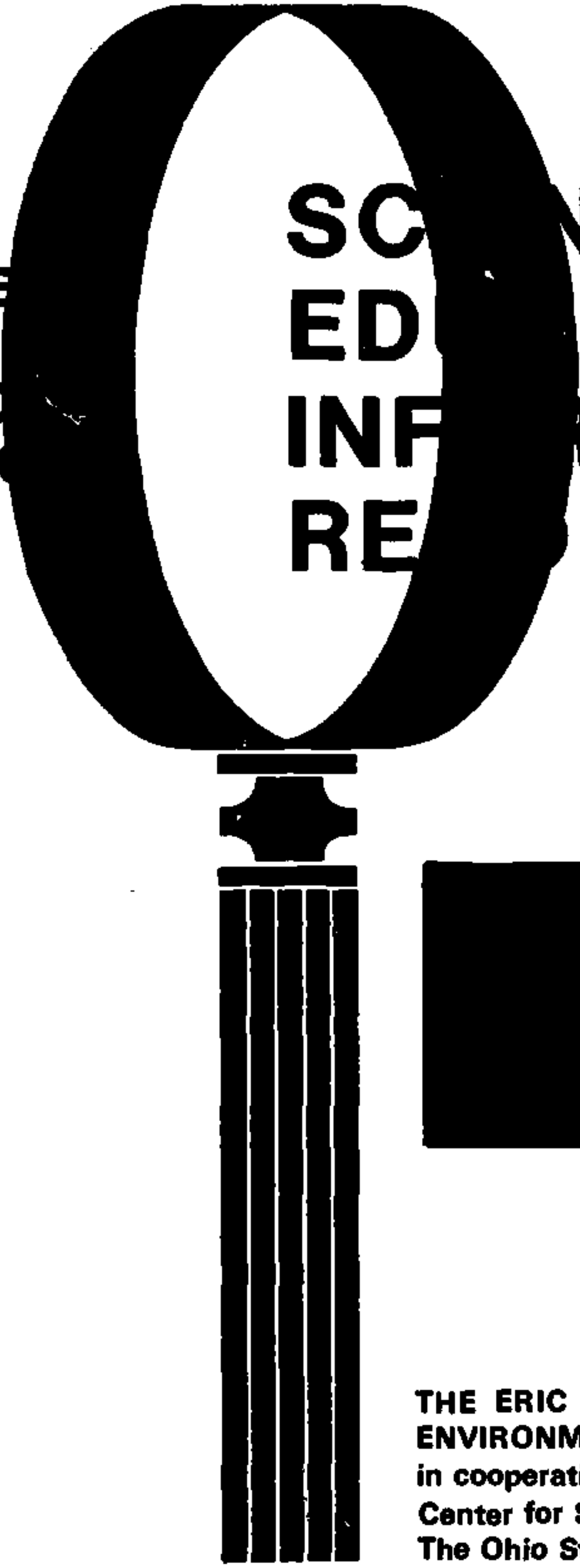
DOCUMENT RESUME

ED 090 056 SE 017 763

AUTHOR	Schaff, John F.; Voss, Burton E.
TITLE	Secondary School Teacher Education: Where are We Going?
INSTITUTION	ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, Columbus, Ohio.
PUB DATE	Mar 74
NOTE	123p.
EDRS PRICE	MF-$0.75 HC-$5.40 PLUS POSTAGE
DESCRIPTORS	Educational Programs; Inservice Education; Preservice Education; *Program Descriptions; *Science Education; Science Teachers; Secondary School Teachers; *Symposia; *Teacher Education; *Teacher Educators

ABSTRACT

Thirteen papers relating to secondary school science teacher education are presented in this publication. This material is the result of a joint NARST-AETS panel at the 1973 annual meetings of the two organizations. Most papers are descriptions of preservice programs carried out at diverse institutions. Major topics are related to educational objectives, new challenges, educational technology, research possibilities, continuing education for experienced teachers, education accountability, integration of educational courses, teacher responsibilities, program flexibility, early clinical experience in teacher preparation, performance-based or competency-based programs, integration of minorities, inner-city experience, humanistic approach, reasoning and conceptualizing abilities among students and teachers, and future prospectives. Included is a transcript of the panel discussion with audience comments and questions. (CC)



SCIENCE EDUCATION INFORMATION REPORT

THE ERIC SCIENCE, MATHEMATICS AND ENVIRONMENTAL EDUCATION CLEARINGHOUSE
in cooperation with
Center for Science and Mathematics Education
The Ohio State University

ED 090056

SECONDARY SCHOOL TEACHER EDUCATION:
WHERE ARE WE GOING?

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National Association for Research in Science Teaching

Association for the Education of Teachers in Science

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March, 1974

EDITORS' NOTE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has again cooperated with the National Association for Research in Science Teaching and the Association for the Education of Teachers in Science in the production and publication of this document. The material contained in this publication resulted from a joint NARST-AETS panel at the annual meetings of the two organizations which occurred in Detroit, Michigan, in March, 1973. This joint meeting was well attended. However, panelists did not have the opportunity to present their papers, due to time restrictions, and were limited to brief reactions concerning the contents of these papers. In order to provide the science education community with more information concerning the topic "Secondary Science Teacher Education: Where Are We Going?" we are pleased to be able to provide this document containing the panelists' papers and a transcript of the panel discussion and the audience's comments and questions.

Patricia E. Blosser
Stanley L. Helgeson
Editors

This publication was prepared pursuant to a contract with the National Institute of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent National Institute of Education position or policy.

FOREWORD

In response to a request from NARST and AETS, a discussion session was organized so that NARST and AETS members could openly discuss a topic of mutual concern. Because numerous changes and new developments are occurring in teacher education, the symposium organizers decided that a timely and challenging topic for discussion would be "SECONDARY SCIENCE TEACHER EDUCATION: WHERE ARE WE GOING?" A group of NARST-AETS members active in secondary science teacher education was asked to prepare papers responding to this topic as they perceived it in relation to recent trends and developments in their own institutions. It was suggested that they include results of research, development and program activities, and point out implications for the future.

Individual papers prepared by the panel participants were exchanged about one month prior to the meeting. This provided each member a short period of time to read and study the ideas presented by the group in advance of the scheduled discussion session. The panel was informed that individual papers would not be read, reviewed, or summarized by their respective authors at the beginning of the discussion session. The entire one and one-half hours would be devoted to a synthesis and evaluation of the ideas, points, programs, etc. presented in the papers. In addition, the panel was informed that audience participation in the discussion would be encouraged.

The symposium organizers wish to express their appreciation to the panel and members of the audience for their excellent contribution to the program.

John Schaff

Burton Voss

NARST - AETS JOINT PANEL

Organizers and Co-Chairmen:

John F. Schaff	University of Toledo
Burton E. Voss	University of Michigan

Panelists:

Harold M. Anderson	University of Colorado
Paul E. Bell	Pennsylvania State University
Patricia E. Blosser	The Ohio State University
Robert G. Bridgham	Stanford University
Calvin W. Gale	Michigan Technological University
James J. Gallagher	Governors State University
John J. Koran, Jr.	University of Florida
Victor D. Morris	University of Maryland, Baltimore
John F. Schaff	University of Toledo
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Leslie W. Trowbridge	University of Northern Colorado
Burton E. Voss	University of Michigan
Robert E. Yager	University of Iowa

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BOTH . . . AND

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Throughout the past several decades discussion about preparing science teachers has centered around questions like "which is the best method, . . . ?" A comparison between two methods, guidelines, approaches, philosophies, textbooks, or curriculums would follow.

In the vernacular of the biologist, science teacher trainers have tended to be splitters. For two reasons, the described "either . . . or" tenet is no longer appropriate. First, the research generated has not shown such dichotomous thinking to be consistently productive in any one way over another. Secondly, the complexity of the needs of today's student and the society which pays for his education suggests that simple, single dimensional schemes are likely to be improbable answers to the charges thrust upon today's educators. The publics are demanding that we be accountable in too many ways.

This presentation will describe similarities between the dilemma of preparing science teachers in the 1970's and the manner in which two successful enterprises have approached problems of similar dimensions--football teams and NASA.

Let us examine the charges before us. The publics are crying for several features that appear at first to be incompatible:

1. Science teachers must be accountable for producing students who know science. The populace is impatient with excuses.
2. There is general impetus to provide interesting alternatives for students at all levels. Since each student defines "interesting" in different terms, this charge is a most complicated one.
3. Science teachers as well as all others are being asked to build in the human aspects of teaching. Subject matter in itself is inadequate.
4. Sciences must be integrated with themselves, the social sciences, mathematics and technological fields. Pure science or pure mathematics is no longer acceptable.
5. Science teachers will have to produce a general public that is sympathetic to the support of continued scientific and technological effort nationally.
6. We should not expect financial backing in preparing teachers to meet these demands.

The students aspiring to become science teachers also ask some challenging demands of us:

1. Instruction should be a model of what they are to do as science teachers.
2. They want more real experience both in the classroom and in the laboratories throughout their preparatory program.
3. They wish to be treated as individuals and as persons.
4. They wish to enter a field that has self-respect among its practitioners and warrants respect from the rest of the academic community.

Meanwhile, the teaching practitioners have essentially one general wish--they desire the autonomy to teach in the best possible way. This means financial security to be sure. But it also means the privilege of continuing their own education in ways that are meaningful to them and the managing of the system in which they work to facilitate their best aspirations and efforts rather than thwarting them.

The American Association for the Advancement of Science has developed some similar charges which are in themselves acknowledged reflections of those previously described:

1. Each college teacher of science should present his specialty as an interaction of science processes and science knowledge.
2. He should also present his course in a way that each idea is placed in context with the personal impact it has on the student's own life and the implications it has for mankind in general.
3. The ideas in the course should impart the interactions they have with the other science disciplines, with mathematics and with the several social sciences.

This array of challenges by the several influential voices interested in the preparation of science teachers constitutes a complex and bewildering set of conditions to meet. We no longer have the option of meeting one condition or the other. Our task is meeting one condition "both . . . and the other multipled many times." If we look at the task NASA adopted for itself, we see a similarly complex challenge. The challenges before a football coach are just as demanding and follow an inflexible and rigorous time schedule. Now how would they attack their problem?

Both of these endeavors maintained a basic underlying philosophy that is not very obvious among educators generally nor science teacher trainers specifically. They operate on the premise that they can win - that they can overcome all obstacles and be successful. As the little red caboose in the children's story suggests, we each must remind ourselves frequently, "I think I can, I think I can!"

What other characteristics can we glean from the operations of football and NASA that might be helpful to us in facing this involved a task? Both enterprises employ a systematic way of analyzing the factors affecting their performance. One of these factors is the use of man power. Once this role analysis is done, a personnel needs priority system can be established and then the "most likely to succeed" candidates can be recruited.

The systematic approach does not permit very much to be left to chance. The recruited personnel are then subjected to intensive training. They must perform in adequate ways - no laissez faire nor mere experiencing of situations. Instead, realistic simulations are arranged in which the participants must not only experience but perform in predetermined ways under those conditions. NASA calls these experiences "simulations"; football calls them "scrimmages" or "practice games."

Another important technique is the monitoring and readjustment that goes on, both during the simulations and during the actual space shot or game. The monitoring is a data-gathering exercise in which computers may be employed to arrive at suggested "adjustments." These adjustments are dependent upon the quickness and astuteness of the participating personnel. Therefore, two characteristics of the recruited manpower are (1) the capabilities to follow suggestions based on data and (2) to adjust quickly. Flexibility is a function of capability to do alternative skills and a willingness to do them as directed or as the situation demands.

Monitoring is not left completely to the mechanized hardware. Astronauts must be able to perform diagnostic and corrective procedures; similarly, football players must "read" signals and cues and take on-the-spot corrective measures. Hence, another characteristic of the recruits is that of being able to perform diagnostic measures, make decisions, and deliver a correction that is compatible within the system.

Monitoring does not rely on a single type of data input either. Numerous counter checks are being utilized to test the validity of data obtained. Therefore, it seems unwise for educators to continue looking for the single fountain of perfection. Instead, all data input techniques should be developed, used, and compared for accuracy of implications.

Both football and NASA have exploited the public relations factor in continuing their programs. "PR" is not limited to the management and special agencies. No, players and astronauts are taught how to conduct themselves to build the correct image and enhance the interest of the public. Another quality of the recruit must be that of personal color and his potential for providing good "PR."

Operational definitions of good "PR" are hard to come by. However, a few obvious characteristics might be recalled. First, a program must have a quality which is easy to associate with human endeavor. Second, that human quality must include the public - Mr. Citizen must feel an identity with the people in the program and with the program itself. Third, the public must be updated continuously of the changes that are being made, the strategies, the intricacies, the need for qualified personnel, the awesome tasks those personnel accomplish, and the ways in which the program itself and the changes in the program will benefit mankind better.

These are the details. How many mock-ups, charts, animations have you seen that describe the exact orbits, time checks, positions, use of equipment, etc., to be followed by the astronauts? Or how many times have you been permitted to hear of the strategies, personal decisions, training rigors, game plans, opponent scouting reports, or even plays being called during a game provided by your favorite football team? Now think again, how does your favorite science teacher training program fare by comparison? Gotcha!?

A final component of the ongoing attention to systematically dealing with the important considerations in a program is that of team morale. Both football and NASA provide several guidelines. First, differences between persons are accepted. Astronauts displayed different kinds of personalities and were played up as being distinct. Likewise, there is very little similarity between double zero Otto of the Raiders, Franco Harris of the Steelers, Broadway Joe, or Mercury Morris.

Closely associated with the acceptance of personal differences is the second guideline. Both football and NASA capitalize on the special talents of their personnel. Thirdly, the idiosyncracies, whims, and personal problems are dealt with. These superstars are not isolated. They are encouraged to become involved with each other, with their leaders, and with management.

If we consider the preceding analysis seriously, and consider the analogues as being examples of successfully solving very complex problems that are of the same magnitude of complexity as preparing science teachers, we are bound to come to some considerations worth inspection.

Education in general and the preparation of teachers in particular have left an awful lot to chance. At least some elements should be subject to systematic analysis and treatment. Educational researchers should be about the task of performing that analysis and develop the means for treating those appropriate aspects! We are going to have to move to a criterion referenced orientation. Not just the easy stuff, but complex, human performances that employ all levels of cognitive, psychomotor, affective, social, and decision making skills. Education is complex beyond the capabilities of single thinkers to contemplate simultaneously the effects of altering a variable on all other known variables. We must, therefore, go to technology, especially the computer, to enlarge our capabilities to keep track of effects.

We must accept the changing role of science teachers as they are confronted with the possibilities of working with paraprofessionals, interdisciplinary teacher teams, curriculum development, scientists and technologically trained persons, and the public more closely. It appears that the teacher is being liberated toward true professional status, and at the same time, he is being asked to accept the new responsibilities that accompany first class professional endeavors. Several characteristics will be needed by the science teacher of the 1970's. These include:

1. He will need knowledge from the several sciences, the processes they use in scientific thinking, the interactions of the knowledge and process components, the interdependency across the several sciences, the influence on and by the social sciences, and the capabilities and limitations of mathematics and each of the sciences. Such a level of competency will almost certainly demand involvement in research planning and implementation at least in one field of science before graduation.
2. He must be analytical and accept the responsibility of modeling this approach constantly before his students. He must forego the practice now very common of encouraging idolatrous worship of the big names of science. He also must become much more precise in his transmission of information through the use of operational definitions, logically developed arguments and the language of mathematics.
3. He should also be capable of employing the use of computers for his own research or that of others. He should know the capabilities and limitations of the present computer technology.
4. He should be able to provide examples of the application of science principles, concepts, and processes to the everyday living of the several student types represented in his enrollments. He should also be able to anticipate the implications of these concepts on mankind.
5. Pedagogically, he should be flexible. This means that he should be able to deliver quality instruction using several different modes of transmission and combinations of all the available curricula.
6. He should also be sensitive to the changing needs of his students, capable of diagnosing instructional and learning problems, willing to make pedagogical decisions based on the diagnosis, and monitor the results during instruction.
7. He should accept the responsibility of guaranteeing instructional results - not just for the academically talented, but appropriate expectations of all calibres of student interests and capabilities.

8. He should be socially and politically sensitive. He should adapt his instruction to meet the local needs and priorities, but at the same time begin the task of enlightening the publics of the ways for achieving quality science education for all students.
9. He should be able to develop and test curriculum. He should be willing to base his decision on research data and contribute in ongoing manner his own findings from action research.

It behooves science teacher trainers to establish performance criteria that will guarantee proficiencies in each of our products. Our work in the past decade is on the right track, but we have not been aggressive enough. Some approaches that are being tried are described below.

The most rigorous broad-base program of instruction requirement (1) has been modeled by the science education doctoral program at Oregon State, which demands that its students have strong majors in each of the sciences plus educational research.

At the undergraduate level students may be encouraged to specialize in more than one field which can often be accomplished without many extra semesters of work being demanded. Another approach is to encourage students to become proficient in additional fields during the acquisition of the master's equivalent certification requirements.

Requirement (2) will be one of the toughest to effect. The National Science Foundation has been encouraging change here--especially in offering financial support of student-generated research. This program will continue for high school, undergraduate and graduate levels. Unfortunately, most college science teachers tend to imitate the demigod model by scattering the updated pearls of knowledge and paying little attention to their students' capabilities of analyzing data critically, designing research around a knowledge base, and implementing empirical investigation.

The Materials Science Department of Penn State has initiated a course for science teachers that attacks such practical problems as analyzing the component materials used in an automobile and prescribing the most economical way of disposing of each material through recycling, incineration, or biodegradation.

Requirement (3) has been approached in four ways at Penn State. Some preparation programs require students to take a computer science course in FORTRAN programming. Others learn how to employ digital computers for problems raised by the Materials Science course. A third approach used by the math education faculty is that of teaching BASIC language and having the aspiring teachers develop programs which utilize the computer as a tool in solving problems currently used in existing science courses.

The fourth approach is one of familiarizing students with their most vigorous competitor, CAI. Students may opt to take several courses on the IBM 1500 system which permits a saving or more flexible use of student time. Mobile vans now permit this CAI system to be taken to outlying districts for inservice instruction. A tool that should be seriously considered for its potential in teaching inductive thinking and mathematical modeling is the APL language.

Requirement (4) can be approached in a variety of ways. The Tilden, New Hampshire, Schools developed an environmental approach which is strong in its application to everyday living. That program is also being expanded by the five-county KARE project, Bluebell, Pennsylvania, and by a summer workshop for new science teachers offered by Penn State in cooperation with the Philipsburg-Osceola Schools.

Wilson High School in Washington, D.C. has a practical science course for non-academic students which should be considered by other districts.

Requirement (5) is being attacked at Penn State by having students in the science methods courses meet prescribed competencies in their microteaching sessions. These students must also team teach an episode which incorporates three different student activities and meets prescribed objectives and instructional mode requirements.

Requirement (6) is now more nearly possible at Penn State than a year ago. The special education department now offers a course in classroom diagnosis of student learning difficulties by CAI on the IBM 1500 system with audio and visual display capabilities. In 1965-67 Oregon College at Monmouth piloted another approach to this task using a battery of 16 mm projectors, life size wall projection screen and class simulation. Generally, classroom diagnostic and prescription techniques are unsophisticated.

Requirement (7) can best be met by individualized approaches using either class activity approaches like ISCS or the modular approach like ISIS.

Penn State is beginning an assault on requirements (8) and (9) by assigning action research development projects for all master's degree students in Science Education. Several of these have actually been implemented after students returned to their classrooms. This sort of activity should be given more credence by NARST --possibly an Action Research Review in the Newsletter or the Journal.

There are additional developments around the nation that appear to have potential. For instance, a number of people are looking at psychological characteristics that are related to subject matter. Stafford (9) cites one kind of relationship that bears watching--the presence or absence of the father in the home affects student mathematical ability. (Assuming the stability of such a finding, what are the implications of marriage alternatives (11) being pushed on the future manpower capabilities in quantitative reasoning?)

New sequences of experiences in teacher education must be employed. Some of the requirements were identified in the various projects funded under U.S. Office of Education Grants. More specifically directed to our concern, Florida State has been modeling three different science teacher training programs for the past several years.

Field experience is one of the essentials. Surprisingly, early field experience as being tried at Penn State, tends to promote interest in additional field experiences throughout the preparatory years (10).

One trend in these alternative preparation programs is the development of instructional modules. Modules are generally criterion-referenced instructional packages that do not demand the three-lecture-per-week format. Audiotutorial styles have been generated at Purdue and Cornell (7). Packaged printed modules are being developed at the University of Toledo (8). BIOTECH has expanded its base to welcome all contributors (4).

Competency-based instruction can be handled in several ways. One description used in New York includes experiential components (1). Another style is to require hand-in material that reflects the competency with a good bit of flexibility in the manner by which it was attained. This latter procedure was used in the conception of the competency-based methods course used at Penn State (2). Broader competency-based teacher education programs are being encouraged by the Pennsylvania Department of Education through workshops involving several hundred college faculty members.

A variety of classroom observation tools have been tested by the Northwest Educational Research Laboratory (5) which can be combined with monitoring techniques used in conjunction with Computer Assisted Instruction and microteaching. Progress of students through conventional experiences can also be monitored by computer, but more meaningfully recorded if they are competency-based modules as is being done by the Admiral Perry Vocational Technical School in Ebensburg, Pennsylvania.

Recruitment being tried by University of Iowa combined with data about career decision factors and attempts at role descriptions (6) tend to suggest that many of the ingredients are at hand, but need to be put together. Large amounts of synthesis funds are not available, so cost-benefits analysis techniques should be employed to permit the "buying of time" for further experimentation (3).

A final suggestion seems worth noting: students entering teaching are often not committed to the profession until after student teaching, after which large numbers drop out at least temporarily. If students could be charged with the responsibility of providing their own relevance, their own early field experience and generating some of their own training to enhance their capabilities, those that accepted the challenge could provide the momentum necessary to provide the level of competition necessary to make an impact nationally.

The needs for the 1970's and 1980's are for science teacher preparation programs which turn out professionals who are BOTH highly trained in the science enterprises AND highly skilled in the pedagogical sciences. This kind of teacher can be produced if we are serious about meeting today's challenge.

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SECONDARY SCIENCE TEACHER EDUCATION:

WHERE ARE WE GOING?

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Introduction

"Where we are going" in secondary science teacher education, to use Tyler's conceptualization (19) of the factors which influence any curriculum, depends upon the combined effects of societal, disciplinary, and learners' requirements. One of our important tasks as science educators is to examine how these factors have influenced the education of secondary science teachers both past and present and try to make valid forecasts for the future of our profession.

The complexity of forecasting is highlighted by the changes which have occurred in science education during the last half-dozen years. In 1967, there was a crucial shortage of qualified secondary science teachers, and only the most gloomy pessimist would have forecast oversupply; but within three years oversupply was a reality. Nor would it have been easy to forecast in 1967, that in less than half a decade, our nation's view of education as a powerful resource for solving many contemporary problems of society would have shifted to "giving up on education without really trying it" (6). Events such as these dramatize the influence which society has on our work. Recent changes in our understanding of our students' needs and increased understandings of the nature of knowledge and how it is engendered in learners also have impact on our future work.

As science educators, we are triply hit by recent changes in attitudes toward education. First, our university budgets either have been reduced, or projected increases have been retarded. Second, the demand for graduates of our programs to fill vacant teaching positions in high schools has all but disappeared. These facts are evident to all and need no documentation. Third, the educational community as a whole, including science educators, has come under much criticism regarding the competence of graduates (9,11,15,16). As a consequence, accountability and its step-child, performance-based education, are contemporary issues of major importance. Our current situation is neither bright, nor hopeless; but there is little reason to believe that it will improve significantly during the next few years. Thus, the science education community must respond to these new realities, and the nature of our response will, in many ways, be a major criterion for assessing the quality of our effort during much of the remainder of this decade and perhaps beyond.

The purpose of this paper is to identify and describe some responses which secondary science teacher educators should make to contemporary and predicted situations. Some of the situations and responses are derived from analyzing current educational literature and all are influenced by my current work in a new, metropolitan-focused university. In spite of the fact that the situations and responses are highly interrelated, they will be discussed serially.

Continuing Education for Teachers

One form of our response should be to place greater emphasis on continuing, or in-service, education of teachers. This action can help in overcoming criticisms of low teacher competence, without overburdening the job market.

If this action is to be successful, we must do more than merely offer the same courses that have traditionally been given. A lesson from the history of science may have relevance. Scholars in natural philosophy began to make contributions of significance when they joined forces with artisans and craftsmen in identifying and resolving real, work-a-day problems. If we, as scholars in science education, work with teacher-craftsmen we may be able to make advances on two fronts:

1. With our help, teachers may be able to find ways of applying current knowledge of curriculum, learning, motivation, and instructional technique in resolving practical problems of teaching science in high schools.
2. With their help, we may be able to design new research, acquire new data, and reformulate our conceptualizations and theoretical structures making them more useful in helping teachers interpret data they receive from their students and plan appropriate actions.

