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ABSTRACT

The second yearbook of the Association for the Education of Teachers of Science (AETS) is composed of a series of position papers and reactions to these positions. The papers are divided into three sections. Section one includes five papers (and reactions) concerned with new directions for pre-service and in-service education of science teachers. Section two's material (two papers and reactions) is concerned with humanistic education. One of the papers contained in section three presents a lengthy description of a psycho-epistemological model for teaching science and its articulation with classroom activities. (PEB)

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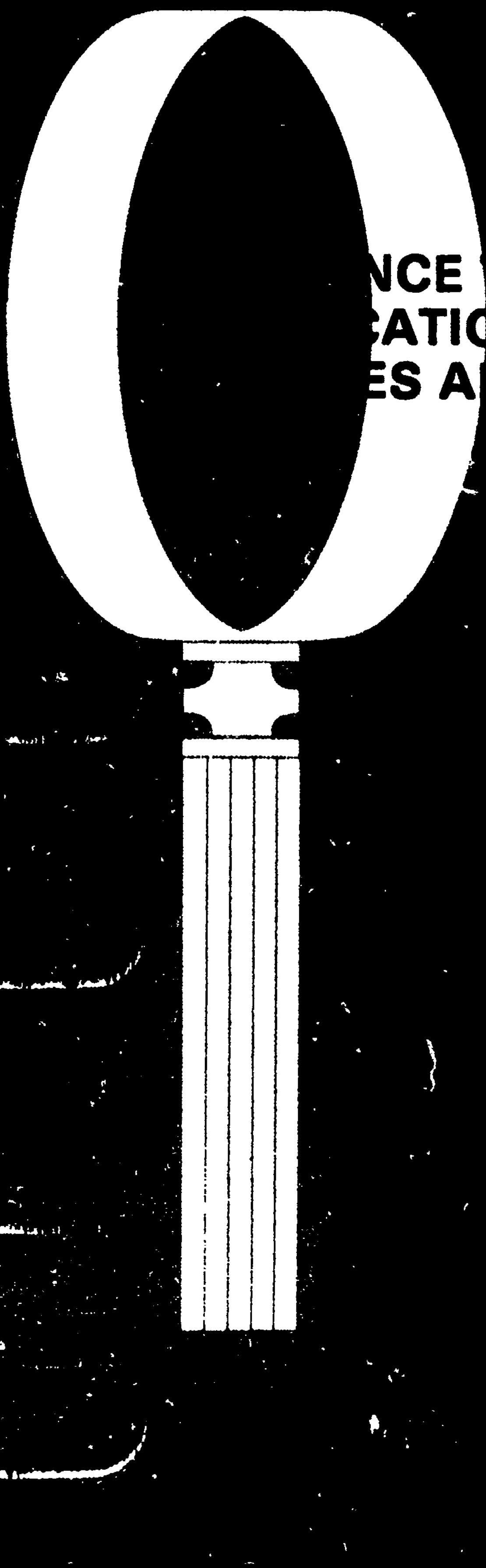

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1975 AETS YEARBOOK

SCIENCE TEACHER EDUCATION 1974: ISSUES AND POSITIONS

Edited by

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Teachers in Science

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Foreword

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education is pleased to cooperate with the Association for the Education of Teachers in Science in producing this Yearbook, funded in part through the Center for Science and Mathematics Education, The Ohio State University.

ERIC/SMEAC and AETS are currently cooperating on a third publication. We invite your comments and suggestions on this series.

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PREFACE

The Second Yearbook of the Association for the Education of Teachers in Science is markedly different from its predecessor and represents the continuing interest of the Association to provide a major new service to its membership and to the profession. The First Yearbook, authored by A. L. Balzer, T. P. Evans, and P. E. Blosser, was very specific and detailed as suggested by its title: A Review of Research on Teacher Behavior Relating to Science Education.

The second volume is composed of position papers and reactions selected from those invited by President Robert Yager for the 1974 Chicago Convention. President Yager gave the authors freedom in the selection of their topics. He was well aware, of course, of the specific professional interests of each and was confident that the papers would thus result in a broad treatment of important problems and issues in the profession today. As the reader will see, his faith was borne out.

The papers and reactions have been organized into three major parts. The first treats new directions in science teacher education, and the second deals with the growing interest in humanistic education. The third part assembles several other important concerns of the position paper authors: a psycho-epistemological model for teaching science, the problem of behavioral goals and measurable outcomes, and the intuitive belief that science educators should themselves exemplify the spirit of science.

Part I: New Directions in Pre-service and In-service Education of Science Teachers

The past decade has witnessed dramatic developments in the pre-service and in-service education of secondary school science teachers. The most notable change is found at the pre-service level of teacher education where the shift has been from the dominance of university personnel with on-campus programs to efforts of on-site cooperation with the personnel of the public schools. Teachers in preparation are spending an appreciably greater amount of time with children and youth in the schools and in the communities, and public school personnel are having a greater voice in planning, executing, and evaluating practice and policy.

The change in direction is also being experienced at the in-service level of teacher education. The professionals in the field are being heard as they state their needs for assistance in coping with the dynamic problems of education today and as they express interest in a more vital role in undergraduate education programs. There are a number of forces at work bringing about the changes at the in-service level, not the least of which is a general disaffection with the results of almost two decades of financially supported on-campus post-baccalaureate science teacher education.

The papers which follow spell out in some detail the emerging practices and the rationale which supports each plan. Among the papers the reader will find, in varying degrees of attention, discussions of the limitations of past approaches, rationales supporting arguments of new attack, and descriptions of on-going practices.

Four of the papers which follow describe new experiments in science teacher education. Donald Ring describes an Illinois project involving the cooperation of several universities and a number of school districts. In addition to presenting an operating model for the pre-service education of teachers, he lists guidelines for effective cooperative programs and teaching behaviors (along with associated activities designed to elicit the behaviors) which are to be the outcomes of the field experiences.

The Iowa Project ASSIST is presented by William Sharp and is different in some ways from others described in this part of the Yearbook. Regional Centers have been established in the state and cooperation now exists among the university, the State Department of Public Instruction, and school districts. Both pre-service and in-service programs have been developed, and, in fact, a functional part of the in-service program is its fusion with the pre-service.

Paul Koutnik's paper is concerned exclusively with the in-service education of the secondary school science teacher. Working in the Mid-continent Regional Educational Laboratory in Kansas City, he surveys in-service projects described in the past five years, summarizes comments and reports which relate to the effectiveness of in-service education, and adds a discussion of a major project developed at his own center. Several criteria for guiding the development of in-service programs are included in the paper.

David Butts proposes the establishment of teacher centers to be used as vehicles for change. Examples of centers from England and the United States are chosen as models, and it is noted that the two approaches differ in organization and purpose. The English model, as described, serves in-service purposes and is essentially separated from the university. The Texas model exists for both pre-service and in-service purposes and provides for very close working relations between the public school system and the university.

The paper by Ronald K. Atwood concludes the first part of the Yearbook. In his paper he examines the ERIC-AETS publication In Search of Promising Practices in Science Teacher Education. The original project was designed to obtain information about science teacher education today and to locate practices which appear to have promise. Atwood analyzes the report using a check-sheet which he devised and provides descriptions of typical science education programs and offers general impressions of the report.

Part II: Humanistic Education

In both pre-service and in-service education of teachers few concepts are receiving more attention than humanistic education. The influence of such persons as Maslow, Combs, Rogers, and Fromm is widely felt in books, research efforts, journal articles, courses and seminars. The advocates of humanistic education are eager to see it extended into elementary and secondary classrooms. At the conceptual level, if not in practice, their interests are being honored. For those alert to recent developments it is apparent that the concept is in need of continued refinement of definition, clarification of theory, description of application to the classroom, and suggestions and guidelines for evaluation and research in the field.

Two of the position papers in the Yearbook address themselves to this development. In his research on perceptions of effective teaching Rodger W. Bybee found two important categories of characteristics of effective teaching: adequacy of relations with students in class and enthusiasm in working with students. Bybee's discussion of these two categories is clearly within the humanistic model. Having made his case for the place of adequate personal relations and enthusiasm in teaching, the author then takes the position that these two facets of effective teaching can be deliberately made a part of the undergraduate preparation of science teachers. Specific suggestions are offered for carrying out the task.

David H. Ost openly champions the place of humanism in education today. Following a discussion of the nature of humanism as the term is commonly used in current educational debate, the author then demonstrates the parallels and congruencies between humanism and the enterprise of science. The position then follows that the natural alliance should be reflected in science curricula and in science teacher education.

Part III: Other Issues

The position paper of Charles M. Weller is unique in this yearbook if for no other reason than its length. As he properly notes in his introduction the paper may be read as three independent statements. At the outset he presents a remarkably lucid description of science, labeling his description "a psycho-epistemological model." The model is posed as a paradigm for science education. The two sections which follow suggest clear implications of the model for classroom teaching if the model is accepted, and the potential application in science teacher education. In the discussion of the latter point the author introduces the important but little-used concept of community -- important both in his model and in viable conceptions of the nature of the university. The reader may find a parallel between the sense of community mentioned in this paper and the concept of humanism expressed in others.

Science educators and science teachers have long had the intuitive feeling that they should be exemplars of the scientific spirit. William R. Snyder proposes that we "check our intuitions" and utilize where possible the method of science, which operates essentially from an empirical base. The paper presents a number of benefits to be gained from checking on intuitive decisions and relying more fully on the scientific approach.

Acknowledgments

The preparation of the Second Yearbook has been the result of diligent, professional, and friendly cooperation of a number of AETS members and committeemen. President Robert E. Yager extended invitations to the writers of the position papers and was prominent in urging financial support for the Yearbook. Stanley L. Helgeson of ERIC/SMEAC at Ohio State University was the important liaison agent for the Yearbook budget and for final preparation and publication of the volume. He was of invaluable assistance to the editor. The Yearbook Editorial Board was ultimately responsible for the major decisions regarding the yearbook, and it is to be commended for the enthusiasm with which it assumed its obligations. Members of the board are David H. Ost, Chairman; Charlotte M. Boener, Julian Brandou, James P. Hale, Addison E. Lee, and Douglas A. Roberts. Brandou and Lee, as new appointees, joined the board in its last meeting in Chicago.

Fred W. Fox, Editor

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PART I

NEW DIRECTIONS FOR PRE-SERVICE AND IN-SERVICE EDUCATION OF SCIENCE TEACHERS

CHAPTER 1

SCIENCE TEACHER EDUCATION: WHOSE RESPONSIBILITY?

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

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

Background to Cooperative Teacher Education

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

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

The disparity that exists between theory and practice in teaching has frequently been identified as a major problem in producing effective teachers (13). The variations in teaching science in the public school as well as the lack of implementation of new teaching techniques in college make it difficult to transfer the concepts developed in methods classes to the reality of public school classrooms. Gallagher suggests that "a significant portion of elementary and secondary school people have difficulty in reasoning from principles and abstractions to actions, and in conceptualizing data and experience from real-life situations" (7, p. 8). He concludes that science teachers need experience in conceptualizing and reasoning from principles as this skill is a fundamental part of the scientific process.

Whether the failure to find relevance and actual value in the theories commonly taught in methods classes is a result of the disparity between the college and public school experience or the inability of teachers to exhibit skills in formal reasoning does not detract from the point that a viable teacher education program must enable the participant to see the relationship of what he learns while in the program to what he needs to know during his employment as a teacher. Jackson (8) points out that the conceptual language of teacher education must not contradict the teacher's sense of reality if it is to have both explanatory and descriptive relevance. It is probably not beyond the experience of any interested observer to have been clearly informed about the lack of opportunities to apply many of the ideas one has been introduced to in a methods class; that this is at least in part due to the separation of the college and public school institutions seems to be a valid assertion.

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

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

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

> "Indeed, if we describe the output of a teacher education program in terms of beliefs, becoming, security and acceptance, meanings and subjectivity, we are describing socialization rather than teacher education and find ourselves with no justification for creating the institution of teacher education for these purposes. . . The ambiguity of these goals or procedures has permitted a sloppiness in the teacher education enterprise which the public cannot and will not tolerate " (p. 1).

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

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

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

A Proposal for a Cooperative Approach to Preparing Science Teachers

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

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

1. An attitude of trust on the part of each member toward his own and the other members' contribution to the preparation of teachers.

2. An acceptance of the legitimate interest of all members in the preparation of teachers.

3. A willingness of all members to share resources and to invest some of them in the preparation of teachers.

4. The production of an effective program of teacher education.

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

The creation of a "new Partnership arrangement" (15, p. 178) is not sufficient to guarantee the development of an effective teacher education program. The willingness of the university staff to change some of its traditional roles in preparing teachers and of the public schools to accept some responsibility for this activity is not sufficient to produce a viable cooperative. It is the opinion of the author that an effective cooperative teacher education program will exhibit the following characteristics:

1. The program offers the student alternatives in the activities he follows and the people with whom he works.

2. The curriculum provides experiences which encourage the discovery and development of ideas, values, and qualities through personal involvement in real situations. Provision is made for experiences which encourage personal growth.

3. The student teacher makes use of a wide variety of resources including some contact with age groups he does not intend to teach.

4. The cooperating institutions have dual staff appointment. College and public school personnel contribute equally to program planning and to decisions affecting the operation of the cooperative.

5. Recommending a candidate for certification is done from the cooperative rather than from either of the institutions alone.

6. In-service and pre-service training are integrated. The role of the university staff in in-service activities is much larger than it is in the traditional program.

7. Methods and other professional courses are taught at the public school site using a programmatic, i.e., experience based, rather than didactic format.

8. The program is sufficiently flexible to provide undefined options to the student teachers and to encourage change within the cooperative.

9. There is relative independence from the bureaucratic structures of the institutions involved.

10. There is a willingness on the part of the staff to share in contributing to the success of the student teacher.

11. Supervision of student teachers is largely done by public school staff.

12. Support is derived from all participating institutions.

13. Grades and recommendations for student teachers are determined by the personnel most responsible for the activity being evaluated.

