5) products and processes of science are vehicles through which other ends are met; (6) the child is presented with situations where he actively creates structures which fit his conceptual development; (7) the learning environment responds to children's initiation and exploration; (8) the learning environment offers many opportunities for children to explore and interact with objects and peers with a minimum of imposed structure; (9) the teacher perceives the helping task as one of freeing, assisting, releasing, and facilitating; and (10) breadth of problem-solving opportunities is considered more important than complete mastery.

Y-4. THE THEMATIC ELEMENTARY SCIENCE INDIVIDUALIZED STUDIES (THESIS) PROGRAM

Harry Zuurbier, Director, The RISE Project, Bishop Carroll High School, Calgary, Alberta, Canada

In man's development the search and discovery of his own humanity comes first. A child wants to play, and through play it learns as by instinct. This relationship between play and learning has been investigated by Groos and Hall. Schiller and Spencer have developed a surplus energy theory in which play is considered to be an urge to explore; to learn. Such theories necessitate for the individual a selective freedom, and a personal trust, as advocated by Froebel, Pestalozzi, Dewey, and Montessori. Under these circumstances learning becomes a student commitment as expressed in the intellectual and emotional forms; knowledge can be acquired for its own sake, according to interests, and often in clusters or "anchorage points," according to Ausubel.

To accommodate these interests, curricular selections in the form of nongraded learning situations must be provided, as well as the acceptance of divergent learning levels and rates. Such reform suggests a framework that is interdisciplinary by nature and open by intent. Sears and Kessen (1964) proposed a four-theme science framework in their position paper for the AAAS (Energy, Matter, Life, Universe).

The THESIS-Program consists of such a four-theme framework with multidimensional learning selections from existing instructional media. While it has all of the positive attributes of a truly individualized program, the student's place and progress are being determined by the unique THESIS CONTINUUM PLACEMENT CRITERION. The progress results have been computer analyzed during the second part of the 1969-71 implementation.

GROUP YY

ELEMENTARY SCHOOL SCIENCE: INDIVIDUALIZED INSTRUCTION

YY-1. INDIVIDUALIZED LEARNING UNITS: A FOUR-STEP APPROACH TO INDIVIDUALIZED INSTRUCTION

Joseph Abruscato, Assistant Professor, University of Vermont, Burlington

In recent years the need for science instruction, at all levels, to respond to individual differences has been heavily emphasized. Unfortunately, much of the discussion has been theoretical, with little attention to a practical step-by-step approach to the preparation of individualized procedures. A goal-referenced approach to individualized instruction, which has been well received by both elementary and secondary school teachers, has been developed.

Teacher prepared Individualized Learning Units (ILU's) reflect teaching abilities with respect to (1) preassessment; (2) preparation of behavioral objectives; (3) development of procedures; and (4) development of evaluation techniques. Individualized Learning Units have been developed by teachers with respect to (1) enrichment; (2) remediation; and (3) an alternative to the usual mode of instruction. The success of the units is largely due to the manner in which teachers apply the basic principles of reinforcement, repetition, logical sequence, and active student involvement, to the development of individualized procedures.

YY-2. PROPOSAL FOR A SCIENCE TEACHING EDUCATION PROGRAM IN INDIVIDUALIZATION (STEP-IN)

Albert P. Nous, Assistant Professor of Education, Department of Elementary Education, University of Pittsburgh, Pittsburgh, Pennsylvania; and Mitchell E. Batoff, Associate Professor of Science Education, Jersey City State College, Jersey City, New Jersey

This proposal attempts to improve elementary school science teaching and learning by developing competencies to individualize experiences in the learning of science. The process of individualization involves the assessment of a child's needs within the learning environment and the development and provision of resources and alternatives to meet these needs.

STEP-IN is comprised of four phases: Phase one, introduction to aspects of child development and education, attempts to make individuals more accommodative to patterns of child behavior and to utilize this knowledge in the assessment learning process. Phase two identifys and develops specific resources and alternative procedures for an individualized environment through the "unit box" approach. Phase three, examines and categorizes resource objectives and flexibility, providing a pool of resource experiences to promote particular concepts and skills for a student. Phase four integrates previously introduced teacher competencies for the individualization of instruction into the daily planning of learning activities, selected from the Pittsburgh model.

In an individualized environment varied resources, such as programmed material, filmstrips, and student-directed investigation on various science content, allow for a child's initial exposure, reinvestigation, and extended study, with alternative procedures suitable for varied sensory modes or patterns of logical thinking. Appropriate models of learning and evaluations of and for a child change constantly as he accumulates experience.

Resources constructed by participants are examined for potential integration and use within an individualized setting, based on how well the activities promote competency, autonomy, and socialization.

Phases of STEP-IN are cumulative in that the resources developed in previous phases are integrated into a system of alternatives, which allows for individualization and openness in learning.