In addition to in-service programs designed to upgrade teachers' knowledge of science and help them expand their effective repertoire of instructional techniques, in-service work should foster development of teachers' educational leadership capabilities. To do this in-service work should focus on:

1. identifying and solving educational problems;
2. increasing knowledge of, and skill in, curriculum planning and implementation;
3. increasing knowledge of instructional materials developed by commercial and research groups;
4. developing skill in tailoring commercially available instructional materials to local and individual needs;
5. developing attitudes and skills so that teachers use their own instruction as an object of inquiry; and
6. developing ability to use principles and theoretical structures as tools for analyzing instruction and planning improvements.

Competency-based Programs

Partly in response to criticisms of teachers' ineffectiveness, competency-based programs for education and certification of teachers have received much attention during the past five years (4, 10, 17, 18). Because certification is becoming increasingly competency-based (5), it is reasonable to expect increasing emphasis on competency-based teacher education programs.

Elam (4) described five essential elements of competency-based teacher education:

1. Teaching competencies should be role-derived and specified in behavioral terms.
2. Assessment criteria are competency-based, specify mastery levels, and are made public.
3. Assessment requires performance as prime evidence and takes student knowledge into account.
4. Any student's rate of progress depends upon demonstrated competency.
5. The instructional program facilitates development and evaluation of specific competencies.

Examination of current examples of competency-based teacher education programs suggests that we have yet to achieve a high degree of conformity with Elam's model. Considerable work needs to be done if this educational innovation is to be more than a passing fad. Making competency-based science teacher education viable is one of the challenges which our professional community faces.

In addition, Broudy (2) and Howell (8) offer some cautions regarding competency-based teacher education. Broudy states that we will probably be able to produce better "didactic technicians," but we should recognize that laboratory work, clinical teaching and internship are needed to illuminate, exemplify, and utilize theory in order to produce a highly professional teacher. Howell warns that if teaching performance is to be evaluated in detail, some theory of teaching is needed to guide the evaluation process. Further, he states that if teaching performance is to be judged on the basis of pupil learning, care must be taken to eliminate or account for sources of error in measuring pupil learning.

Integration of Minorities

If current trends continue for the remainder of this decade, and beyond, integration of minorities into formerly white, middle-class schools will be increasingly common. Science teachers will share in the responsibility of making integration beneficial to students from both minority and majority sub-cultures and the science education community must help science teachers acquire needed skills and attitudes. The task is multi-dimensional. Science teachers must develop respect for cultural diversity and acquire skills of communicating and working effectively with students from various sub-cultures.

Development of these attitudes and skills is similar for all teachers, but science teachers must recognize that they also have special problems not shared by other teachers. Traditionally, very few minority group students have enrolled in science in high school and even fewer are found in college science courses. The reasons for this are complex, but the following may be contributory:

1. Few minority group role models are available in the sciences and in science teaching.
2. Idealistic young minority group students see the sciences as contributing little to their peoples' advancement; whereas, social sciences, the arts, and politics are perceived more favorably.
3. Upwardly mobile young minority group students see the arts, politics, athletics, and the professions, but not science, as a means of achieving personal goals.
4. For a variety of reasons, minority students frequently have not experienced success in science classes.

As science educators, we must find ways of helping secondary science teachers help minority students acquire positive attitudes and useful skills relating to science. One way of doing this is to present science not as a "rhetoric of conclusions" but as a human endeavor which has had profound consequences on the quality of human life. Another way is to include, as an integral part of science teaching, development of intellectual skills which will enhance the probability of students' success in science. More important, development of science-based intellectual skills will provide minority students with another resource for more effectively coping with the technological environment in which they live.

Science as a Humanity

The recently published Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics (1) contains two major statements concerning sciences' humanistic relationships:

> Guideline II--Teacher education programs should provide teachers with knowledge and experience to illustrate the cultural significance of science, to relate science and technology to social conditions, and to apply analytical methods of science in multidisciplinary approaches to studying and solving societal problems.
>
> Guideline III--Teacher education programs should provide opportunities for prospective teachers to gain insight into the intellectual and philosophical nature of science and mathematics.

Similar suggestions can be found in the literature of science education of at least a generation ago (14). In spite of the recurrence and reasonableness of such suggestions, and the prestige of those who make them, few teacher education programa provide effective vehicles for helping prospective or practicing teachera acquire knowledge of acience from other than ita technical perspective. In order to overcome this weakneaa, action on aeveral fronta may be neceaaary:

1. Coursea in history, philoaophy, and aociology of acience can be included in both pre-aervice and in-aervice programs.
2. College science couraes can be broadened to include s cial and humaniatic perapectivea. A few good models already exiat and othera can be developed (7, 12).
3. Humaniatic perapectives of acience can be included in science methods couraea.
4. Prospective and practicing teachera can be given experiencea with programs such as <u>Project Physica</u> and <u>The Man-Made World</u> which preaent acience from a broad perapective.

<u>Reasoning and Conceptualizing</u>

During recent months, I have been a participant-obaerver planning curricula with a large number of teachers and aome administratora in a variety of contexts. Although I have no ayatematic evidence at hand to aupport it, the experience has led me to a atrong hunch that a aignificant portion of elementary and aecondary school people have difficulty in reasoning from principlea and abatractiona to actions, and in conceptualizing data and experience from real-life aituationa.

As acience educatora, we generally asaume that theae capabilitiea are acquired in early adolescence (13). Thua, in preparing teachera, we generally do not attend to development of reasoning and conceptualizing skilla. Even though we assume adulta are capable of formal reaaoning, complex, multidimensional tasks auch aa curriculum planning are difficult to conceptualize and consequently, people may tend to revert to more primative reaaoning akills when engaged in them. Since aucceas and profeaaional growth in teaching depend, at leaat partly, on a teacher'a ability to reason from principlea to action and, in turn, to conceptualize experience and learn from it, development of reasoning and conceptualizing abilities may need more attention in teacher education programs than it haa received in the past.

Regardlese of the validity of the hunch stated above, experience in conceptualizing and reasoning from principlea ia a skill that acience teachera ahould develop aa it ia a fundamental part of acientific proceasea and, thus, ahould be included in a aecondary teachera' preparation (Guideline IV) (1). This ia a broadly uaable akill and ahould be developed not only in relation to aciences, but alao in relation to teaching.

Science Teacher Education at Governors State University

The following description is provided as an example of one institution's response to contemporary issues of science education in a metropolitan area.

In an effort to formulate a balanced program and respond to the several issues specified above, the Science Teaching faculty at Governors State University is developing and implementing a competency-based, preservice/inservice program for educating science teachers for elementary, middle, and high schools. At present, program plans are being reviewed by the Bureau of Teacher Certification of the Office of the Superintendent of Public Instruction, State of Illinois. Learning modules and self-instructional packages are being developed to aid students in acquiring competencies which are continually undergoing refinement.

Competencies have been described in three broad areas--science content, professional education and interdisciplinary studies (3). In general terms, it is expected that graduates of our program should be able to:

1. demonstrate knowledge of and ability to apply concepts of the environmental sciences including biotic, abiotic, and interactional concepts;
2. describe and utilize inquiry processes in generating and applying knowledge;
3. retrieve and interpret information acquired through inquiries of others;
4. describe the origins and evolution of scientific knowledge using concepts from the history, philosophy, and sociology of science;
5. utilize contemporary concepts of learning processes in diagnosing students' learning needs and in planning and implementing instruction;
6. describe and apply concepts of curriculum design in planning and organizing curriculum;
7. demonstrate a broad repertoire of skills in teaching;
8. use his (her) own instruction as an object of inquiry;
9. utilize knowledge of social, economic, ethnic, political, and religious principles in interpreting actions of individuals, groups, and institutions;
10. demonstrate skill in working and communicating with individuals from a diversity of cultural and intellectual backgrounds;
11. describe major conceptualizations and processes in one or more fields of inquiry or expression other than science; and
12. formulate, verbalize, and derive actions from a value set based on contemporary scientific and humanistic knowledge.

In addition to these general statements, more precise, demonstrable competency statements are being developed along with meana to aid students in acquiring them and procedures by which faculty can assess achievement. Development of competency-based instruction is an agreed-upon thrust for our whole University. Consequently, faculty members have support in this task from a staff of instructional designers and encouragement from all levels of administration. Moreover, we do not have impediments to innovation often found in older universities. In spite of all of this, the task of developing and implementing a comprehensive competency-based program is not easy. One reason lies in the fact that when several people engage jointly in program development, non-verbalized, and often unrecognized, differences emerge in fundamental beliefs about the nature of knowledge itself and how it is engendered. This tends to retard effective action, largely because the persons involved have difficulty in recognizing the need to employ an expedient in removing this block. Another reason is the difficulty in detailing competency-statements, learning tasks, and achievement measures with the necessary specificity without falling into the trap of triviality. This is confounded by simultaneously engaging in the creative but difficult task of using existing concepts of instruction, learning, and curriculum to analyze and help resolve current problems of practicing classroom teachers as part of our commitment to in-service education.

The challenge of developing a competency-based teacher education program causes us to look at the procesaes of educating secondary t.achers both from a global and microscopic perspective. With several groups of science educators in different universities generating competency-based programs, each attending to the many dimensions of the task, research and practice in science teaching will be revitalized.

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SECONDARY SCHOOL SCIENCE TEACHER EDUCATION:

WHERE ARE WE GOING?

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Introduction

Secondary school science teacher education at The Ohio State University appears to be going in the direction of a program that is field-based and that involves early, continuous experience; a unification of courses in educational "foundations" and in science education; the use of computer-assisted instruction to provide immediate feedback to students; and an emphasis on self-evaluation with the opportunity to self-select out of the program at various points. Our program attempts to combine the acquisition of educational theory with experiences in the classroom. Preservice secondary school science teachers participate in a five-quarter program during which they work at different grade levels (elementary, junior high school, senior high school) and in different community settings (inner-city and suburban).

Background

Often, in order to know where you are going, it is helpful to realize where you have been and/or where you started. A little background information seems to be in order to enable the other panel participants to view our present, and proposed, program in its proper perspective.

Program modifications were begun, in 1968, in order to provide students with experience in inner-city schools prior to student teaching. Many job openings were in large city systems, in inner-city assignments. OSU student teaching assignments in science had been made primarily in Columbus schools which more closely resembled suburban placements as well as in surrounding suburban school systems. In the hope that our graduates would be able to be successful in an inner-city placement in their first teaching position if they had worked in an urban school setting during, or prior to, student teaching or that they would be able to interview more wisely, the Science (and Mathematics) Faculty began restructuring the practicum courses and student teaching.

Eventually this restructuring extended from the senior year down into the junior year, resulting in the present program that spans five quarters: three in the junior year and two in the senior. In our "old" program, students enrolled in a curriculum course (Education 435) which provides an introduction to teaching in general and teaching at the secondary school level in particular and in a course in educational psychology (Psychology 230) before they had any contact with the science education faculty.

In addition, the students completed a requirement of the College of Education for which they observed in some school for one or two weeks in September before the OSU Autumn Quarter began. This "September Field Experience" is very unstructured and students receive no University supervision during this time.

The initial meeting of preservice secondary school science teachers and OSU science education faculty was in a general methods course for science education majors. This course was followed by a special methods or practicum course and by student teaching. In some instances, students enrolled in the practicum course concurrent with student teaching. Many students had little, or no, work in the public schools other than the September Field Experience before they began student teaching. Some found, in the last quarter of their senior year, that they had chosen to pursue a career for which they were unsuited or in which they were unhappy.

Early, Continuous Experience

Our present program has a single point of entry: Autumn Quarter of the junior year. (Some of the students in the junior program have accumulated enough credits, due to change in majors, to be classified as seniors but, for our purposes, they are considered as "juniors.") In the junior program, students work in the schools two half-days a week, for ten weeks, each quarter. (A five-quarter overview is appended to this paper. A more detailed description of each of the five quarters is included in the AETS-ERIC publication, "In Search of Promising Practices in Science Education.") Unless scheduling problems or personality conflicts dictate otherwise, the students remain together as a group under the supervision of the same faculty member for the junior program.

This provides an opportunity for the students to get to know each other, and at least one faculty member, well -- an objective that is often difficult to achieve in a student body as large as that of Ohio State's. The faculty member has the opportunity to watch the students grow and develop insights into teaching as well as acquire skill in teaching. After the initial one-on-one tutorial situation in the Autumn Quarter of the junior program, the students work in teams of two or three for the next three quarters and again work alone during student teaching.

Students begin, in the J-1 quarter, in a junior high school in a tutorial setting. In addition to tutoring, students work in the science classes as teacher assistants. They may have an opportunity to teach a lesson for the total class, depending on their interests and those of the cooperating teacher. They observe in other subject areas and generally get acquainted with the functioning of the junior high school to which they have been assigned.

The following quarter, J-2, they teach science to elementary school children. Juniors work at all levels, K-6, and observe age groups different from that to which they have been assigned for teaching. In most instances, the students experience the most freedom, as well as responsibility, in their teaching for the five quarters while they are in the elementary school. This situation occurs because most of the elementary teachers with whom we work concentrate on subject areas other than science in their classrooms.

In the J-3 quarter the students move to senior high schools, working in a class in their specific content area. During this quarter they work primarily on developing and guiding laboratory activities.

In the senior program, students spend a half-day in the schools, five days a week for ten weeks in the S-1 quarter. They work in an inner-city school for half of the quarter and in a more suburban assignment for the other half. Groups switch school assignments in the middle of the quarter. This procedure helps to minimize, to some extent, problems in placement and supervision.

For student teaching or the S-2 quarter, the student may choose a specific school or type of community setting in which he wishes to work. Student teaching involves a full day, five days a week for ten weeks.

Unification of Theory and Reality

In addition to the early and continuous experience in the schools, some modifications have been made in the curriculum and psychology courses. These courses are service courses for the College of Education and are required for all preservice secondary school teachers. Usually these courses are taught by doctoral students, many of whom are just beginning their programs.

The Faculty of Science and Mathematics Education was able to involve the Curriculum and Foundations Faculty and the Department of Psychology in a cooperative venture for our students. Special sections have been set aside for science (and mathematics) students, and program modifications have been made in these sections. Large lecture sections in which information concerning educational theory was transmitted have been eliminated. Instead, students present problems they have encountered in their teaching or faculty members identify situations they have observed and an effort is made to identify and relate relevant theory to these experiences.

In the junior program, attempts are made to relate school experiences to content from Curriculum and Foundations (systems for observing classroom interaction: verbal and nonverbal; group processes, etc.) and from educational psychology (cognitive development, motivation, perceptual psychology, etc.). In the S-1 quarter, educational philosophy and sociology are related to problems encountered when teaching science.

Science Education Program Components

Our present program is composed of three phases during each of the four quarters that precede student teaching: school experience, on-campus activities, and seminars. Some of the seminars take place in the schools so that the cooperating teachers may participate and/or observe. Additional seminars are held on campus in which individuals from other faculties participate, to relate theory to practice.

While the students are involved in working in the schools, their on-campus science education activities are focused on becoming more aware of science as a process of inquiry and also on the development of teaching skills such as questioning, lesson planning, etc. In order to emphasize the process aspect of science, students work on individualized laboratory activities which they perform as pupils and then critique as future teachers. They gain experience in analyzing laboratory activities relative to level of difficulty, the science processes involved, etc. and begin to build a personal portfolio of activities which they use during their teaching as undergraduates and which they can take with them for future use.

Some of the laboratory activities have been written so that the students interact with a computer and receive immediate feedback concerning their progress. At present we have a functioning program relative to behavioral objectives. We are in the process of adapting some of the laboratory activities so they contain a computer-component. None of these have reached a trial stage yet.

During the J-1 quarter, students are involved in some microteaching activities so that they have the experience of working with small groups and of evaluating their teaching style as it is recorded on video or audiotape before they begin small group teaching activities in the elementary school in J-2.

Program Modifications: Experimental and Otherwise

The OSU science education program has been, and will continue to be, a flexible one in terms of activities and approaches. For example, the on-campus individualized laboratory component of the program was developed prior to the extensive involvement of juniors in the public schools. As our students have worked in the schools, the focus and emphasis of this part of the program has caused changes in the laboratory component. As faculty members move into, and out of, program responsibilities, changes occur because of the interests and expertise of the specific faculty member responsible for a particular portion of the program.

This year we are conducting our own course in educational psychology, on an experimental basis. The juniors meet once a week for a two hour lecture-question session. Lectures are presented by faculty members from Curriculum, Science Education, Exceptional Children, Educational Development, and Special Services. These individuals contribute their expertise in motivation, behavior modification, perceptual psychology and creativity, and interpersonal relations, to cite a few areas. The juniors contract for a grade. The contract involves weaving together the educational psychology topics and science lessons, rather than treating them as two separate entities as in past quarters.

Another experimental program component scheduled is being tried during this Spring Quarter. Known as either the S-3 quarter or the "capstone quarter," it involves only the earth science majors and some of the general science majors. These students, who are completing their student teaching during the Winter Quarter, are involved in combined study and research projects during S-3. Faculty in the Department of Geology and in the School of Natural Resources work with these students and with science education faculty members.

Evaluation and Self-Selection

There are no objective tests in our program, at present. Instead, students and faculty confer at scheduled intervals during each quarter as well as whenever either student or faculty member thinks a conference is necessary. Our program encourages, and demands, self-evaluation.

Within the present format, students have the opportunity to view themselves as teachers and to check their projections against work with pupils during their first quarter in the program rather than having to wait until student teaching to discover that teaching is, or is not, for them.

During the 1971-72 academic year, 50 juniors began the science education program in the Autumn Quarter. Thirty-five remained in the junior program the following June. Of the 15 who chose to pursue another major, only one individual was counselled out (after two quarters of work in the schools). The other 14 (some of whom the faculty thought were doing good jobs) assessed their satisfactions and frustrations and decided to pursue other careers. At the end of Autumn Quarter, 1972-73, eight of the 50 juniors left science education.

The J-1 quarter is a time of worry and frustration for most of the juniors. They have been conditioned, during their public school and prior college educations, to accumulate large amounts of factual information and retrieve it for written tests. In our program, they are expected to engage in self-evaluation, to be assessed (self and other) on the basis of their teaching performance, and to learn to identify and use inquiry teaching techniques. For most juniors, tutoring means telling. There is much cognitive dissonance as the juniors struggle to formulate an inquiry style of tutoring and to accept the idea that their pupils should be encouraged to become independent learners actively engaged in doing science rather than passive recipients of much of the scientific information that the college junior has managed to accumulate.

Some of the people who leave our program find they relate less to their students than to the content they teach. Many of these decide to pursue science majors and aim for graduate work in science. Some find they do not feel comfortable in the role of teacher. They may have problems with discipline or motivation or both. Others have been so successful in traditional science programs that attempting to use inquiry as a teaching technique is, from their point of view, unreasonable and impossible and not worth the effort.

Those who like, and remain in, the program graduate as more poised, experienced, and capable individuals than were the majority of our former graduates when they completed student teaching. The products of our present program should be more effective teachers, in their first jobs, in terms of helping students learn. They should, we hope, remain in teaching longer and should be more able to be successful in urban assignments.

Research Related to our Program

A number of research studies related to our program have been completed in the last few years. Four doctoral dissertations in science education (3, 4, 5, 10) and two in mathematics education (7, 8) have focused on the program *per se*. An additional dissertation, recently completed by Lucy, involved an evaluation of the on-campus laboratory component of the program as that component existed prior to 1970. Complete citations of these studies are given at the end of this paper.

In addition, two research studies focusing on the development of questioning skills have been completed (1, 2) and a third study is in progress.

A doctoral student (6) has formulated a dissertation in which she investigated the philosophy and objectives of our present program and in some way related this to involvement with cooperating teachers.

There is much that could be, or needs to be, done in terms of program development and research related to our undergraduate program as a whole or to various aspects of it. Program modifications will have to be made, if restricted funds dictate decreased involvement in the schools. In addition, the program components (on-campus, seminar, and school experience) need to be reviewed and revised so that articulation of these parts is a definite, recurring process. Emphasis on science process skills and on development of teaching techniques needs to be woven in a spiral pattern into each of the five quarters of the program.

Summary

The secondary school science teacher education program at The Ohio State University will probably continue in the general direction it has taken in the past several years, unless the financial situation at the University and within the College of Education dictates otherwise. That direction is identified by five quarters of work in the public schools, at all educational levels (elementary and secondary). This school experience is closely supervised by senior faculty members and some graduate students. Preservice secondary school science teachers are encouraged to view themselves as teachers whose primary function is to help their pupils learn to use the processes of science as they investigate and inquire and attempt to become independent learners. The preservice teachers are expected to acquire insights into the teaching-learning process as well as skills in scientific inquiry and in teaching strategies. They are also expected to evaluate themselves as they progress through the five-quarter program and to assess their effectiveness as a teacher in various socio-economic settings and at different grade levels.

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4

FORMAT FOR UNDERGRADUATE PROGRAM IN SCIENCE EDUCATION

The project consists of five quarters (J_1, J_2, J_3, S_1, and S_2) which incorporate course work and experiences meeting all state certification requirements. Please do not enroll for any "required" education or Psychology courses (except Psychology 100) until you have consulted with an adviser in Science Education.

	AUTUMN QUARTER	WINTER QUARTER	SPRING QUARTER
JUNIOR YEAR	J_1 (5-8 hours credit) JUNIOR HIGH SCHOOL 1) Tutor one 9th grade student two days/week, one period/day 2) Observe a) this student in class (preferably science class), b) other teacher, c) general functioning of the school 3) Attend seminars twice a week after school 4) Work on laboratory modules in 274 Arps Hall <u>Time needed for project</u>: 1) two half days (M/W T/Th) for school experiences 2) two two-hour blocks for on-campus laboratory work	J_2 (5-8 hours credit) ELEMENTARY SCHOOL 1) Teach science two periods/week (one period/day) in grades K-6 (grade assignment stays the same all quarter) 2) Assist cooperating teacher in other activities in class 3) Observe at other grade levels 4) Attend seminar once a week after school 5) Perform additional laboratory activities in 274 Arps Hall <u>Time needed for project</u>: 1) two half days (M/W T/Th) for school experiences 2) two two-hour blocks for on-campus laboratory activities	J_3 (4 hours credit) JUNIOR OR SENIOR HIGH SCHOOL 1) Teach laboratory activities two periods/week in your content area 2) Observe a) other science teachers in your content area, b) teachers of other sciences 3) Assist cooperating teacher in other duties 4) Attend seminar once a week after school 5) Do laboratory activities in 274 Arps Hall <u>Time needed for project</u>: 1) two <u>consecutive</u> half days a week (M/T T/W W/Th) for school experiences 2) two two-hour blocks for on-campus laboratory activities
SENIOR YEAR	S_1 (17-18 hours credit) JUNIOR or SENIOR HIGH SCHOOL 1) Participate in orientation program 2) Teach half days in an inner-city type school for half the quarter; other type for the other half 3) Conduct lab activities in practicum course on campus 4) Participate in philosophy of education seminars 5) Conduct addition activities related to individual and small group studies	S_2 (15-18 hours credit) JUNIOR or SENIOR HIGH SCHOOL Full-time student teaching in either an inner-city type or more suburban-type school (type of school determined by the student in consultation with adviser in program) Time needed for project: the school day Time needed for project: the school day	CONTENT QUARTER S_1-S_2 sequence may be completed Autumn and Winter Quarters, Winter and Spring Quarters, or (if need be) Autumn and Spring Quarters

SECONDARY SCIENCE TEACHER EDUCATION:

WHERE WE ARE GOING AT THE UNIVERSITY OF IOWA

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In September of 1970 a grant was awarded by the National Science Foundation to the Science Education Center at the University of Iowa for the development of pre-service programs for teachers of secondary school science. The program was called Iowa-UPSTEP (Undergraduate Pre-service Teacher Education Program). The rationale for this program and a report of its progress is a response to "Where We Are Going" at the University of Iowa. This also represents our analysis of the problems of teacher education for the eighties and our plans for meeting these challenges.

Iowa-UPSTEP was conceived with the idea that a new kind of science teacher is needed. Too many persons in the Teacher Education Program at the University of Iowa were persons who aspired first for medicine, engineering, or some other related vocation. The staff at Iowa was concerned that too few secondary teachers actively recruit some of their best students for their own profession. Instead teachers are more concerned and interested in recruitment for medicine, engineering, and similar professions.

An important part of Iowa-UPSTEP is recruitment in the high schools of Iowa (and the Midwest generally). Secondary Student Training Programs (SSTP) are available for several hundred sophomore and junior high school students for a six week period during the summer. Ultimately most of the UPSTEP participants will have been involved with us first as participants in one of our Iowa-SSTP Programs prior to selection. Iowa-UPSTEP participants and all SSTP students are outstanding high school students--fully capable of making any vocational choice. Thirty students are identified as UPSTEP students prior to enrollment as freshmen students at the University each fall. They are visited in their high schools. Hopefully, all will have been on the campus for a full summer prior to enrollment as full-time freshmen students as SSTP participants. If they were not SSTP students, they are invited to spend several days on the campus following high school graduation and prior to enrollment as freshmen in the fall. As UPSTEP participants, the students are treated as members of an Honors group for indeed they are Honors students.