14. There is some formal commitment of the institutions to the cooperative center; e.g., contract, dual staff appointments, budget allocation, etc.

15. The field experience will extend over a period which is longer than the time allowed for student teaching under the traditional program.

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

CTEP: A Success Model of Cooperative Teacher Education

The benefits from shared responsibility of teacher education can readily be predicted from the characteristics listed previously. Some of these would fall in the category of fulfilling legitimate interests, increasing resources, and providing more realistic experiences. However, the purposes of this paper are better served by describing a successful model of a cooperative center. Such an operating model is the Cooperative Teacher Education Program (CTEP). Its description here should serve the purpose of clarifying the position described earlier.

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

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

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

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

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

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

1. To develop the candidate's awareness of the individual needs of students and their responses to curriculum decisions and teaching strategies.
   Associated activity: Mini-teaching

2. Self Awareness

   a. To develop the candidate's self-perception (particularly as it relates to the educational profession), and to develop his sensitivity to self-concept development in others.

   b. To provide the candidate with an opportunity for communicating with his colleagues about self and group identified needs.

   c. To provide an opportunity for reflection on personal teaching experiences in relation to role expectations.

   Associated activity: Human Relations Groups

3. To develop the candidate's knowledge and skills in teaching his subject.
   Associated activity: Subject Area Seminars

4. To develop the candidate's knowledge about the political, legal and societal characteristics of the institution of school.
   Associated activity: Institutional Study

5. To develop the candidate's insights into the development of children and the progressive changes in their capacities to learn concepts.
   Associated activity: Elementary Teaching

6. To provide experience with the mechanism of individualized instruction and its associated benefits and problems.
   Associated activity: Individualized Instruction Unit

7. Human and Institutional Awareness

   a. To define the candidate's assessment of his values and strengths through the analytical observation of a variety of schools, teaching fields, and grade levels.

b. To develop an awareness of the specialized resources and techniques used in elementary and middle schools.

c. To develop an awareness of the broad individual and social influences on a student emanating from the community he lives in.
Associated activity: Observation of the community and elementary, middle, and secondary schools.

8. To develop the candidate's ability to make decisions, initiate programs, establish goals, select cooperating colleagues, and succeed independently.
Associated activity: Election of program of extended group teaching and cooperating staff

9. To develop the candidate's experience with normal classroom management over an extended period of time.
Associated activity: Extended group teaching

10. Self Direction

a. To provide the candidate with an opportunity to direct his experience in CTEP and to provide leadership to the program.

b. To increase the candidate's ability to self-determine his activities when controlled by an organized institution.
Associated activity: Participation in the Planning Committee

11. Evaluation

a. To develop the candidate's competence in making conclusions about his experience in teaching and its potential for satisfying his career needs.

b. To assess the behaviors and potential of individual candidates with reference to the teaching profession.

c. To generate data in order to judge the efficacy of the CTEP model for teacher education.
Associated activity: Evaluation Seminars

12. Alternative Education

a. To help the candidate develop the skills necessary for discovering learning experiences available to students within the community.

b. To develop the candidate's ability to assess the appropriateness of various community experiences.

c. To help the candidate develop selection criteria for student participation in community experiences.
Associated activity: Instructional Settings

In the two-plus years of operation, CTEP has undergone considerable program evaluation. Perhaps one of the advantages of this type of effort is the fertile ground it offers for research. Four doctoral studies have been made and an extensive evaluation of attitude and behavior change was done by the University of Illinois. The evidence which has been collected supports the conclusions that the program is 1) at least as effective in developing teaching skills as is the traditional program; 2) the participants exhibit a positive attitude toward CTEP; 3) CTEP has generated enthusiasm and behavior change on the part of the involved public school personnel; 4) student teachers perceive the experience as a realistic introduction into teaching. (A more detailed report of the results of these studies is being prepared at this writing.)

Summary

The position of this paper is that the present state of teacher education is characterized by the dominance of the university in everything but the practice teaching experience of the student teacher. It is the opinion of the author that the disparity between theory and practice in teacher education would be reduced by the establishment of cooperative centers using the combined resources of both the university and public school. In this way, student teachers would be offered a system of alternative models from which they could choose in selecting the site and program of their professional preparation. The features which identify a cooperative teacher education program are generalized about the areas of the broad use of resources, offering realistic alternatives and instruction through experience. One model -- the Cooperative Teacher Education Program (CTEP) of the University of Illinois, Northern Illinois University, Northeastern Illinois University, High School District 214 and Elementary Districts 25, 21, 23, 15 and 59 in Illinois -- is offered as an example of this approach to teacher education.

In a basic sense, the responsibility for teacher education belongs to the student teaching candidate himself. It is only through personal growth that a student teacher is going to improve his effectiveness to his students. The role of any outside agency is really only one of creating a climate which is most effective in encouraging personal growth in the student teacher. (Whether the best way to do this is by a process of prescription or by interaction between the prospective teacher and significant experiences is not clear.) The author's position is that a sharing of the responsibility for teacher education will provide a more realistic and reasonable climate than is true in any program of student teaching where a single agency dominates that experience.

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REACTION

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The student teacher, the students, the communities, the school staff and the college staff are all agencies which share the responsibility of science teacher education, according to Dr. Ring. Does it necessarily follow that the university and public schools adequately represent these agencies? Who really represents the student teacher in the science teacher education process? Who really represents the students in the elementary and secondary schools? Who (or what) represents the community?

A person decides, for whatever reason, to go to college. A person decides, for whatever reason, to become a science teacher. At this point who is responsible? Are adults responsible for their careers? What now is the function of the college of education, the college of arts and sciences, the community, the elementary and secondary school systems, the practicing teachers, or the teacher professional associations?

Dr. Ring contends that all of these agencies are supportive of the student teacher and that responsibility is shared equally by each member.

It can be argued that the responsibility is shouldered by each agency in turn. The college of arts and sciences offers a series of courses for the student teacher. The college of education offers courses in the applied social science, teaching, for the preparation of the teacher. The school system acting for the student, the teachers, and the community provide pre-service practice for the student teacher. So everything is fine.

But what input did the student teacher have? Was there a special individualization process in the college of arts and sciences? The college of education? Did the student teacher meet with a committee of members of the community? Did the student teacher meet with school students to plan a teacher education program? Do elementary and secondary teachers meet with the student teacher to agree upon a program? Does, in fact, the student teacher have the opportunity to exercise the right to be responsible for her or his career? In most instances the answer is <u>no</u>. The student teacher does not have the opportunity to be in charge of a personal career. Dr. Ring is quite correct in indicating that there is a disparity between theory and practice in science teacher education.

CBTE is another can of worms. What is a good measure of the success of a teacher? Do we look at the product (former students) 20 years later? How is success measured for them at that future time? If most of the former students are successful, by some standard, is the teacher who was once a student teacher then found to come from a maximal science teacher education program? Who is responsible if Johnny can't read science?

The primary conditions for forming the cooperative arrangements outlined by Dr. Ring are well taken, as long as the membership is not limited to just the college and high school. The cooperative teacher education program characteristics listed by Dr. Ring could form the basis for a tentative checklist for teacher education programs.

In regard to the CTEP there is a question whether or not the behaviors listed are actually behaviors or general objectives. This writer would tend to regard them as general objectives. The program itself is certainly a step forward with regard to teacher education cooperation between college and school systems. At some position beyond this lies the utopia of individual responsibility for career salvation.

CHAPTER 2

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

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

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

The issue defined herein concerns the remaining work of effecting real change in school science instruction through the proper implementation of the national curricula and their inherent philosophies and pedagogic strategies. Three points are to be discussed: 1) the national science curriculum materials represent too abrupt a shift in educational expectations and are incompatible with the basic structure of the American school; 2) the collaborative efforts among schools and universities, initiated in development of the curricula, will be vital to the success of their implementation; and 3) a regionalized concept of teacher education, both pre-service and in-service, shows promise of being an effective agent of change.

The Structure of the School

In his book The School as a Center of Inquiry, Robert Schaefer (9) presents a vivid and realistic picture of the work-a-day world of the school. Based on an industrial model, the American school of today is a product of an age now past where standardization of skills and jobs were of prime importance. The school is structured as a hierarchy, with teachers playing the role of bureaucratic functionaries -- replaceable cogs in the big organizational machine. The schools ". . .are essentially educational dispensaries -- apothecary shops charged with the distribution of information and skills deemed beneficial to the social, vocational, and intellectual health of the immature" (9, p. 43). Alvin Toffler writes: "The most criticized features of education today -- the regimentation, the lack of individualization, the rigid systems of seating, grouping, grading, and marking, the authoritarian role of the teacher -- are precisely those that made public education so effective for its place and time" (11, p. 400).

Being products of the industrial age, we have embedded within our national psyche today the idea that the industrial model is universally acceptable, is the American way, and is a thoroughly satisfactory experience which remains an effective model for education.

Elwood Cubberly articulated this point in 1916: "Our schools are in a sense factories in which the raw products (children) are to be shaped and fashioned into products to meet the various demands of life. The specifications for manufacturing come from the demands of twentieth century civilization " (2, p. 338).

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

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

Pseudo-Authority

The view of the school as a dispensary and the perfunctory nature of the task of teaching in the minds of many, results in teachers being given little real professional authority. The syllabi, the textbooks, the schedules, the length of sessions, and other learning parameters are all controlled by supervisory personnel. The teacher is expected to work all day. He suffers from a lack of an analytical and inquiring tradition. In many cases he has been trained through a teacher education program which was vocationally oriented.

A type of pseudo-professional authority does develop however. Shaefer alludes to the quasi-instructional freedom that develops from the "isolation of teachers in walled-off classroom cubicles" (9, p.41). The teacher has the ability to close the door to other adults and thereby he protects his "kingdom" from excessive supervisory control.

Through this isolation he enjoys a kind of autonomy that should not be mistaken for professional authority. He is free to behave as he chooses with respect to personal teaching style and his relations with teachers, as long as he maintains a degree of disciplinary control over his classes.

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

Dependency on Authority

One major unfortunate consequence of restricting the teacher to a pseudo-professional status is the fact that it strips him of a sense of personal capability for genuine participation in finding the way. He is often at once authoritarian and dependent upon authority from whom he expects answers to be short, to the point, and not ambiguous. Virtually nothing in his "professional" training provides him with the basic skills of inquiry. More important, nothing in his preparation provides him with a tradition of inquiry. The theoretical and philosophical under-pinnings which serve as guideposts in making critical educational decisions lie outside his realm and render him professionally impotent. Three common responses often encountered when working with secondary teachers, which are related to this sense of helplessness, are: 1) to develop naive dependence on some authority (this can lead to difficulties stemming from unrealistic expectations from the authority); 2) to reject all authority, carte blanche; or 3) to vacillate between dependence on authority and rejection of authority on the basis of the quality of their respective rhetorics or congruence with predisposed beliefs. The industrial model of the school, the vision of schools as knowledge dispensaries, the lack of inquiring tradition in the school, and the suppression of genuine professional development of teachers are seen as major influences which resist the establishment of inquiry-oriented curricula. Unless this basic structure of the school is understood, unless the school is radically changed and inquiry as well as teaching is emphasized, our national curricula will remain an interesting curio outside the mainstream of mass education. They simply are not compatible with the current consciousness of what comprises a legitimate education.

School-University Collaboration

On the topic of articulation and collaboration Dewey (3) says:

> "There is much of utter triviality of subject-matter in elementary and secondary education. When we investigate it, we find that it is full of facts taught that are not facts,

which have to be unlearned later on. Now this happens because the 'lower' parts of our system are not in vital connection with the 'higher'. The university or college, in its idea, is a place of research where investigation is going on, a place of libraries and museums, where the best resources of the past are gathered, maintained, and organized. It is, however, as true in the school as in the university that the spirit of inquiry can be attained only through and with the attitude of inquiry. The pupil must learn what has meaning, what enlarges his horizon, instead of mere trivialities. He must become acquainted with truths, instead of things that were regarded as such fifty years ago, or that are taken as interesting by the misunderstanding of a partially educated teacher. It is difficult to see how these ends can be reached except as the most advanced part of the educational system is in complete interaction with the most rudimentary" (3, p. 92-93).

The success of the development phase of the national science curricula was, in large part, a function of the articulation and collaboration among persons representing all phases of the education community. Unfortunately there is where it ended.

The job of implementation was left up to the institutions of higher learning and textbook publishers. Considering the extent of the problem from the perspective of the radical changes in thinking and school structure, the teachers who were able to receive in-service training were far too few to create any lasting and/or widespread impact. In essence, the implementation efforts over the past ten years have been disappointing in scope. For all practical purposes, when the money and effort expended in this direction are considered, it must be concluded that they have failed.

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

Herbert Thelen sees a profession as being "composed of people who think they are professional and who seek. . .to clarify and live up to what they mean by being a professional." He also maintains that the only way to generate the profession is through the interaction of the various parts. "They must give each other information, share, experience, plan together and take part in all that we usually mean by formal and informal communication. They must also engage in reflective and human communion that builds the sense of community" (10, p. 201).

The successful implementation of inquiry will require the development of a community of scholar-teachers who are organically linked to the academic world through a university faculty (9). The teacher must intellectually and physically be a part of the curriculum development effort. No matter how complete a "package" may be, its full value lies in the quality of the human intervention of a wise teacher.

The school and university must become active partners in inquiry. As David Hawkins (6) suggests, teachers must not be shown the way, but must become part of the effort to find the way. If the university assumes a facilitation role in enabling the school to investigate and deal with its own problems, the school in return will become a resource of research strength and an enthusiastic participant in inquiry.

Teacher Education

One of the most fundamental questions now facing teacher education is whether or not teaching is a technical process (7). For years, efforts have been made to define effective techniques of teaching which clearly show significant advantages as expressed in learner differences. For years the results have been disappointingly the same -- no difference or no replicable -- differences.