Individualization is not a curriculum but a process of dealing with individual learning. The key to the implementation of these processes is the accommodative teacher.

GROUP Z

ELEMENTARY SCHOOL SCIENCE: SCIENCE AND SOCIAL AWARENESS

Z-1. WHERE ARE YOU? RELATIVITY IN THE UNIVERSE AND IN THE FAMILY

Linda Jones, Assistant Professor, San Fernando Valley State College, Northridge, California

No abstract submitted.

Z-2. ECOLOGY INCLUDES YOU

Larry Schafer, Assistant Professor, Science Education Center, Syracuse University, Syracuse, New York

No abstract submitted.

Z-3. YOU DECIDE DECISION MAKING–A GAME OF VALUES

Ann C. Howe, Assistant Professor, School of Education, Syracuse University, Syracuse, New York

No abstract submitted.

LATE PAPERS AND REPORTS OF SESSIONS

AETS CONCURRENT SESSIONS

SESSION A-2

THE UNIT BOX APPROACH: A NOVEL FACET OF ELEMENTARY SCHOOL SCIENCE TEACHER PREPARATION*

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

The Unit Box is the center of focus and primary assignment in an innovative elementary school science methods course developed by the author at Jersey City State College.

Each student (college seniors in most cases) assembles a discovery oriented, materials centered, multimedia unit package built around a commercially available and tested unit of study. These classroom-tested units are modular in nature and are either teaching units, resource units or quasi-resource units. Students put together their Unit Boxes during a five or six week period prior to beginning the student teacher experience and use the Unit Box during student teaching. The Unit Box provides an opportunity for apprentice teachers to *do* with children the kinds of teaching-learning they joyfully experienced in their methods course; with materials at hand an ideal can become a reality, not a pious wish. Hopefully, these future teachers will continue to use their Unit Boxes in their own classrooms after graduation and possibly put together additional Unit Boxes during subsequent years.

The Unit Box Approach is novel in that students are not required to write a unit as is often the case in a methods course. Consider the following.

Do prospective elementary school teachers in their senior year of college generally have: sufficient science background to write enlightened science units; experience, prior to their student teaching, to write appropriate science units for children; adequate time and resources at their disposal (within a five or six week period along with three other courses) to do a thorough job of writing realistic units; enough enthusiasm for science to do a thorough piece of work on a science unit; more skill in writing science units than teams of teachers, scientists, and science educators in spite of meager background in science, and little or no experience at or zeal for "sciencing;" or more skill in writing science units than teams of experienced people who are knowledgeable and enthusiastic about science, who have time and financial resources at their disposal, who have diverse competencies, and who are in a position to write, try out in many classrooms, get feedback, and rewrite?

The author's answer to all the foregoing questions is an emphatic no.

By virtue of these and other considerations the writer developed the Unit Box Approach as an alternative to the usual practice of having students write units in a methods course. In sharp contrast to the conventional assignment of writing a unit, students are asked to start with a good commercially available modular Teacher's Guide and bring together all the hardware – in multiples – all the supportive software, all the media, ready to do an effective job of teaching the unit. The thrust of the Unit Box Approach is implementation of a classroom-tested written unit, not curriculum development, not writing interminable lists of pervasive and persuasive objectives, not copying lists of activities, or similar paper and pencil exercises. Emphasis is on procurement, fabrication, and improvisation of appropriate concrete manipulative materials, in classroom quantities of 15 or 30, to teach the unit.

Why so many of each item? Why provide materials at all? The actualities of scientific investigation, whether by children or adult scientists, entail direct experiences with the multitudinous phenomena of the real world, opportunities to manipulate variables and invent organized explanations of observed phenomena. In short, this involves experiences in search of meaning. Enlightened teaching that gives excitement and pertinency to the learning environment, entails the fostering of direct meaningful experiences with phenomena. For these goals, materials are needed. General exhortations, good intentions, grand proposals, and impressive lists are all meaningless sterilities unless and until they become operational in the classroom. One aim of the Unit Box Approach is to foster maximum involvement of each pupil in his search for first-hand evidence and meaning. The aim is to provide materials so that learning can go well beyond empty verbalisms of talk and chalk that lacks an experiential base. This is not a utopian impossibility but a mandatory condition for teaching children. It is a compelling reason for the materials emphasis in the Unit Box Approach. Certain items, to be sure, are included in the Unit Box – singly, or in small numbers for demonstration purposes; but these demonstration items are not the mainstay of the unit. The manipulative materials are, – the sine qua non of the Unit Box.