The first phase of the Iowa-UPSTEP program provides an opportunity for the participants to meet and interact with some of the most prominent scientists at the University of Iowa. Weekly seminars are conducted which add to the student experience with various areas of science and various scientists. Such interaction, with persons recognized as leaders in their fields, is a unique experience for freshmen students at the University. The Iowa-UPSTEP participants are invited to visit research laboratories, participate in field excursions, and conduct individual investigations in the several areas of science.

The second phase of year one of the Iowa-UPSTEP program emphasizes problems in communicating science and an analysis of the communicative process itself. The Iowa-UPSTEP staff believes that one of the most important aspects of science teaching is to be able to communicate effectively. Therefore, communication becomes the logical area for investigation for students who are considering science teaching as a career. Potential science teachers should be aware of the methods and modes of communication that are available. A series of weekly seminars demonstrate that different methods are required to communicate with different people at various stages of physical and mental development. The problem of communication in science in "Our Changing Society" ends phase two of the freshman year.

During phase one of the second year of Iowa-UPSTEP, the sophomore students are involved in role playing, simulations, and micro-teaching experiences involving their peers. Additional inquiry teaching techniques which include the use of audio-visual materials are emphasized. Teacher behavior in the classroom is coded by utilizing the interaction analysis instrument developed by Amidon and Flanders.

Throughout the second phase of the second year, the sophomore students are participating actively in early exploratory experiences in public schools of Iowa City. The purpose of this early exploratory experience is twofold: first, to provide the opportunity to observe and participate in the duties and responsibilities of teaching in order that a rational decision can be made concerning the suitability of teaching as a career; and second, to provide the student with first-hand experience to insure maximum gain from advanced, professional education course work through the interaction and communication with the cooperating teachers.

The program goals and experiences for the early classroom experience are as follows:

1. Develop insights and skills involved in establishing empathetic relations with school age children and youth.
2. Come to respect and understand each child as a unique person.
3. Gain information about characteristics, interests, needs, and developmental processes of children and youth through observation of their behavior in a variety of settings.
4. Gain insights and appreciation of the social interactions, value systems, environments, and concerns of pupils.

5. Gain knowledge of the way pupils think and learn.
6. Assess potentialities and interests in teaching as a prospective occupation.
7. Secure firsthand experience and knowledge of the organizational structure and inter-personal relationships of the professional staff of public school systems.
8. Gain knowledge and some experiences with instructional processes and media in schools.
9. Develop an appreciation of the inter-relationships and joint responsibilities of teachers and parents in guiding the educational growth of children.
10. Participate in, and become familiar with, professional inter-relationships, activities, and organizations of teachers.
11. Participate in some types of community-school organizations and activities.

Several types of early experiences are available. These are:

1. Observing classroom instruction and procedures.
2. Aiding the classroom teacher with routine clerical and administrative experiences.
3. Assisting in working with individual pupils and small groups in learning situations.
4. Assisting in selecting and preparing learning materials.
5. Assisting in diagnosing learning problems for individual pupils.
6. Assisting in supervision of play activities and some extra-curricular activities.
7. Involvement in parental conferences.

In addition, bi-monthly seminars are held where the Iowa-UPSTEP staff and participants discuss various aspects of the early experiences. Because the early exploratory experience is an experimental program prior to student teaching, several group discussions are conducted in which students, cooperating teachers, and the Iowa-UPSTEP staff collectively evaluate the program.

At the beginning of the junior year, the Iowa-UPSTEP participant is encouraged to apply formally for the teacher education program at the University. At this point, Iowa-UPSTEP participants follow the usual sequence of professional courses--although all of these are specially structured because of the new student needs stimulated by the Iowa-UPSTEP program.

Special new courses have been developed for the junior-senior Iowa-UPSTEP participants. These courses are available for all UPSTEP students--those committed to a teacher education program, those still undecided about their vocations, and those planning to enter other professions. We find that Iowa-UPSTEP continues to be a viable experience for students with a variety of career goals. In addition, persons not identified previously as UPSTEP participants are invited into the group as science teaching majors. Special courses for the junior year include:

1. One in the student's major field to explore the rationale underlying the organization and presentation of introductory courses.
2. Meaning of Science which considers the elementary philosophy and logic that characterize science.
3. Multi-media Instructional Techniques which provide the students with opportunities to develop and utilize multi-media.
4. History of Science which examines the major steps in the development of twentieth century science.
5. New concepts for secondary schools including computer assisted instruction, learning modules, programmed sequences, open classroom, differential staffing, and new curriculum structures.

Another unique experience of the Iowa-UPSTEP program is the summer institute where Iowa-UPSTEP students interact with experienced high school teachers and graduate students in science education. The summer experience is designed to provide assistance in the preparation of specific teaching materials in each of the major disciplines. The experienced teachers are the cooperating teachers the following academic year for the student teaching experiences. The graduate students are concerned with evaluation and assist with research designs created to evaluate new curriculum materials, new course organization and sequences, and new teaching styles.

During the senior year, the Iowa-UPSTEP participants follow a program similar to the present professional semester at the University of Iowa. Because of the background which the Iowa-UPSTEP students bring to the professional semester, all of the discussions and activities have more meaning and can be dealt with in greater depth. The total program has operated closer to classrooms and teachers. Indeed, one of the major developments is a cooperative program involving men of science, teacher educators, in-service teachers, and real schools as learning laboratories.

The major effort of the last undergraduate semester is an original research project initiated and supervised in the major science area. Here the UPSTEP students learn what science is through a direct experience. They also gain new experience in communication and in working with people.

The Iowa-UPSTEP students who accept teaching assignments in cooperating midwestern high schools are involved in a three week summer conference following graduation and prior to the commencement of teaching duties. The conference involves former participants in NSF in-service programs, directors, and instructors of similar programs as well as several regular teachers who will be co-teachers the following year with the Iowa-UPSTEP graduates. The faculty of the Iowa-UPSTEP program at the Science Education Center does not want to send the Iowa-UPSTEP students to their first teaching assignment without knowing the school, personnel, curriculum, and many of the students. We feel this conference can help complete the cycle as we strive for a cooperative approach to teacher education.

Iowa-UPSTEP, with an initial focus on recruitment, is evolving into a program of societal awareness concerning problems, issues, and objectives of science and teaching. It is proving to have an important general education function within the University and also an important community focus statewide. Students in the UPSTEP program have been identified as having the capacity to become leaders in scientific fields. Those who decide to continue in science have had the opportunity to become intimately familiar with the many problems of public education in our free society. They have contributed through their presence in classrooms to making that education more meaningful. They have also had the opportunity to develop communication and teaching skills, and they are all familiar with modern concepts in activity-centered teaching.

The University of Iowa Teacher Education Program is strengthened by the involvement of UPSTEP students and other University and community leaders brought in as part of the UPSTEP program. Currently discussions are being held with representatives from the other twenty-eight colleges in Iowa with teacher education programs. One outcome of these discussions is a plan to establish cooperative centers in Iowa where in-service work with teachers, interaction among staff members from a variety of colleges, and a semester-long internship for student teachers from several colleges can be implemented. Iowa-UPSTEP can then be a model for statewide improvement of teacher education.

We are striving for greater communication with ourselves as a staff, with our students, with teachers and administrators in the schools of Iowa, with other teacher educators. We operate from the premise that we are all limited by our past experiences and that we can only grow by trying the new and gaining insight from others. We certainly can not raise our sights and improve our society (and our schools as a microcosm of that society) if we are isolated from one another and if we are satisfied with the status quo.

SECONDARY SCIENCE TEACHER PREPARATION

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Present Program

Students enter the undergraduate science teaching certificate program the beginning of their junior year. They are assigned to an Education School advisor, or if they prefer to remain in the College of Literature, Science and Arts, they are advised by a member of that faculty. About half of the science teaching candidates remain in the College of L. S. and A. The student must have at least a "C" average to enter the program and must satisfy the School of Education that "he or she possesses attributes which are necessary or desirable for teaching."

A recent development in the School of Education is that Program Directors will be named for secondary education fields such as science, mathematica, etc. The Program Director will serve as the team leader to work with persons from educational psychology, social foundations, methods and directed teaching placement to coordinate the entire undergraduate certificate program. Thus, a student desiring a teaching certificate in science will report to the Program Director in that area and receive counseling toward that goal.

Major Fields

Students can select majors in biology, chemistry, physics, earth science, general science, physical science and environmental education. A group major consists of thirty-six semester hours of credit and a single field requires thirty semester hours. Minors are also offered in each field mentioned. Biology majors still outnumber all of the other fields by a two to one margin. The most common minor is general science since the majority of placement openings are in this field.

All majors and minors are worked out in cooperation with the science departments in the University.

General Requirements

Each student selects a major and a minor. These credits, plus approximately forty credits in general education (social sciences, languages, literature, humanities, etc.), plus twenty credits in education make up a total of 124 credits needed for graduation. This package can be completed in eight semesters and seems to be the general plan the School of Education will follow. There is no move toward a five year internship type of program. A student with a B.A. who has a B average can take a combined Master's degree and teaching certificate program, but few students have opted it.

Professional Education

Education courses required for the teaching certificate are becoming field based and performance oriented. Students are required to take educational psychology (3 credits); a course in the history of education, or philosophy of education, or educational sociology (2 credits); a special methods course in the teaching of science (3 credits); a practicum with the methods course (2 credits); directed teaching (8 credits); and a seminar with directed teaching (2 credits).

Opportunities to select unusual programs at Michigan are quite good. Presently a student can select a program sequence with an emphasis on urban education, which would require a year of internship in Detroit; a semester abroad in which methods and directed teaching can be taken in Sheffield, England; a professional term in science teaching, or the regular half day directed teaching program.

New Directions

The Professional Term in Science Teaching

Prior to the Fall Term of 1971, science students were assigned to a half day of directed teaching and were supervised by a "generalist" in education. The methods course was a prerequisite to directed teaching. During the Fall Term of 1971, the Professional Term in Science Teaching was initiated. Science methods (3 credits), directed teaching (10 credits), and the seminar (2 credits) associated with directed teaching are offered in a fifteen credit package. The objectives of the program are:

1. To relate the methods of instruction in science more closely to the directed teaching experience. A University science education supervisor works closely with the student teacher insuring instant feedback on performance. The University methods instructor also makes visits to the student teaching site for direct observation of student performance.
2. To provide a situation whereby the student teacher can obtain a full day directed teaching performance.
3. To include secondary science teachers more directly in the development of teacher education programs in science.
4. To use secondary science teachers and university science educators to develop criteria for a competency based program in the preparation of secondary science teachers.
5. To develop a science teacher who has knowledge of the tasks one must perform in the classroom and who can demonstrate them effectively.

In order to meet these objectives, the program follows this plan. The student is assigned to a science teacher in an Ann Arbor junior or senior high school for the semester. During the first half of the semester, the student teacher takes instruction in methods at the University at least four hours per week. The remainder of the time the student is expected to follow his or her supervising teacher's full day schedule in the public school. A separate student teaching seminar is held, usually Thursdays from 4:00 - 6:00 p.m.

During the first two weeks, the student teacher is an assistant to the teacher in many ways; he grades papers, takes attendance, learns the names of the students, assists with laboratory and demonstrations, visits other classes and other schools, and, in general, learns the philosophy of the school. After the first two weeks of the semester, the student begins teaching one period per day, and after the first eight weeks, the student adds to his teaching load to the point where at times the student is teaching all the classes of the supervising teacher.

The Professional Term program has provided a much more flexible schedule for working with students. The students become more committed to the total school program, they have the freedom to visit other schools, and they can attend professional meetings with the science education faculty. In addition, the students have more careful supervision from a science specialist and above all in their evaluations, the students feel someone in a large university "cares" for them.

Multi-cultural Preparation

The University School of Education has provided five one half day sessions in multi-cultural methods and materials for student teachers at the beginning of each semester. After this year, individual instructors will integrate these methods into their regular courses.

Performance Based Programs

There is a Task Force on Innovative Education which is developing performance based objectives for teacher certification. In science teacher preparation we are developing objectives in both methods of teaching and the techniques and lab skills within the subject field the person is preparing to teach. The research we are conducting in teacher classroom behavior is guiding the methods performance behavior (2). The model that is used is interaction analysis, inquiry teaching behaviors, psychology of learning contributions from Bruner, Gagné, Piaget, Ausubel, and newer concepts of humanness in education. The teaching of values and attitudes is also receiving much more emphasis.

The skills and techniques competencies have been developed for subject fields in biology, chemistry, physics, and earth science. The biology area is the best developed one at present (1).

Computer Simulation

A project in computer simulation of teaching is well under way this semester. "Teach II" combines the results of teacher questionnaires, random numbers, and an interactive computer model in an attempt to simulate the influence of teaching strategies on student achievement, attitude and study skills. The results of student teacher performance on the program have demonstrated a bright future for the computer in teacher education.

Summary

The major effort at Michigan has been oriented to integration of the education courses, studying the kind of teacher we would like to produce and attempting to match this "model teacher" with teacher behaviors, applying a more personalized approach to teacher education and simulation. One of the concerns we are planning for, but have no concrete plans at present, is the program of courses for the preparation of unified science teachers and multidisciplinary science teachers.

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SCIENCE TEACHER EDUCATION:

WHERE I THINK WE ARE GOING

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In past years few teachers have expressed approval of their teacher preparation experience. Almost every major institution has conducted follow-up studies with feedback evaluation of their teacher education program. Almost invariably the results were critical if not condemnatory. The methods course in specific subject matter areas usually fared better than the teacher education program as a whole, but certainly never escaped unscathed.

My Experience

During the last year I worked with eight prospective science teachers in a new program initiated at the University of Colorado. It was exploratory in the sense that we operated a modular, field-experience centered program intended to be more relevant to the needs of prospective teachers. The program was hastily conceived and initiated without having all the materials needed for a good program, but the feedback obtained from students and cooperating faculty has been positive, at least so much so that we are obligated to continue this operation. And, it is very doubtful that we will ever return to the old college class-centered program that was separated from the student-teaching experience.

Very briefly, our teacher program spent as much time in public schools as on campus. Applicants were screened by myself and public school teachers. We had a picnic for cooperating teachers, prospective teachers and myself after which we tried to develop a feeling of trust and a sense of direction. The prospective teachers spent the first two weeks of the fall semester helping open school as general flunkies. The remainder of the semester they spent one-half time as instructional assistants (IA's) in school and one-half time studying modules in the professional education program. After the Christmas break the IA's became student teachers at the same school. The shift from IA to student teacher was gradual. I served as a "stream leader" and tried to spend ten hours per week with the prospective teacher but other duties reduced this to about seven hours. After April 1, these student teachers will shift to an alternate experience that may involve teaching at another level, in a very different community or even in a non-public school situation.

Viewpoints Based On My Experiences

Where are we going in Secondary Science Education? As a professor I'd like the assurance of knowing, but I don't. At the same time I find a feeling of adventure and excitement in the ambiguity that exists. I suspect that if other members of this group were certain, the question wouldn't be asked.

There are two reasons why the question could be asked that are apparent to me. One is that we need a consensus and a sharing of ideas. The other may be that some things are going badly and we'd better change.

To me personally, I know directions in which I hope our program will go, yet I look for it to be evolutionary and change as time passes. Research, evaluation, and philosophy are all likely to help us to determine better directions.

The following viewpoints are thoughts based primarily on informal evaluations of a program in its first year. They are not so fixed that they will not be changed. I certainly appreciate the opportunity to learn from others in this group.

Administrators of curricular programs and teacher institutions have tended to endorse some particular form of teaching activity or strategy despite limited research evidence of its superiority in augmenting learning. There has been an emphasis on "best method" and attempts have been made to drastically change teaching behavior. Most of these efforts have met with at least partial failure. Teachers tend to develop their own teaching behavior, although they may modify in terms of observed or advocated teaching. It is true that certain skills can be taught in a training situation but a permanent change occurs only if the teacher is convinced that teaching is improved by the change. Our task in teacher education then becomes one of providing situations where the preservice teacher expands his concept of good teaching.

Until we have more reliable knowledge of the effects of teaching strategies and actions, those of us whose major activity is preservice preparation of teachers may do well to turn our efforts to expanding the prospective teachers' repertoire of strategies and activities.

Each person is born with certain talents and has undergone a series of experiences of his own that have made him different from his fellows. Prospective teachers, as well as the pupils they will teach, are unique. Only during the last fifty years have we talked much about this and only during the last few years have schools started to do much about it. Schools still operate, for convenience sake, by teaching classifications of students who have some common characteristics. But if we can adapt our teaching to the uniqueness of the individual we may enhance both learning and the motivation to learn. Therefore, as teacher educators we need to provide different experiences and activities for each unique individual, offering a number of options in our programs which will be selected after assessing his qualities.

We also need to remember that there are many other places where people learn besides the school. In fact, if our education had stopped when we completed school, most of us would be ignorant. A modern student learns a great deal from the various communications media and from his fellow students. The school perhaps has some responsibility to help the student acquire skills which will enable him to be successful in many different learning situations. It is for this reason that I would recommend very strongly that in our preparation of teachers we encourage teachers to have a variety of activities including teacher-led presentations, teacher-pupil interaction, and especially the development of pupil-to-pupil interaction. There also needs to be a lot of opportunity for a student to search for materials and to educate himself. We are likely to encourage this kind of teaching and thus provide the incentives to students to learn by themselves only if we offer prospective teachers an opportunity to experience this themselves.

The successful teacher needs to be a leader or showman and thus capture the imagination and cooperation of pupils. Yet activities must be justified as being educational rather than just entertaining. The teacher's action should lead pupils to work by themselves.

During this year I have tried to show my prospective teachers some examples of creative work suggesting that they come up with ideas of their own. The response has been gratifying to our cooperating public school teachers as well as to me.

The college supervisor should work in conjunction with teachers in giving opportunities for a number of varied activities. The activities should be specified as to type, but suggestions for developing them can very well be left to the creativity of the student. As an example of creativity I report the following actions of my students and a helpful cooperating teacher during a unit on evolution.

One of the IA's dressed up and made a presentation as a reincarnated Darwin. They presented a re-enactment of "Inherit the Wind" with the public school pupils participating as jurors and in other minor roles. They brought in the film "Voyage to the Enchanted Isles" and discussed some of the implications with the pupils. At one time educators would have shuddered because this film was believed to be beyond the capabilities of the junior high school student. Yet, students today view television and are intrigued by films of this kind. Shall we avoid reality? Our IA's pulled it off without undue problems.

A representative of a fundamentalist religious group presented the creation view and the IA's showed commendable restraint during the presentation. While the students have had this type of experience they were given the opportunity to complete a module which required the student to read a number of short articles that dealt with the evolution-creation teaching controversy in California.

In general, the module should provide a basis for understanding how to handle controversial issues. I hope this provides an illustration of how we can interrelate university work with in-school experience.

It is beneficial for prospective teachers to gain experience in working with small groups by dividing a cooperating teacher's class into smaller sections, carrying on individualized experiments, or conducting small discussion groups. Our prospective teacher can become part of a group and interact with them, serve as a small group leader or simply be an observer. One has to be careful so that the prospective teacher does not become a lecturer to a very small class. Another activity IA's may carry on is tutoring individual students. I found cooperating teachers were pleased to have the student who is a trouble maker or who learns extremely slowly, taken aside for individual help. This activity is of mutual benefit to student and the prospective teacher. The student gets individual attention and some degree of personal help. The Instructional Assistant gains some insight to the behavior of the individual pupil and may appreciate how this particular pupil differs from the rest of the group with whom he has been associated.

Many others in class activities serve to broaden the perspective of the prospective teacher, and yet have him be useful to the class. If he helps in many classrooms with different teachers, he observes the differences in teaching and the differences in classes as well as the reactions of the groups to the differences in teaching. These observations can then be used as a basis for discussion of strategy, teaching mannerisms, and personal planning. Coupled with some appropriate reading, these experiences develop some questions and thoughts that never really penetrated the consciousness of college students under our old system. It is exhilarating when pupils raise questions about the effectiveness of laboratories, classroom explanations, simulation games, inquiry sessions, or the effectiveness of certain disciplinary techniques. At the same time as a university professor I am humbled by the fact that I do not have answers to many questions. Even worse--I fear I never will! But the next generation probably will produce much more knowledge and maybe take those revolutionary changes which mark the progress of science--and the other fields that revise their model.

One major problem for many members of the human race is to develop the ability to interact honestly and openly with other human beings. Many of our past experiences have taught us that there is a hierarchy and that we must be certain to maintain our status in this particular kind of society. We often have failed to recognize psychologically the reaction of people to people is very much colored by this hierarchical system. Much talk has centered on the importance of helping teachers develop an awareness and sensitivity to the feelings and needs of pupils. Perhaps the most effective way of teaching is by example. What would happen if those of us who are responsible in teacher education were to shed our titles and our posture of authority, can we be friendly and very openly and frankly discuss problems with our prospective teacher? In the past there was very little trust and confidence in the relationship between student teacher, university supervisor, and public school teacher. Yet, we must develop a feeling of professional unity and an understanding that the responsibility of developing a student teacher to his potential is something we will achieve best if we work cooperatively. This must not be taken to mean blanket approval for all who seek certification. If we can frankly help the aspirant see his shortcomings and show what is required, he likely will withdraw to other endeavors. If he refuses after a time of probation and individual help, we must protect America's children by refusing to work further with him.

During the last several years there has been a strong movement towards making teachers accountable for the learning of their students. As science educators, we are likely to be held accountable for the preparation of future science teachers. Some people are frightened by the prospect while others look upon this as an opportunity to improve the quality of our product. Certainly the accountability movement is one that commands our attention. Its good or ill may depend in part on actions that we take.

I see a very real danger if accountability becomes so simplified that all emphasis is placed on the product. Especially would I fear that situation, if accountability were reduced to examining only certain competencies. I have no quarrel with maintaining that our program teaches certain competencies. I object if all competencies must be attained by all teachers. I see in our society very diversified performance, even by our teachers of science. Very significant differences exist in the direction in which individual teachers wish to go. I dread a superficial list of competencies of which we would say "this is the minimum basis for certification." I take great comfort, however, that regardless of how we may attempt to manipulate and direct the preparation of teachers, the human organism is likely to teach itself for survival.

Problems

Any time a program of the type we have undertaken at the University of Colorado is initiated, there are a number of rather serious problems that develop. I describe a few of the more important ones. A great deal of experience and a great deal of evaluation in research is necessary before we will ever get to the point where we have a program that we can feel is strong. Yet, as I am talking about these problems, I hope that they will not be a basis for rejecting the new system.

When students are placed in schools for the purpose of participation and learning, there is a very real danger that both students and cooperating teachers think of it as an apprenticeship. In an apprenticeship the learner simply patterns the master to whom he has been apprenticed. In our program we hope that the system of teacher education will help to improve the cooperating teacher as well as the student teacher. Our cooperating teachers have been almost unanimous in their feeling that having these young, aggressive, intelligent student teachers around has been stimulating to them. They feel that there are some things that they learned from the association. A problem may also be encountered where the cooperating teacher will expect the instructional assistant or student teacher to spend a great deal of time doing repetitive, menial tasks. A certain amount of this kind of work is necessary for learning, but care needs to be exercised so that the student has a variety of activities which improve his performance.

Another problem that we encountered was that Professional Education people are reluctant to revise their offerings in terms of what is relevant to the problems that the student teacher will encounter. Of course, there are principles that transcend the simple solution of each mundane problem. However, I believe that the students' acceptance of Professional Education as a meaningful and helpful activity is enhanced when it is applied to the solution of those real problems with which one deals in the classroom. There is no denying that the problem in the local classroom may not be those which he encounters when he gets into a different situation. My point is simply that, if he has found material in professional education modules that was relevant to the solution of his problems in this particular situation, he is likely to look to this source for help in the different situation with a new set of problems.

Perhaps the greatest difficulty that is encountered with this new program is that it requires a good deal of time and dedication on the part of the university personnel. If the university suparvisor does not spend much time in the school and does not work in partnership with the cooperating teacher, this system may very well degenerate to a system of apprenticeship. University professors too often are faced with the problem of meeting publication expectation. I have spent some time with several students and we have done some meaningful research. I have encouraged them to submit their work to others under their own names. Finally, I would like to point out that changes in teacher education ought to be based upon data. Universities ought to provide time and compatent research personnel to develop dasigns to answer the pertinent questions, to create appropriate instrumentation and analysis and then incorporate the findings into changed action. As I look at this general area, I see it as one of the most fruitful directions in which we could go in conducting meaningful research. And, I hope that it will produce significant results for the improvement of American science education.

COMPETENCY, COOPERATION AND CHANGE

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Accountability for All

Education accountability should not be an albatross hung on the neck of the classroom teacher as a punitive symbol of penance for societal failures but rather a communal bowl of opportunities purchased and prepared by certain segments of the society for the nurture and development of the student. Each of the societal segments involved in the purchase, preparation and serving of the school offerings as well as those who teach the chefs, suggest the ingredients, and analyze the results must accept the responsibility of submitting evidence of the merits of their contributions.