A technique, as defined by Ellul (5),is a standardized way to achieve a predetermined end. Regardless of the current fascination with the issue of competency or performance-based teacher education, few if any clearly defined and measurable skills of real significance have been recognized. In fact, recent studies of the subject show that no entirely satisfactory description of performance-based teacher education has been formed (4). From all appearances performance-based teacher education can be defined as "a slogan system in search of followers" (7, p. 10).

Teaching is not a science in the sense that it comprises theory with reasonable powers of explanation; or in the sense that there can be defined a single correct way to accomplish a given goal. Unfortunately many professors of education pretend to know what the techniques of teaching are and create false expectations on the part of students who come to their classes expecting to have the closely guarded secrets revealed to them. On the other hand, we can define the science of teaching, although in a preparadigmatic state, as being the continuing and dynamic search for creating more effective learning environments.

Teacher education must become less concerned with information and techniques already discovered and become far more interested in the strategies for acquiring new knowledge. We must consider our goal to be the preparation of beginning professionals who possess the trained capacity and attitudes necessary for life-long learnings, not the production of polished practitioners (8, 9).

Pre-service Teacher Education

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

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

Regionalized Teacher Education

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

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

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

Regional Involvement

A basic premise of Project ASSIST is that persons closely involve with students and classroom activities need to play a major role in 1) the development of any new approach to the implementation of effective science programs and 2) pre-service and in-service efforts to develop teachers with the pedagogical skills and philosophical equipment to teach through inquiry.

A regionalized concept comprising 18 centers throughout the state was adopted. Key leaders were selected from the ranks of teachers and science supervisors in each of the centers to serve as coordinators of

ASSIST programs. The programs are designed in response to defined needs within each of the respective centers and include needs assessments, program evaluation, in-service teacher education, pre-service teacher education, and community involvement activities. The regional coordinator is a member of the community the center serves, has many personal and professional contacts within the community, and works to ensure that center activities are indeed responsive to the needs of that community. The regional concept has had major impact simply because it has provided a mechanism through which teachers, administrators, students and community representatives can participate in the definition of needs and become a part of the effort to meet them. Thus, plans developed at the regional level are congruent with local expectations.

The Regional Center concept has allowed a greater involvement of school personnel in the process of inquiring into their profession. Conferences and meetings involving teachers and administrators serve to focus on professional concerns. These concerns include questions about the effectiveness of existing programs. These meetings resulted in a "tooling-up" to meet newly recognized demands. Two major curriculum areas widely defined in Iowa where mutual efforts are needed include programs concerned with elementary school science and environmental studies. In-service programs in the form of workshops, minicourses, and extension courses have been developed in many regional centers with university assistance and personnel. New life has been sparked into curriculum development and implementation throughout the State.

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

Cooperative Effort

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

Pre-service Goals

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

1. Interaction Among State-wide Resources. Meetings and discussions catalyzed by ASSIST have identified the human and material resources found scattered throughout the many colleges and universities within the state. Areas for possible sharing of resources to fit regional needs were outlined.

2. Identification of Master Teachers. The closeness to the "grass roots" allowed by the regional structure of ASSIST has greatly aided the recognition of outstanding programs and teachers who are willing to serve as human resources.

3. Administrative Arrangements. The Project is exploring means of creating administrative or contractual arrangements between schools and the university which better serve the needs of the pre-service teacher and the school. An example would be the arrangement between the Sioux City schools and a local college where master teachers are given released time to participate in a college science methods course in return for the assistance afforded by teacher interns.

4. Communication. The enhancement of communication between schools, the university and the State Department of Public Instruction has been a major accomplishment of the project to date.

5. Certification Criteria. The improved communication capability and newly recognized goals and needs have stimulated a scrutinizing of the appropriateness of present certification criteria.

In-service Teacher Education

The in-service component of Project ASSIST promises to be one of the most important. However, no component of the project is an island to itself, but is related and/or complementary to others. Clearly, one of the goals of ASSIST is to erode the interface, and to provide continuity between pre-service and in-service teacher education. The early identification of practitioners willing to work toward the development of new teachers has already been a rewarding and effective mechanism for enhancing the professional growth of both. Theory and practice come closer together through the harmonious working relationship of a university student and an "Old Pro." To date ASSIST has functioned to create summer curriculum development workshops comprised of teams made up of a practitioner, a pre-service teacher and a graduate student. Such teams developed a new kind of wholesome relationship based upon mutual respect for the complementary skills possessed by each team member. Plans for the inclusion of pre-service teachers in the implementation of the instructional packages they helped to develop are now being finalized.

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

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

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

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

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REACTION

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Back in the old days of curriculum development, meaning in the early 1960's, I was a member of one of the NSF project teams - for preparation of the CBA (Chemical Bond Approach) materials. The sub-team leader with whom I worked was Tony Neidig, a chemist from Lebanon Valley College in Pennsylvania. Whenever team members presented materials to Tony for editing or checking he would read them, ponder for a while, and then when he had decided that they were all wrong he would begin his talk with the team member by saying, "I agree with you one hundred per cent, but . . ." Without meaning the same thing here at all, let me begin by saying that I agree with Professor Sharp one hundred per cent. However, I do have some comments on several parts of his position paper and perhaps a few questions to raise.

CBA went the way of the dinosaurs very early; other initialled project materials have hung around longer, but many others too are disappearing from the educational scene. Why? We in CBA used to say that it was because our materials were ahead of their time but this was just to make ourselves feel better. The truth is that CBA as well as PSSC and most of BSCS (and probably CHEM Study as well) was written at an extremely high level of sophistication <u>for teachers</u>. It wasn't all that hard for kids because they had no base of experience with which to compare it, but teachers <u>did</u> and they knew it was <u>hard</u>! So what did we do in our institutes to prepare teachers? We taught them the advanced stuff required to handle CBA, et al. and then <u>they knew for sure</u> that the courses were not for high school students.

All the curriculum projects did (and do) have two things in common -- the cooperation among diverse groups of specialists in the development of materials and the basic inquiry-oriented approach to instruction. This is true of both secondary and elementary level materials. Let me talk about the second of these first.

Professor Sharp makes the point that our schools seem to suffer from some sort of cultural lag in that they are still seen basically as knowledge-dispensing institutions and that teachers must be authoritarian in order to survive. He is absolutely right! The AAAS Science - A Process Approach materials were certainly among the earliest to try to get kids involved in doing experimentation, but Oh! how they have been mishandled! We have some beautiful (though sad) videotape footage showing a teacher demonstrating experiments for kids with all of them crowding around clamoring, "Let me do it! Let me do it!" But she would not. The ESS packages are beautiful but how many teachers really use them? And ES -- send kids outdoors alone with cameras? Can teachers really get by with this sort of thing? I agree, our schools are behind the times.

If Professor Sharp is right in this respect, how about his contention that teachers are pseudo-professionals? Well, I really don't know what a professional is but I'll accept Thelen's definition and I'll add to it that a lot of people think that doctors (MD's that is), dentists, etc. are professionals. There seem to be two keys to being a professional -- first, you must think you are one, and second, you must belong to a group to which there is limited access, either by the artificial process of limiting admission outright, by the intelligence requirements, or by some other means, and hence which is seen as desirable by others who are outside the group. (Lots of people would probably like to be doctors but feel that for some reason they couldn't get into the group. How many people feel the same way about being teachers? On the contrary, most people think of themselves as potentially better teachers than those who have actually become teachers.) This sounds a bit cynical but I'm not sure that we can do much about making teaching a profession. And that's to worry about because the real essence of Professor Sharp's paper is the professionalizing of the teachers who get involved -- it is this that makes regional teacher education more effective than other patterns.

So let's go back to, let's see, it was my third paragraph and pick up the other common item among curriculum projects. The old CBA gang was a close-knit group. We liked each other. Oh, we argued and battled over items in the course but we liked each other. And there was a real CBA esprit, among students and teachers in the program as well as among the project team. (I went into a classroom once and the kids were wearing homemade tags. One said, "We'd work on Sunday for Mr. Mundy." Another said, "Today CBA, tomorrow the world." They really liked CBA, and they really liked Mr. Mundy.) Why? Well, perhaps it was because we were all involved as equals in what we viewed as an important development. If you will, we were professionals because (1) we thought we were and, (2) we were members of a very limited group which was desirable to others. Now the question is, will this work with groups of teachers in regionalized teacher education programs such as that proposed by Professor Sharp? If it will then we are on the road to professionalizing teaching <u>for those groups</u> (not for the whole set of people called teachers). We are making use of one of the important parts of the initialled curriculum projects, and we can set the stage for invoking the other important aspect of those projects.

The paper provides six pages worth, nearly half of it, of evidence that groups of teachers can become professionals along with university personnel and state or community individuals concerned with the same problems. I too can point to experiences with groups where this worked. At Florida State University we had a program which we called QUEST (Quality Undergraduate Education for Science Teachers). Ron Townsend and Dorothy Schlitt started it, others too numerous to name them here got involved eventually, including the students. The basic procedure was to provide for continual contact among the students who were preparing to be science teachers, the university professors who were supposed to prepare them to be teachers, teachers in the local schools, and kids. They studied together, talked together, taught together, commiserated together, argued, fought, designed procedures, collected materials, drank together (water, of course) and in general behaved as if they were equals engaged in a very important process -- the education of public school kids in science. Also the group had limited access; only a select few got into the QUEST program. After about three years of this I couldn't tell who was a professor and who was a teacher trainee. I mean, the students were just as likely as the professors to come to me and suggest course changes, or to complain about some administrative decision, or to ask for support to do something that they felt was needed. I believe that those students actually thought that they were full equals with the professors in the program (and I know that they felt superior to certain other professors). The materials they developed were, of course, inquiry-oriented; they used the initialled project materials for sources. They entered into full time teaching with attitudes of inquiry and the need for continued learning on their own parts. And I'm sure that they are still bugging the school principals or superintendents with whom they now work in efforts to continue the professional experiences which they had at Florida State.

So, you see, I do agree with Bill Sharp one hundred per cent.

CHAPTER 3

IN-SERVICE EDUCATION: THE FOLLOW-THROUGH

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In-service teacher education, as I define it, is training which occurs subsequent to receipt of the teaching degree, takes place on site or near the teachers' districts, and consists of summer and/or academic year work while the teacher is employed. In-service training for science teachers often is conceived by persons other than the professional teacher who is to be the trainee. Very often it is not initiated by the trainees' school or district, but by a local or regional teachers' college or department of education often in cooperation with a "subject matter" department. Usually these departments are also involved in pre-service teacher education. Until recently, schools and districts, while sometimes giving credit for BA or MA "plus" hours (earned during the school year or in the summer), have not as a regular practice sponsored programs under district supervision to bring in-service teacher education into the schools for planned professional growth. National Science Foundation institute grants and title programs probably have done the most to foster and establish such projects which have been jointly sponsored by a district and college.

Occasionally a large district and more often a state agency, college, or non-profit institution have sought to assure continuation of an installed program. The literature, discussions at regional National Science Foundation project directors' meetings, and contact with summer institute participants revealed that an institute without a mechanism to insure application once the participant is back in class has little chance for creating "enduring change". If professionals are to be life long learners and self-refreshers, then access to continued awareness of new developments and re-training if desired is necessary. To some extent it could be argued, then, that a given re-training experience can be broken into two phases: the theory* and the supported practice. Just as it is correct not to forget about the education of a teacher after he receives a BA, it also is correct to provide him support after a summer or other theory-based in-service session.

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*In this sense, theory is used to denote orientational and instructional parts of in-service experiences as separated from actual practice <u>in</u> and regular use <u>of</u> those things to which the trainee was oriented and in which he was instructed. These parts are not necessarily linear in sequence.

Special acknowledgement is given to Richard M. Bingman, Lowell A. Seymour, and Larry F. Padberg, McREL, for their critical review and constructive suggestions during preparation of this paper.

The provision of after-theory support is important to any innovation involving teacher training and seems to be common in comments on the stability of curriculum or instructional changes. Therefore, rather than concentrate on unique approaches to in-service education (what is unique to one may be shopworn to another), I should like to draw attention to in-service projects, comments, and reports which relate to the effectiveness of in-service education, the problem of support, and other factors influencing the worth of in-service training to the profession.

A review of the last five year's of ERIC entries based on descriptors related to in-service teacher education and printed out by Project Communicate at the Kansas State Department of Education, a review of other literature and reports, and products of McREL's in-service-centered Inquiry Skill Research, Development and Adaptation program were the sources of background information for this paper. With some exceptions, the in-service programs reported on were either not formally evaluated or their evaluation was not of the kind which would suggest replicability since they were carried out for district "X" and its unique needs.

Several ERIC reports reviewed dealt with continuing training for the beginning teacher. An example is the proposal of various "Helper Roles" for new and younger teachers (5). A "Helping Teacher" program in the Wilmette, Illinois district individually teamed 80 first-year teachers in nine elementary schools with experienced teachers to assist in planning, observation, and self-evaluation. An individualized program of teacher experiences was developed jointly by the new teacher and one or more staff members. Released time was used for workshops, demonstrations, and consultation with an advisor-consultant from the staff of a college. No evaluation data are present; however, the district was planning to extend this program throughout the new teachers' pretenure period (7).

Reviewed reports on projects included those

(a) concluding that criteria to measure the effectiveness of in-service programs must assess change in student outcomes,

(b) recommending establishment of formal standing committees and task forces to plan in-service education at the district level,

(c) containing explicit instructions on the conduct of workshops (10, 6, 8)and others directed at specific situations, such as cross-ethnic sensitivity, self-awareness, and other specialty emphases.

I have elected to discuss only those projects I consider to be either directly related to science education or of a general application nature.