Where and how do students obtain all these materials? Students procure materials for their Unit Boxes by various means. Some devices they build. Other things they improvise from a recycled object. Scavenging plays a prominent role in the Unit Box experience. A great many items must be purchased, but a concerted effort has been made, over a four year period, to search out sources of inexpensive equipment. Both students and the author have contributed numerous resources to a growing repertoire of free and low-cost hardware which continues to expand and increase in usefulness. Each semester it becomes easier and more economically feasible to obtain certain items. True, assembling a Unit Box can be an arduous task but students find it to be a practical and richly rewarding experience. Some find it to be fun. Others would consider it enjoyable if they had more time to complete the task. In all cases, it illustrates a cooperative (rather than competitive) venture between the college teacher and his students.

How and where does the student begin? Part of the first session in the methods course is used to expose the class to a wide, varied, and enticing smorgasbord of Modular Teacher's Guides. At this first meeting students have a chance to give a cursory glance to more than one hundred units. In addition, the author distributes to each student printed items that provide brief descriptions of the hundred or so Teacher's Guides. These units are suggested for their use and available to them on campus.

Each student, after consultation with his cooperating teacher, selects one unit around which to build the Unit Box. Students are urged to select a unit topic in which they can become immersed in preparing and deeply involved in teaching; it should be a topic they can pursue with élan, one they can become enthusiastic about doing in the classroom. A central and significant aim of the Unit Box Approach is to have each student teacher acquire some depth of knowledge in one area through firsthand experience, and furthermore, to develop some expertise in exploring this topic and teaching the unit. In the overall design a deliberate attempt is made by the author to have each student pursue a different topic. The feeling is that both students and their teacher learn more through a great variety of units being assembled in each class.

What are the sources of the Teacher's Guides used for Unit Boxes? To date, the writer has used mainly four sources of teaching and resource units: those developed and classroom tested by the Elementary Science Study (ESS); the Modular Experience in Science Units (EIS) authored and tested by Tannenbaum and Stillman; the units developed and field tested by the Science Curriculum Improvement Study (SCIS); and the pre-primary unit *Sense and Tell* authored and tested by Marshall, Podendorf, Swartz and Shoresman. In addition, several successful unit boxes have been assembled using MINNEMAST Units as a start. Together, these five sources – ESS, EIS, SCIS, MINNEMAST, and *Sense and Tell* – offer the student one hundred and forty choices of units in science and mathematics. Furthermore, a multitude of additional unit modules, particularly quasi-resource units, are available from other sources, although some of these are less accessible and/or have not undergone as much classroom testing as those units previously mentioned. The use of some of these dark horse units is under investigation by the author. The printed exercises developed by the Commission on Science Education of the American Association for the Advancement of Science (AAAS), Science—A Process Approach (S-APA) do not seem to lend themselves to the Unit Box Approach as used by the writer. Nevertheless, this matter is still being explored.

Where and how do students obtain the Teacher's Guides? The Teacher's Guides for each modular unit are made available to students through the College Bookstore and in some cases by their professor. The writer inventories the Bookstore collection at least twice a year, and re-orders units each semester so as to up-date the stock of Guides available to students. The author orders between four and forty copies of each Teacher's Guide. The number varies with the title. The writer has also established a full collection of ESS, EIS, SCIS, and MINNESMAST Teacher's Guides in the Curriculum Materials Center and placed similar sets on reserve in the College Library at Jersey City State College. Thus, students may examine the units briefly in the first class session, and may peruse the units in the Curriculum Materials Center, or sign out units for a week from the reserve section of the library, before purchasing a unit in the College Bookstore. Students are also free to examine units from the author's personal collection.

At the conclusion of the 5- or 6-week methods course, each student brings his completed Unit Box. During this last meeting students have an opportunity to examine the Unit Boxes prepared by the total group. Moreover, the author spends about twenty minutes with each student until all the Unit Boxes are seen, discussed with the students and photographed. The conference appointments are set up at the previous class session when a sign-up sheet is circulated. These twenty minute conferences often continue until late at night.

Subsequent to the 20-minute conferences at the conclusion of the Methods Course, students go out into the schools and begin student teaching. Ideally the student teachers will be given an opportunity to use their Unit Boxes and see some of their efforts come to fruition during the apprentice teaching experience. Commencing with the Fall Semester of 1969, the author began a follow-up program to assess the Unit Box Approach in action. This topic will be fully treated in a report of the four year follow-up study to be published in 1973-74.

As of June 1972, 650 Unit Boxes will have been completed since January of 1969. These were done in twenty-eight classes which the author has taught during seven semesters at Jersey City State College. Prior to the Spring Semester of 1969, the author had students write units — a practice which is widespread in methods courses around the country.

In summary, the Unit Box is mainly but not merely a collection of things, assembled, used, and owned by the student-teacher; it is a teaching-learning mediating system interlocking materials and media with the development of concepts, process skills, pupils' self-image and desired attitudes toward school, science, and above all – towards learning. The thrust of the Unit Box Approach is implementation of a tested unit, not curriculum development.