Even though the 1972 Gallup Poll of Public Attitudes Toward Education (5) found that the public puts most of the blame for a child doing poorly in school upon the child's home rather than upon the teacher or the school, the continued cry via media, journals, and taxpayer committees is for increased fiscal and scholastic accountability in education. Leiberman's "common sense" definition that accountability exists ". . . when resources and efforts are related to results in ways that are useful for policy making, resource allocation or compensations" (9) was and is a fine idealization of accountability potential in education. Stephen Barro (3) correctly asserts that "Each participant in the educational process should be held responsible for only those educational outcomes that he can affect . . ." However, the narrow view that educational accountability is only for the classroom teacher, the school administrator and perhaps the Board of Education seems to be perpetuated in specialized articles by economists, engineers, systems analysts, researchers and educators. As components of progress in education many of these articles point to the need to scrutinize the learner, the evolving structure or the processes of education within our present system. Alkin's call for school board-goal accountability, administration-program accountability and teacher accountability on outcomes (1) as well as Edward Wynne's plea for educational researchers to consider schools as ". . . our apparent constituency" (15) must be considered part of the total accountability picture. As the accountability spotlight broadens from the classroom teacher to the many interrelated areas of management (fiscal and academic), research, technology, curriculum, learning theories and methodology perhaps we should look more closely at the specific competencies expected of teachers as well as the responsibilities and involvement of the institutions and personnel who prepare and service the teachers. What competencies should be expected of science teachers in this technological society where progress both relies upon and fosters scientific change?

Cryatal Ball Competencies

Toffler's "Future Shock" (13) was a lightning bolt reminder of what many people already knew but were too busy trying to keep up with the accelerating rate of change to consider in depth. The science teacher is faced with the realization that many "facts" learned yesterday are brought into serious question today and may be discarded as outdated fiction tomorrow. New words are entering the science vocabulary more rapidly than textbooks or science dictionaries can include. Entire fields of human endeavor such as bionics, laser technology or plate tectonics continue to evolve from new needs and new knowledge. Thus science teachers must not be satisfied with spoon-feeding high school students soon-to-be-obsolete facts but must develop competencies in guiding students to learn to cope with and adjust to change. We need new means by which science teachers can maintain an awareneas of the ever expanding frontiers of scientific research and application.

Introductions found in many high school science texts of the sixties and seventies proclaim the need to teach science students to deal with change but few teacher education courses boast the same objectives in any demonstrable way. It would appear that the same philosophy of keeping science instruction relevant to changing knowledge and technology should also apply to the education of science teachers. Not only must science teachers have competencies in the latest educational technology and an understanding of this generation of learners' needs within the context of a changing world but they must be prepared to adapt to and even cause necessary changes in our schools. It has been prognosticated that the future science teacher will spend more time (1) diagnosing individual student differences, (2) analyzing learning difficulties and aptitudes of the students and (3) prescribing and developing instructional materials and techniques for students as individuals rather than leading a class of students through a maze of fleeting facts in lock-step precision.

The National Science Foundation invested many dollars in support of the development and implementation of new science courses during the 1950's and 1960's as well as in the re-education of science teachers to teach the new courses. Against this background the educational programs for pre-service science teachers have continued to follow the traditional prescription of required education courses usually isolated from each other and the real world of the secondary science classroom. Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics (7) points to the "tradition-bound" science and mathematics teacher education programs as " . . . derived from existing school curriculum . . ." and the need for schools to ". . . keep pace with cultural change . . ." The guidelines go on to recommend that " . . . teacher educational institutions examine the degree to which their programs reflect progress in science, new emphasis in education, and changes in society."

Swimming Instruction Should Take Place in the Water

This paper is not suggesting the rejection of traditional topics for preservice science teachers such as curriculum development, educational psychology, learning theory, evaluation procedures, instructional techniques, general and special methods, educational technology, etc. but rather that such topics be taught in relationship to the viable "real world" of the elementary and secondary science classes rather than in the sterile surroundings of a college lecture hall with only the professors' own experiences and memories to provide secondhand and often obsolete relevancy. The laboratory school although providing an atypical picture of the secondary and elementary school setting did serve as an intermediate step for preservice teachers as they moved from the idealistic college student role into the realistic day-to-day activities of a beginning science teacher. However, due to financial pressures and the high cost of maintaining a special laboratory school, many colleges of education have been forced to abandon these prototype school settings. Rather than reverting to teaching how-to-teach by proxy the colleges of education could seize the opportunities of our times (demand for accountability, search for relevance, need for classroom research and closing laboratory schools) by moving the teacher education programs into contiguity with today's actual elementary and secondary schools. Each course, topic and concept raised by the education professor could thus be examined and evaluated by the preservice science teacher in the crucible of the present day science classroom.

Three R's of Teacher Education

The teacher education program suggested here for preservice science teachers is only a beginning of an outline proposed to:

1. emphasize the relevance of necessary knowledge and skills proposed by professors of education within the context of elementary and secondary science classrooms,
2. enhance the resources (human, material and service) available to schools by closer cooperation between college of education faculties and the schools from which they receive their clientele and whom they serve,
3. increase the potential for educational research that might have immediate impact upon classroom instruction rather than dissipate in the upper atmosphere of academic debate.

Thus the three R's of relevance, resource and research are the aims of a cooperative structure between colleges of education and elementary and secondary school systems.

From the Ivory Tower into the Action Arena

Most of the plan that is suggested here is neither new or innovative in terms of what has been proclaimed in other places by more articulate spokesmen. The setting of the public and private schools as a place for preservice science teachers to learn their profession is the premise upon which the widely practiced activity called "student teaching" is based. Even the necessity for preservice science teachers to become involved in secondary and elementary science classrooms early in their college career is an integral part of many recently revised teacher education programs. The only variation from these changing, progressive programs which I believe would accelerate our progress in many of the processes of education is an in-depth involvement of the college of education faculty members in the day-to-day activities of the secondary and elementary school systems.

Because of the variations in schedules and contractural procedures in colleges and universities it is not possible to suggest an overall approach to implementing the involvement of college of education professors in the school systems. The suggestion here is that cooperative efforts be established between willing school systems and colleges of education to conduct pilot programs of joint employment of professors directly involved with the education of preservice teachers. For a certain period of time (nine weeks or one quarter, for example) during the school year a science education professor would be employed full time as a science teacher, science supervisor, researcher, program evaluator, curriculum developer, or other possible positions within the total environment of a school system. This day-to-day involvement would not be as an observer of student teachers, director of a one day workshop nor just conducting extension or inservice courses, but actual involvement in the implementation, evaluation and revision of the ongoing science program of the school. This would undoubtedly enhance the professor's own proficiencies in the education of preservice teachers, observing and critiqueing student teachers and in conducting more realistic workshops and inservice courses for experienced science teachers. Future cooperative efforts that might evolve from such a college-school venture are only limited by our traditionally bound experiences separating the tower from the arena.

Competencies for Change

The clarion call for change in education comes from many directions and levels. The newly established National Institute of Education was formed as a response to the President's request, "As a first step toward reform (in our schools) we need a coherent approach to research and experimentation" (11). State offices of public instruction are calling for accountability measures, specified objectives and complete reviews of present educational structures such as described in the booklet, "Action Goals For The Seventies" (2) by State Superintendent of Illinois Michael Bakalis.

Leading educators outline "competency based teacher education programs"(6) and present evidence for changes effected in children by those teachers educated under "performance-based teacher education" (12).

If the efforts of the university based science educators continue taking a path essentially separate from the schools in research, philosophy, methodology and teacher education, their effectiveness in fashioning educational competence for change in the schools will be greatly limited. If the science teachers in the schools continue to work on a day-to-day basis without readily available resource people working with them on research, curriculum development, evaluation and new technology, they will fail in their pursuit of educational excellence. With the total involvement of science education professors and others from the colleges of education in the schools for extended periods of time not only the schools' programs and inservice competencies would be enhanced but the preservice education of science teachers would reap the benefits of relevancy (in the schools of today), resources (of experienced teachers and "real-live students"), and research (with immediate impact on classroom instruction). The effects of such direct involvement in the schools by university faculty members could provide a basis for changing research techniques and reporting so that communication of the findings would be understandable and useful to the classroom teachers. This type of cooperative effort might initiate heretofore unthought-of objectives, instructional procedures and evaluation techniques for science teacher competencies now so prominent in both the public and educational mind (8, 10).

In the education of preservice science teachers and the continued evolution of productive centers of science education, we must provide for all aspects of teacher training (sociological, psychological, and educational) in an environment which provides daily contact with students in classroom situations. Preservice science teachers should receive experience in observation techniques including the use of interaction schemes. They should design curricula and tests, develop inquiry instructional packages and laboratory techniques, do microteaching with video tape analysis and participate in role playing simulations of classroom conditions. Involvement with pupils in classroom activities is essential and provides varied experiences for implementing and evaluating competencies in actual teaching encounters. If, along with this active involvement of preservice science teachers with "real" students in today's classrooms, the total involvement of science educators in the elementary and secondary schools for extended time intervals could perhaps provide positive responses to both of the questions presented in the January 1973 issue of Phi Delta Kappan "Are teacher preparatory institutions necessary?" (4) and "Are educational researchers necessary?" (14)

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INIQUITOUS REVOLUTIONS AND MULTIPLE CONSTRAINTS IN SCIENCE TEACHER EDUCATION: PROSPECTS FOR THE FUTURE

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It must be extremely perplexing for pre-service science teachers entering student teaching to discover that many of the cognitive and affective behaviors developed in their content and education courses are out of phase with current classroom practices in schools. Extensive change and innovations have occurred in many secondary schools and teacher education programs during the past decade. However, other secondary schools and teacher education programs reflect a limited number of innovations which has brought considerable conflict for pre-service teachers between what they learn in their education courses and what they encounter in school as they engage in student teaching. This has created numerous binds for students attempting to implement innovations learned in university courses into traditional classrooms. Many wonder whether or not they are caught in a losing struggle of vicious circles of educational ferment.

Probably the most prominent innovation to occur in secondary school science teaching during the past decade has been the development of curricula in which students learn through guided inquiry oriented experiences. Stimulated by an implementation of these new curricula in secondary schools, science teacher education programs have been redesigned to examine and develop the inquiry learning process. This has created a major bind for pre-service science education students because very few, if any, science courses as well as foundation courses in education are taught using inquiry oriented instructional strategies. To further reinforce the bind, science methods instructors attempting to prepare pre-service teachers to implement inquiry oriented curricula have been known to present lectures on inquiry teaching or conduct seminar type discussions based on preassigned articles read by the students. As these students progress to their student teaching experience a double bind emerges when they are assigned to classrooms using inquiry oriented curricula and face the enigma of becoming involved in a teaching-learning experience with which they may know something about, but have had no actual experience. Similarly, student teachers assigned to classrooms using traditional teaching-learning techniques also become involved in a double bind because they are not able to implement an instructional style "learned" in their methods course.

Let us for a moment focus in on another innovation in science teaching which is encountered in many methods courses: individualized instruction. According to one definition, individualized instruction is a procedure which aims at providing a unique program to each child, and takes into account all the differences that exist in body chemistry, experimental background, specific interests, purpose needs, and learning skills and styles among children (4). Among the binds created for pre-service teachers by this innovation is one of not having any college courses where they have experienced individualized instruction anywhere near the scope implied by the definition presented. A second bind occurs when pre-service science teachers discover that prerequisites for individualized instruction include diagnosis of learner entry behaviors related to what is to be learned and prescription of appropriate instructional strategies in a fitting sequence for which they have not been prepared. Fortunately for student teachers, the intensity of the second bind is lessened owing to a limited extent in which secondary school science curricula have been individualized.

I doubt if there is a pre-service science teacher education program existing in which students do not encounter the topic of behavioral objectives. Cogent arguements are presented concerning the value and necessity of having clear, precise statements of the learner's behavior that will be accepted as evidence of accomplishment. Writing behavioral objectives a la Mager (7) or the ABCD format (6) is a commonly prescribed student experience in teacher education programs. However, have we specified the cognitive, affective and psychomotor behaviors to be accomplished in our methods courses? How did we ever get into this trap (bind)? To what extent has our dedication and allegiance to behavioral objectives lured us into requiring students to state terminal behaviors in specific terms for teaching broad concepts, general principles, common understandings, and the outcomes of student inquiry which presents another bind for students.

Two analytical systems which have been integrated into science teacher education programs are microteaching (1) and interaction analysis (3). Considerable time and effort is devoted to developing different teaching skills and styles with the aid of one or both systems. Extraordinary attention is given to the development of indirect teaching (good) behaviors on small groups of students in university classrooms. Then inevitably some student teachers are assigned to situations, encounter a bind, where they must use direct teaching behaviors to present science lectures to classes of 100-125 students three days a week and maintain two double period laboratories per week. Of course this is a result of a bind in which the right and left hands are not coordinated; or stated in another way, the science methods instructor had no way of knowing where the student teaching office would place the student teacher.

One could continue on and point out additional binds and vicious circles from an examination of innovations associated with accountability, programmed learning, educational technology, interdisciplinary or integrated science, the non-graded or open school concept and team teaching. However there is no need to perpetuate further embarrassment or possible boredom. Enough evidence has been presented to illustrate two basic problems in science teacher education; first, scientists and teacher educators at the university level need to inculcate within their own programs the methods and techniques demanded of their students, in other words practice what they preach. Science instructors need to build more inquiry-oriented learning experiences into their courses and provide means of accommodating individual differences beyond the scope of honors, majors, and non-majors courses in the same subject. They should be challenged to investigate the possibilities of teaching science on an interdisciplinary basis. You may recall from the ROSES report (8) that even though prospective science teachers viewed science content courses as having the most practical value to them as a teacher, they felt their courses had been too specialized and rarely, if ever, exposed them to inquiry teaching. Secondly, teacher education institutions need to have strong working relationships with local schools, and their programs need to be process oriented and field (school) centered. Pre-service science teachers need continuous opportunities to study and examine the theoretical concepts of teaching and learning in the context of current practices occurring in science classrooms rather than in isolation within the ivory tower. Again referring to the ROSES report (8), it was clearly evident that preservice science teachers had limited respect for their education courses. They regarded these courses as useless, a waste of time, and irrelevant to their future areas.

Fortunately current trends in science teacher education denote a move toward eradicating many of the binds, weaknesses, and discrepancies characterized. These trends are reflected by changes in science departments of Arts and Sciences Colleges and new developments in teacher education within Colleges of Education. To gain insights on prospects for science teacher education in the future, it seems appropriate to examine some of the specific changes and trends occurring.

Whatever the cause, whether it be student unrest and criticism of courses or faculty initiative in recognition of a need for teaching effectiveness, chemistry departments are undergoing an era of ferment concerned with what is being taught and how it is taught (11). Chemistry professors now feel that one of the chief objectives of general college chemistry is to arouse and sustain the students' interest in chemistry and to motivate them to learn the subject. This is quite a contrast to general chemistry courses taught with a "survival of the fittest" objective and designed to "weed out" the non-science oriented student. Remarkable as it may seem, chemistry departments are now designing courses adjusted to meet the needs of the students involved. Realistic problems now form the basic orientation of many chemistry courses rather than the covering of information. Among the many innovations appearing in current college of chemistry courses are the Keller Plan of self-paced study, computer assisted instruction, individualized instruction, and chemistry taught within integrated science courses or interdisciplinary physical science curricula. All of these innovations were presented and examined in several contexts at the Mt. Holyoke Conference for Education in Chemistry (10) last summer. Among the participants were industrial and college chemists, high school chemistry teachers and science education specialists concerned with chemistry teacher education.

Equally exciting changes are occurring in university physics programs. In a recent volume published by the National Academy of Science (9) an entire chapter was devoted to a comprehensive examination of physics education at all levels ranging from the elementary school through higher education. In a discussion concerned with education of pre-service science teachers it was pointed out that secondary and elementary school teachers do not take advantage of inquiry-oriented curricula, necessary for the development of logical thought in students, because college professors do not provide examples of inquiry oriented courses. It further stated that honest physics courses for teachers of the future will be those that induce students to learn for themselves, and pointed out that physics courses desirable for the purpose of teacher education can serve admirably as liberal arts courses. Physicists are now cooperating with professional educators in developing and experimenting with courses taught in their subject matter specialties. It is becoming apparent to these instructors that college students intending to become science teachers can be led to explore, measure, compute, err and recover, and elicit unanticipated conclusions. These cooperative endeavors by instructors reveal a change in attitude of college and university faculty members when they assume a responsibility for the quality of physics teaching in schools. They are entertaining such questions as, "Why do so many well-educated, highly intelligent persons find physics dull, threatening, or mysterious while physicists consider their subject an exciting and rewarding intellectual enterprise worthy of pursuit with fervor?" New developments in college physics curricula are based on concerns of making physics more interesting, challenging (not difficult), contemporary and providing more effective instruction.

Effervescence of the same magnitude is transpiring in biology and earth science departments of Arts Colleges. Bridges have been constructed in these content areas to provide collaboration between educators and scientists in developing courses for pre-service science teachers. Numerous innovations are being implemented and students are providing significant contributions and inputs in their evaluation process. Student evaluation of teaching is a commonality rather than a rarity on college campuses today and evidence demonstrates this practice will not diminish in the near future.

Having briefly examined innovations in science departments, let us turn to an inspection of teacher education programs. Arousing excitement and stimulating attention in this field is the "competency-based teacher education" (CBTE) or "performance-based teacher

teacher education" (PBTE) movement (2, 5). It has provided a vehicle through which major innovations are being implemented in teacher education programs in Colleges of Education. Among these innovations are the specification of course and program objectives, development of isstructional teams composed of foundations and content methods instructors, individualized instruction, incorporation of major field (school) experiences, and implementation of student evaluation and feedback systems.

The most difficult and crucial component of any CBTE program is the specification of objectives, i.e., the stating of terminal competencies of students resulting from instruction. Inherent within this task is the identification and specification of competent teacher characteristics and behaviors. This backs educators right into the box of teacher evaluation which has been and still is a nemesis of school administrators, teacher certification agencies and teacher educators. Some pressing questions have evolved with the CBTE movement. To what extent will techniques be developed to measure the exit behaviors of pre-service teachers emerging from CBTE programs? Will the assessment devices developed be any better in measuring the complex process of teaching than current practices? They may be more effective in measuring specific teaching skills, but will they be valid for evaluating the total process of teaching in a variety of instructional environments? Inadvertently, instructors may place an over-emphasis on development of specific teaching skills rather than concentrating on the whole teaching process as it relates to classroom performance due to the difficulties of writing behavioral objectives for high level cognitive and affective abilities. Despite the problems, teacher education instructors are being forced to clarify the objectives of their courses and programs. This should make them more relevant and useful to pre-service science teachers in the future. Hopefully, a long term outcome will be a more valid system of teacher certification and evaluation which identifies teaching competency in a variety of situations and respects different qualities of outstanding teachers.

Amalgamating foundations and specific content methods professors of CBTE programs into instructional teams has forced faculty members to wrestle with the identification of generic and content based teaching behaviors. The instructional teams, when combining educational theory with classroom application, launch directly into the problem of identifying which instructional skills and processes are dependent upon the content logic of specific subject areas for effective implementation. In addition, considerable duplication of instruction is reduced by using instructional teams. Furthermore, reinforcement of ideas and concepts examined by students result from a concurrent study of science teaching from theoretical and methodological perspectives.

Instructional modules are another significant feature of CBTE programs. They provide a viable means of individualizing the instructional process to meet specific needs of students. Using preassessment devices incorporated within instructional modules, students are provided opportunities to demonstrate competency in various instructional components prior to engaging in the learning process. Students successfully demonstrating competency on pre-tests are guided directly into alternative instructional modules appropriate for their weaknesses. Generally, the instructional modules are self-pacing in their design to accommodate different rates of student progress. Many also provide students with opportunities through extended instructional activities to develop competencies beyond the minimum level. Provisions are included for removing deficiencies through remedial instruction. Students not achieving minimal competency after completing an instructional module are provided avenues for recycling through the same or alternate modules designed to meet the same objectives.

A highly significant innovation concomitant with CBTE is an incorporation of field-based activities within several instructional phases of the program. Students are afforded opportunities to observe and participate in specific learning experiences in a wide variety of classrooms. For example, when studying adolescent behaviors from a theoretical approach in the university classroom, pre-service science teachers concurrently examine adolescent behaviors in schools. Not only are the general characteristics of adolescence studied, but in addition, secondary school student behaviors are examined both in science classrooms and non-classroom situations. The interaction of different science teaching strategies and styles with various adolescent behaviors are observed. Behavior modification techniques and skills are applied to actual behavior problems occurring in science classrooms.

Pre-service science teachers investigate the total school system as part of their field activities. Inquiry is made into school policies, administrative and faculty attitudes, teacher liability and responsibility, school facilities and resources available for instruction, interactions between faculty and students and administrators, teaching styles and instructional strategies in different instructional settings, and student responses to the school environment. Pre-service teachers get to know the science program and faculty over a long period of interaction prior to student teaching which removes many uncertainties and provides a base for building their confidence before they assume student teaching responsibilities. Also, potential mismatches between student teachers, cooperating science teachers, and schools are resolved before it is too late.

CBTE field-based programs have inaugurated closer functional relationships between university professors and secondary school teachers. Science teachers are invited to participate in program planning meetings and module writing sessions with university foundations and science methods instructors. A residual effect resulting from this cooperative endeavor has been the development of effective and meaningful in-service programs for experienced science teachers. Encountering new approaches to science teaching and recent contributions to science content during strategy sessions, practicing teachers visualize the need for in-service development. Results of these in-service programs have greater impact in promoting necessary changes in secondary school science teaching because they have been cultivated by a perceived need viewed by all concerned.

Definite strides have been taken to remove the binds and vicious circles prevalent in science teacher education programs of the past. Innovations in science departments and teacher education programs reflect a concerned and concentrated effort by university faculties toward removing the chaos, ineffectiveness and mindlessness from science teacher education. There is limited evidence to suggest that, in universities where CBTE programs have been implemented and science departments have been slow and reluctant to change, a current ROSES (8) study might result in pre-service science teachers viewing their education modules as much more valuable than science courses. Of course, work must be continued until all components, both science and education courses, of programs for preparing secondary science teachers are valuable. The trend of having pre-service science teachers directly involved in experiences similar to those they will be engaged in as student teachers, i.e., scientific inquiry and the teaching process, will surely continue. This will make their transition to teaching smooth and productive rather than frustrating and hectic.

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SECONDARY SCIENCE TEACHER EDUCATION:

PROSPECTIVES ON PROGRAM TRENDS, RESEARCH AND IMPLICATIONS[1,2]

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For many years the education of science teachers appears to have been guided intentionally or unintentionally by a philosophy, characterized best by Comb's work (2, 3). He describes as basic concepts in the process of becoming a teacher in the latter manuscript in the following ways:

1. The production of an effective teacher is a highly personal matter, dependent primarily upon the development of an appropriate system of beliefs.
2. The production of an effective teacher must be regarded as a problem in becoming.
3. The process of becoming must start from security and acceptance.
4. Effective teacher education must concentrate its efforts upon meanings rather than behavior.
5. If sensitivity and empathy are prime characteristics of effective helpers, and if behavior is the product of perception, teacher preparation programs must shift their main concerns from objectivity to subjectivity.

"Basic concepts" of this type, and many similar ones are nothing new. They characterize an enterprise in which neither input nor output has been accurately described, and for which the intervening experiences generally have little if any theoretical or empirical support (15). Indeed, if we describe the output of a teacher education program in terms of beliefs, becoming, security and acceptance, meanings and subjectivity, we are describing enculturation rather than teacher education and find ourselves with no justification for creating the institution of teacher education for these purposes since the job has long since been completed, no operational description of the educational product, no way to determine how to arrive at these

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1. Adapted from a presentation made to the Faculty of Education, University of Calgary, Calgary, Alberta, Canada, January, 1973.

2. The author wishes to express his appreciation to Ms. Anne Hays for her assistance in developing this manuscript and to Dr. Mary Lou Koran for her critical interaction with me on these topics.

states, and no way to assess when we have achieved them. The ambiquity of these goals or procedures has permitted a sloppiness in the teacher education enterprise which the public cannot and will not tolerate. Not knowing where we are going, how we are to get there and what the product will look like when we arrive is a luxury educators can no longer afford.

What has resulted is the movement to performance based teacher education (5, 6). In performance-based programs, performance objectives are specified and agreed to in rigorous detail in advance of instruction. The student preparing to become a teacher or the in-service trainee must either be able to demonstrate his ability to promote desirable learning, or exhibit behaviors known to promote it. He is held accountable not for passing grades, but for attaining a given level of competency in performing the essential tasks of teaching. The training institution is itself held accountable for producing able teachers. The emphasis is on demonstrated product or output. Acceptance of this basic approach has program implications and research possibilities that are quite exciting and can shape both a setting for science teacher training, and what can take place within this setting. This paper will focus on three areas: 1) what should the "climate" for secondary science teacher training be?; 2) what should the "output" of the program be?; 3) what are the research possibilities of such a program?