One project, "Evaluation for Individualized Instruction" reported by Brown et al., is based on the premise that "one successful initial approach to the improvement of individualization of instruction is through the improvement of teacher-made tests"(4). The 87-page manual of workshops which run the gamut from very general objectives through behavioral hierarchies, statistics, item writing, reliability, and validity plus the general premise should be of particular interest to student teacher supervisors. In most cases, the supervisor can sample very little actual teaching but, between visits, is able to review tests constructed, administered, and scored by the student teachers, set objectives, and plan for the next session of review.

A review of mostly generic in-service teacher education literature showed that a main theme was the greater significance of considering professional teacher education as a whole rather than as pre-service and in-service education. For whatever reason, perhaps a need to classify everything, the evaluation of a teacher has not been treated continuously as it ought to be. A collection of essays edited by Rubin (9) contains proposals dealing with the most logical perspective from which to view any kind of non-random education: for example, from the position of the learner as a participant in a continuous activity throughout which people, experiences, and their influence (interactions with methods instructors, administrators, children, parents) come and go (9, p. 43). The only person who can really control the process toward some end is the teacher (learner) himself. Seen from this perspective, the separation of teacher education goals into pre- and in-service sets may not be efficient.

Robert N. Bush in "Curriculum-Proof Teachers" (9) describes a six-year teacher education program which requires close collaboration between college faculty and district administrative personnel as a beginning teacher moves "toward full licensure." Bush proposed this in 1965 at the 19th TEPS conference. Certain pilot programs have gone this way but there seems to have been little general determination to treat teacher evaluation as a continuous plan. His consideration of teachers training each other as compared to the "noblesse oblige fashion of condescension, which characterizes supervision and in-service education in American schools (just as it also permeates our patronizing attitudes toward helping so-called underdeveloped nations)" (9), is placed in the context of advocating an end to the idea that in-service education is done by "experts" to "non-experts."*

How often have we heard or participated in discussions involving terms like "retreading," and does not the system use academic credit as its primary reward for in-service re-training? A reward system is not wrong but as much effort should be spent on converting the reward to an intrinsic one or one closer to the re-training itself. Increased professional skillfulness would seem to be a true reward which could render graduate credit superfluous. Credit is fine for the teacher seeking an advanced degree, but will his motivation for self-improvement be as great after the MA + 30 is earned? Or should still another token reward be used? Rubin thinks not. "Accordingly, in-service education must

*One reviewer of this manuscript suggested that Bush's comparison, itself, was condescension in reverse and a misapplication of non-elitism.

begin with perception, kindle the freedom and the lust to change, then provide a method and support, and end in the confirmation of newborn habits, in this form, professional growth becomes self-transcendence" (9, p. 276). I suspect, however, that one major factor preventing wider attention to the development of "in-service" programs based on a plan to nuture self-transcendence is the phasing out of exterior rewards and phasing in of professional ones. "Transcendence" is hard to record on transcripts!

At present, the self-evolving teacher is a goal at various stages of recognition or approach. It probably is a goal most teacher educators would accept. For educatior to remain a field in which the mass of practitioners are trained and then refreshed almost exclusively by former practitioners would be unfortunate. It is not wrong for practitioners to leave the classroom to do research and to refine aspects of training or practice in order to impart it more efficiently to others. It is, I think, wrong that no recognized niche generally exists so that the practitioner could combine research on teaching/learning or training of other practitioners along with his own teaching in the elementary or secondary school.

Those of us who are former practitioners-turned-trainers should consider some intermediate steps. For instance, in-service training programs which can be generalized to areas other than only science could be given a priority, not as a generic movement away from science education, but out of appreciation of the likelihood of greater impact and survival potential in schools. Next, programs which have mechanisms to support the newly acquired skills, even when the "trainer" leaves, ought to be given priority by the schools and universities. Again, survival potential plus the opportunity to place reliance on practitioners to carry the torch and thus take responsibility for professional development is emphasized. A third priority is that in-service programs be able to be appraised in terms of student performance. In practitioner-client types of professions, the quality or worth of the things the practitioner does should be judged in terms of what happens to the client. It is perhaps a truism, but worth stating when considering the merits of different or possible in-service programs, that student needs are the only basic justification for any kind of teaching, be it teaching of students or their teachers.

Thus, the position taken is simply that the science education community should emphasize in in-service training any program which (a) offers generalizability of valuable skills to subject matter other than science, (b) includes some system to assure the new methodology, approach, or upgrading of performance continues when the original trainer has departed, and (c) can be evaluated for its effectiveness in terms of student performance.

This may suggest, for example, less emphasis on the short performance objectives workshop so popular in the last few years, and more emphasis on training to implement behaviorally evaluated instructional systems. In-service project developers or consulting professors should concentrate on the generalizable aspects of what they plan to do for science teachers with an eye toward building instructional theory not limited to elementary science, biology, chemistry, physics, etc. Furthermore, planning should include attention to follow-through which includes a model for evaluation of both teacher performance and student outcomes which can be overseen by the schools without continuing dependence on the trainer, professor, or developer.

James Stone (12) in his critical analysis of the Ford Foundation's Breakthrough Programs in teacher education, constructed a six-stage developmental paradigm for innovative curricular experiments in teacher education. The paradigm which follows is his extraction of a general sequence from his review of all the Ford Breakthrough Projects.

Stage I is Idea to Action, including preparation of the seed money proposal with assurances of cooperation by local school districts and the state's certification unit.

Stage II is Launching, in which the program now faces everyday realities, academic professors laud the program, school districts praise the quality of new teachers coming out of the program, and conventional program personnel criticize the program and wait for it to "run its course."

Stage III is Showdown, in which the success of the program results in modifications to the conventional program. Those who waited for the new program to run its course now confront it. Stone indicates that the issues are: Should it be continued with regular college support? Should it be blended with the conventional program? Should a new program be evolved using parts of both? He notes that a compromise is reached at this stage and that both old and new operate as parallel programs with institutional support.

Stage IV is Impact on Other Curricula, in which the program is extended up and down in the K-12 teacher training program of the institution. It also is used in in-service training and applied to other areas, such as teachers of the disadvantaged and training of supervisors and other school personnel. Graduate programs also are based on ideas of the new program.

Stage V is A Changed Climate on Campus which results from all curricula being pervaded by the original spirit. Innovation and an "open" atmosphere pervade the campus, and a new measurement for student behavior and faculty freedom and responsibility is seen.

Stage VI is Changes in the Community, in which the cooperating schools become experiment-minded. This leads to cooperative school-institutional research with parents also involved in the school-university relationship! Stone notes that as of 1968 none of the programs begun in the early 60's had reached nor seemed immediately likely to reach Stage VI; one was at Stage V, a few were at Stage IV, and a larger number were at Stage III.

Stone then proposed techniques to reduce the dilution or compromising which started at Stage III. He refers to the term 'cooptation' coined by Selznick (11). Cooptation takes place when members of the institution are in tension with those advocating the new program. They offer compromises in return for their cooperation, and the new program advocates must accept the compromises. To combat cooptation, a prestigious leader must be at the project's head in Stage I. The Department of Education faculty must be brought into the planning at this stage. Not doing this seemed to be the main source of conflict at Stage III. Staff members who might later be threatened are involved or coopted themselves at an early stage.

Stone, however, recognizes that lack of conflict or competition, resulting in a stable atmosphere, has been seen as a prime reducer of the need for change. The schools exemplify this with their monopoly on who educates and the guaranteed flow of students compelled to attend. He indicates that rather than use the "necessity of conflict for change" hypothesis against early involvement of other faculty, the leader should involve them but not avoid conflict which occurs. The conflict should be turned to constructive purposes.

Early Stage I involvement of school districts is described for its absolute necessity and then: "The institution (college or other post secondary institution) must carry considerable prestige."

In 1968 Stone offered this paradigm as a hypothesis and as a "useful theoretical concept with possible wide applicability in higher education." The question I considered was whether Stone's paradigm had been tested or applied further. I know of no concerted attempt to apply a modification to his paradigm for science education per se. However, elements of the stages and, particularly, mechanisms to combat cooptation have appeared in certain projects -- science education, other curricular areas, and general projects.

The installations and evaluation procedures of Individually Guided Education being promoted by the Wisconsin Research and Development Center for Cognitive Learning and I/D/E/A, the educational arm of the Charles F. Kettering Foundation, are elaborate and effective modifications of Stone's stages from the perspective of pre-college schools as "institutions." However, where Stone hesitates to tell the leader how to deal specifically with would-be cooptators among the traditional faculty, IGE-installing schools have simply "honorably transferred" them to a cooperating school. The further extension of this parallel to post-secondary institutions could be interesting to explore. An IGE installation depends on an intermediary, usually a college, who will train the appropriate staff members of a number of cooperating schools. In his absence, the schools follow a step-wise developmental plan within which they commit themselves action-by-action to directed change over a period of as much as 10 years. The basis of evaluation is the progress of the individual student for whom instruction is tailored to begin at his particular level of entry with respect to desired skills. A review of the descriptive information available from IGE and on-site visits with IGE, I/D/E/A staff at an IGE league of schools in Dayton, Ohio, suggest to me that this project for in-service teacher training and school change meets the previously stated criteria of (a) generalizability to many subject matters (all are involved, and science, reading, and mathematics are usually given prime emphasis in schools starting out on this path), (b) assuring continuance after "infection," and (c) focusing on individual student performance which serves as a basis to appraise total program effectiveness.

The IGE/multiunit strategy is not the only such project which could be cited. On a different scale, Mid-continent Regional Educational Laboratory has been diffusing an in-service training program which includes generalizability, continuation potential, and mechanisms to utilize student performance as an index of program success. This program is one of the growing number of competency-based teacher education programs and is selected for discussion due to its correspondence to the author's criteria stated above. Instructional Staff Development was developed jointly by McREL and Teachers College of the University of Nebraska. The ISD package consists of six sequential components of training which use examples from secondary biology and social studies. The package was field-tested with teachers and classes in these two disciplines (generalizability), is designed for installation by a college instructor or large district trainer as an intermediate agent who in turn trains building level trainer/teachers who should have released time to carry out training of five or more building faculty during the year (continuance), and depends upon microteaching and whole-class feedback, interaction modeling, and paper-pencil student feedback as some of its means of pacing and evaluation (effectiveness related to student performance). This system of training of trainers of five or more teachers is stated in the ideal, for example, in the implementation design by which the project was field-tested. During the first year of diffusion, however, the system was modified and adapted to meet specific requirements of districts of different size and with different resources.

The six ISD components of instruction each of which (except Component I) consist of cycles of sensitization, instruction, practice (micro), implementation (whole class), and assessment are as follows:

I. Orientation to Inquiry introduces the trainee to the nature of inquiry teaching and the philosophy behind its use. "Are These Inquiry?" illustrates on videotapes inquiry and non-inquiry classroom episodes.

II. Inquiry Influence trains the teacher to recognize inquiry learning situations through microteaching examples. Trainees practice interaction coding and learn to interpret the results in terms of classroom behavior.

III. Inquiry Behavior introduces four teaching models and includes an inquiry analysis system. "Inquiry Skills," "Cognitive Inquiry Behaviors," and "Affective Inquiry Behaviors" are videotapes illustrating changes in teaching skills and the effect they have upon the learner.

IV. Behavioral Objectives defines teacher objectives and how they may be obtained through the language of instruction. Trainees plan microteaching episodes to bring about the desired objectives. Videotapes to accompany the unit are "Implementing Objectives," "Objectives of Different Categories," and "Identification of Objectives."

V. Pupil Centered Inquiry introduces revised interaction analysis categories to record desired changes. The unit includes use of the inquiry log to reveal the extent of inquiry learning. A videotape "Pre-Posttest V" is used to measure inquiry progress in trainees, and "Phases of Inquiry" illustrates progress in behavior toward pupil-centered inquiry.

VI. Affective Behaviors teaches the trainee how to promote behaviors by his pupils which will lead to a better atmosphere for inquiry and how to increase these behaviors and use them in a planned way to implement learning. Three videotapes illustrate this training: "Implementing Affective Behaviors," "Student Views of Affective Behaviors," and "Teaching Students to Use Affective Behaviors."

The installation of ISD depends on training for classroom teachers (T_3) who are trained by trainers (T_2) who were trained by Intermediate Agents (T_1). McREL, or designees, offer the T_1 training. When recruited or when they contact McREL, representatives of an agency* are informed through awareness sessions and literature of the costs and conditions under which ISD can be installed so as to be likely to have criterion effectiveness. It is noted that, although biology and/or social studies teachers should be a focus, the training has been opened up for other areas. So far only one intermediate agency has limited installation to grades 9-12 science. Others have decided to go to other areas as well and attempt generalizability up and down the grade levels (recall Stage IV of Stone's paradigm).

Agencies submit installation plans to McREL which explain, within limits set by the developers, how the program will be installed and maintained, numbers of T_2's and T_3's, subject area and grade levels, time allotted for T_1, multimedia assistance availability, whether T_2's and T_3's were volunteers (important), nature of the teacher reward system, released time, and means of evaluation. These data collected with a questionnaire enable McREL to select agency plans with a likelihood of successful continuance prior to the sale of packages and arrangements for assistance.

A similar model of installation also is being prepared for McREL's Inquiry Role Approach (2) product. IRA is a student-oriented instructional/curriculum program based on the use of role differentiated student teams.

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*It is convenient and meaningful to use the term "intermediate agency" which has a somewhat similar meaning in the IGE program.

It is designed for use by secondary school biology teachers and classes to meet objectives in the areas of social skills, inquiry skills, attitudes which support inquiry, and subject matter understanding (1). McREL is in the process of cooperating with the publisher in establishing an in-service training system on a model basis to (a) enable study of the degree to which IRA training needs parallel those of ISD and (b) establish a set of reference points for others who wish to install the program. The extent to which IRA in-service training does follow suggestions for in-service education given in this paper, and intended by program developers, will hopefully be learned in some detail this year.