***Adapted from Chapter I of a forthcoming publication.**

SESSION A-3

THE ROLE OF AUDIO-TUTORIAL INSTRUCTION IN SCIENCE TEACHING

Mrs. Jane Abbott gave a description of how students can produce A-T units, and how any teacher can get started on a small scale and small budget. The "Class Without Failures" is based upon a basic core of A-T biology mini-courses which all the students will be required to take, with a larger number from which they may select those in which they are interested. Students never fail as such, if they do not complete the course in one year, they finish the remaining units during the summer or the next year to pass the course. The emphasis is upon short, relevant, interdisciplinary courses covering a broad spectrum of interests which the individual student can complete on his own at his own pace.

Mr. Ronald Perkins began his presentation with questions. Do you lecture, perform demonstrations and place yourself at the focal point of your own course? Do you set the pace for your students, keeping them all doing the same thing at the same time? Most of us have taught that way. Chemistry at Exeter High School has been taught on an individualized basis for the past four years, and it has evolved to the point where no large group instruction is given. Formal instruction is available through audio-tutorial devices which form the heart of the individualized approach. In fact, the course is almost completely self-running with the teacher assuming the role of bookkeeper and resource guide. Reference was made to the following: (a) class structure for A-T instruction; (b) role of the teacher in A-T; (c) advantages of A-T; and (d) student response to A-T. The characteristics of the course are: (1) A free classroom; (2) Behavioral objectives; (3) Learning designed around an Ausubellian model of cognitive structure; (4) A-T as the major mode of instruction; (5) Chapter tests must be passed; (6) Student fits the course to his needs; (7) Early course completion; (8) Little competition between students; and (9) Everyone could receive an "A".

Mr. Theodore D. Filteau describes the Mount Wachusett Community College development of an auto-tutorial biology program with the assistance of a Title III curriculum development grant during the 1969-70 academic year. Colleges and universities with innovative programs were visited. Of particular interest were the auto-tutorial programs of Dr. Postlethwait of Purdue University, Dr. Howard Kieffer of the University of Illinois and Richard Blazier of Parkland College, Champaign, Illinois.

The auto-tutorial system consists of three types of learning experiences: (1) The general meeting at which all students in the course meet with the instructors for one hour. The purpose of this meeting is to evaluate the students achievement of the objectives, to impart general directives, show films or present guest speakers; (2) Two one-hour discussion periods per week. A group of 15 to 20 students meet with a discussion leader to discuss the unit studied in the learning center the previous week; (3) The learning center where the student carries on his independent study.

The audio tape is not used as a lecturing device. Instead, it is used to guide a student's activity to such things as readings, film loops, microscope slides, demonstrations, experiments and video tapes. Additionally, the tape is used to provide "organizers", that is, they introduce the student to an instructional sequence in terms that are easily understandable, thus preparing him for the concepts.

Perhaps one of the most successful parts of the program has been the utilization of senior biology majors from nearby Fitchburg State College as monitors in the learning center. These young biologists perform their student teaching requirements by assisting in the development of audio visual materials, by conducting discussion groups and by assisting in the evaluation process.

Dr. Martin Thorsland was involved in developing an A-T approach to instruction in an introductory physics course with an enrollment of approximately 400 students at Cornell University. Two 2-3 week units were presented via A-T to about 50 students as an initial attempt. Favorable results led to further development the succeeding year. During 1970-71, the A-T mode was used for nearly the entire year for 70 students. The remaining 300+ students received instruction via the conventional method. The A-T group received all instruction in the learning center.

During 1970-71, a "formative evaluation" of the trial was carried out. Data on which to compare achievement and attitudes toward the course were obtained. The A-T and non A-T groups were compared to assess whether the following goals of the exploration were met: (a) to increase positive attitudes toward the course without loss of understanding of subject matter; (b) to increase positive student attitudes toward the laboratory and make the lab more meaningful; and (c) to increase personal contact in the course.

Findings and conclusions from this comparison were as follows: (1) The attitudinal objectives were met in the trial, as significantly more A-T students than non-A-T students responded favorably to questionnaire items *directly* related to the objectives—there were no differences in response to items unrelated to the expressed goals; (2) the A-T and non-A-T groups did not differ significantly on achievement; (3) The integration of lab work with the rest of the course produces significantly more favorable impressions of the meaningfulness and value of the laboratory type experience.

Dr. Kenneth Jerkins cautions that A-T can be misused. As is true of any other mode of instruction, there are pitfalls in the use of the audio-tutorial systems as well. The use of audio tapes for lecture purposes is totally unacceptable. One should never believe that teaching with this method is easier than a more traditional mode. One must be prepared to spend many hours in preparing and modification and development of audio-tutorial programs. The audio-tutorial mode of instruction is currently being introduced in the biology department at Morgan State University. One point that was made clear is that there is no "one" definition of audio-tutorial instruction and that there is no "one" way to best organize or make use of this method of teaching.