What Should the "Climate" for Secondary Science Teacher Training Be?

The following statements partially characterize the evolving "climate" for secondary science teacher education at the University of Florida.

1. Courses and regular scheduled classes do not exist. The program is flexible and mobile, with opportunities for small group, large group, individual instruction, and off campus or "field instruction."
2. Proficiency is determined by performance. Students either pass or fail; meet criteria or not.
3. Field experience in the public schools is continuous and includes tutorial work, observation and experience guiding instruction, evaluating it, and testing hypotheses relative to instruction.
4. Field experience includes encounters with the parent, the community and state agencies with education related missions (environmental protection agencies, City Planning, etc.).
5. Students are responsible for completing performances. They may work at their own rate or be assigned to instructional treatments according to their unique goals or aptitude characteristics.

6. The program may be completed in different amounts of time.
7. Planning and decision making occurs cooperatively and includes faculty, students, parents, and school personnel.
8. Extensive utilization of multimedia, microteaching, and other simulation techniques (gaming, decision making, etc.).

As Voelker (20) points out, programs of this type require:

1. extensive practical experience with public school students,
2. limitations on enrollment and an emphasis on intellectual rigor,
3. specified selection criteria,
4. built in mechanisms for change,
5. degrees of flexibility that would make it difficult to refer to "a program," and
6. new partnership arrangements and reaffirmation and redefinition of old arrangements.

<u>What Should the Output of the Program Be?</u>

Secondary school science teachers should possess a wide range of teaching skills and strategies which could be subsumed by such models as McDonald's (12) taxonomy of teaching behaviors. These would include teaching operations, organization of content skills, and strategies for handling types of content. In order to function in the above context science teachers will have to:

1. Have an excellent academic record and aptitude characteristics suitable to the teaching role (flexibility, tolerance for ambiguity, communication skills, content knowledge).
2. A commitment to continuous education in the discipline, discipline-related fields and pedagogy, both before and after initial training.
3. A background in the social sciences, art, and other areas of the humanities.
4. A breadth and depth in the content and process of science.
5. A knowledge and understanding of the history and philosophy of science.
6. A knowledge and understanding of adolescent psychology, psychology of learning and group and organizational dynamics.
7. A desire to work with people in a dynamic environment.
8. Skills in inquiry, decision making, and information acquisition and processing.

Basically, the Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics (1) is a good beginning point for describing the types of products we would like to see in science teaching. The only caveat one could add would be an emphasis on quality rather than quantity and a movement in each of the areas specified "beyond the information given." We must stride to meet and go beyond these standards while keeping pace with the demands of a rapidly changing world (7).

What are the Research Possibilities of Such a Program?

In the open-flexible, performance oriented setting described, one would expect a wide range of research projects to flourish. Subjects in research studies should include parents, children, in-service teachers, or teacher trainees. Opportunities would be available to manipulate instructional systems, test the effects of acquired skill on subsequent performance and learning; design instructional systems to fit individuals, and a wide range of other areas. The following are a few areas which seem to have promise:

Research on Modeling, Feedback and Practice

There has been considerable basic and applied research in the above areas (8, 9). It can be roughly grouped into research on demonstration variables (type of models); practice variables (amount of practice); and feedback variables (amount, kind and contiguity of feedback). In these studies the dependent variable is usually a teacher behavior clearly defined and the independent variable is a treatment designed to influence this behavior. Performance based teacher education programs will function to clearly define a wider range of behaviors to be used as independent and dependent variables in science teaching research. Similarly, these programs will place demands on exploring alternatives for producing the types of outcomes desired. Research of this type should be built into every science teacher education program whether in-service or pre-service. At the same time, flexible programs, with teacher trainees in the schools, homes and communities at an earlier time, and for longer periods, provide the opportunity to explore such variables as modeling, decision making skills, attitudes and influencing values of parents and children toward such critical areas as the environment with the teacher in training becoming the researcher. Thus, acquiring both theoretical and research skills. Other possible areas of study here would be early stimulation of children, transfer reinforcement and practice resulting from parent education to student education and studies of the effects of acquired teacher behavior on student learning (8).

Evaluating the Effects of Instruction on Student Learning

Performance based education programs place an emphasis on acquired student behavior or "affective orientations." An important question that is yet to be explored is the association between acquired teacher behavior and student learning. Performances commonly identified as those teachers should be able to exhibit should be subjected to empirical scrutiny using rigorous experimental designs or quasi experimental designs of the type Okey (16) describes, to determine their effects on learning. The final outcome may well be an empirical rationale for teaching teachers what to do and say and a criterion for evaluating teacher training, and instructor competence. For instance, if we teach teachers to employ wait-time, what are the effects on student learning? Preliminary studies by Rowe (18) suggest that among other things, increased wait-time on a teacher's behalf results in an increase in level and type of student response. This is the type of empirical data needed to support the contention that wait-time is an important skill for teachers to acquire. Data of this type could be gathered by teacher trainees or in-service teachers under the direction of faculty researchers while contributing to preparing these trainees in an open environment to be hypothesis makers and testers.

Of course, studies of the type described do not necessarily require a changed science teacher training context in order to be conducted. However, the emphasis in the future on well educated, dedicated and skilled teaching candidates working in an open, flexible, environment permits their use as both the subjects of studies (producing a more homogeneous nation wide sample) and as researchers in studies. As both F. J. McDonald (13) and Rothkopf (17) emphasize, having trained, intelligent observers systematically looking into schools, homes and communities and recording what is happening, is the beginning point for designing instructional materials and programs that will produce adaptive learners.

Individualization of Instruction

Performance based instruction within an open-flexible environment permits a wide range of individualizing methods. Unfortunately, in most treatments of this topic the individualization component is <u>rate of learning</u>. Students or teacher trainees are given a pretest, prescribed instructional activities and a posttest. Generally, modules as they are commonly called, are used as the instructional system. All students are given the same module to learn a set of objectives from, and they do this at their own rate. This procedure is boring for both the "enlightened" instructor and the instructee, and probably a given "module" is not the optimal instructional system for all students. Although a predominant method of teacher education at this time, the modular approach suffers from a variety of problems suggesting research in the following areas:

1. Examining the effects of knowledge of objectives vs. no knowledge on variables such as student learning, teacher organization, motivation, and the like.
2. Examining questions relating to the exploration of organizing content and its effects on learning vs. organizing cues or (mathemagenic behavior) during instruction with whatever content is in use.

3. Questions involving the entire area of reliability, validity, and measurement of criterion-based materials in modular form.
4. Questions relating to participant motivation in modular instruction.

Other approaches to individualization of instruction include attempts to match method with learner aptitudes or "traits." Cronbach (4) defines aptitude as any human characteristic that influences learning. This definition would include affective, cognitive or psychomotor characteristics.

In the research on this area, alternative treatments are selected which are designed to promote a certain type of learning. Each treatment is analyzed to determine what cognitive factors or other traits might facilitate learning. These relationships are hypothesized and tested.

An example of this line of research in teacher education is the M. L. Koran (11) work. In this work it was shown that teacher trainees, including a science sample, could be assigned to instructional treatments corresponding with how they learned best. Thus, optimizing learning for individuals with specific characteristics. These studies have shown the efficacy of exploring this entire area with regard to science teacher training. Carried to its logical and practical conclusion, science teacher trainees could be assigned to training methods on the basis of how they learn most efficiently and proceed through a teacher training program by studying instructional materials which are congruent with their own learning patterns (inductive, deductive, visual, verbal, etc.). A similar tracking system could be used to train teachers for different roles (14).

Needed Research

1. Replication of earlier study in teacher training with both cognitive and affective (Myers Briggs type indicator) "aptitudes."
2. Exploration of a wide range of alternative instructional treatments designed to achieve similar objectives.
3. Studies of the present school organization to determine ways and means of implementing a differential staffing based on different skills or roles.
4. Psychometric research to develop instruments to measure aptitude.

Conclusion

I have attempted to show here in very abbreviated form some of the practical conditions and research benefits of operationalizing instructional goals and expanding the character of programs in science teacher education. In the past, teacher educators have operated on a continuum from some level of specificity to some level of ambiguity. This has not permitted effective teacher training or research. With the movement towards accountability, a positive outcome may well be an expanded research horizon, since this movement will require specification of outcomes, attention to methods to achieve them, and an emphasis on evaluation. The type of context for teacher training programs described, and the types of products desired as outcomes of these programs suggest that the two sets of endeavors are highly congruent and that the future will see an emphasis on excellence, training experience with a wide range of clients, and practice supported by research. It is probable that what has been taking place is not entirely "bad" or ineffective, but rather what will take place will occur after testing and demonstrated effectiveness.

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SECONDARY SCIENCE TEACHER EDUCATION: WHERE ARE WE GOING?

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I have chosen to answer the question posed in the title of this paper by emphasizing several areas or trends which appear to be thrusting themselves forward in this period of revolutionized teacher education practices. To gain a perspective in analyzing this problem I should like to refer to the role of the secondary teacher as I perceive it for the future.

Traditionally, the teaching task was limited. The teacher was a purveyor of knowledge, an organizer of facts, a dispenser of information. These were his main commitments. In addition, the good teacher developed love of learning and focused the vision of his pupils on lofty goals. Today's teacher has taken on additional responsibilities of part-time parent, counselor, and companion. His role as an educator, however, remains with even greater emphasis but the total task has grown.

Some of his tasks may be eliminated or minimized in the future. It is less likely that he will be saddled with tasks of money collection, food dispensing, inspector of health, director of public entertainment, supervisor of detention, and curator of records. Recognition of the real role of the teacher as that of a developer of youthful minds will bring into proper balance the assignment of teaching tasks.

Teachers are educators, not educationists. Their competencies are with children, not with theoretical designs for education. William Burton expressed their role as follows: "Teaching is not a routine or rule of thumb process. It is a genuine intellectual adventure. Teaching demands the ability to adapt boldly, to invent, to create procedures, to meet the ever-changing demands of the learning situation. Continuous imaginative anticipation of the mental processes of the learner is necessary. The ability to keep subtle and intricate learning processes moving toward desirable outcomes without domination or coercion does not result from training and devices and tricks of the trade" (2).

In the new mode of teaching there will be a shift from dispenser of knowledge to director of inquiry. The teacher will transfer from primary information source to co-discoverer with students. Processes of telling will become questioning, and techniques of inquiry will reign over accumulation of factual knowledge.

Managerial skills become important. How does one help a class identify problems for study, accommodate individual differences, motivate the unexcited, plan the logistics of individual experimentation? How does one keep the goal in sight, overcome frustrations, know when the solution is reached?

What about evaluation? Can one test for inquiry skill development? What knowledges are minimal? Is the student ready for advancement to higher levels of learning? The complexities of the problem seem large. The teacher in his new role must be a master teacher. His training must be outstanding. He must have a superior grasp of subject matter. He must be cognizant of the best teaching techniques. He must be imbued with the spirit of inquiry himself. He views teaching as a complex art, a sophisticated interchange between the teacher and the pupil.

Teachers prepared for these roles do not happen by accident. Their training in colleges and universities must emphasize these very traits. To guide inquiry learning, a teacher must be an inquirer. Dogmatic content courses do not promote inquiry, experimentation may. Dogmatic content courses do not engender skills and discovery teaching. Opportunities for creative planning, teaching by inquiry, and inductiva methods must be present. Laboratory oriented classes may tend to develop these competencies.

The practice teaching experience will become increasingly important. Closer liaison will need to be practiced between methods instructors, supervisors, and classroom teachers. Frustrations brought about by differences between theory and practice, differences in philosophy, and poorly coordinated programs need to be minimized.

The role of the teacher is complex--student, educator, researcher, counselor. All these and more are roles played by the teacher in his daily activities. A balance is needed among these various facets. A high level of competence is required in each.

We are presently in a period of over-supply of teachers. In terms of the job market we are back to the conditions of the late 1930's and 1940's. It is common for five or six people to be searching for every available job. We are in the midst of a tightening economy as far as budgets for education is concerned. Because of this the master's degree is not necessarily an advantage for a beginning teacher and frequently is a detriment. To secure a job in this competitive market small things make large differences. The ability to handle a club or other type of extra-curricular activity, a background of experience in travel, and hobbies pays dividends in securing that first job. I have made it a practice in dealing with my secondary methods students to require from them a rather detailed resumé of information on their experiences with children in experiences besides practice teaching; in their hobbies, reading habits, and travel and other special abilities which they can cite. I know from personal experience that recommendations which I have written containing this practical information have made the difference between securing a job and not securing one. We in the teacher training institutions are obligated to emphasize to our prospective teachers the need for maximizing their talents and communicating to principals and superintendents their abilities in an effective manner.

We have read and heard much in recent years of increasing the level of humanistic modes of teaching in the classroom. The impetus for this has been serious exposés of conditions in some of our classrooms, particularly in the inner-city as cited by Charles Silber in Crisis in the Classroom and others. It is rapidly becoming apparent that if children in science are to remain interested participants in this most vital area of knowledge, something must be done to improve our quality of teaching so that we can avoid turning these students away. We have an important role in the teacher training institutions to convey this perspective to our beginning teachers. Success in teaching depends on good student-teacher rapport more than anything else. There must be developed a feeling of mutual trust between the teacher and his students.

In many cases the experience of students may have been that of subservience to a rigid disciplinary teacher who taught in a very mechanistic way and showed poor human qualities. To overcome this, the new teacher should invent ways to stimulate mutual trust, understanding, and dependability, and to find reasons to talk to students about their activities, interests, athletic events, travels, and other matters of personal concern. He should display human characteristics of love, sensitiveness, honesty, and kindness, and do everything possible to treat all of his students impartially and fairly. He must try to de-emphasize competition for grades and attempt to develop an inner motivation, encouraging students to carry out the activities in his science classes because of the satisfaction they gain in being successful.

The teacher must try to enlist the help of parents. The majority of parents are concerned about the education of their children. It is true that there is a small minority not interested in the way their students perform at school. They may feel that education for them is a waste of time, but the vast majority feel otherwise. The teacher may make phone calls to parents to commend their children for successful endeavors and to ask them for assistance when problems arise. He may invite parents to school by setting specific appointments with the parents at mutually convenient times.

The teacher should try to think of each student as an individual with personal feelings and aspirations. Respect his individuality. Credit him for his maturity. Try to lead rather than coerce. Build on his successful gains and foster an adult relationship. Secondary school students frequently respond favorably when treated as adults. Teachers should indicate that they expect mature adult behavior. Do not expect miracles, but look for rather slow changes in development. If teachers expect the best from high school students, most of the time they will get it.

It is becoming evident around the country in the teacher training institutions that emphasis on early contact with pupils is gaining popularity. The old objection to permitting younger students who have not been through the complete gamut of course work, methods work, and practice teaching to have contact with students in the high schools is gradually fading away. The ideas of internship, intimate contact in the classroom situation and working with children at a stage when young people are making up their minds as to their potential careers in education are considered to be more important.

In our own school we have instituted a course in science education entitled "Introductory Science Field Experiences." In this course prospective teachers, as early as their sophomore year, are encouraged to gain teacher aide experience in the public schools of nearby towns and cities. In these experiences they tutor children, assist the teacher in planning and record keeping, take children on excursions, occasionally do small group teaching, and infrequently may teach the whole class. This experience may be done two or three times before they take the regular course in methods of secondary science teaching and before their regular practice teaching assignment. We are finding this to be a successful route to student teacher encouragement and to the formation of suitable habits in the teaching situation.

An additional influence coming into the foreground at the present time is that of increased attention to learning theory particularly of Combs, Maslow, Bruner, Rogers, Piaget and others who might be classified as third force psychologists. The influence of these individuals is becoming felt through attention to more humanistic teaching and also through recognition of some of the limitations of children and the maturational stages through which they pass. As an example, while Piaget's findings have largely been applied to the elementary school level, we have had a recent research study done by some of our doctoral candidates concerning the transition from concrete operational to formal operational thinking at the junior high and senior high levels (1). In this study more than 400 junior high and senior high students were interviewed and given a series of Piagetian tasks designed to differentiate between concrete and formal operational thinking. The findings show that there is a significant relationship between scholastic success of eighth, ninth, tenth and eleventh grade students and their performance on the Piagetian Task Instrument. Students described as formal operational received higher grades in science than non-formal students. Piagetian cognitive development, a physiological as well as psychological process, appears to be a major factor in determining grades received by science students.

A significant relationship was found between intelligence quotients scores and performance on the Piagetian Task Instrument. Junior high school science students showed a .28 correlation coefficient between intelligence quotient scores and performance on the PTI. Senior high school science students showed a .31 correlation coefficient. No significant relationship was found between sex of the students and their performance on the PTI. Apparently boys and girls develop at an equal pace from the non-formal to the formal operational level.

The findings of this study indicate at certain grade levels and/or subject areas public school science students who demonstrate formal operational logic tend to receive higher grades than non-formal operational students. Perhaps in science, instruction should be designed for students who are in the various stages of cognitive development. Lower grades received by non-formal operational students may be due in part at least to their cognitive developmental stages over which they have little control.

A significant implication of this study can be directed toward teacher training institutions. Individuals preparing to teach junior or senior high school science should develop an understanding of Piaget and developmental theory to aid them in providing better instruction for students in science.

If the cognitive development stages of students help determine their scholastic success in science, then teachers should be knowledgeable in the methods of assessing cognitive development. The ability to properly determine students' cognitive levels is necessary for effective planning and sequencing of science instruction.

Considerable attention is being given these days to matters of individualizing instruction. Where in our teacher training institutions are we giving the skills and competencies needed to handle instruction in this mode? Unfortunately, most of our teacher training is geared toward the traditional mode of handling mass classes in numbers varying from 10 to 50. While these techniques are important and need to be taught, we must at the same time be providing the skills to handle the newer modes of teaching. The recent NSTA publication by Henry Triezenberg entitled Individualized Science: Like It Is is a good beginning toward the assemblage of materials to use in methods classes to meet this growing need (4).

Many of the problems faced by science education today are magnified several fold in the inner cities of our large urban communities. Since a large fraction of our potential teachers will ultimately become teachers in such communities, we are obligated to provide experiences that will prepare them for this rather unique type of science teaching.

What are the special problems of teaching science in a highly urbanized community? Much has been heard in recent years about the problems of teaching science in what sometimes has been called the ghetto. The inner-city of our large urban centers frequently is made up of minority groups scattered about in their various communities within the city. Children of these groups are attending schools often more than 50 years old. The schools are out of date in terms of their structure and the congestion surrounding them forms an extremely difficult environment for teaching science.

It has been estimated that 70 percent of the population of America lives in only four percent of the land area. This means that a very high population density is found in the large cities. Our concept of a pastoral America is largely outmoded. Yet the children being educated in the cities must develop a sense of ecology, of the interrelationships between organisms and their environment. If they are to develop this sense, they must do it in the context of their immediate community. These children cannot all be transported to the country to view rural America and even if they could, it would not be a realistic learning experience for them because it is not their home nor the community in which they live. It is necessary to develop real meaning and understanding about the environmental problems of living in a large city. Most of these conditions are man-made, but they are no less important and vital to the growing young person and to the development of his concepts of science.

Many times the urban student is thought of as being under-privileged. At first glance this may seem like an anachronism when one considers the varied resources in the city available for educational development, but in many cases because of poverty, extreme provincialism, racial prejudice, and many other reasons, students from minority groups in the inner-city are in fact under-privileged. The resources for them to learn about science in their homes are minimal. The interest and motivation to probe into scientific problems and issues is lacking.

In addition many of these students have poor self-concepts. They have been told they are deprived. Attending their schools may be adolescents of more affluent middle class families of different backgrounds. The minority student may get the impression he is a second class citizen. Because of national origins, problems of language are very important. Even middle class English usage may seem like a foreign tongue. Often tests which are frequently highly verbal tend to discriminate against the urban student because of this factor.

An important key to success in teaching science effectively in the inner-city is to devise methods of breaking the cycle of frustrations students frequently have. Many of them have been unsuccessful at coping with school work in a rigid system and have developed negative attitudes. The climate for learning must be improved. Creativity should be encouraged. Students should be recognized for their creative talent. The teacher should begin with things of interest to pupils and allow divergence to exist. The student's need for success must be served. His image must be changed from one of low status to one of high status. This can be accomplished by showing appreciation for his efforts.

Students who intend to teach in urban areas or inner-city schools are advised to seek out practice teaching experiences that will give them the best possible preparation for such an assignment. This might involve student teaching in a school similar to the type they wish to teach in ultimately.

As an example of a situation providing the type of relevant experience needed in this situation, the University of Northern Colorado has developed an innovative plan for qualified juniors and seniors who are preparing to teach in the secondary schools of the inner-city (3). Participants in the program spend much of the first four weeks of the quarter engaged in concentrated study in areas of concern related to specific course offerings. Emphasis throughout the program is on preparing prospective teachers for working in urban schools whose populations are composed of children from culturally diverse backgrounds. At the same time it is recognized that there is more to developing teachers for inner-city schools than simply making them aware of the cultural differences among the children they will be teaching. The teacher's positive self-concept and feelings of adequacy to meet his own needs and those of his students form the basis from which he can function effectively as a teacher and must be taken into consideration in any program for teacher preparation.

Methods used in the program include team teaching, seminars conducted by key personnel from schools and community agencies, and trips to the inner-city to discuss issues related to urban education with representatives of community groups.

Other activities which are included in the field experiences include the following:

1. A six-week live-in experience which is one of the most important aspects of the program. Whenever possible and with the consideration of the student's needs and wishes, housing for the participant is arranged in the city with a family whose life style is significantly different from that of the student.
2. At least one half of each day of the six weeks period is spent working with children as a teacher assistant in an urban deprived school of the participant's choice. Work in the school is under the supervision of experienced, highly qualified school personnel.
3. Additional time is spent actively participating in the work of public and private agencies in the community so that the students gain a greater understanding of the social groups that make up the community.
4. Seminars are coordinated with both types of field experiences in an effort to provide a basis for solution of the sociological, psychological, and educational problems encountered.

Results indicate that students trained with a plan such as described above enter the teaching profession and seek out communities similar to the ones in which they did their practice teaching. The background of personal experience at a practical level which they have secured in their student teaching enables them confidently to attack the problems of teaching in the inner-city.

Another factor to be considered in the teacher training institutions for prospective science teachers is the ultimate impact of the National Assessment of Educational Progress. This program has been in existence about nine years and is designed to learn what children know at ages 9, 13, 17, and young adult levels. At this stage about a half dozen subject areas have been assessed or are in the process of obtaining data and another half dozen are in the planning stage. The data for science, citizenship, writing, and reading show amazingly homogeneous results and similarities. The breakdowns in the analysis of data by region, sex, color, size and type of community, and parental education indicate that in all of the subject areas these factors appear to have a similar influence. That is to say, whether it be science, reading, citizenship, writing, literature, or conceivably any other subject, students who are black, female, children of parents with less than eighth grade education, living in the inner-city, in the southeast, tend to be low on all of these measures. On the other hand, children of well educated parents, of middle-class communities, white, suburban, and living in the northeast tend to be at the other end of the scale.

This information must be made available to potential teachers. There must be a more complete awareness of the effects of region, sex, color, size and type of community, and parental education, and teacher training institutions must take the responsibility for attempting to analyze and seek out possible solutions to these disparities in educational level and performance displayed by the National Assessment results.

In addition, the National Assesament exercises have uncovered a misplaced over-emphasis on knowledge of a factual and conceptual nature, whereas the areas of process, skills, attitudes, and interest development have been minimized. As an illustration, in the first round of the science assessment 67 percent of the exercises tested knowledge of a factual and conceptual nature, 21 percent dealt with process skills, 6 percent dealt with understanding the investigative nature of science, and 6 percent dealt with attitude and appreciation development.

A significant trend in recent years concerning preparation of secondary science teachers is the thrust toward competency-based teacher training. More than a dozen states at the present time have some type of legislation requiring this type of approach to teacher training. Many problems are inherent in this, and it is important that teacher training institutions give their full attention to it. What skills does a teacher need? How does he gain these skills? How does he internalize them? How can these skills or competencies be evaluated for certification purposes? How can the "whole teacher" be produced in order to avoid fractionation and over-emphasis on highly specific skill competencies? How can the traditional credit-block system be circumvented? All of these and many others are questions that need to be answered in the near future. Because of the emphasis on accountability in our schools at the public school level and also in the colleges, the competency-based teacher training system will become an even more important aspect of teacher training.

One further point which to this moment cannot be discerned as a trend but in my opinion is one which needs to have considerable attention. Some years ago a study of elementary and secondary teaching in Colorado was done by our staff at the University of Northern

Colorado. It was found at that time that over 50 percent of the teachers in the state had less than five years experience. This suggested a number of things, one of which might be that there is an extremely large teacher turnover in the first five years of teaching. Either teachers are moving out of the state for better paying jobs in other places or they are leaving the teaching profession. Because of our concern that the latter might be true, we have thought that a system should be developed in which beginning teachers in their first year could be given extra special attention through a visiting supervisor from their teacher training institution, by the use of a buddy system or a big brother system in their own school district, or some other method that would assist beginning teachers to overcome some of the frustrations and problems of adjustment inherent in the first year. It is well known that beginning teachers are at the bottom end of the totem pole and are frequently assigned overloads and distasteful tasks just because they are new and eager. This system works to the detriment of the total school because the highly qualified, creative teachers who will ultimately become master teachers are discouraged from continuing. This aspect of follow-up which should be considered as an extension of the teacher training program is one that has considerable potential and should be developed in greater detail.