I hope that the position taken and the related and semi-related information provided serve as a stimulus for discussion in detail not only of the specifics of generalizability, continuance, and student centered assessment, but also of clues to the documenting and assessing of any in-service program ongoing or proposed. Training programs which can generalize teaching skills to areas in addition to science, include a support system running through the academic year, and use student performance as a measure of effectiveness should be given top consideration by in-service science teacher educators.

I would suggest yet another "clearinghouse" to accumulate information on new strategies in use, or soon to be in use, and to address the issue of after-theory support mechanisms which give continuance a chance and perhaps give a boost to self-evaluation based on intrinsic rewards. Information on projects which have, as a component, a plan to make the project or its intended derivative(s) self-renewing or self-supporting would be indexed and made available to AETS, perhaps in a future edition of the Newsletter.

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REACTION

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My first reaction to Dr. Paul Koutnik's article must be to the definition of in-service education. I find it imperative that we not categorize the education of teachers into pre-service and in-service components. I strongly support the views of Corrigan (3) who suggests that the improvement of schools through pre-service teacher education has failed and that new teachers are "swallowed up by the system." He continues by suggesting that there are career teachers who have 20 or more years of teaching left and that they must be reeducated along with new teachers. This requires a strategy which brings together pre-service and in-service teachers in a team approach. The Corrigan design recognizes

> ". . .that pre-service education, in-service education, and schools and colleges themselves are interrelated in interacting components of one educational system. Resources, both financial and personal, must be directed toward strategies that link schools seeking to change with teacher education institutions, seeking to break out of established patterns. Shuffling courses about is not the answer. A major shake up is needed in both the form and substance of teaching education, from the beginning introduction to teaching -- extending throughout the teacher's lifetime career." (4)

We, as science educators, in rapidly expanding conceptual fields as well as teacher education should consider the education of professional teachers as an ongoing process.

Although most models for post-degree teacher education may not be unique I think that it would be legitimate to include them in this paper. As Dr. Koutnik has reviewed the last five years of ERIC entries I am sure that he encountered several that could have been included but were excluded in that there may not have been a science emphasis. Some models which I found interesting upon a cursory examination of the literature and discussion with members of the Professional Studies Division of Buffalo State University College (SUCB) were:

1. Advisory Approach to In-Service Training (7)

2. Emory University Program (10)

3. Teachers Training Te[illegible]rs (15)

4. Teacher Centers (11) (14) (2)

5. Portal Schools (13)

6. Teacher Corps (Buffalo/SUCB) (9)

7. Teacher Corps/Peace Corps (Lackawanna/SUCB/Afghanistan) (8)

8. Beginning Experienced Teacher Program (BET) (6)

9. For City Education Program (FORCEP) (6:5-13)

10. Undergraduate Urban Teacher Education Program (UUTEP) (*)

11. A Personalized Approach to Competency Education (APACE) (**)

The Advisory Approach to In-service Training is characterized by the following in-service training strategies:

1. Providing in-service assistance to teachers only when such assistance has been requested by them;

2. Providing assistance in terms of the requestors' own goals, objectives and needs;

3. Providing such assistance <u>in situ</u> rather than in courses, institutes or seminars;

4. Providing assistance in such a way as to increase the likelihood that teachers become more self-helpful and independent rather than helpless and dependent.

This project was evaluated although the methods of evaluation were not noted with the exception of what appears to be an interview or subjective report. The reporters however feel that the findings support a change from traditional modes of in-service training to programs that provide help for teachers in their individual classrooms.

The Emory University Program involves pre-service students who have already earned an undergraduate degree in a field other than teacher education and participants who are experienced elementary school teachers. Participants are paired to form teaching teams and share the responsibility for the elementary classrooms and each team member attends classes at the university. Evaluation of this program is subjective but more objective data are now being collected (10).

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* More information concerning the UUTEP Program is available from Dr. Richard Collier, College Learning Laboratory, SUCB, 1300 Elmwood Ave., Buffalo, New York 14222.

** More information concerning APACE is available from Dr. Lois Pearson, State University College at Buffalo, 1300 Elmwood Ave., Buffalo, New York 14222.

The Teachers Training Teachers program in Florida is a model for the in-service training of teachers in environmental education but might well be adapted to any conceptual area. This model consists of four phases, a state meeting, regional workshops, district workshops and finally local school workshops. This model works on the multiplier idea in that participants in one phase will be the trainers in the next phase. In practice $5,600 was budgeted for this program and the program could potentially reach 35,000 teachers. The multiplier aspect of this program resulted in teacher involvement in planning, conducting and evaluating the workshops (15).

There seem to be several Teacher Center Models [(11), (14), (2)] too numerous to list. The reader might best read the Spring 1974 issue of the Journal of Teacher Education. Whatever the model for Teacher Centers, science education should certainly be included.

The Portal School Program was developed as a mutal agreement among the American Federation of Teachers, The Philadelphia Public Schools, the school community, and Temple University (13). An adaption of this model has been incorporated into many other projects. For example, this model was used by the Teacher Corps Program at SUCB. In the 7th Cycle Teacher Corps Program the emphasis was on the development of diagnostic/prescriptive teaching materials as related to learning problems in the regular elementary classroom using the Portal School Approach. Both the interns and the regular teachers received training in teaching all children including those from the exceptional education classrooms. This model allowed the formerly segregated child with learning difficulties to be kept in the mainstream of education (9). In the present Teacher Corps Cycle each Portal School is associated with four satellite schools. There are only ten interns in this program plus the school principals and supervisors who will work for change through an in-service program for the teachers in each of the schools (9). In the combined Teacher Corps/Peace Corps Program at SUCB the in-service component consisted of the lead teachers in science, mathematics, and English of the Lackawanna School District participating in the same classes with the interns. When the interns went to Afghanistan as Peace Corps Volunteers they in turn worked with both pre-service and in-service teachers (8).

Also of interest at SUCB are three undergraduate programs FORCEP, UUTEP and APACE and one graduate program,BET. Each of these undergraduate programs held in cooperation with the college and several local school districts has resulted in requests for in-service classes, seminars and workshops by the teachers who work with the undergraduates in the classroom. The fourth program, BET, is an in-service program for inner city teachers. Members of the teams from each Buffalo school included new teachers and experienced elementary teachers. Also included in the program were supervisors and administrators. This program was funded for three years and ran without funds for one more year. Two hundred and fifty teachers participated and 85 per cent are still teaching in inner city schools. There was a strong science segment in this program. After a lapse of one year this program has been reinstated as a four semester program which can lead to certification in New York State. The new BET also calls for school teams and the curriculum will be as follows:

1st Semester - Broad Curriculum Content

2nd Semester - Reading/Mathematics/Arts

3rd Semester - Science/Social Studies/Arts

4th Semester - Independent Study (Action Research in the Classroom) or Seminar in Teaching the Disadvantaged or Nature and Needs of the Disadvantaged

The science component will be integrated with reading, mathematics and social studies. This model is easily replicated by any school district and need not be orientated to the inner city. Both the FORCEP and BET programs have been evaluated (6:16-23).

Evaluation of the effectiveness of the in-service programs in general, let alone the science segment, was difficult to find. The evaluation of the BET and FORCEP programs mentioned above was on the effect of the program on attitudes and self-concepts of the students. The evaluation of three NDEA In-service Institutes at Ball State University has been undertaken by Sauter (12), Allen (1), and Fischle (5) and also measured changes in the teachers. I must agree that this area, in-service education, needs to be evaluated in terms of student performance.

I strongly support Dr. Koutnik's statement regarding in-service training programs which can be generalized to areas other than science education, those which are interdisciplinary in nature and those which have a built in "follow-through" mechanism. I would add to this that strong school administrative support is necessary if there is to be change as a result of in-service education. In several programs in which I have worked with in-service teachers the best success has been where there was at least administrative recognition of the change in the classroom.

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CHAPTER 4

TEACHER CENTERS: VEHICLES FOR CHANGE IN SCIENCE TEACHING

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Teacher Renewal - A Significant Need

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

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

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

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

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

A third strategy for continuing education of teachers is a teacher center. While examples of teacher centers can be found in both England and America, their origin,operation and target populations have distinct contrasts. As illustrated by one set of teacher centers in Texas, such as those at the University of Houston, West Texas State, and the University of Texas at El Paso, formal American teacher centers are usually characterized by being:

-- a group of dedicated college staff working

-- with undergraduate or prospective classroom teachers

-- in a field-based competency-based teacher education program.

Informal American teacher centers such as the Chicago Teacher Center are characterized by being:

-- a place to come to make materials

-- supported by private foundations

-- a place developed to fill the felt needs of classroom teachers

-- a convenient location

-- a place where staff are excited about what they are doing -- and provide models for other teachers.

In their informality, a few American centers are more like English centers than they are like the more formal collaborative centers in Texas.

Other examples of collaborative teacher centers such as those being developed in South Dakota could be discussed. Since these are more in the planning or pilot phase, the teacher centers in Texas will be described because they are now operational.

In contrast, teacher centers in England (e.g., Southampton and Plymouth) are basically a non-university-based group of teachers working with quite autonomous school heads:

-- involving about 85 per cent experienced teachers

-- in cooperative efforts in setting aims, goals, and curriculum alternatives that will fit their own needs.

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

Organization

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

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

People

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

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

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

Program

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

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

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

Teacher Centers -- An Organization Solution for Teacher Renewal

Teacher centers are ways to facilitate continuing education. In England and America, they are focused on facilitating teachers. The primary target of English teacher centers is experienced teachers working on problems relevant to them in a context that serves as a forum for curriculum development. More formal American teacher centers are focused on a target population of prospective teachers working on acquisition of preselected competencies that are required for certification. While both centers have evolved as a response to a political decision, the nature of that decision has shaped the primary focus of centers, e.g., in England school reorganization results in a curriculum development focus for their centers while in Texas competency-based certification has resulted in the focus of the centers on pre-service teacher education.

Both ideas has been successful in specific instances. Yet to be determined is their potential as merged vehicles for change. Is there a basis for both experienced and prospective teachers to share together in shaping the program of a center for continuing education? Can this be accomplished through the mutual involvement of experienced and prospective teachers in a resident-intern pattern?

Based on experience both in England and America, the answer to this question seems to be dependent on the staff. Success of a teacher center can be expected to be directly related to the people in the center. Thus the unanswered question: Can people be found who have the confidence and competence to utilize current needs of experienced and prospective teachers as a vehicle for a functioning center for continuing education of teachers?

In this blueprint or proposal for an active teacher center, the plan for its organization, the people it will serve, and the program are described.

The Organizational Plan

A single assumption underlies the organizational structure of this Teacher Center Strategy. Its purpose or basic mission is that of facilitating a personalized and individualized education in the sciences for each participant, be he child, parent, administrator, teacher, college student, or professor. Thus each partner must give that which will enhance this mission, and each partner must receive that which will enhance his own goal. Figure 1 illustrates this concept of partners giving and receiving.

The People

Within the Teacher Center Strategy there will be a dual focus on challenging experiences for children coupled with equally challenging staff development experiences for experienced and prospective teachers. These opportunities will include contexts in which teachers can initiate their personal renewal through study of programs in the sciences, through "hands-on" examination of alternative programs, through experiencing the responsiveness of programs to needs within their own school, and in the second year, through in-depth renewal via renewal leaves.

An example of the Teacher Center Strategy operation is the "hands-on" renewal facility. This facility will be a public school maintained by the school system. Within the central facility, children, teachers, and prospective teachers will come together for these experiences on a regular schedule, such as once each four or five weeks. For example, college faculty will work with prospective teachers developing interdisciplinary topics prior to the field experiences. This development will include both academic content and teaching strategies. During a given week the schedule of the facility might be as follows:

Monday (a.m.) The prospective teacher component will meet with staff and university faculty to plan, for children, learning experiences in the sciences to be scheduled on Tuesday, Wednesday, and Thursday of that week. While these learning experiences will be in different areas, appropriate resources will be available to assist the prospective teachers in this planning, both with instruction and diagnostic data collection.

Monday (p.m.) Prospective teachers will visit the classrooms of the children scheduled to go to the facility and will collect diagnostic performance data on children.

Tuesday Field day at the facility for all classes of one grade level; for example, fourth grade from eight elementary schools.

Wednesday Field day experiences at the facility for all fifth grades from eight elementary schools.

Thursday Field day experiences at the facility for all sixth grades from eight elementary schools.