SESSION AA-1

SUMMARY OF RECENT RESEARCH ON SCIENCE TEACHER EDUCATION

Robert Howe, Director, ERIC Information Analysis Center for Science Education, The Ohio State University, Columbus

Presented were references concerned primarily with the observation and analysis of teacher behavior (verbal and non-verbal) in a classroom setting. The references were described and those available through the ERIC Document Reproduction Service were identified.

Results of the review of nearly 100 studies involving the development of observational instruments and the collection of descriptive data on teacher and student behavior were summarized. The report included educational levels, areas of research emphasis, and methodologies used in the development of these studies. A majority of the studies did not include explicit attention to the theoretical basis for instrument development or selection. Among those which did so, the philosophy and objectives of the new curricula formed the most common basis. Broad trends in the data concerning teacher orientation and student orientation, level and type of cognitive behaviors, and the nature of science were identified.

Also summarized were the results of a review and analysis of research in the area of teacher education. The research reviewed was limited to investigations which utilized a system for the systematic observation of classroom behaviors and which involved classroom behaviors as a dependent variable and the method(s) to change the behaviors as the independent variable(s). Documents representing 175 investigations were identified. Sixty of these investigations involved science classroom behavior. All the documents were reviewed and grouped into six categories based on the type of independent variable used in the investigation. The six categories are: (1) Instructional sequence; (2) Student teaching and cooperating teacher influence; (3) Teacher perception or expectation of students; (4) Student influence; (5) Situational variables; and (6) Feedback. Generalizations of the research findings and recommendations for future research and applications were presented for each of the six categories.

The final presentation was concerned with the description of a teacher education program at The Ohio State University designed to change teacher behavior, and analysis of research designed to assess program effects on teachers. Data gathered has provided input which has been applied to effect changes in the preservice program. Teacher behaviors have been changed in desired directions.

The presentations indicated that teacher behaviors can be modified in desired directions. The relationship of teacher behavior to student outcomes was discussed and some types of needed research were identified.

NSSA CONCURRENT SESSIONS

SESSION N-2

FUTURE-SHOCK: ABSORBING, RE-DESIGNING THE SCIENCE CURRICULUM

Dr. Thomas Overmire initiated the session with a brief description of the book *Future Shock* and then presented his personal reaction to the book as part of the analysis. He stated that the book dealt with societal changes resulting from the accelerated rate of change present today, the expanse of the population, the fantastic increase in knowledge and reading material, and the radpid growth of technology.

Five areas of interest to Mr. Toffler were things, places, people, organizations, and information. Dr. Overmire discussed the characteristics of the plastic society, planned obsolescence, throw away articles, and a system of modules that compose much of the society. He considered the migration to and from places and the lack of orientation to location and jobs. People have "throw-away" friends with whom they establish numerous levels of transient relationships. Life styles, the subcultures of youth, and non-involvement have permeated the populace in such a manner as to produce rapid changes in short periods of time. Organizations are experiencing rapid alterations in their lines of authority wherein personnel have greater loyalties to personal ideologies and disciplines than to the organization. The information pool has expanded at such a phenomenal rate that crash courses have have been implemented, and people have altered their lifestyle to adapt to the new societal emphasis.

Dr. Overmire pointed out that we must learn to protect ourselves from future shock by determining our level of sensitivity, by seeking quiet, by finding our level of stability, and by utilizing the human organism's ability to adapt to change.

Mrs. Meltha Watts presented the audience with a "curriculum experience designed to develop the feeling of future shock". The participants were asked to complete a set of questions and experiences in extremely brief periods of time. The participants reacted to attitudinal statements, developed operational definitions, reacted to many of Toffler's concepts of future shock, exchanged personal feelings of success, and developed justification for various statements in an attempt to cope with dramatic change in scientific laws.

The audience reacted individually to the experience and Mrs. Watts planned to analyze the papers and return the results to the participants. Her objective was to establish a setting in which each participant could experience future shock and then receive feedback on their reaction to his experiences.

NSTA INVITED PANELS AND SYMPOSIA

SCIENCE AND SOCIETY: SERIES A, B, and C

SESSION A-4

THE NEED FOR POLITICS IN SCIENCE EDUCATION

Francis X. Finigan, Director of Science, Winchester Public Schools, Winchester, Massachusetts

For many years I have been concerned with the irrational approach by science educators to the interface between the science education profession and the political and social world.

It is evident to me that if we are to have any effect in shaping science education policy we must begin to actively participate at all levels of contact with society. We must learn how to use political power to achieve educational ends and we must be willing to exercise this power.