Observation of the great variety of teacher training modes extant about the country indicates that a great deal of experimentation is going on and one might view this in a highly optimistic light. Certainly the old established traditional methods are being subjected to critical analysis and scrutiny. The special problems involved in today's teacher training, particularly in a period when science is receiving a de-emphasis is producing concern among trainers of teachers. I am particularly happy to have the opportunity to participate in this panel at the NARST meeting to discuss the problem of Secondary Science Teacher Education: Where Are We Going? The ideas brought forth at this conference will undoubtedly bear fruitful rewards in the near future.

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SCIENCE, SCIENCE EDUCATION, AND THE FUTURE: CONCERNS AND SUGGESTIONS

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It is important that we continually examine alternative directions for secondary school science teacher preparation. It seems of equal importance at this time that such an examination include consideration of the much broader educational, social and political contexts within which such alternatives would have meaning. Within this broader context we also need to re-examine the traditional roles, relationships, and responsibilities of science and science education to each other and to education as a whole, and make decisions about what these should consist of in the future. It is quite probable in light of the rapid changes which are manifest in so many other societal aspects, that change is needed here as well.

Even with all the change and confusion of the modern world, the scientific enterprise as a viable organism is doing just fine. Scientific and technological output and the number of scientists and engineers in the job market both seem to have been increasing exponentially for the past 150 years or so, with a doubling time of 12-15 years (1). This increase seems not to be depending very strongly on changes in pre-college science education, since the greatest change in that area didn't occur until the early 1960's. Thus far it seems to be feeding on itself, or to put it another way, every time a scientific model is outmoded, the one which replaces it is seven times as powerful. Growth begets growth.

Although the discoveries of science and the inventions of technologists have had a disruptive effect on mankind for a long time, it has only been since 1940 that the scientific phenomenon has begun to be viewed as both benevolent benefactor and potential destroyer by a significant and growing number of people. At the present time there seems to be an even more rapid growth in anti-science and anti-intellectual attitudes among young and old alike, which is being expressed in a number of ways. Some of the more obvious examples can be seen in such simple things as the booming interest in astrology; an increasingly bitter attack, both verbally and physically, on the scientific community regarding its relationship to the Military-Industrial Complex; and in recent cut-backs in government funding for basic scientific research and continued space exploration.

Perhaps this anti-science feeling is not totally unjustified. Perhaps there is a rational base for many of the criticisms. It is certainly true that a great many of the scientific advancements of the past thirty years are very closely tied to a series of crises which have affected both society and the individual in a variety of frightening ways.

Witness the reality of a nuclear age, with drastic immediate consequences for hundreds of thousands of Japanese. During the 1930's the theoretical framework for splitting the atom was available, but the necessary money for very expensive empirical verification of those theories was not. The federal government was the most likely source for the funds. The scientists faced a critical need, and the government was faced with the reality of World War II. The nuclear age dawned with an abruptness and a horror that has not yet been fully assimilated and may never be forgotten. Thus far all the humanistic utilizations growing out of that situation have not succeeded in overcoming the initial damage done by the bombs. From this time on the scientist could no longer be viewed by society as a harmless individual who liked to putter around in a laboratory. He could even be dangerous.

The advancement of science was by this time an extremely expensive undertaking. By the middle 1950's there were again many theoretical constructs in the sciences which awaited either verification or rethinking due to lack of sufficient funds for experimentation. Then came another fortuitous crisis in the form of Sputnik. The intellectual approach to fund-raising hadn't been working well enough, but the threat of any enemy satellite carrying nuclear bombs and/or canisters of germs over our heads turned out to be a veritable motherlode for the scientists. We had to be first on the moon, and had to build bigger and better and more powerful ICBM's and nuclear warheads and develop more potent biological organisms. This undertaking would call for more scientists and updated science programs at all educational levels.

We have just passed through a "post-Sputnik" period of fifteen or so years of intense activity aimed at improving science education at all levels. The curriculum projects developed and implemented at the pre-college level during this time were based on a perceived need for new science content which would lead to increased understanding of recent advances in scientific concepts and principles. Central to the new curricula was the advocated teaching approach of having children learn science by doing science in a manner similar to that in which scientists themselves did science.

Although the new curricula were developed fairly quickly, the greatest problem arose in terms of their implementation. Massive in-service programs were provided to prepare teachers who possessed the desired philosophy, teaching techniques, and knowledge of the subject matter itself. Science Educators at the university level restructured their science teacher preparation programs to prepare new teachers for the new curricula demands. By the time the smoke began to clear, it was apparent that a large number of the new curricula were being implemented in some way by teachers with little or no specific preparation, but simply out of necessity since their school districts had adopted the new curricula across the board. At the same time, prospective secondary school science teachers who had been specifically trained to teach in the new science curricula found quite often that they had to accept positions in locations which did not offer the new curricula as an option.

It is unlikely that the new curricula contributed much to the advancement of science during this time. As late as 1970 it is doubtful that half of the students entering college had experienced one or more of the new science programs. There is also little, if any, supportive evidence that the new curricula are any more effective in preparing students for college-level science than the old curricula were.

It is unfortunate that the vast effort aimed at improving pre-college science education didn't result in any large changes in university-level science programs. The machinery was somewhat new, of course, and more advanced concepts were presented earlier in the curriculum, but essentially it was business as usual with very little emphasis on improving science education, particularly for the non-science major. Without postulating a cause-effect relationship, is it possible that more anti-scientists are currently being produced than are scientists? (3)

Overall, science does not seem to have suffered greatly during this time when measured in terms of an increase in the number of Ph.D's in science and the amount of new science knowledge based on the number of research reports published. Indeed there may be too many scientists being produced today if you consider the number of new Ph.D's in science who can't find work for which they are trained.

During the late 1960's many segments of our society began to question the continued outpouring of billions of dollars for improved weapons systems and for sending men to the moon. While the space program greatly increased scientific knowledge about the universe and the solar system in particular and had many positive side benefits for mankind in terms of space medicine, microminiaturization, and materials science, people want to know why our technology can't provide them with automobiles and washing machines that don't continually break down. They are asking why billions of dollars are being spent to develop man-killing germs while so many people live in psychological, educational, and economic poverty. These seem to be awfully good questions.

There was also a decline in the amount of monetary support for scientific research and science education over the last two or three years of the 1960's. Is it only coincidence that more and more people, led to a large extent by scientists, have recently begun expressing strong concern about an "ecological" crisis?

The ecological crisis differs both qualitatively and quantitatively, however, from the two crises described earlier. It differs qualitatively because it does not result from an outside enemy against whom the country can stand united. <u>This</u> crisis is a result of what people have done with the scientific and technological knowledge available. It has become very apparent that scientific endeavors and their technological counterparts are definitely not neutral in effect, but must be handled with extreme care. There are even mutterings from here and there, growing louder, that much more control needs to be exercised on the scientist in terms of what he will be allowed to investigate. (Let's face it, a lot of people really didn't experience much psychic joy in seeing a man land on the moon, and most people will never experience, through scientific endeavors, anyway, the emotions of a Watson or Crick or Feynman. The fruits of science, bought with the public dollar, are beginning to taste bitter indeed.)

The ecological crisis is quantitatively different because of its magnitude and complexity. It likely won't be solved as simply as the development of a superbomb or the engineering of a space walk. It cannot and will not be solved by purely scientific and technological means. It must be recognized as a "people problem," and thus one which is not likely to be solved without serious consideration of the social, psychological, educational, and political environments of mankind.

It is sad, but probably true, that our world today is so delicately balanced that we need to be very careful about our future actions. What we need to do is to determine just what the survival rules are, and make sure that enough people understand those rules. Responsibility for the latter seems to be the major responsibility of our schools. It is doubly unfortunate at this particularly critical point in time that the job is not getting done.

Potent voices have been raised recently in which educational problems have been raised and possible directions have been suggested to help alleviate those problems. Hurd identifies some of the science-related problems as follows:

> 1. How can we develop ways to learn and manage large amounts of new knowledge?
> 2. How can we take advantage of the power of theoretical knowledge and, at the same time, provide information on the practical problems of the "real world"?
> 3. How should we prepare young people for a life of radical change in which the pace and depth of change are accelerating?
> 4. How do we develop people who are attuned to change, and who have qualities of versatility and adaptability?

<u>Essentially these problems involve educating for instability</u>. (2) (under-scoring mine.)

In <u>Designs for Progress in Science Education</u> (5), we find:

> It is evident that we must prepare our present students for life in a society the nature of which, to a large extent, we cannot predict. We must, therefore, enable our students to <u>accept and adapt to constant change</u>,

> to rely upon the broad conceptual schemes of science and upon the processes of science, and to form habits of interdisciplinary thinking, in order to make these adjustments. (Underscoring mine.)

Before we move to design and implement educational programs which are intended to "educate for instability" or to "enable our students to accept and adapt to constant change," perhaps we should consider other alternatives. One such alternative would be to design an educational system which would enable students to acquire decision-making skills about <u>what kind of changes</u> will be valuable, and how rapidly those changes <u>will be permitted</u> to occur. Producing action-oriented and trained individuals in the latter way seems more likely to result in an environment of healthy, controllable changes than would result from an approach which emphasizes passive "acceptance" of change.

Alvin Toffler said it very well in <u>Future Shock</u> (6) and many other sources are currently raising valid and meaningful objections to the uncontrolled impact of accelerating applications of scientific knowledge on our lives, resulting in rapid changes which neither individuals nor societies can understand and cope with.

What does all this have to do with science education? Scientists and technologists have generally gone about the business of advancing science and technology, with very little attention being paid to the resultant effect on people. Far too many of the pre-college science courses in the past seem to be designed to support science and far too few seem concerned with people. More and more, people are beginning to recognize the disparity that exists between the supposedly "neutral" quality of scientific endeavors and the effect of application of scientific output on society. Many now see a technologically dependent society which is being increasingly viewed as harmful to both the psychological and physical health of mankind.

Perhaps we in science education have become as egocentric as scientists and technologists are perceived to be by many people. The Educational Policies Commission in <u>Education and the Spirit of Science</u> (4) concluded, in part:

> To communicate the spirit of science and to develop people's capacity to use its value should therefore be among the principal goals of education in our own and every other country.

This seems very presumptuous on the part of science educators. Suppose that the values scientists hold of science are <u>not</u> the same values as are held by most people. Not only is there a question of whether we <u>can</u> impose the values of science on everyone, there is a deeper <u>moral</u> question as to whether we <u>ought</u> to do so. Certainly at the very least, the matter requires further thought. After all, just because the basis for scientific validation lies with experimental verification of theories, human values are not necessarily so restricted (or dependent).

Perhaps it is time for scientists and science educators to assume a different role from the customarily recognized ones of doing science and teaching science. Perhaps in concentrating our energies at this time on such a thing as environmental science or unified science or a K-12 science curriculum we are unnecessarily restricting our vision and our capabilities. It is also quite likely that such efforts will be insufficient in light of the nature of the problems facing us. Can we, as science educators, continue to bury our heads in science-type sand and hope that the recipients of an education consisting of an unrelated series of specialty-oriented experiences will somehow be able to integrate those experiences into a meaningful life style?

What would happen if we collectively decided to cut science education free and allow it to "float" on the educational market while we devoted our efforts toward reassessing and planning for a total overhauling of our educational system? What kind of actions might we decide to take if our aim were to redefine educational <u>policies</u> rather than educational programs of a short-term nature? What might the results be if we committed our efforts to cooperative involvement with other educators and with other people within a broad educational, social, political, and economic context in an attempt to fulfill our responsibilities in preparing a survival-oriented society?

A great many voices are crying out for educational change. What seems to be lacking is sufficient numbers of people willing to commit themselves totally to identifying the job to be done and then getting on with doing it.

It is suggested here that we, as science educators, demonstrate our commitment to bringing about those changes in our educational systems and in our society which are deemed most likely to result in meaningful future human existence. It is suggested that we move directly and actively into the political arena as well in order to put our proposals before those segments of our society which have the capability of most rapidly effecting the policy changes necessary for implementation.

It seems woefully inadequate at this time just to commit ourselves to preparing secondary school science teachers to teach another "band-aid" science course.

I am at least as committed to the development of competency-based teacher training as are the other committee members. Before such an approach will enable us to maximize our effectiveness, however, we need desperately to decide on our <u>goals</u>. We can't do this piecemeal. We need to develop a more clearly identified set of goals <u>first</u>, then apply the best method(s) of attaining those goals.

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SOME THOUGHTS AND PROPOSALS IN TEACHER PREPARATION

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Introduction

One predictable feature of planning for school-related programs in the next decade is demographic. The school-age population is becoming smaller, year by year, and it will be at least ten years before there will be a leveling off. The decline may go on even longer than ten years. That could be wonderful news for school men. It may ease the financial bind of schools. As school tax bills hold steady or drop slightly, tax payers may take a less critical stance towards "add-ons" in school programs and we may find more adventuring. As buildings are closed and staff are reshuffled within districts, the chances of introducing new organizational patterns and new curricular ideas may be improved. Outmoded and constricting buildings can be withdrawn from use now that all our facilities are no longer jammed with students.

I think it worthwhile to remind ourselves of the positive possibilities for education opened up by the decline in school populations. If we take a more limited view -- that from schools or colleges of education -- there may be a tendency to see the effects of a decline in population in negative terms. It's easy enough to see why a population decline could have serious effects on schools or colleges of education, since we are carried as a kind of overhead on the whole enterprise of schooling. If the enterprise becomes less sizable, then the overhead is probably going to shrink, too. To the extent that we, i.e. schools or colleges of education, are justified by our training of new entrants to teaching, we will almost certainly experience cutbacks. The demand for new teachers has dropped fairly drastically and, though teachers' associationa' insistence on smaller class sizes may meliorate the situation somewhat, is not likely to increase substantially in the immediate future.

From the standpoint of an institution that has seen a paid internship in teaching as <u>the</u> device for teacher preparation, the situation seems even more severe. If openings for newly prepared teachers have become less plentiful, openings for interns are even more difficult to find. Those which can be found are often questionable training grounds for teaching. When teachers of any kind were in short supply, an institution that could supply a reasonably able group of interns had some leverage. It could channel the flow of interns to schools that made an effort to so define and support intern placements that they provided helpful introductions to teaching. That leverage is gone and only the professional responsibility of school people can be relied on to maintain the educational value of intern placements. Sometimes this is not enough.

At first glance, the decline in enrollments seems likely to have destructive effects on schools or colleges of education. Perhaps that's because we looked at tha effects that are predictable if we continue to define ourselves as we have in recent years -- primarily as teachers of newcomers to the profession. But we, too, have a chance to rethink what we're about and to reorganize our resources in ways that will be most productive for education. So the question is, what are our opportunities in the new situation?

One significant problem that schools face is how to adapt school programs to changing demands when school staffs are bacoming more stable than ever. The hope that the introduction of new, young teachers into a system would produce change was always somewhat naive; now it looks forlorn. The changes that schools will have to make if they are to be effective educational institutions are going to be executed by the people who are already there -- or they will not be made at all. What can teacher training institutions do to help these people, the experienced teachers and administrators in schools, recognize where change will be nacessary and find the appropriate change to make?

Programs for Experienced Teachers

One model for providing assistance is fairly familiar. Those in the teacher training institution diagnose the areas where change is needed, design the changes that are thought appropriate, work out a training scheme to help teachers and administrators acquire the skills and understandings needed if the change is to be effectively instituted, and bring the experienced practitioners to the teacher training institution for re-training. In medicine this has been an effective procedure for keeping practitionera "current." I question whether in education the model will be appropriate, except in isolated cases. Medical training is associated with an institution, the teaching hospital, that provides a setting that is both controlled enough for good research and development and typical enough to screen out the impractical. Lab schools are the closest thing to an educational counterpart; these have only rarely drawn a student population like that of the teaching hospital (a mix of representative cases <u>and</u> hardest cases) and in any casa have been slowly vanishing from the educational scene. The claims of teacher training institutions to exhibit the "best practice" are rarely believable since the institutions are so tenuously associated with practice of any kind.

One variant of tha definition and modelling of "best practice" has been developad recently and is likely to continue. This is the "technical skills" approach to teacher training and retraining. Its most publicized forms at the moment are microteaching, minicourses, and competency-based teacher training. In microteaching and minicourses particular categories of teaching activity that are thought to be important elements of "best practice" are defined and modelled, and the individual being trained is given the chance to practice using acts in these categories. In general, emphasis is placed on getting those trained to the point where, within the practice situation, they are producing a large number of the acts in question, whether these are reinforcement of student responses, questions of a certain kind, or whatever. Competency-based teacher preparation uses a similar model of success, and defines teacher capacity for "best practice" as fluidity of teacher acts in a broad array of stipulated categories.

I don't believe these variants of the define and model approach to teacher preparation are adequate for either beginning or experienced teachers, but they certainly are useful. They are similar to the finger exercises of a musician* or to the repeated sketching of isolated elements of the environment that some artists have used to extend their facility. There is considerably more to being a musician, an artist, or a teacher than possession of a collection of isolated skills. However, if you know what you're up to and where, when, and how a skill is likely to be of use, acquiring and extending the skill can make you a better performer. I would be much more impressed and optimistic about the recent emphasis on skills training of whatever kind if there was evidence that attention hadn't been unduly diverted thereby from the question of how skills, knowledge, and purposes can be effectively integrated within the range of constraints found in ordinary teaching situations.

Indeed, how one works out intelligent adaptations to the changing conditions of a teaching situation seems to be the area that has been most neglected in the recent past. It is also, I think, the one area where the knowledge and expertise resident in schools and colleges of education can continually make contributions to the preparation of experienced practitioners. Certainly there is no reason why schools or colleges of education should be the training grounds for the acquisition or extension of defined sets of new teaching skills. The success of the minicourses of the Far West Laboratory indicates that the ability to perform novel teaching acts can be acquired without leaving the school district, in a form of in-service training. While schools or colleges of education are not-so-necessary middlemen in the acquisition of new teaching skills, they are (or should be) possessed of the most up-to-date analytic competences of expertise in evaluation, and they have easiest access to the thought of the broad academic community. This means that schools or colleges of education can act as early-wormers pointing out the implicationa of new knowledge for school programs before those implications become evident to everyone. They can also help teachers and administrators to frame questions about their programs that will make weaknesses evident and suggest the kinds of actions that will repair the weaknesses.

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*An example used by Gage to justify the Stanford R & D Center's continuing interest in technical skills training.

In terms of the programs that might be designed, this means a cooperative arrangement between school districts and schools or colleges of education. A school district could nominate troublesome problems and the staff members who will be centrally involved in attempts to deal with the problems. The school or college of education could nominate some movements in the design of school programs -- shifts in curricular emphasis, in the uses of staff, in methods of evaluation -- that seem likely to have broad impact. The program focus in a given period would be defined by the overlap of the two sets of nominations. The program for the training of the selected experienced teachers or administrators would consist of providing them with tools they can use to sharpen their understanding of their problems, of opportunities to use these tools under the guidance of the faculty of the school or college of education, of surveys of the resources available that are potentially applicable to their problems, of considerations of how these resources can be adapted in possible solutions to the problems, and of opportunities to design evaluations of the effectiveness of the decisions eventually made.

Let me run through one hypothetical example to indicate how such a program might work. The college of education has indicated that one theme that will be explored is how science teaching might be expanded to include the uses of knowledge gained from science in guiding action. The larger college or university includes some faculty members in the sciences and engineering who are interested in the interactions of science, technology, and society and some courses are available that deal with one aspect or another of these interactions.

In this example, a school district indicates its problem to be the selection of a new text for its seventh grade general science offering. There is fairly widespread agreement that the junior high school science program is inadequate, and the text selection offers a chance to institute changes in the seventh grade part of the program. Another year of science is required of all students; most take it in the ninth grade, but some (who are science-oriented) take it in the eighth and take a biology course in the ninth. The seventh grade science teacher who is spending a year at the college is also chairman of the text selection committee that will decide on the new text.

During the first portion of the year the teacher learns to use a variety of data-gathering techniques: observation of teaching, testing for a variety of outcomes, survey designs, interviewing, etc. He interviews sixteen students in two high schools about their junior high school science experiences: likes and dislikes, what they've since found useful, etc. The students are selected by the amount of high school science they've taken and the junior high teachers' recollections of students' reactions to junior high school science. To determine what the current program is like he interviews some of the junior high teachers: mainly those teaching seventh grade science, but some teachers of the second course as well. He also gathers a representative sample of teacher-made tests and of teacher handouts, characterizes the demands made in the existing text, and observes a sample of classes. His observations are alternatively "free" and guided by an adaptation of an existing observation instrument designed to gather data that seems particularly important in the light of his other data. He institutes a Delphi-like nomination of the important outcomes of junior high science by junior high teachers, high school teachers, junior high and senior high students, and parents. He asks junior high school guidance counselors to note the counseling problems that are associated with science courses. He gathers science data from the school system's testing program.

The data he gathers is used to develop a summary of what each group currently concerned with junior high science wants from the program. The teacher also suggests some demands on the program that are likely to be made if the uses of science for decision-making become a serious curricular goal. He meets with the text selection committee and they decide which of the desired program features are likely to be much affected by the choice of a text. They work out a procedure for rating the texts in terms of these selected features. They also work out a way of noting classroom procedures demanded by the use of a particular text. With these instruments the committee develops a picture of what might be gained from the use of texts that are available or soon to be available, and of the demands that the use will make on teachers and other resources of the district.

When the committee makes its text recommendation it also notes program areas that will not be effectively served by the selected text and recommends a summer curriculum workshop to develop and adopt materials in these areas. The committee report is supplemented by a report from the teacher who has been trained indicating:

1. troubling aspects of the science program untouched by the text selection and recommending study or action for these aspects,
2. teaching skills or approaches that may be needed to make effective use of the recommended text and suggestions for teacher re-training,
3. expectations of different groups for the revised program that are not likely to be realized and suggestions for dealing with the gaps,
4. resources that could be used in the summer curriculum workshop, and
5. a sketch of evidence that could be gathered to monitor the success of the text adoption and related activities.

While this example is unrealistic in some ways, it does suggest what both school systems and experienced teachers or administrators might get from the program. The teacher gains an ability to bring a variety of accessible data to real problems in meaningful ways and an opportunity to develop some competence and understanding related to significant new ideas in educational practice. The school system has a significant problem defined competently, some sensible approaches to it outlined, and the chance to keep the teachers' new competence trained on this or allied problems. I'd guess (hope) that both sets of benefits will be seen as worth some cost, i.e., that teachers and systems would pay to participate in such a program.

What are the benefits to the school or college of education? The faculty will have a chance to learn how the research techniques and principles of program development it commands must be adapted if they are to yield useful data in particular circumstances. They will also have a chance, if they maintain contact, to follow the introduction of one variant or another of new designs in school programs. For example, if you believe as I do that science teaching will come to include teaching of technological thought and about the social institutions of science and technology, one might be able to collaboratively design and monitor curriculum devices that attempt to do this kind of science teaching.

Benefits for the Preparation of Beginners

There is another benefit for schools or colleges of education that could be allied with such a program for experienced teachers. If the teachers were drawn back for relatively full time study they would free a teaching position that can be used for the internship of two or three beginning teachers. Proper conditions for these internships could be made a pre-condition for the college of education -- school system collaboration in the program for experienced teachers. In this way a portion of a reasonable training ground for beginners could be secured.

It seems to me that an internship does provide a part but only a part of the training ground that one would hope for. In an internship a beginner finds the full set of demands faced by the practitioner. Thus in a sense the internship is recommended by its reality. The drawback of the internship is that the reality it represents is only one among a wide variety of realities faced by teachers. It seems to be difficult for beginning teachers to appreciate how narrow the experience of the internship really is. They are not very able to imagine how their teaching will have to change as the character of their students, or the demands of the subject metter, or the support of the community, or ... is changed. Thus, it seems to me that along with the depth of experience provided by an internship, one would want to provide breadth by placing the beginner in a relatively non-demanding apprenticeship in two or three other, contrasting teaching situations. I suspect this is best done during the same time as or immediately after the internship experience. Thus, it could be done during a fifth year program although it would take some careful scheduling. While undergraduate programs have the apparent advantage of scheduling teaching experiences over two or three years, the advantage may be an illusion if the internship is as crucial for refining perceptions of teaching as I believe it is.