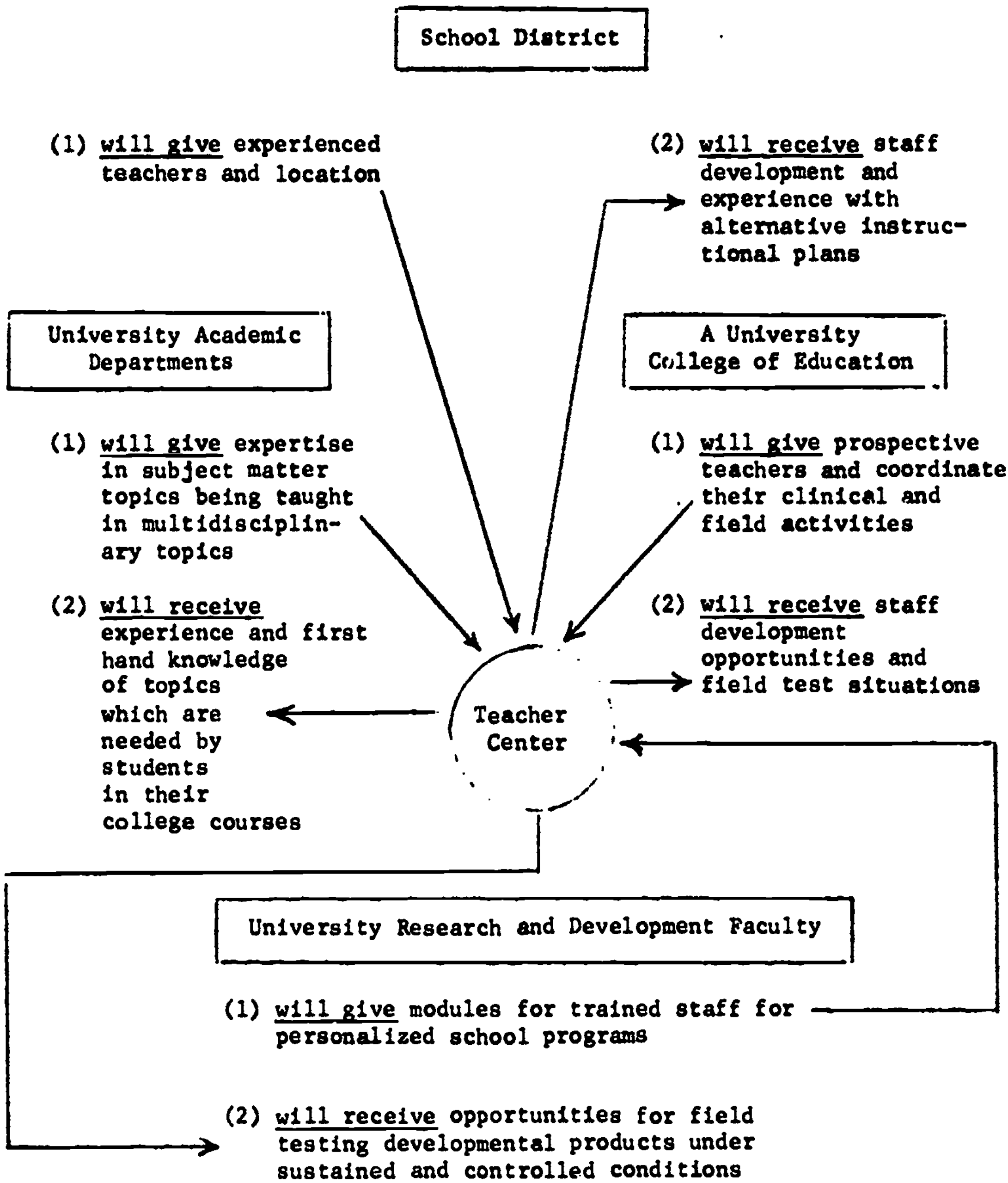

Figure 1
Illustration of Basic Assumption of
Mutual Cooperation in
The Teacher Center Strategy

Thus, on any one of these three days, activities of the facility would be utilized to provide spring-board experiences for children from 24 classrooms in eight schools, their teachers and the prospective teachers who at that time were working in those classrooms. Following the spring-board activity at the facility, the supervising teacher and prospective teachers would return to their own classrooms and continue instruction in activities on the interdisciplinary topic which had been introduced during the field day experience.

The schedule for one of these days might be as follows:

Time	Children N = 720	Experienced Teachers N = 24	Prospective Teachers N = 150 junior level and 24 senior level
8:00			Arrive at Facility. Modify plans based on diagnostic data of children's performance
9:00	Arrive at Facility	Arrive at Facility	
9:10	Involved in learning experiences	Staff development activities	Responsible for guiding children's learning experiences
10:10	Recreation break	Confer with prospective teachers	Confer with experienced teachers
10:30	Independent study in interest areas which would be designed and monitored by prospective teachers	Analysis of films and tapes made at 9:10 teaching session working with prospective teachers	Analysis of films and tapes made at 9:10 teaching session working with experienced teachers

11:30	Lunch	Lunch	Lunch
12:45	Second involvement experiences with topic	Personalized instruction strategies or observation of prospective teachers	Responsible for guiding children's involvement experiences
1:45	Travel to school	Travel to school	Planning time for modification based on experiences with children

During these days of activities members from academic departments of the University would be invited to serve as resource persons both in the development of individual topics and in observing the instructional interaction with children. Opportunities would also be provided for them to work with children who have interest in exploring specific topics in the sciences at a greater depth.

Figure 2 illustrates how experienced teachers might be involved in their own renewal. Figure 3 illustrates the renewal opportunities essential to the prospective teacher education.

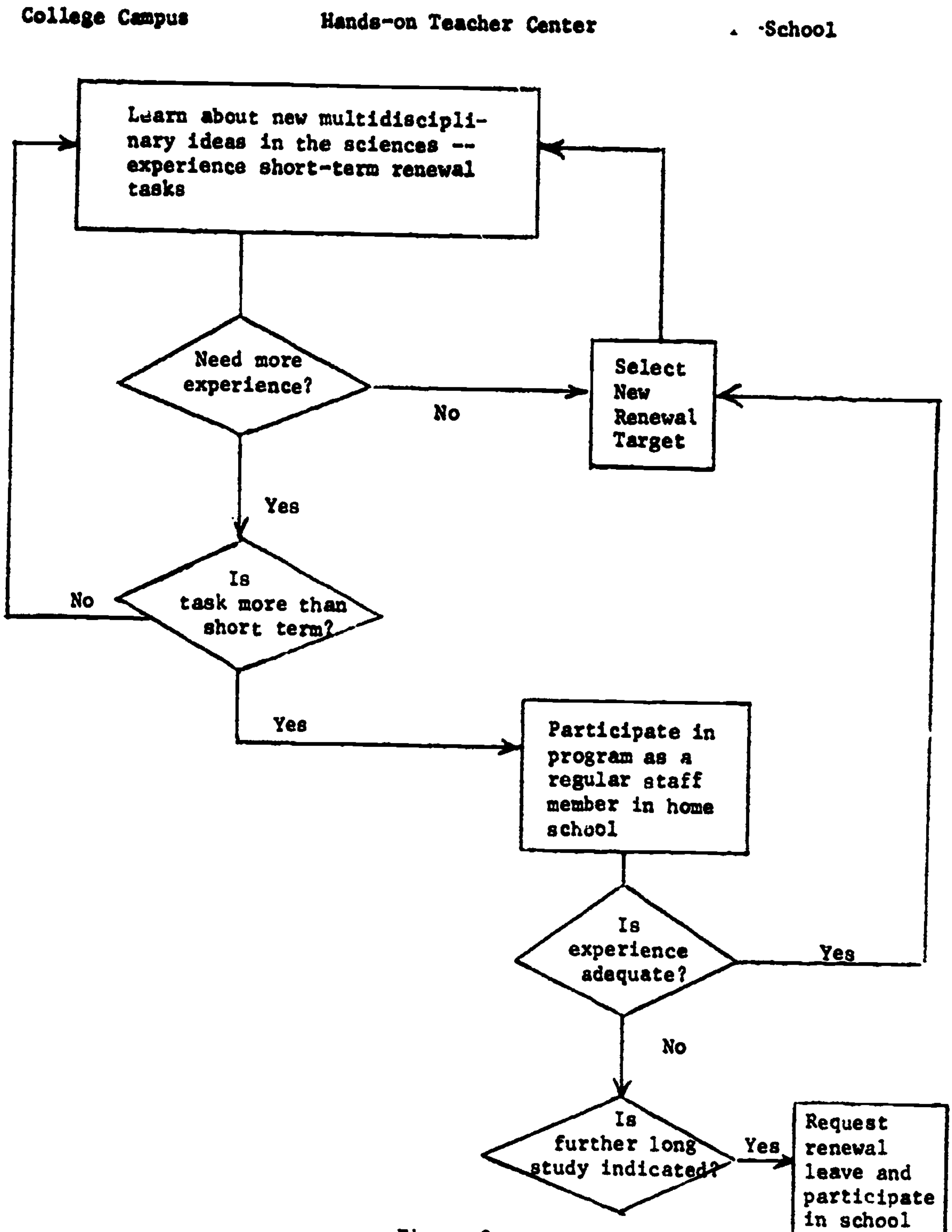

Figure 2
Experienced Teachers Plan

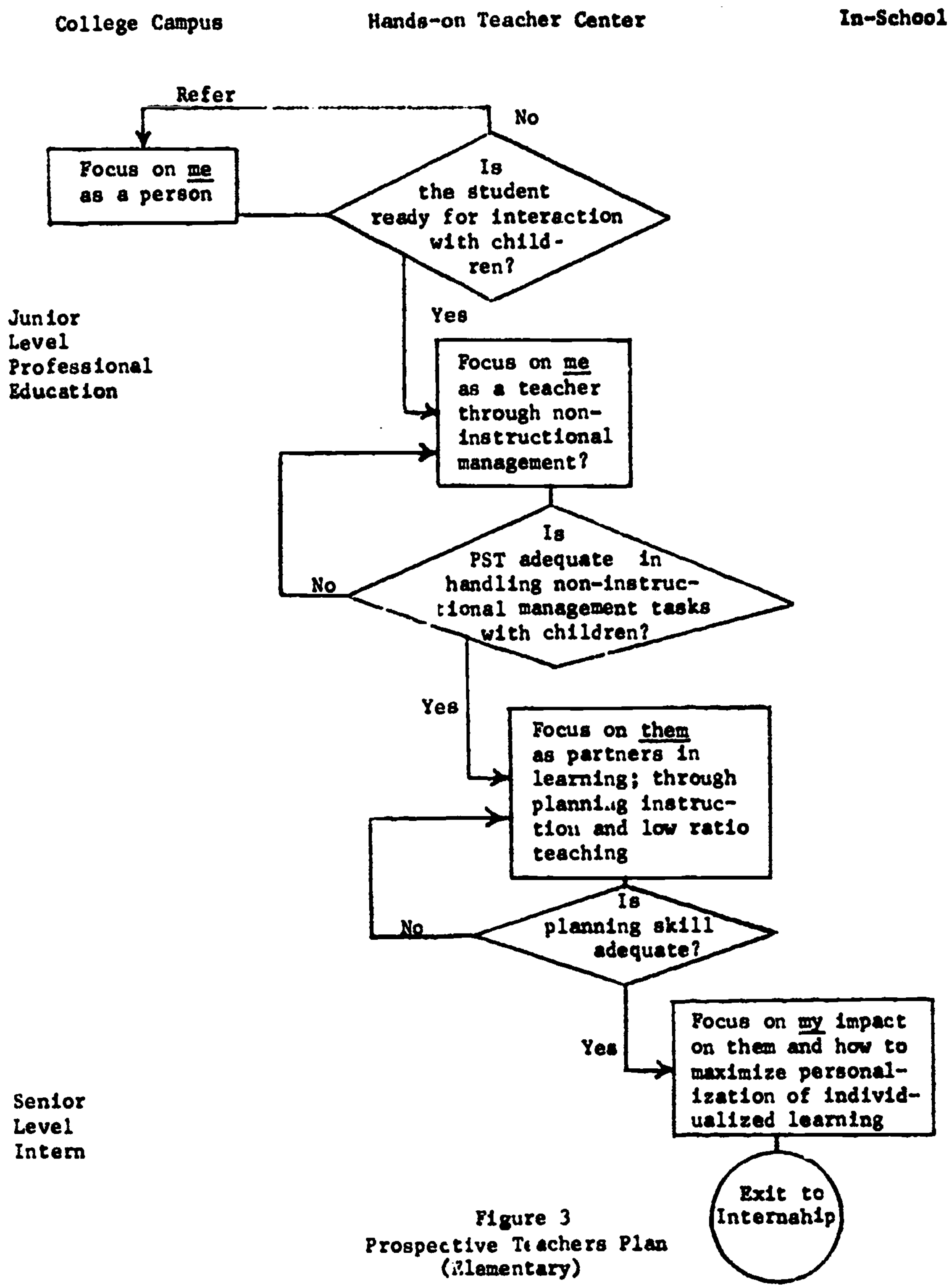

Figure 3
Prospective Teachers Plan
(Elementary)

The Program

The Teacher Center Strategy is a dramatically different approach to a very long standing concern -- how to help individuals, be they teacher or child, to have the confidence and competence in the sciences so that they can participate in both today's and tomorrow's world. This strategy provides a place and opportunity for growth in a variety of contexts:

- -- short-term "hands-on" learning growth for experiencing and acquiring specific knowledge and skills in the sciences and mathematics;
- -- longer term in-school growth focused on application and modification of programs selected by the faculty of the school involving both prospective and experienced teachers;
- -- in-depth growth focused on personal development through the facilities of college resources which are made accessible to experienced teachers.

This plan is designed so that it will support systematic responsiveness to the new challenges of our tomorrows which require us to change today.

To attain long term or basic change one must affect not only the knowledge and value systems of people but also the institutions in which they function. The Teacher Center Strategy will provide a viable context for reaching (and changing when appropriate) knowledges and values while securing commitment for change. We now have access to many components of this important task:

- -- new curriculum approaches in science, mathematics and the social sciences,
- -- in-service teacher education programs,
- -- resource personnel training procedures,
- -- undergraduate teacher education sequences.

What we need is a setting in which all of these resources can be organized into a meaningful whole. We believe that such a renewal strategy would be a way in which

- -- we can explore what makes sense to children;
- -- prospective teachers can actively participate in the development or modification of curricula to meet children's needs;
- -- experienced teachers can explore the usefulness of a variety of curriculum approaches to meet their own and their children's needs;

-- college science and mathematics professors can observe the reality of school and use this context as a vehicle by which they can help experienced teachers and prospective teachers to find relevance in the academic disciplines;

-- the entire team of experienced teachers, prospective teachers, college faculty and children can collect evidence and make value judgements about the utility of science and mathematics and the social sciences in making learning experiences more enriched, personal, and relevant.

Thus the purpose of the <u>Teacher Center Strategy</u> is to utilize a dramatic idea -- creation of a renewal strategy and resource which features giving and receiving of <u>all</u> its partners in such a way that will maximize foundation and local institutional support for change.

<u>Teacher Centers -- An Illustration of a Vehicle for Identification of Relevant Needs</u>

The major goal of the <u>Teacher Center Strategy</u> is to facilitate schools in providing a personalized and individualized education in the sciences for each participant,

-- child

-- experienced teacher

-- administrator

-- prospective teacher

and

-- college professor.