I have been criticized in some areas for expounding this view. For example, some of the organizations have been fearful that they might lose their tax-free status if we enter the political arena. To many individual educators, moreover, the word "politics" seems abhorrent.

I, however, when using the word politics go back to the true definition of "politics", – the art of the possible.

I quote from an article by Edward Karns, Supervisor of Elementary Studies, Parma City Schools, Ohio.

"No segment of American government is so thoroughly political as the schools: The effects of political activity are felt in every American school system regardless of its size or composition. Teachers and educators must realize they are not outside the body politic in a protected ivory tower; they are in the center of a political arena."

I am not talking about our individual voting habits. We do vote on election day. NEA research shows that in the last national election, 91.2% of teachers voted – a substantially higher percentage than in any other segment of the population. But only 8.7% contributed services as workers on behalf of a political party and only 11.6% contributed money to a political party.

What this means to me is that we have not had inputs into political decisions. Science education is too important to be left to politicians, but decisions continue to be made by people outside of science education.

I am concerned not only with science education but with science in general.

At the present time, the United States is the only country in which the support of science has experienced a cutback during the past few years. The worry is that there exists a negative response to recent education by the people in a country where it takes time to rekindle the fervor of past years to create new opportunities for young people in science education.

Of even more concern is the feeling that the most important scientific discoveries have been made and that the house of science has been completed.

There is the further cry that science must always be relevant.

If science education is to be maintained and improved science educators must not only learn about the structures which control societal and political decision-making, but must also be able to practice those logistics of accommodation and maneuvering that are the basis of political action. We must become aware of the strengths, the weaknessess, the opportunities, and the influences, that will govern the future of education and make us sustaining members of the educational community.

It is our job not only to maintain the level of science education but to change it for the better.

As I speak before various educational groups, however, I still do not sense whole-hearted commitment to involvement. So let me list for you some of the things that are going on, an awareness of which, hopefully, will stampede this growing ripple into an overwhelming surge.

In the August 1971 issue of the "Journal of Chemical Education," Anna J. Harrison asks,

"Has it been the unannounced policy of the National Science Board for several years to phase out Science Education Support at NSF?

In 1970, $120.2 million was appropriated, $100.6 million in 1971 and only $77.3 million in 1972. In congressional hearings on these cuts the House Appropriations Subcommittee pointed out repeatedly ... that the battle for funds was being fought in the wrong arena and suggested that the academic community should make a more effective input into policy decisions before another NSF budget goes to the White House. They also expressed considerable interest in the avenues open to the academic community to make such an input."

Or how do you react to an editorial by William Lippincott:

"Challenging all the other gremlins gnawing away at higher education for harassment-without-accountability honors of the biennium is accountability itself. It is such a morally commanding; pragmatically compelling, and logically satisfying concept that few can see beyond its deceptively simplistic facade to the incredibly complex issues that must be dealt with if its results are to be trusted and acted upon.

Who could possibly be against accountability? What could be more reasonable than to require of institutions and teachers that they render an accounting of educational results commensurate with the massive investment this society has made in them? And yet, how is it decided just who is accountable for what and to whom?"

He further stated, "The real issue here centers on the intellectual and spiritual gap between the higher education community and the society outside, and on the extent to which the college graduate of 1971 is adequately prepared by training or attitudes to be comfortable enough in the world as it exists today to be a productive and creative citizen."

Let's examine another facet of politics in science.

How do you react to or how do you answer a statement in a pamphlet of SESPA (Scientists and Engineers for Social and Political Action)?

The Role of the Science Teacher

"In general, teachers in this society are oppressed by unfavorable working conditions, low pay, and, most important, lack of decision-making power. These problems are aggravated for science teachers, in that a science teacher is stuck with a curriculum and laboratory equipment that he did not choose.

He has no funds to buy equipment that he and the students might want to work with. The critical decisions – what to learn, what tools to use – are removed from student and teacher, to some curriculum expert who has the purchasing power, or to some academic curriculum designer who has a preconceived and narrow-minded notion of what students need.

Beyond that, science is a politically charged subject which teachers are expected to deal with in a "neutral" manner. No wonder students are turned off when, for example, a teacher attempts to discuss problems of ecology without discussing the politics and economics of consumption and waste.

Another very serious problem is that the science teacher does not have access to scientific research as it progresses. Industrial and academic laboratories have few provisions for students and teachers to visit, and virtually none for them to work there. Teachers and students are informed of current research by means of patronizing propaganda such as NASA films, etc. In short, science teachers are shut out from science. Students sense this, and the relationship between teacher and student is further compromised."