The emphasis I give here to the character of teaching experience in teacher training is based on my belief that teaching is best thought of as a craft. The preferred method for learning a craft is, it seems to me, an apprenticeship. Certainly the testimony of beginners I've had contact with at Stanford and at Harvard indicates that the apprenticeship -- the internship or practice teaching -- is seen as the most valuable element in their preparation. I believe we'll generate more effective programs in teacher preparation if we think seriously about how we can make the apprenticeship most valuable and about what other experiences, academic or otherwise, will most enhance the value of the apprenticeship. Courses in methods, in educational psychology and sociology, in tests and measurements are not self-justifying. It is only as these courses can reasonably claim to make the beginner's apprenticeship a more adequate preparation for teaching that they deserve a place in a program of teacher training.

There is a potential benefit to running both the programs for experienced and beginning teachers with the emphases indicated. There seems to be a widespread suspicion of schools or colleges of education among teachers. We are often accused implicitly and sometimes explicitly of describing an ideal set of affairs, what ought to be done, without much consideration of the practical constraints of real classrooms. Teachers, on the other hand, often seem from our perspective to equate what can be done in a situation with what has been done. I doubt that this tension between perspectives will ever disappear. However, by involving schools or colleges of education more heavily in the planning and provisioning of apprenticeship experiences and by transferring some of our academic skills and hopefully "vision" to experienced teachers in the schools we may reduce the gap. Perhaps then the beginning teacher will not so often be caught between the impractical "ideal" and the stodgily "practical" but will be able to make use of two complementary insights about teaching.

TECHNOLOGY AND SCIENCE TEACHER PREPARATION

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The phraseology varies among the many goal statements for science education, but in one form or another, each set of goals establishes as one aim of science education, the development of knowledge and understanding of modern technology and of the relationships among science, society and technology. The expression of this goal for science education seems to be a recognition of the need for a technologically literate as well as scientifically literate citizenry.

The assignment of a high priority to this goal of science education seems to be justifiable both logically and practically. Science and technology are so intricately related that we often are unable to distinguish them from each other. Science and technology are interrelated and interdependent. Conceptually, methodologically, and philosophically the fields of science and technology share many more similarities than differences. If one were assigned the task of categorizing scientists and technologists as well as scientific knowledge and technological knowledge, he would face an impossible task.

But we do have fields of knowledge we label technology and we do have individuals we label technologists, persons whose principal concern is the extension and application of scientific knowledge in the solution of society's problems. Among these are our medical doctors, engineers, dentists, foresters and technicians.

This goal becomes important to us as we consider the need to educate a citizenry knowledgeable about its cultural roots and heritage, and knowledgeable about the dynamic elements and needs of the culture and the society. This goal also assumes importance as we assign to the school the responsibility for career guidance and preparation. It seems only logical that within the science curriculum children should have opportunities to learn about the vocational opportunities in science and its applied fields.

As science educators, we have tended to ignore the technology goal as elementary and secondary school science programs have been designed and implemented and as we have trained science teachers for these programs. The post-Sputnik science curriculum reforms produced programs with modern scientific content, programs in which the outdated science as well as the descriptive and applied science were eliminated. But we have ignored the fact that technology also has a recent history and we have ignored the fact that science and technology have grown closer together. The past decade of science education has been devoted to the concept of "pure science," i.e. "pure physics," "pure chemistry," and "pure biology."

Today's secondary school science textbooks rarely contain any mention of the technological fields. In the physics textbooks, there is no mention of such fields as mechanical engineering, electrical engineering, civil engineering or geophysics. The chemistry textbooks contain no reference to chemical engineering or metallurgical engineering, although alchemy is frequently described in some detail. Earth science textbooks do not mention geological engineering, mining engineering or the minerals industry. The health vocations, forestry, and the other applied biology fields are not mentioned in the biology textbooks. The applications of scientific knowledge in the practical solution of man's modern day problems is more or less ignored in today's science curricula and textbooks.

Present secondary science teacher preparation programs tend to prepare "pure science" science teachers. Prospective physics, chemistry, biology and earth science teachers are prepared in their academic fields almost exclusively within the appropriate university academic science departments. Their scientific training is focused on the theoretical knowledge of field. Federally funded training programs for experienced teachers tend to concentrate on "pure science" education. As a result of these and other influences, we have prepared a generation of science teachers well educated in science knowledge but inadequately educated in technology. In the past, prospective scientists, science teachers, engineers and other technologists shared some common courses and curricula. Now we teach freshman chemistry and freshman engineering chemistry, physics and engineering physics. Presumably, one course is pure science and the other includes applications and technology. It would seem that if we wish to have science teachers teach youth about modern technology and about the relationships among science, society, and technology, we must devise programs to provide this knowledge to teachers.

I do not believe we will be allowed, in the upcoming years, to continue to ignore technology and the technological vocations. Through the past decade, the science curriculum pendulum has swung to the extreme "pure science" position. I believe it will swing back toward the middle ground and as it does, we will need to educate teachers prepared to teach youth about both science and technology.

SECTION II

Panel Discussion

PANEL DISCUSSION

Schaff: (Introduction)

Welcome to Session Xib entitled Secondary Science Teacher Education: Where Are We Going? This session is somewhat different in that the panel members have exchanged papers and had an opportunity to digest their contents prior to this meeting. They will now engage in a discussion of the ideas, points and programs presented in the papers.

I should mention that the panel members were asked to respond to the topic as they perceived it in relation to recent trends and developments in their own institution. No other guidelines were given; consequently, the papers reflect some common thrusts and considerable variety in ideas.

First, I would like to introduce the panel members to you. (Each panel member introduced)

Now, I will turn the session over to Burt Voss who will act as moderator for the discussion.

Voss: (Moderator)

Since we have a large number of panelists, we decided not to ask each panelist to give a five minute presentation. That would take up most of our time. We are going to simply open up the discussion to members of the panel to say anything they'd like to get the ball rolling. We are concerned about science teacher education, particularly for secondary school teaching. What are we doing? Where are we going? I have had a chance to read the papers and think they are pretty fascinating. People are doing some exciting things and are looking ahead. I am ready now to allow one of the panelists who feels that the spirit has moved him to start. Is there anyone who would like to make a couple of comments? I didn't hook up these chairs electrically so I am sure no one is going to jump. I know there aren't very many bashful people on this panel. Who would like to take a crack?

Bell:

I would like to raise a question to Vic Morris. In his paper, he described something that several of the papers alluded to, and that is the tight market as far as employing teachers. We are finding in Pennsylvania that this isn't so for science teachers, and I was wondering if there are data from the other states indicating whether science teachers fit the general pattern or whether there still are openings?

Morris:

My concern wasn't so much with whether or not there are positions open for science teachers. My question was that maybe we are missing the boat if we think solely in terms of science; that perhaps science can get along without us if we look at the past record. The new curricula which have been developed have not had much of an impact on college science enrollments, and yet science and technology in terms of the number of reports, research papers, and the advancements in scientific and technological knowledge has continued to increase at a doubling rate for about eleven years. This includes about three to five percent of the people we train in our high school science programs. My concern is that at the university level, in particular looking at attitudes of students, we are probably producing more anti-scientists than we are scientists. Maybe in science education we need to take a larger look at the overall picture of education and maybe let science itself float for awhile. Maybe there is something else we could be doing in terms of a broader educational picture than just saying we are going to train a teacher to teach science. So I guess my question is: Where is science education going in the future, but not in terms of just science programs? Where are we going in education, and where are we going as a nation? What are we as science educators going to do about it?

Voss:

I think this might raise a question concerning the humanistic aspects of science and of teaching that I saw a few comments about. Paul (Bell), has your question been answered before we might move into that?

Bell:

I'll come back later.

Bridgham:

The title of this panel or the title that we are supposed to address ourselves to is Secondary Science Teacher Education, Where Are We Going? What struck me was the presumption, as I read the papers, that secondary science teacher education consists of work with preservice teachers. That is, by and large the papers are focused on work with the beginner. Basically, they concentrate on work with undergraduates or a fifth year program or something that looks into a fifth year, I think that's simply a strategic mistake. I think we are still going to have to spend a lot of time and effort working with beginners, but it seems to me that if our concern is with the state of science teaching in schools, then we ought to be spending a fair amount of time worrying about the kind of work we could be doing profitably with experienced teachers. I think the job market is not so "red hot," and I suspect that if we want to justify ourselves, we are going to have a harder and harder time justifying our existence solely in terms of the beginners we are working with.

They are going to decline in number, and if we do keep our enrollments up, we are going to find ourselves in the embarrassing position of bringing people through our programs and letting them go and saying "The Lord will provide." I am not so sure the Lord will, in these circumstances. But even more, we often talk as though there is a lot of leverage to be gained by working effectivaly with beginners. That is, we can really make profound changes in schools. I think sometimes the arguments are that we can take these vibrant young people and sort of put them out in schools, and they are going to transform the school. Yet, all of our background experience indicates that, by and large, young teachers go into the worst positions. They have the least leverage of anybody in the building, and the major problem seems to be that about half of them are gone in about three to four years. Although I am not sure how that has changed the job market, the half life of a teacher is really kind of slim after the initial preparation. If we really want to have something to do with changing schools, then I think we had better think hard about effective ways of working with experienced teachers, because they are the people that are out there. By and large, the people who have experience are the ones who for one reason or another do have some kind of leverage in the system. If we can get them to change, I think we are likely to see that the schools will change faster than if we spend all of our efforts working with preservice teaching. So I would like to argue for some consideration of what we could do with experienced teachers. I suspect that the answer is not going to be one thing. I suggest that one kind of thing would be appropriate for an institution which has a diverse set of research and evaluation skills lying around, and other answers are going to be appropriate at other institutions. It seems to me that at least a larger proportion of our thrust ought to be moving towards work with experienced teachers.

Voss:

Great. Do you think we might follow that up with some ideas on field-based programs in which some people are working with the experienced teacher and pre-service teacher at the same time? I know there is some of that going on.

Trowbridge:

Let me say a little bit in regard to that too, Bob (Bridgham). I got the feeling for awhile,when you were talking, that you had written part of my paper, because I had made some reference to the identical problems that you identified. I, too, feel that we are probably losing some of our best teachers through bad working conditions when they arrive on the scene as a fresh, new teacher but fail to get the required support from the institution from which they were graduated and probably do not get support in the school. Some years ago, quite a long time ago - about 10 years ago I think, we did a study in the State of Colorado in which we surveyed the teaching experience of the teachers and found that more than half had less than five years experience. Now this means to us that after five years a lot of them were getting out of the field or they were dropping teaching as a profession. What I am saying is that there was a tremendous turnover, because the young teachers that remained had only a few years of teaching experience on the average. This I think may be supported again in a replication of that study which is being run right now. This supports what you are saying, Bob (Bridgham), that we need to do something to give young teachers moral support and a pat on the back. You see we are doing an injustice to the teaching profession by not allowing these sharp, young teachers to get into a good situation. They are put at the low end of the totem pole. They are given all the dirty jobs and given the extra duty. They are at the lowest salary and are at the whim of all the experienced teachers in the system. It takes a pretty strong will and strong mind for a new, young teacher to fight against that. They may have all the good ideas in the world, but it is pretty hard to put them across when you are just beginning.

Well, one idea that we have not yet tried which is being used at the University of Wyoming and which we are looking at very seriously is the Portal School Plan. In this plan master teachers, leaders in the small schools, come back to the university for a summer or more of work and then go back into their school district to conduct in-service type programs that would help to upgrade the teaching and the educational system. Now the typical off-campus or continuing education kind of program has an expert from the university who goes out and teaches a class in a school. Teachers take this class and maybe they do something about what they learn or maybe they don't. I think that this thing we are talking about would employ people already in the system. It would identify the potential teaching leaders and there is nothing like having one of your own giving you help rather than to have somebody from the outside. So in a way, this would serve two functions. It would help to upgrade the teacher leader and keep him in the system, and it would also help upgrade the other teachers who are taking the courses.

Townsend:

First, Bob (Bridgham), you say in your paper those in the teacher training institution diagnose the areas where change is needed. I really question whether they can do that if they stay at the university. It goes along with the problem we are talking about--experienced teachers. First of all, the teachers won't listen to it. You can have more of an effect on the beginning teachers because you have got the club there. The experienced teachers will look at some of these diagnostic results and say, "But you don't understand the problems in the school," and I think they are correct. You go along and say, "Design the changes that are thought appropriate." I would question that by asking, "Thought appropriate by whom?" And then along with what Les (Trowbridge) was saying, you were also suggesting that we bring them back to the university for retraining, which I think is the wrong setting.

Bridgham:

That is exactly the model that I rejected.

Townsend:

Okay, but you are saying this in terms of a need to get to the experienced teachers and, these are not in your words but it came from several of the papers, straighten them out. I think even getting somebody from the school back to the university and sending them back to the Portal Schools would not be nearly as effective as getting some people from the universities into the schools for more than just a workshop or short-term basis. The university people should be there a length of time on a day-to-day basis so that they can work within the context of the school and with the problems of the schools. The problems change so rapidly that the people at the universities looking at their own experience in the public schools aren't aware of the present problems or even where they can help. Their solutions aren't for what is needed today, they are for what was needed maybe five years ago or maybe more.

Blosser:

I will respond peripherally to Bob Bridgham's concern. Because I am so involved with preservice people and fifth year people that we treat as preservice at Ohio State, when your paper came in which concerns interns I thought, "Gee! Yeah! There still are institutions that are running teacher intern programs and they have problems too." While I would agree with you that we have to work on inservice people, I think maybe a mechanism that we might try is working with preservice and inservice simultaneously (backing up what Ron (Townsend) says) out in the schools. We have a program that includes heavy school involvement for five quarters and I have been in some schools for three years now, working with the same teachers. While I am in there ostensibly working with juniors while they teach science, the regular teachers are affected too. If they're aware of it or not, I have seen some changes in their behavior in the way they handle kids that I didn't see when I went in there three years ago. Maybe we don't need to bring teachers back to the campus, but support some of the things that I think Ron (Townsend) has said. Let's take the campus out to the schools and let's work with preservice and inservice people at the same time. Maybe the preservice people will end up in those schools where they have done some of their preservice work and then start helping inservice people change. I think they gain more credibility as a beginning teacher if they have been there before and are not just brand new to that building when they have gotten their Bachelor's or MAT degree or whatever.

Gallagher:

I looked at all the papers that I received and think 11 out of 12 had a reference to the need for an early clinical experience in teacher preservice education. There are I think, three papers which talked about programs for experienced teachers. I think it is unfortunate that we didn't in our papers make the connection that Pat (Blosser) just described more obvious because I think that is where the action really is: where we combine the inservice training of experienced teachers with the preservice teachers. I think there are many mutual benefits to be gained from working with experienced teachers, especially as we go along with the training of our preservice teachers. There are certainly benefits to the experienced teachers from the continued contact with the university. There are also benefits to the preservice teacher from the point of view of having continuing contact or long range contact with the real world. Also, I think there is a great benefit to us. In my paper I described what I think is a lesson that we can learn from the history of science. In the history of science, the scholars about the 16th and 17th century began to make some very significant contributions when they began to combine their efforts with those of craftsmen. It was in the history of science, the union of the scholar and craftsmen which led to the scientific revolution in the 17th century. It may be that we are on the verge of a revolution in education. Especially if we, let's say we are presumptuous enough to say, that we are the scholars in the field of education, combine our talents with the craftsmen in the field, the experienced teachers in the field, to address ourselves to significant issues of research, the preparation of new teachers, and to the on-going preparation and professional growth of experienced teachers.

Bell:

In support of working at the site of the school, it seems safe to assume that we need experienced teachers in the role of helping us out even though we might be missing a bet on changing what now is. For instance, if we were to take first-year teachers and work closely with them by using them as cooperating teachers, guide teachers, and so forth, we might derive several advantages. One, we might provide them some supervisory kind of help, a continuation from their college supervision which in many districts they now don't get. Secondly, their ideas are still fresh and we can capitalize and reinforce those fresh ideas. Thirdly, and maybe most important and one that Les (Trowbridge) raised, is that since they have now been given what I call the "crappy jobs" at the low end of the totem pole, the districts might be under pressure, since they are now a showcase room having people visiting all the time, to let up on that kind of aspect and give them some reasonably good opportunities to succeed. So it might be that we can work with the new ones as well as the old ones.

Koran:

I've been jotting down some notes; about a million things here. Probably what I say will be at least disarticulated and I hope not incoherent. But to start with, I was a little distressed when I got the topic for this symposium and it focused on secondary science teacher education. This suggests that there is something unique about training secondary science teachers that distinguishes it from training elementary teachers to teach science or training any other kind of teachers to teach anything. I generally have the orientation myself, and I find after going to a number of meetings and editorial board meetings and so on that this is not one that's held in great agreement by my colleagues, that science is simply a vehicle. If we are training teachers to perform in a number of ways and we just happen to be the fellows who know something about science, then we use science as the dependent variable and teaching skills of various sorts as independent variables. This is our modus operandi. That is one kind of reflection of it, and it is kind of just an initial thing.

Secondly, we're debating here about what the target population is, and I don't think that anyone in the audience will disagree at this point that preservice teacher education certainly has to be wound down. If we overproduced, in 1985 or so we would have enough teachers in every field to populate every schoolroom that we are going to have available. The way the growth curves are going in terms of population, we're getting more kids in certain areas and fewer kids in other areas. We better be aware of this and start looking at what kinds of people we want to produce and in what areas, and where we want to put our money. I don't think people would disagree that one nice place to put our money at this point, in terms of rational expediency and keeping universities in business and keeping colleges of education going, would be in the inservice type of activity. It is rather a depressing situation to my way of thinking. We've really been on the gravy train in science using NSF money and all sorts of other kind of money and, focusing on this target population that we've all been talking about that would be profitable to focus on, we really haven't been making an awful lot of progress. One of the reasons is because we've been producing a lot of people who we call teachers who are really not intellectually well developed. They are not people who have any kind of commitment to continuous learning or any kind of commitment to particularly working with kids. I think one of the things we have to do is start integrating into our programs, and even being selective in this inservice kind of orientation, the notion of picking and choosing the people who are out in the schools now. We need people who have intellectual commitment, who have the greatest potential for a wide range of development, who are going to be continuous learners, who provide models for kids whom they would like to have become continuous learners and focus on that kind of activity. I hope I was mildly coherent, but that is my first round performance.

Gale:

About two or three years ago I moved to an engineering institution, and I daily get brainwashed by the civils, the mechanicals, and others. I'd like to voice some of their concerns and pick up a few points that some of my colleagues have made. There are some red-hot areas--job opportunities--right now. There is a shortage of engineers who are in that part of the engineering job cycle. There are many opportunities for two-year trained technologists, and I think this has some bearing on our science programs and our teacher preperation programs. We've done a pretty good job of upgrading our science programs over the last decade or so. We have purified the science programs. If you look at a chemistry textbook you don't find chemical engineering mentioned. You don't find metallurgy mentioned except that it is an extraction of metal from ores. You look at a physics textbook and you don't see mechanical or electrical engineering or civil engineering even mentioned. We could say, "Well, maybe the science teachers introduce these ideas in the discussions," but science teachers come through programs which have been purified at the university level, too. The chemistry teacher doesn't start off with the chemical engineers. The chemical engineers are over in the general engineering chemistry course, and they're in their own organic courses and so on. The physicists have their own general physics course, and engineers have their own beginning engineering physics course, and so we don't rub elbows in the beginning courses. I think we have in our teacher preparation programs lost any allegiance to technology in the development of any understanding of technological fields. I think this is a very serious problem, and I think this is something that we're going to have to look at very seriously and try to develop some programs that will bring back to the science--the junior high and the science courses--some understanding of technology. I think it is a vocational problem. I think in a broader sense it's a social problem.

Voss:

Thank you. I think one of my own concerns in teacher education, both preservice and inservice, that we have alluded to just a little bit has been the fact that most of the schools and teachers in our section of the state of Michigan are spending a great deal of time on the question: How can I be a more humane teacher? Also there is a large amount of inservice through multi-ethnic workshops. Where are we going? How do we treat kids as persons? How do we relate more effectively to them? This is a great concern that I face in the area in which I work, and I think we need a lot of good thinking about it.

Townsend:

In talking about what's happened, I guess in the 60's, in terms of the new curricula and also the inservice institutes - the summer institutes, it appears to me, and this came as a shock as I went back into the high school, having taught at the university for several years just prior to that, what we've done to the teachers. My perception of what we've done to the science teachers is we have given them a great respect for the changes in science and the advances in science, and at the same time we have taught them to suspect the science education or maybe just education theories and "educationese," if you will, the terminology, and some of the things that won't work in the real world. Now those are two different things that I perceived getting a lot of the science teachers back to the universities has done. I think you are going to have trouble with your inservice programs just because of this suspect nature of our present teachers. I am generalizing, but I think it's quite a large number of them that have this suspect. It's not that they completely say you're wrong, they just suspect whether some of these things will work, even the humanizing, whether these will work in the real world of the school where they are working day to day.

Gallagher:

I agree with what you've just said, Dr. Townsend. The teachers in the schools really are suspect of education, especially the educators. I can remember my own experience. My first day of teaching I met a teacher who was a sixth grade teacher in the room right under me. I walked down the stairs at the end of the day and Mrs. Myrtle Rice (the teacher's name), a stereotype of the schoolmarm, said to me, "One thing I would advise you is to forget everything you learned in your education courses if you want to be a successful teacher."

The reason I wanted to get in at this point is I wanted to present what might be a tabulation, an incomplete tabulation, of what the common thrusts were in the dozen papers that I read. I think it would be helpful if this information was made available to the audience before we open the session to audience participation. The one topic that I mentioned is the need for early clinical experience in preservice teacher education. I think 11 out of the 12 people had some reference to that. Performance-based teacher education also was a common thrust. I think that was 11 out of the 12. Then I came up with four other areas, and I'll ask the other panelists to add those that they perceive I've missed because I didn't do this rigorously. After I read the papers I tried to record what the commonalities were. About three or four people talked about programs for experienced teachers. About three people mentioned preparation for teaching and/or integrating minorities, inner-city experiences, and the like. A couple of people mention science as a humanity, and I didn't get to read Dr. Gale's paper for some reason or other. I don't know if I haven't seen it or what the problem was, but I would like to expand that topic as to include both science as a humanity and technology as part of science. I think those fit into a category that needs discussion in the future of teacher education. And then the final category that I have, and there were two people who mentioned this, reasoning and conceptualizing abilities among students and teachers. The whole story on reasoning and conceptualizing abilities just isn't in yet and there is a lot of new thinking in this area which is going to have rather significant implications for teacher preparation. Are there other categories of response that I missed in my analysis?

Blosser:

I think a couple of papers talk about developing modules which could be a kind of a competency-based thing, Jim (Gallagher), but it wouldn't necessarily have to be.

Gallagher:

Well, I threw it into that category.

Schaff:

Just to mention one thing, Jim (Gallagher), and maybe the rest of you may recall that the January issue of Journal of Chemical Education referred to the big conference at Mount Holyoke last summer where the chemists discussed a lot of changes in their curricula. I would kind of like to open up a question. We have in our universities complained that the chemists lecture and don't incorporate alternative methods which we feel should have been used. If you read the article, they are describing the use of multi-media, inquiry, and things of this sort. I wonder how real this is or is it just a publication from a conference. Likewise, in Prospectives in Physics which was published by the National Academy of Science, by Handler, there is a section, Chapter 11 I recall, concerning changes in physics. I alluded to these in my paper and I put them in because I am wondering if these are changes that are occurring or just something that's described in the book? Now when I investigated our own institution (I am from the University of Toledo), I am pleased to inform you that Prospectives in Physics was given to me by the Chairman of the Physics Department. He said, "Have you seen this chapter?" He had read it and had several questions which we discussed. It is true they are not implementing a lot of the ideas mentioned, but he is concerned, and he wanted to have quite a talk about the possibility of getting some of them incorporated within their own physics courses. The chemistry people are also doing some changing along these lines. My concern is: to what extent is this representative at the university level? Maybe some of the people in the audience would like to speak to that. But at least the science areas are giving overtures to making changes which might help us in preparing the backgrounds of preservice teachers and also help us in the continuing education of inservice teachers.

Koran:

Two points: one is kind of an observation. There is an awful lot of talk about humaneness, humanism, humanistic approaches to instruction and so far I found very few definitions of them. I really don't know how to operationalize it. I would be hard pressed in figuring out how to go about producing it or influencing it in a teacher education program. I wanted to make that one reaction.