<u>Emerging Needs</u>

Our schools and our children have experienced the reformation of mathematics and science curricula in the 60's. New ideas in new packages have been brought into schools as solutions for today's needs. However, students have joined in an unmistakable chorus of critics who claim that schools in general (maybe even in the sciences?)

-- contribute to the negative enhancement of children

-- destroy curiosity

-- stifle one's natural desire to learn

-- undercut one's confidence

-- negate one's individuality

-- confine one's creativity

-- encircle one's freedom of thought

-- undermine one's self-confidence.

Renewal is needed -- renewal of the dignity of the individual as reflected both in his general educational experience and in his experiences in the sciences. We need to

-- return the initiative for learning to the individual

-- nurture his sense of potency

-- walk in the shoes of the learner long enough to find out what tempts him to learn again.

In one school system, an analysis of current educational practices in mathematics and science indicated that many meaningful practices were being utilized as vehicles for improving the educational experience of each child. There was an emphasis on the individual child through individualized learning

-- emphasis on the knowledge, understandings, skills and feelings of individual teachers through staff development programs

-- emphasis on flexible grouping of children according to need made possible through a variety of patterns of teaming among teachers

-- emphasis on cohesive awareness of individual contributions from contrasting ethnic backgrounds

-- emphasis on accountability through involvement with a variety of competency based learning programs.

These were beginning points to further the goals which have existed for many years -- the best possible educational experience for each child which reflects both changed conditions today and likely challenging changed milieu of tomorrow.

Careful listening to concerns of teachers, administrators, and other members of the professional and home community identified five current and specific needs upon which the program for the Teacher Center Strategy could be focused.

Need #1 SKILLS IN DESIGNING INDIVIDUALIZED LEARNING

It is widely recognized that mathematics or science instruction designed for bunches of children will never be adequate for the specific problems of the individual child. However, most mathematics and science curriculum materials now available for use by teachers are designed for "bunch" instruction. They must be translated into materials flexible for individualized learning -- a task that requires of the teacher a specific set of competencies plus time, both of which are strongly felt needs of teachers.

Since no set of materials which will provide for every eventuality in the learning encounter can likely be created, teachers must have as one of their competencies a system or framework for individualizing the learning of children. Within this framework, it is essential that individualization include the substance of the learning materials to match the child's interests, the format of the learning materials to match the child's learning style, and the response opportunities of the learning materials to match the child's individual pace.

> What is now needed is a systematic opportunity through the Teacher Center Strategy to involve all the teachers in acquiring skills essential for planning individualized learning opportunities in mathematics, science, and the social studies which provide for variety in su-stance, style, and pace based on the child's needs.

Need #2 SKILLS IN PERSONALIZING INSTRUCTION

In the intense emphasis on improved programs and more skillful teachers of science or mathematics, there is a grave danger that the object of the enterprise -- the child -- will be lost. Dehumanization seems to be coupled with the computer card and the massive population groups. In schools, learning should be and must be an intensely personal experience. However, for teachers who receive their education in a mass-produced, impersonal college program, the task of personalizing interaction with students is both new and unfamiliar territory.

Bold alternatives are available. The development and field testing of strategies for personalizing the preparation of teachers and personalizing school experiments has been a major program of The University of Texas Research and Development Center for Teacher Education. As an integral part of this program, assessment of the individual precedes his personal awareness of his ability to perform or to do. In this awareness phase, what the individual knows about himself and what the instructor knows about him is shared so that, in effect, my knowledge and your knowledge becomes our knowledge. Then, in the arousal phase, it is the instructor's task to translate needed goals into a context that will likely be perceived by the learner as desirable or relevant -- hence enhancing the likelihood that he will be ready to learn. The fourth phase of the R & D personalizing plan, achieving, is the option by which the individual can resolve his needs. Personalization occurs within a task-related context. Presently, the tasks of science and mathematics teaching have been one of the main focuses of attention.

> What is now needed is a context in which these strategies can continue to be used to personalize the learning of prospective teachers and experienced teachers and children.

Need #3 CULTURAL UNDERSTANDING

In the diverse cultural milieu of a metropolitan area, there is a rich heritage potential that needs to be tapped. The dignity of each individual can be enhanced by a positive utilization of that which he can contribute to the group. Although few will disagree with this view, observations in many classrooms indicate that little substantive outcomes of this view are visible. Listening to teachers suggests the conclusion that the absence of many of these cultural contributions is not the result of intentionally ignoring them but the result of lack of knowledge of them.

> What is now needed is a context in which both children and teachers can experience the joys and delights of the world as viewed by others. The contributions of Blacks, Mexican-Americans, Czechoslovakians, Scandinavians, Germans, and other cultural or ethnic groups of our community must become part of the educational experience of each child. It is equally relevant to note that these contributions are a two-way experience. Members of cultural groups both enhance and are enhanced by shared experiences which are possible within the context of such curriculum materials as Man A Course of Study.

Need #4 UTILIZATION OF A VARIETY OF CURRICULUM ALTERNATIVES

Through the combined efforts of members of the academic community, teachers, and psychologists with support from the National Science Foundation, a variety of cost-effective curriculum materials are now available. There is a real need to assist teachers in translating these materials into experiences relevant to children.

> What is now needed is an opportunity through the Teacher Renewal Strategy to provide simultaneous staff development for experienced and prospective teachers as they combine efforts to modify mathematics, science, and social science curricula materials to meet the needs of individual children. It is relevant to note here that one important dimension of this need is the translation of these curriculum materials, most of which are designed for "bunch" instruction, into plans for flexible use with "big bunch," "little bunch," and "me alone" individualized learning opportunities.

Need #5 PERFORMANCE BASED EDUCATION

Community opinion suggests a greater demand for school accountability as to how the community resources are being invested. In recent discussions with parents, teachers usually are the most trusted component of the school whereas "new practices in science and mathematics" and athletic programs are usually the least trusted or the most suspect. A clear demand for performance to match pronouncement is desirable in the already heavily taxed community.

This accountability may be considered as two dimensional. First, there is a widely felt need for colleges to prepare prospective teachers to cope with today's real world so that school administrators are not faced with the continuous need to retrain every newly graduated teacher. Second, although it may not be widely described there is an equally important need for schools to communicate to colleges the kinds of contextual and professional knowledges or skills which are needed for effective teachers.

What is now needed is continuing opportunity for dialogue between academicians and professional educators on the college campus and between these groups and experienced teachers -- even between college professors and children! Through these dialogues it will be possible to further extend a performance based education to involve viable alternatives which will permit flexibility to match individual personality, learning styles, and the essentials of the subject matter to the learning encounter. In meeting this need, we must be aware of the danger inherent in appearing to say that everybody must do the same thing, even though we allow them to select their own pace. Variability in both substance and style is essential if the performance-based program is truly individualized.

Summary

Teacher Centers are ways to facilitate the continuing education of teachers. English teacher centers and the more formal American teacher centers have marked contrasts in their organization, population and programs.

A unique and promising alternative to the American teacher center illustrates a way to help children and teachers to have both confidence and competence in the sciences necessary to participate in today and tomorrow's world. The strategy provides for three kinds of activities for teachers which will enable them to work more effectively with students; short term growth experiences focused on specific knowledge and skills in the sciences; longer term in school growth focused on application and modification of programs selected by the teachers and involving both pre-service and in-service teachers; and in depth growth focused on personal development through faculty renewal leaves.

Utilizing the Teacher Center Strategy, experienced teachers and their children work together with prospective teachers and university staff in designing and testing multidisciplinary topics. University staff monitor the implementation of the teacher education activities and classroom use of the multidisciplinary topics.

Expected outcomes of the Teacher Center Strategy are:

1. Within the public schools, children will be experiencing a personalized education in the sciences.

2. Experienced teachers will have opportunity to acquire needed competencies in the sciences.

3. Both primary and intermediate experienced teachers will have experienced a personalized teacher education program in the sciences which will enable them to be more self-starting, self-directing, and self-renewing.

4. College professors in the sciences will have opportunity to experience and observe the real world of children learning. These opportunities will then provide the stimulus for modification of the college courses (academic and professional) in the sciences for prospective teachers.

5. Through the involvement of the undergraduate teacher education program within the context of teacher renewal, the University pre-service program will be changed to help the prospective teacher to cope with both today's reality and tomorrow's unknown.

6. Prospective teacher preparation in the sciences will be relevant to the requirements of children's personalized learning in the sciences.

7. A group of leadership resource personnel will provide the school system with the staff necessary to maintain the renewal strategy.

8. A Teacher Center Faculty will be furnished and maintained available for short and longer term experienced and prospective teacher use -- thus providing a context in which both of these tasks mesh into one continuous task.

Thus, the <u>Teacher Center Strategy</u> in the sciences is a combination of needs and resources of a school system and a university in a unique opportunity to help children and teachers experience the joy, the excitement, and the intellectual power of the sciences.

REACTION

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The concept of teachers' centers which combine the functions of preparing prospective teachers and providing renewal for experienced teachers has a great deal of promise. Professor Butts spelled out many of the advantages of such an approach and has given us an operational framework for one. Implementing such a concept, however, is always much more difficult than it appears on the surface. Creating a new institution and making it effective within the context of the other institutions with which it must interface is bound to be difficult. To do so requires a thorough understanding of how such a center will relate to the other institutions and organizations involved, such as the school or school district, the college or university, and other groups such as teachers' organizations. The key question is how to implement the concept and give such a center a realistic and vital character. For discussion purposes, let us pursue this matter in the context of the experienced teacher's involvement in such a federation, i.e., the teacher renewal aspect of a center.

If we are talking about teacher renewal we must begin to ask questions like "for what purposes is renewal being sought" and "what kind of renewal is involved." The usual response to such questions relates to the actions of an individual teacher in his or her classroom. Such a response is inadequate. We must examine these questions in the context of both the total program of the school in which the teacher works and the nature of the particular curriculum change being sought. Such considerations also lead to the questions of who will provide the financial support for such a teacher center and what will be its form of governance. In other words, who will determine the nature of the program and its purpose? The reality base described in the activities of Dr. Butts' paper is necessary but we must go beyond this to analyze carefully what kind of an orientation these reality-based activities will take.

With these questions in mind, let us look at two specific topics that must be considered in attempting to find answers to such questions. One consideration is the variety of problems encountered in bringing about curricular change. An assumption here is that a renewal center, if it is to be vital, must take account of such problems and assist in producing the particular curricular change desired. Experience with many attempts over the past decade or more on the part of science educators to introduce new curriculum programs and related new teaching approaches, establishes how difficult this task really is. Many problems are encountered. At the elementary school level, for example, much of the problem seems to be related to the utilization of "hands on" materials. Such work with materials is at the heart of modern elementary school science, yet there is much evidence that the incorporation of extensive materials of this nature into classroom practice is one of the key obstacles to the utilization of the new science. For reasons that seem somewhat difficult to understand at times, "hands on" materials often are largely unutilized except within the context of some support or reinforcement which is external to a teacher's involvement with his or her particular class of students.

This relationship of the problems of implementing curriculum change and conditions external to the given classroom leads us to a second area of consideration. Any attempts to bring about teacher renewal must be related in tangible ways to the total school program. Professor Butts began his paper with the statement that "teaching is a lonely task," implying that the teacher largely works in isolation. I would not disagree with this statement but would suggest that it may be the source of much of the difficulty of implementing curricular change and that we cannot afford to accept this assumption as a basis for operation. Attempts to bring about curriculum change must be done in the context of the total school setting and be viewed as a cooperative venture on the part of teachers and administrators within a given school. Much of the work that is being done in staff and organizational development today should be of interest to us in this regard. The process of bringing about change in an educational organization is receiving extensive attention today and the results of such study are relevant to our concern with establishing a teaching center. Attention must be given within a particular school to the educational goals being sought and the process by which they are identified and translated into actions that are evident in the instructional program. If the activities of a teacher center are to have an impact on learning, they must be related to these overall activities which take place (or should take place at least) in a particular school.

In summary, the teaching center idea has a lot of promise. Whether or not it will work in practice is highly dependent upon its relationship to the various groups involved in its operation and the total educational process it is designed to influence. Persons attempting to establish one need to give careful attention to the literature in organizational development, educational planning and the process of curriculum change. As science educators we know a great deal about teaching science. If we are to put our knowledge into operation in American education, we must understand more fully the dynamics of the educational system we are trying to impact and the processes by which change can be brought about in it.

CHAPTER 5

ELEMENTS OF SCIENCE TEACHER EDUCATION ABSTRACTED FROM THE ERIC-AETS: IN SEARCH OF PROMISING PRACTICES IN SCIENCE TEACHER EDUCATION

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Introduction

In Search of Promising Practices in Science Teacher Education, referred to herein as SPPSTE, was initially made available at a forum on science teacher education during the 1973 Annual Meeting of AETS and NSTA. The ERIC publication resulted from a joint project of AETS and the ERIC Information Analysis Center for Science, Mathematics and Environmental Education at The Ohio State University. The project's purpose was to obtain information about the status of science teacher education and to identify practices, and ideas for practice, which appear promising. The AETS membership (approximately 600) and a sample of the membership of the American Association of Colleges for Teacher Education (approximately 400) were asked to participate in the project by providing a brief program description, listing available materials, and responding to a special scheme, or format. Fifty responses, a return of approximately five per cent, are included in the body of the report. Sixteen abbreviated responses, listing such things as available materials and references to programs, but not including a program description or completing the special format are listed in the appendix.