Another interesting report comes to us in the third annual survey of the Public's Attitudes Toward the Public Schools, 1971, conducted by Gallup. Seventy percent of those polled were in favor of local schools giving national tests so that their educational achievement could be compared with students in other communities. Many science educators feel that educational achievement is difficult to measure in communities that vary so greatly. This type of test would put undue pressure on both teachers and students. But what input do we have into whether these will be given or what they will contain?

The last newsletter of the Commission on College Physics also reported a startling statistic. On the average, the dropping of distribution requirements at the schools sampled resulted in a 47 percent decrease in the enrollment in the introductory physics offerings. The data from deans for all science departments were similar. I suggest to you that these portents of the counter culture must be heeded in the high schools and junior high schools.

The President's Commission on School Finance, in its report of March 3, 1972, states that the future role of education will require strong leadership and must be action oriented to meet the needs of school districts. 82 percent of the five-year old population and 29 percent of the four-year old population are now enrolled in early childhood education programs.

The commission stated, "we have neglected the educational needs of the 40 percent of high school graduates who do not go on to higher education. It attacked the system of teacher accreditation, and suggested a reduction in numbers of incompetent teachers.

It wants states to reexamine certification procedures and to consider periodic review of tenure as well as peer and student review of teacher performance.

Should we have an input there?

Finally, did you know that The Electric Company, a TV presentation for primary school pupils has over 4,000,000 viewers and that in 1970 Americans spent more than twice as much money on pet food ($969.7 million) as they did on textbooks ($454.7 million)?

Today with prospects of fewer jobs for teachers, we cannot afford to be the "docile handmaiden" of public education. We must play a role in determining school policies. We must make the public aware that participation in decision-making improves performance. With the growing competition for the educational dollar, science teachers must press their demands with hard hitting organization at all levels.

Hopefully, teachers are beginning to realize that to improve their own school system, to improve science education, they must become actively engaged in the final decisions, the legal decisions, the moral decisions, and the political decisions that will change the educational system.

The recently published "Guidelines for the Preparation of Secondary School Teachers of Science and Mathematics" by the American Association for Advancement of Science, states that, "It is conceivable that in the future it will be the secondary school teacher who serves as the intermediary between science and society providing the feedback science and technology will require to assure their social responsibility". Is that how secondary science teachers feel today?

As Karns said, "Individuals alone can exert some influence; however, organized groups can exert significant influence. Democracy cannot function without organized power. Our political parties themselves are examples of organized power, and they are foundation stones of representative government." Such organizations as NSTA can provide an effective vehicle for science teachers to make known their views and to shape the future policy of science education. We have not been effective participants in our development. Our inputs have been consultive, not decisional. J.A. Battle wrote, "Without a politics of education that is intelligently led and altruistically based, there can be little hope for gaining quality education within a democracy."

In his book "Pedagogues and Power: Teacher Groups in School Politics", Alan Rosenthal suggested three programs for consideration:

(1) Organizational strength or group resource.
This includes the size, the wealth, the legitimacy, the access, the cohesion, and the leadership of the organization.
Numbers are relevant because the larger the group the greater its wealth, and therefore the more support for group activities to increase cohesion, to propogandize outsiders, to develop programs and to wage combat with school authorities.

(2) Organizational behavior
Unless, a group wants to share in determining educational policies for a school system its numbers, wealth, and other resources will remain stagnant. Although group strength offers a potential for influence, to realize that potential, an organization must translate it into purposeful behavior. But this comes down to a function of leadership and rank and file motivations.

(3) Organizational opportunities
This includes factors such as state or local statutes or regulations, the style of the political community, the conduct of educational chieftains. What opportunities exist to translate the ideas into action?

I have not attempted to outline a course of action. There is no one best answer. I have tried to urge upon you the necessity of reform.

As Lippincott stated, "Widespread support is claimed for the view that the national commitment to education and science has not paid off, and that the American public is now in the process of deciding how best to otherwise invest its resources for the future.

If there are reasonable alternatives to our present commitment to education and science, they have not yet been presented with any cogency.

Perhaps the greatest single step educators and scientists can take at this time and in the face of the incredible array of difficulties before us is to abandon their posture of professional isolationism. We hope to achieve a rationality of public will sufficient to sustain the open, stable, progressive, creative society which we all want and in which we can each find freedom and fulfillment."

BREAKING DOWN THE WALLS: SESSIONS A and B

BREAKING DOWN THE WALLS

SESSION B-12

ALTERNATIVES TO TRADITIONAL SCIENCE SEQUENCES

Mr. Joseph Maurer described the development of a series of mini-courses as an alternative organization for science offerings. Their effort was to fit the program to the student and to create new relationships between students, science teachers, administrators, and counselors.

A survey was conducted to determine student interest in possible course offerings. The survey results were used to determine actual offerings.

In the first year four mini-courses were offered, and in the second year eleven were offered.