The second one is that I think in our field we've been guilty of producing a lot of pseudo-scientists. A lot of science educators are either frustrated scientists or pseudo-scientists. Consequently, when these people teach methods classes, what happens is that we have kind of a bastardized science course. A lot of our trainees are going out into the schools; they have been doing it for a long time, with no knowledge what so ever of, at least the meager kinds of information we have, about learning. For instance, we do know something about process acquisition. There is a lot of research in the area. We know something about concept formation. In fact we know more about concept formation than we normally even encounter in meetings such as this. But we do know things about decision-making theories; we do know about small group kinds of dynamics. There is an awful lot of research on this that we're not introducing to our students and we're not putting science in the context of these types of things. We do know something about hierarchical instructional systems. Relative to modules, we know that they are extremely costly to produce, that they have to be produced for particular individuals and if you start out making modules, you are going to wind up having to produce a different one for every human that you intend to confront with a module. We do know things from the research at Bell Laboratories and Rothkopf's work about teaching kids how to process information, process written instructional material in science and process pictorial information. We do know an awful lot about media, except if you go to Purdue or a lot of other schools you have got multi-media systems being laid on our teacher trainees and providing probably the worst examples of how to use a multi-media instructional system. And, consequently, these people go out into schools and they really don't know how to use a multi-media instructional system. We do know a lot of things about modeling. We know, for instance, that all of our trainees come out of academic departments and they're all watching professors. The dominant model of the academic professor is to walk up and give a lecture on something and assume verbal communication is sufficient to learn a concept or a high level problem solving situation. So, to boil it down, our science educators or science teacher trainers are responsible for teaching our trainees, the people who are in the schools who are now inservice people, and our preservice people, a lot of things and I suspect thay have all been the wrong things. We haven't been teaching them how to teach and, consequently, going back to the target population we're all concerned about, we almost have to go back to that group and start all over, teach them how to teach, teach them what we know about learning since teaching is related to learning in a very direct way. I think we could assume that most of them know science because they have been exposed to a lot of people who maybe know only science.

Voss:

I think it is time to turn it over to the audience and here is a question --

Audience:

I'd like to ask the group to go back to your first comment. I think in the last couple of minutes you came back to it again, on the training of these teachers and you are emphasizing the inservice teacher, what science content, what education content, and even what technological content, would you throw at them? Secondly, how are you going to get them into the system? in other words, what specifics are you going to give them and how are you going to handle it? For example, isn't this something of what the summer institutes were supposed to do? I suspect they may have failed; if so, why? Maybe I'm wrong, maybe they succeeded, but isn't this what the summer institutes were going to do and if they didn't fail, what can we do to change this? In other words, how do we do this change? What specifics can we give the teachers?

Trowbridge:

All right, let me react to part of that statement. First of all, the very fact you use the term "throw at them" kind of repulses me.

Audience:

Translate that to whatever words you like.

Trowbridge:

It's a little hard to translate that word if you're talking about the way we train teachers. However, I would agree that probably the answer to the question that came up before about the kind of reaction one gets when he goes out into the schools and talks to a teacher and the experienced teacher says, "Well, forget about everything you learned in your education classes. That is not the real world." Maybe part of the reason is the very fact that the last 15 years we have put a great deal of money into retreading and retraining teachers and, for the most part, these teachers of science who have come back to our summer institutes and, in particular our academic year institutes, were not trained in education, but they were trained in science. That is to say, they were there to upgrade, to bring their knowledge of the frontiers of science back up. And so they haven't really learned education. Now maybe that is a failure on our part. We have not been generally involved in those kinds of things except in perhaps on a kind of a fringe level.

Audience:

Let me interject a comment here. I don't think they've learned the science very well.

Trowbridge:

Okay. That may be as it is. But anyway I think that we have failed in that sense. We also failed when those teachers were pre-service, too. There were a lot of instances where the teachers who went out from our methods classes and so on would turn back and say, "For God's sake, don't ever give me another methods class. You know I just can't stomach that kind of stuff!" And we have had lots of instances of that. I forget what else I was going to say, but go ahead.

Bridgham:

I don't agree with John (Koran) in the sense of teaching. I think we misconstrue what classroom teachers face and the kinds of things they're up to. I'm late doing it, but I just finished Phil Jackson's book Life in the Classroom. It is a delightful book and one of his main themes is that after all, when you look at it, the things teachers try and are trying to do is not the sort of thing that people in education have destroyed and, in particular, they do not essentially engineer their classrooms. John (Koran) is talking about, it seems to me, how you would go about organizing or engineering the learning of students.

Jackson's point is, in fact, what teachers do and I think he makes a reasonably good argument for it, being adaptive in the school situation. It is: they essentially plot a kind of engineering of learning. Then they get into a situation with activities for their students that they're fairly sure are at least going to engage them because that is, after all, sort of the first thing that they need to have happen. They don't want the room to sort of jump in on them. And then they just exploit, by and large, what comes their way. As a matter of fact, Jackson's sense was that teachers kind of waited for something to happen. That they sort of go in with their plan and if it all ran according to schedule, they were kind of disappointed. They sort of let the thing go and then all of a sudden, something unexpected happened and, wow! That was the time for them to really go. It points, it seems to me, to the variety of things that do go on in classrooms. There are management problems and you know anybody that has worked with beginning teachers knows that at the time. That is one of the things that they're really concerned with. How do you manage a classroom so that you don't have the room in a shambles? These seem to be the most serious problems faced by beginning teachers in the fact that they are real. If you can't manage the classroom, you're in real trouble. And it is very difficult, it seems to me, to lay down general rules of order for classrooms. It seems to me there is more to teaching than the kinds of things that John (Koran) is talking about. I don't want to say that those are unimportant because after all, the point of school is that somehow learning takes place. But teachers do face other problems besides simply engineering a preset of learnings for their students.

It seems to me that I want to disagree with Les (Trowbridge), too. I don't think teachers avoid methods courses because they had a lot of science and haven't seen a lot of education. I think they have seen enough education to know they don't want more. And I think the problem is related to something that John Koran talked about in his paper. It's that we talk about a lot of things, but we simply don't get involved in a realistic way or we don't ask them to be involved in a realistic way via the methods work or via much of the work in education with the actual problems of teaching.

Now to return to the question. It seems to me that there are things that you can do and let me just sort of knock off a set of things. I can think of four different kinds of things that you can do. All of them have been tried and I think under certain circumstances, all work well. And the question, it seems to me, is not just can you do those things, but how do you put them together in a productive way for the kind of conditions that teachers are now encountering and are likely to encounter as we try to make the school a more productive place. That last question is, it seems to me, where the research comes in. That is where we ought to be asking questions. How do we take the stuff that we have and put it together in some sensible way so that we really make contact with what the problems are and are going to be. Let me just sort of trace down a list in not any particular order. If you want somebody who already knows something about teaching to learn how to use new instructional materials, I think the portal school device is a very effective way. I can't think of any better way of bringing somebody very rapidly to a willingness to use new instructional material than to have somebody who has been an experienced teacher say, "Well look, you watch me. I'm gonna try it with these five kids. See how it goes. Okay? Now you see what I did? Now I did that because when I did it this other way, this happened and when I tried it that other way, that happened." You sort of get the experienced teacher saying to the novice with these materials, "Look, these are the things you got to watch out for with this stuff," and everybody says, "Okay, I know about that, I know about that." At that point you sort of introduce the person to the use of materials in a way which it seems to me is directly applicable. It is something that universities do not do well, which I think experienced teachers do well. I think that's the secret of portal schools. On the other hand, you may want people to expand their teaching styles and for the novice, as for the total beginner, you may just want to sort of lay in a starter set of instructional skills. It seems to me that, for things like that, micro-teaching, modeling, and simply sort of definition and practice of particular skills has proved to be very useful. We can, in fact, get teachers to do things that they weren't doing before using those devices. And as a matter of fact as John (Koran) has commented, teachers find it very useful. They come out sort of thanking you for letting them have tried this. You know that is very rare in the education course. We can worry about changes in curriculum content and adaption and it seems to me that is something where the whole resources of the university are needed. It is not something to teach in a school especially if it is going to take a teacher into some relatively new material. I mean we can fuss around with the stuff that we've already done. It seems to me an awful lot of curriculum change is just that. We take 500 of the 1,000 known devices and we package them. Then we say, "I want to change," so we take 20 more off the shelf, replace 20 that we already have in that 500, and we say that we change the curriculum. Well, if you want to change the curriculum in a more dramatic way, that is by really addressing new content, then it seems to me you have to draw on the resources of the university because the university is in fact where new knowledge does get formed. It seems to be that's where you need university and school cooperation.

Voss:

Okay. I think that's been a good recitation, Bob.

Audience:

I would like to just make a few comments and let anybody react any way they want. I'd like to ask this question. Should teacher educators be certified as any other supervisor in the public school system? Should they have to meet that kind of certification? The second thing is, there is a credibility gap as Dr. Townsend has mentioned between the teachers and the teacher educators. I maintain that you need to show them that what you have to say is really important to them. For instance, they don't really feel you know that you are a credible source. The third thing that I would have to say is, should a teacher educator not return back to the public schools for inservice training themselves? And what I mean in this respect is, should they not teach in the public school systems full time every so often, a full year out of every four maybe, to show the public school teacher that they do understand? I was at the AERA convention and was shocked to find the number of people that I met that were in teacher training programs that had never taught in the public school system. I think it is ridiculous to even consider that notion. I think a little cleaning house is necessary.

Voss:

You have a lot of questions. Maybe we can start with one of them.

Audience:

Well, I'd like to make some additional comments.

Voss:

Okay.

Audience:

And the last comment that I'll make is: should the methods courses be taken out of the university into the public school system, put under master teachers who have a variety of methods and who can show people the ins and outs of how to use them?

Bell:

In answer to one question about certification of a supervisor from a university, I think this is all right if you can identify what he should be skilled in.

Audience:

Well, a supervisor in reference to any other public school supervisor of science or mathematics.

Bell:

So far I view those as being inadequate. Now, if you can go for some sort of competency expectation, yes. If it is just a matter of accruing hours or meeting checklist kinds of commitments, I would say it is a waste of time. You aren't going to get anywhere. In terms of experience back in the schools, I think this is a good idea. I'm not sure that a university faculty member should actually teach if it is perceived that he is competing and showing them how, you see.

Audience:

I made that comment in referance to them getting inservice training on how to teach in the secondary school.

Bell:

I think that is a good idea, but I think it would have to be laid out pretty clearly, that's what he's there for rather than for him to be a model teacher or something like this.

Schaff:

To go along with that second point, or the last one you were referring to, I myself have a responsibility for getting into the schools a considerable amount of time because we have participation activities. These are not only just for student teaching, but for a part of what used to be methods courses and are now a part of our team efforts. I think I am learning continuouasly by working with teachars in the schools without having to go out thera and just teach, because I have had several years of high school teaching experience. It takes only about two minutes for me to recall and wake up to the life I onca led when I get into a school. Apparently there is a lot of teaching that hasn't changed. Talking with these paople kaeps me, shall we say, civil and in order. I question what good it would do for me to go out and teach a full year as long as I, representing the university, get into the schools, and work with the teachers. I think that is the critical thing. I know several programs that are promoting that now not a graduata assistant but the faculty members get out into the schools. Wa do that at Toledo in the undergraduate program. There are faculty membars out in the schools working with the teachers. We very seldom see them at the university which is probably causing problems from the students saying, "Well, where are tha faculty?"

Audience:

I would maintain that there is a differenca between going out and visiting and going in on a day-to-day basis, having to prapare, having to meet those classes and meet the problams that arise on an evary day basis; not only in a classroom, but in the total school atmosphere. This is where I think taacher education is really lacking.

Schaff:

Well, I'm saying that when you work with them, that's not visiting. You experience some of their problems.

Audience:

Yeah, but you are working with the teacher, not with the kids.

Schaff:

No, this is during the day when teachers are having their classes; you're involved. I know one school, where just this last quarter, when I took students out to participate I took over the class and let the teacher work with the student teachers or the potential student teachers. That brings me right back to reality quickly.

Audience:

You made another interesting point when you said "just teaching." What do you mean by teaching?

Voss:

Don Ring, another public school person.

Audience: (Ring)

I'm not so sure I agree with your point that it's necessary for a college person to go out and spend a year in the public schools as a bona fide, certified person doing the activities. I think the issue, though, is more fundamental. I think the issue is the apparent separation of the scholarship from the practitioner and I think that the composition of this particular panel is somewhat reflective of that particular issue. Let me back up a little bit here. I think, first of all, the question you're asking about the university education, pre-service education, may be academic. Given the state of teacher negotiations and teacher militancy and their ability to influence a state legislature and the state boards of education, I'm not so sure that that question in five years is even going to be in your domain. I'm thinking that perhaps that teacher militancy is going to take it out and put it in the public schools where they can use it to satisfy their own needs. So I think that's one problem that we have here. Burt (Voss), you brought up a question here that I think is reflective or is an example of the variation, the gap that exists. The schools right now are very tuned in to inservice and humanizing education. What have we had in this conference that has done much to tell us how to humanize education? Now John (Koran), you spoke to that. You don't know how to define it. But nonetheless, if scholarship exists, it's got to address that particular task and I think Bob (Bridgham) was saying some of that thing. It's got to look at the thing. We got a statement last year from Paul Hurd about the involvement of the social and the technical issues in science education, a new look. Where are we this year, relative to what was stated a year ago to this particular issue, scholarship-wise? Now the thing that I'm really questioning here is, what is the significance of the fact that on your panel there is no school representation with the exception of Ron (Townsend) who is only a recent appointment to a secondary school position? I think my point is that there is a separation of scholarship and practitioner. It is not necessarily a good one and I don't even think it is necessary.

Audience: (Sund)

Several statements have been made about education which is a beautiful commodity which includes lots of courses and lots of universities. But in our experience, when you ask students to evaluate science methods courses, it's not as gloomy as you say it is. Maybe this is unique in the state of Colorado. Maybe our educators are different, but is it really true in your state or your school that when science teachers are criticizing education, they're criticizing science education courses? I sort of doubt that, because we've also found in our graduate enrollments--they are not decreasing; if anything, they are increasing. So these are science teachers who are coming back for more education, particularly science methods or related procedures. I'd like to know what the reactions are in your universities? As a matter of fact, I think that John (Koran) just showed that there apparently is a demand.

Audience:

I would like to say something to that if I may. The education courses, I feel a lot of times, are pretty theoretical. The thing that we have been doing in Tulsa, Oklahoma is to take up a concept; a theoretical concept in a methods course. And this concept might be motivation in a science classroom. We then delve into the theoretical aspects of this topic. Then we say, "Let's see if we can apply the theory to the classroom." You develop some kind of a presentation and see if you can motivate these students. Here is a teaching technique they will be learning at the grade level at which they'll be teaching. With an experienced teacher, we try to pick master teachers to do this, they find out if they can motivate students. We have these concepts laid out. They go out and actually get some classroom experience to see what they can do with these kinds of things. I think this is something in humanism that we alluded to. These are the kinds of things that we do. Motivation is a going, an experiencing thing. It is something you can't learn to do theoretically but you can get some classroom experience to find out what the shortcomings are and then come back and relate it to the theory again. It's an experience in what you can't do and what you didn't do. This seems to be working very successfully for us.

Audience: (Haney)

There is one problem in secondary teacher training that I haven't heard mentioned today. Maybe someone on the panel is qualified to speak about it. And that has to do with preparing teachers to teach interdisciplinary science. You know there's a big conference about it in a couple of weeks and we know that a whole issue of The Science Teacher is devoted to it, but they are still turning out, for the most part, physics majors, biology majors, chemistry majors, and earth science majors. General science majors are prepared primarily for junior high school type of teaching. And not only is this concept of interdisciplinary teaching related just to the sciences but I think we're talking of relating it to social sciences and Cal (Gale) mentioned a little bit about bringing technology in. How do we prepare to change our training for secondary teachers so that they do learn some of the technological implications of science? So, when I raise the problem of inter-disciplinary teaching, really, how can we get people to know ehough biology, chemistry, physics to handle the senior year of a FUSE type program we've heard about, then relate it to social studies as well?

Bell:

I would like to cite three examples that have been worked and seem to be working. One, is the Tilton, New Hampshire, project, an environmental science which does not just integrate sciences but also goes beyond that to integrate with the sciences, social studies and the arts. The way they go about this is to do real research. They've not doing canned labs. They're going out into a drainage system for instance, the local drainage system, starting to analyze, monitor streams, sources of pollutants if they find them. Then they start to deal with how to get some response from the community. This usually involves going to look at land holdings, who owns them, who has the responsibility, and talking to boards of directors and so forth. They're getting involved with technology, by mixing chemistry with biology, with physics of stream flow, with things like this. So that's one idea. Another idea that has been tried recently is down at Shippensberg State College in Pennsylvania and I think elsewhere, but that's the only one I know about. They're involving students through their general science program, starting with the first term on campus with research in the areas of geography, geology, meteorology and the associated chemistry and physics. These research projects continue on cooperatively with the assistance of the student and he carries them right out into his student teaching and continues them on under the direction of his cooperating teachers, so they are getting any inter-disciplinary mix through doing research in this way. This is empirical type research and not library research entirely. A third model is being tried at Penn State in the Earth and Metal Science Department where they're involving students with questions about materials and other relationships with technology. They might add questions like, "Okay, here you have an article say, an automobile. How is the best way to dispose of the various materials in that automobile?" There is no way that they can't keep from running across inter-disciplines. I think these lines are much more fruitful than what I have heard coming out of FUSE over the past few years, for instance where a chemistry teacher and a physics teacher get together and decided that one of them is going to present some of this and the other one is going to present some of this,but they're still in the old chemistry class. So I would say if you're going to go inter-disciplinary, let's make it real.

Voss:

I think Vic Morris is next.

Morris:

I didn't think I would have the opportunity to get it in. Jim Gallagher has been talking about the kinds of things that were offered in the 11 out of 12 papers. I'm the twelfth paper. Being the twelfth paper I hope it isn't like being the twelfth disciple. But I have something in response to what Don Ring has indicated and perhaps, some questions the last gentleman in the back raised. My concern at this time is that science educators might be concerned that science education has been leading the way in innovation in program development and changes now for several years since we started getting money when Sputnik went up. We capitalized on it a little bit but we stayed with science. At this point, my question is, why do we just remain concentrating on science education and continue to teach people how to teach science instead of beginning to worry about teaching people to teach people? I think we have a greater responsibility to our society than to just produce scientists or to just produce teachers who can teach science. I don't think we are nearly as much concerned with the future citizen as we should perhaps be. We've been hearing about competency-based teacher education, but thus far, I haven't heard anyone indicate what the goals are. It is my understanding of competency-based teacher education that you first identify your goals. So what kind of product are we concerned about today in science education that will give us the most viable kind of person in the future? The question I have, is emphasis on science at this time going to be sufficient? Also to respond to Dr. Gale, are we concerned primarily with, perhaps, economic sufficiency? Are we interested in changing now, producing more engineers and technologists? We tried that with science and we haven't had much of an impact. They keep on without us. The question is: are there some other aspects of human development that we should be considering? Can we take a look at people and let science find out where it belongs in the whole aspect of the social realm, and can we begin to address ourselves as a body to this kind of situation? As an example, something that is a possibility, do you suppose that science teachers of the secondary level or any other level might be different if they spend eight weeks or a semester interacting with a social studies team--helping to prepare for teaching in social studies? Might they bring a different kind of view point to the classroom? That is a possibility. What would happen if you as science educators moved into the realm of going into the high schools yourselves interacting with people in literature, in art, in music, as a scientist, as a member of developing team? What kinds of different perspectives might you be able to bring? What would happen if our organization, itself, began to interact with the social studies group that is our equivalent and if we had representatives on their development panels and, in on their idea generations? Might we not be thinking perhaps of a completely different future for science education, things we might be interested in doing, and in doing so provide a different kind of service.

Audience: (Snyder)

I would like to make a few comments about some of the points that have been made to the panel. I'd like to preface these with my understanding of some research that is going on in decision-making. It appears that even when a person is given the opportunity of hearing both sides of an issue, chances are he will filter out that which does not agree, and be reinforced by that which does agree. No matter how long we might carry on the discussion, I suspect that all it does is end up basically with the same biases that we entered with. So, therefore, that would perhaps explain any comments that I want tomake, and two of those are directed at Dr. Koran. There is no way we can test it with people at the University of Florida, because I'm at F.S.U. I'd like to think that Dr. Koran's comments are naive.

First off, I for one, and I don't think that I am a great exception to the rule, am inclined to think that we don't know all the things that Dr. Koran says we know about concept development, about decision-making, about media technology and so on. I have been led to believe that more and more as I have worked over the years with the development of curriculum theory. I would challenge Dr. Koran to present the evidence that would be convincing to us and that would more than just allow us to live with our biases as they exist. Secondly, I think Dr. Koran is wrong in respect to modular development. I don't really believe it is necessary to develop a module for every individual teacher in order to meet his specific needs, and I think I can demonstrate why that is not the case and I think we're doing so at ISCS.

The third comment is directed toward, I believe, Mr. Ring from District 214 in Illinois. I am very much impressed with what this gentleman has to say. I think he speaks to all of us very clearly. I think that one of our big problems as science educators is that we go to the public as if we have something for them; we go to the schools as if we have something for them; and for the administrators and teachers, and I question whether or not we really do. I suspect that maybe we do. But I suspect that the attitude we take toward education, and particularly inservice and preservice that really laps over into on the scene - activity of the school, is indicative of an attitude on our part that we think we've got something to say. I question whether we do. I think that, in the future, it may well be that we have less and less to say and the public school people will have more and more to say. And it is my thinking, at least at this point, that we better learn how to listen. We better learn how to listen to the people who are out there really engaged in it. I looked at myself the other day, and thinking about a presentation I was supposed to make tomorrow at AETS, I don't even know what I am going to say. You know it has been about seven or eight years since I have had any significant contact in the schools, and I disagree with the gentleman over here who said we all need to get back and teach for a year. The schools can't afford that, and we can't afford that; it is impractical even though it sounds good. But I have been away from the schools: John Schaff has been away from the schools no matter what he may say about being able to get back there and say "Now I've seen what it's like." The fact is we really don't know what it is like to teach any more. Times have changed. If you think in terms of the Vietnamese returning veterans, what did they say to the people? "My God, where did mini-skirts come from? Where did X-rated movies come from? What is all this problem with dope, marijuana and so on?" They have only been gone six or seven years. That's how long I've been out of the classroom, six or seven or eight years,and it's a completely new world in many respects. And I think we forget that things are changing very rapidly in the schools and they've got things to say and I think we better start listening. That's the humane way, it seems to me, to start in our effort to work through the schools.

Koran:

I guess the most efficient way to respond would be to say that I will send you a bibliography on each of the areas. And after you read it then we can talk about it perhaps more intelligently. I'd like to refer you to the model that Cronbach talks about in Gagné's book. Gagné is one of your colleagues at Florida State, or was, on individualizing instruction. Cronbach and Rothkopf, and I think even Gagné at this point, suggest that building modules is a most unproductive enterprise. It's dull for the builder, and I can testify to that because I've been exposed to that kind of enterprise. It is dull for the student. It targets in on only one individual difference and that is rate of learning. So for all practical purposes, we are notindividualizing instruction. We're just giving kids an opportunity to go through a set instructional system and it is usually the same system for every kid at his own rate. Now you might counter that by saying that we have branching programs. If the student is going through the system and isn't achieving, we can channel him off into the right corner. In any event, the branching program is still a set branching program and still capitalizes on one type of individualization mechanism which is rate of learning. So what I am suggesting is that there are alternatives that are perhaps more efficient, and I think if you go out into the schools, which I do occasionally, I think you'll find that teachers are coming to this conclusion also in working with ISCS materials as a matter of fact.

Voss:

I think we're about far enough here. Dr. Townsend would like to make a remark. The two gentlemen can continue their debate over lunch.

Townsend:

Don Ring mentioned the composition of the panel. It is even worse then you thought, Don, because I was invited to be on the panel while I was still at the University. A couple of things I see that are changing radically in the schools and that we have not talked to is more and more community involvement in the public schools. The public is more concerned than they have ever been. The races for school boards are tremendous. We have one member on our school board who is the chief accountant for the Jewel grocery chain. And is he concerned about what we're doing with every cent and also what's happening in the school. He is challenging us and I think correctly so. One thing they are pushing for is larger and larger classes. You talk about that with your individualization and your modules and even your 24 students to a lab. But beyond that, we have a new grade of student and, this Monday when Dr. Frank Brown from Melbourne, Florida was speaking to the North Central Association, I think he really hit it. Maybe this is where the new students come from and these are some of the results. But he said the liberation of youth and the many freedoms which the courts have given to students within the last decade make it impossible for a school to continue as a custodial institution and at the same time function effectively in the area of teaching and learning. These are some of the things we've talked about, just in the area of teaching and learning. He says this custodianship of liberated young people fosters a climate in which hostility and violence have become commonplace. There is violence, there is vandalism, there is apathy, there is concern for fellowman, and there is degradation of fellowman among our students, and this isn't just in the big cities. This is across the land and I think part of it is this business of we're still trying to be custodians, we're still looking at learning theory, teaching theory, and the kids have been liberated and you can't impose things on them any more like we've been trying to do. I think we better speak to this in terms of our educating inservice and preservice teachers.

Voss:

Mr. Gallagher, and then we're going to have to stop.

Gallagher:

I think I can provide some kind of questioning here to leave people with. We've talked about several new directions in science teacher preparation. I think that there are three questions that might be worth while to ponder as we walk out the door and maybe a little longer. With regard to each of these new directions, what are the factors that are going to tend to inhibit their implementation? What new problems will be created by their implementation? Finally, what problems will remain even upon their implementation?

Voss:

Very good. I think this has been a healthy session. I appreciate your participation from the audience and participation on the panel, and I am not dejected that science education isn't going to work its way out of some of these interesting problems. Thank you.