The following convey some insight into the differences between mini-courses, as conceived at Lindenhurst High School, and traditional science courses.

Traditional courses	Mini-Courses
1. One teacher per year	1. Four teachers per year
2. Fixed sequence per year	2. Flexible sequence
3. Rigid curriculum	3. Choice of four areas of study
4. Single textbook oriented	4. Activity oriented with resource materials
5. Evaluation tends to be punitive via tests	5. Evaluation by alternative means – few tests
6. Teacher directed and controlled	6. Student self-direction and control

Mr. F. Darrell Goar depicted a specific ESEA Title III project which was based on an Ohaus Award winning paper of three years ago. The efforts have been directed toward developing instruction modules. Problems which have emerged are: (1) How to change teacher attitude; (2) Alternatives to traditional grading on an A to F basis; (3) Poor teachers can hide; (4) Safety and supervision problems in relation to laboratory-activity phases.

Mr. Dean Sousanis described his school's efforts to adjust the order of course offerings to Physics (10th grade) so as to place the "simpler" courses first. He supported the view that physics is simpler than biology by contrasting the structure of a pendulum with that of a bug.

In the new sequence the physics concepts become background for a more efficient chemistry that can take students into a study of organic and biochemistry which, in turn, is a preparation for biology.

A major problem in teaching physics to 10th graders is the concept of physics held by physics teachers who tend to make the course too rigorous.

Mr. Sousanis also pointed to grades as a problem, expressing the opinion that physics courses at the college level, in some cases, are less difficult than high school physics.

Mr. William D. Romey engaged in a general discussion of educational alternatives. He pointed out that de-unifying and de-sequencing, changing ways of presentation, providing more out of classroom boxes, describing education in other ways than courses, etc. are ways to produce educational alternatives.

He pointed out that he no longer identifies himself as a science teacher. Instead, he simply says, "Hello, I'm Bill Romey and I'm interested in learning........

He views the science area of a school as a place to keep and use special paraphenalia which is used in a general learning sense rather than for "special" science learning. This fits with his view of himself and also places science as part of all learning rather than a specialized form of learning. Mr. Romey's approach raises the following questions: Why do we separate and compartmentalize learning into science, English, social studies, art, music, etc.? Do we have to do science learning by the clock and calendar? Why can't learning occur as the spirit moves? Why can't you be you and let me be me so that both of us can be free?

SESSION B-15

POLLUTE! WHO US?

The session featured two presenters, Dr. Harold E. Tannenbaum, and Mr. Ralph L. Harding, Jr., as well as a moderator, Richard Scheetz.

Both speakers stressed the seriousness of the diminishing quality of man's environment and emphasized that solutions would require continuing effort over a prolonged period. They agreed that people individually, and collectively through institutions such as business and government, cause pollution. It was also agreed that "if we are to save the environment, we shall have to do it ourselves."

Dr. Tannenbaum described several examples of cultural learnings which have taken place in the past including the cultural pressures which have made spittoons obsolete. Pittsburgh, Pennsylvania 1972 is very different from Pittsburgh 1930, as a result of changes in industry treatment of wastes. Other examples covered: group learning about social security, group learning about Medicare and welfare, and group learning about going to school (high school and college).

Dr. Tannenbaum pointed out that school can and should: provide information about the environment, finding out the facts from all sides; have young people participate in those activities where they can make contributions; and train the required specialists.

With reference to other educational agencies, he stated: the media can present balanced stories by allowing and encouraging everyone to present his side of the story, industrial educational agencies can cut the propaganda and give a truly balanced story, and governmental and educational agencies can use their legislatures for mass educational purposes.

Dr. Tannenbaum called for patience and persistence in pursuing the long-range educational goal of changing people's attitudes and habits as these infringe on the quality of the environment.

Mr. Harding limited his remarks to the industry he knows best, the plastics industry. He reviewed the rapid growth of the industry, which had its beginning in the developing of a substitute for a disappearing natural resource – ivory. It expanded from a one-billion dollar industry in 1946 to a 20-billion dollar industry in 1971. He described this as a period of polyoptimism in which, except for some social pressure concerned with flammability of products and solid waste, the pressure was to develop new products for a wide variety of social uses.

The turning point in attitude of polyoptimism came in 1971 as a result of mounting social pressures. Mr. Harding stated that the plastics industry is committed to positive action for solving the problems of environmental quality. He called for litter laws and litter education, modernized collection of solid wastes, sanitary landfills, modern incinerators linked with power plants to recover the heat energy, and new procedures for resource recovery.

Mr. Harding concluded that the industry had been clobbered, and it is now committed to a positive approach. The industry members are people who are citizens and parents, and as such have an obligation to the next generation. The industry is ready to cooperate.

Pollute! Who Us/ Yes *all* of us. Let's all work together towards a solution.