The special scheme or format was described with the following equation which relates elements of a program or course:

$$\text{Content} + \text{Strategy} \longrightarrow \text{Outcomes(s)} \rightleftarrows \text{Evidence}$$

"Questionnaire respondents were asked to complete a four-column format and were asked to list under:

CONTENT — One or more major idea(s) from the conceptual framework for your science teacher education program

STRATEGY — for each major idea, the teaching strategy used (NOT just the "method" used to implement the idea)

OUTCOME(S) — from the major idea and strategy stated, list the outcome(s) you intend for your teacher candidates

EVIDENCE — the observable evidence you would accept, to establish that your teacher candidates have attained the outcome(s)" (1)

The Task

While consideration of SPPSTE was given at the AETS forum, it was thought that some useful ideas might subsequently be abstracted, summarized, and presented to the membership through a position paper. More specifically, the task was seen as: (1) systematically abstracting information from the fifty contributions which followed the suggested format; (2) describing elements of typical science education programs; (3) expressing some general impressions of the contributions to the report. It was hoped that the position paper would revive interest in the document lest it become part of the history of science education before its potential contemporary usefulness has been realized.

Abstracting Information

After an initial reading of the contributions comprising the document, a check-sheet was devised to systematically abstract information. This check-sheet was completed for each contribution following a second reading. The choice of items for the check-sheet reflects this position paper author's interests and concerns. Identification of the check-sheet items and a brief rationale for several of the items follow. From the onset the reader should bear in mind that the abstracting process is highly subjective and that the original contributions being abstracted include subjective data themselves.

The Check-sheet

The recent decrease in demand for teachers suggests, among other things, that teacher education programs should shift a greater portion of their resources toward meeting long neglected in-service needs. The first item on the check-sheet was used to classify each contribution as focusing on pre-service education, in-service education, or both.

In following the suggested four-part format, only one major idea from a course or program was typically submitted. Thinking that the choice of the major idea(s) might provide some indication of priorities, an attempt was made at classification. One of the first seven categories that follow seemed to fit most of the ideas:

1. Processes of science
2. Science content
3. New science curricula
4. Methods and materials
5. Decision making
6. Psychological or philosophical considerations
7. Nature of science
8. Other

An attempt was also made to classify the strategies identified to achieve the major content idea(s). Student centered, teacher centered, and subject centered were the categories utilized. It was hoped that these categories would provide some indication of student and professor roles and the extent to which students are actively involved in the instructional process.

To classify the outcome expected after employing the strategy, the dichotomy of behavioral or non-behavioral was chosen. This same dichotomy was used for classifying the evidence that the outcome had been achieved. It was thought these results might reflect the popularity of behaviorism in science teacher education.

An assessment of the extent to which each submission reflected a competency-based approach seemed in order in view of the attention the movement has drawn. Categories labeled (1) definitely not, (2) some experimentation, and (3) extensive experimentation to total implementation were utilized.

The departmental affiliation of the person submitting a report was classified as:

1. science
2. education
3. joint
4. undetermined

The motivation for including this item will be identified in the Discussion section.

Rounding out the check-sheet were the following seven questions:

1. What indication is given of attempts to better integrate the science and education components of the program?

2. What indication is given of attempts to integrate science with other curriculum areas such as mathematics, the social sciences, the humanities and technology?

3. What indication is given of attempts to make science teaching more humanistic?

4. Does the description indicate that a considerable emphasis is being placed on science processes as well as science content?

5. To what extent does the program appear to support an inquiry approach to science teaching?

6. Does the program attempt to utilize an inquiry approach in its instruction?

7. To what extent does the program attempt to practice individualization?

The check-sheet utilized the categories, (1) none to token effort, and (2) moderate to strong effort, for each of these questions.

Results

A summary of the check-sheet results follow. Results for the elementary and secondary levels have been listed separately as well as the totals for these two levels combined. The four programs identified as including K-12 have been included with the elementary group. A few entries included only a program description; they do not contribute to items 2 - 5. Up to three ideas from a given entry were included in item 2 when more than one idea was given and the ideas were not classified identically.

	Elem.	Sec.	Combined
1. Pre-service (some program descriptions listed	18	22	40
In-service both pre-service and in-service)	10	6	16
2. Classification of sample major idea(s) chosen:			
a) Processes of science	3	2	5
b) Science content	4	4	8
c) New curricula	1	1	2
d) Methods and materials	12	9	21
e) Instructional decision making	1	1	2
f) Psychological and/or philosophical considerations	3	2	5
g) Nature of science	5	2	7
h) Other	2	3	5
3. Classification of strategy(ies) to achieve major idea(s)			
a) Student centered	19	12	31
b) Teacher centered	1	5	6
c) Subject (content) centered	3	5	8
d) Unable to classify	1	4	5
4. Classification of outcome(s)			
a) Behavioral	5	3	8
b) Non-behavioral	18	18	36
c) Included both kinds of statements	1	5	6
5. Classification of evidence			
a) Behavioral	14	7	21
b) Non-behavioral	9	14	23
c) Included both kinds of statements	1	5	6
6. Is program/program component competency based?			
a) Definitely not	13	16	29
b) Some experimentation	6	5	11
c) Extensive experimentation and implementation	5	5	10

	Elem.	Sec.	Combined
7. Report made by professor affiliated with:			
a) a science department	4	4	8
b) an education department	17	19	36
c) both a science and an education department	0	2	2
d) unable to classify	3	3	6
8. Integration of science and education			
a) None to token	8	16	24
b) Moderate to extensive	16	10	26
9. Integration of science with other curricula areas or disciplines			
a) None to token	21	24	45
b) Moderate to extensive	3	2	5
10. Described efforts to make science teaching more humanistic			
a) None to token	18	14	32
b) Moderate to extensive	6	12	18
11. Seemed to place considerable emphasis on process as well as content			
a) None to token	3	12	15
b) Moderate to extensive	21	14	35
12. Advocated inquiry approach to instruction			
a) None to token	3	5	8
b) Moderate to extensive	21	21	42
13. Appeared to practice inquiry approach			
a) None to token	3	7	10
b) Moderate to extensive	21	19	40
14. Appeared to practice individualization			
a) None to token	11	11	22
b) Moderate to extensive	13	15	28

General Impressions

Before discussing specific item results from the check-sheet, the expression of some general impressions seems appropriate. The focus of the AETS Publications Committee in planning SPPSTE was science teacher education programs and courses. However, several reports that were included in the document focused exclusively on a single course. Other reports gave passing attention to various components of a program but devoted major attention to a single course.

At best one gets a general idea of how a course or program actually functions from reading a brief program description. The descriptions typically include an abundance of general statements with a fair amount of educational jargon. The supposed strengths are likely to be much more obvious than the suspected weaknesses.

The document lists contributing institutions that enjoy reputations for outstanding programs. However, it should be noted that all such institutions did not follow the suggested format, and still others did not contribute to the document at all. The author chooses to avoid singling out a specific program or institution in this paper.

Discussions of Results

Four reports in the elementary group indicated that the program served both a pre-service and an in-service function; two reports in the secondary category also employed th . dual classification. Approximately 29 per cent of the combined entries are in-service. If this is a fair indication of emphasis on in-service efforts, it is clearly inadequate. The needs of the profession in the next decade will require a much higher percentage of our resources for teachers already in the field.

Up to three major ideas from a given report were classified and included in the results for item 2 of the check-sheet. It is not surprising that the greatest frequency was obtained for methods and materials, since a "methods" course was the focus of most individual reports. One can infer that the instruction to choose a major idea from the conceptual framework for science teacher education was perplexing to many respondents. Most choices turned out to be closely related to the product or content goals of a course rather than the theoretical framework of a program. We need a prescription for our tunnel vision so that we can "think program."

It is appropriate that the strategies employed to achieve the major ideas typically involve the student in activities that place responsibility on the student for his learning. The results of item 3 indicate one is more likely to find the teacher or the content to be taught in the center of the stage in the secondary programs when compared to elementary programs. I find this apparent difference understandable but inexcusable.

Most of the statements of outcome were classified as non-behavioral. A statement that utilized an action verb calling for some overt response on the part of the student was classified as behavioral, even though the statement may not have met other criteria often applied. More of the statements of evidence that outcomes had been achieved were apparently behavioral at the elementary level than at the secondary. This result is a bit perplexing in view of the fact that about the same percentage of programs at both levels were involved in experimentation with competency based programs or program components. However, no major secondary science curriculum project has utilized behavioral objectives to the extent of Science - A Process Approach at the elementary level, which might be a major factor in explaining the result of item 5. Returning to the results of item 6, 42 per cent of the contributors are experimenting with competency-based programs or program components. This desirable result is surprising in the light of the many "cold prickles" given the movement at the forum last year. The skepticism of the profession towards extreme behaviorism is equally healthy and desirable.

Some of the most interesting discussions held at national meetings occur among a small group of people in a hotel lobby or lounge. One apprehension extressed in more than one such discussion is based on the perceived recent heavy movement of university science faculty into teacher education. It has been hypothesized that the alleged movement has resulted from the bleak job market for university science faculty, which is related to declining enrollments in university science classes and tighter research funds. While education-science cooperative efforts are considered essential to successful science teacher education programs, it is feared that some university science faculty are now assuming roles in teacher education they are not qualified to fill. This concern prompted the inclusion of item 7 on the check-sheet. The obtained frequencies in themselves shed little light on the question, since the sampling method would be expected to result in a majority of the invitations to participate reaching faculty associated with an education department. However, this concern should receive serious consideration by AETS.

The integration of science and education is generally inadequate. Most of the integration that occurs is accomplished in special method courses. Attempts at integrating educational philosophy, developmental psychology and learning theory with science content, process and material selection seem greater at the elementary level.

The lack of integration of science with other curriculum areas or disciplines at both the elementary and secondary levels is appalling. The lack of integration is one of the biggest deficiencies in teacher education. Mathematics as a tool is most often integrated with science, if integration occurs.

The secondary people have been doing more talking about making science teaching humanistic. Recently developed secondary curricula, such as Project Physics, which reflect a more humanistic approach have probably exerted a strong influence on the extent to which humanism is now valued and espoused at the secondary level. While recently developed curricula at the elementary level, such as SAPA, ESS, and SCIS, are much more humanistic than traditional elementary curricula in that they are less likely to deprive a child of his childhood, they do not make extensive claims of being more humanistic. Efforts to make science teaching more humanistic at all levels should be accelerated.

Elementary science education long ago discovered process and appears to generally place a heavy emphasis on it. While more reports at the secondary level placed little or no emphasis on process in program descriptions, the heavy emphasis on inquiry, evidenced by the results of items 12 and 13, indicates that processes of science are generally receiving considerable attention at all levels. The profession's wide acceptance of process goals is one of its most outstanding achievements of the last decade.

It is also a tribute to the profession that so many institutions are attempting to practice inquiry in their science teacher education programs as well as advocating it for the eventual use of their teacher candidates. On the check-sheet inquiry refers to allowing the student to structure an investigation with a large measure of independence; the teacher serves primarily as a facilitator. Further, an inquiry approach as considered here implies that the prospective learner is actively involved in an investigation; he is not relegated to the role of passive recipient of information.

A considerable amount of verbiage was devoted to the merits of individualizing instruction in SPPSTE. The term obviously has a variety of meanings to science teacher educators. A disappointingly large number of reports seemed to equate individualized instruction with independent instruction. For classification on the check-sheet, individualized instruction was defined by the following criteria: 1) The instruction is self-pacing. 2) The instruction is of interest to the learner. 3) The instruction is psychologically appropriate. With these criteria in mind and loosely applied, 56 per cent of the respondents appeared to have made moderate to extensive progress in providing individualized instruction. In the absence of base-line data one can only express a hunch that a fairly large movement toward individualization has occurred in the past decade. Science curricula such as ISCS and Project Physics have surely promoted individualization in teacher education, as has the competency-based movement. However, the work is unfinished and we should get on with it.

While the report may reflect a somewhat greater emphasis upon the integration of field experiences into more components in teacher education, there seems to be more support for the idea than actual implementation. Token efforts included visits that were apparently not related in any specific way to what was going on at the university campus. Institutions experimenting with competency-based approaches were frequently attempting greater integration of field experiences. Future efforts should focus on controlling the quality of the field experiences, if an increase in quantity is to be productive.

Conclusions

The most popular elements of science teacher education reported in SPPSTE are not in themselves an adequate basis for synthesizing a model science teacher education program for the future. They would be more appropriate for planning a good elementary or secondary science methods course. That would be a worthwhile activity, if it did not deter us from addressing the greater need of facilitating the development of a program which strongly integrates professional education, the arts and sciences contributions and the pre-college classroom. I say facilitating because the actual development will require a team representing all parties involved.

In far too many teacher education programs the elementary science methods course has only a vague connection with what the student experiences in course work dealing with the social and philosophical studies of education. The connection is likely as vague for what the student experiences in the language arts course. The science taken in arts and sciences probably appears quite remote from what's happening in the elementary methods course. All of that may have little to do with what's occurring in the elementary classroom where the student will teach.

At the secondary level analogous deficiencies exist. Granted the science courses taken for the major include content and processes that are relevant for the future teaching assignment, but the student too infrequently gets help in deciding what is relevant, when, for whom and why. Any integration of the social sciences, humanities, arts or technology with science is likely to be incidental. From where will teachers come to teach the Environmental Studies, Human Sciences, Individualized Science Instructional System, and other multidisciplinary curricula? Clearly we must be about reducing these deficiencies.

SPPSTE reveals a great deal about the "state of the art." It should be useful in establishing priorities for action by individuals, faculty teams, institutions, and professional organizations.

Reference

1. In Search of Promising Practices in Science Teacher Education. ERIC Information Analysis Center for Science, Mathematics and Environmental Education. Columbus: The Ohio State University, March 30, 1973.

REACTION

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The assignment of analyzing, synthesizing, and reacting to the ERIC-AETS document represents a formidable task. For his analysis, the author developed a checklist and categorized each "model program" according to the criteria which he felt to be important and according to the data which were provided in the original document. The items which w re examined reflect the interests and concerns of the reviewer; however, he criteria used in analyzing the document are consistent with concerns commonly voiced among science educators. While other individuals might have selected other or additional items in making their analysis, the questions examined by the reviewer reflect legitimate and current concerns of the science education community.

One of the major concerns discussed at the AETS session dealt with the lack of integration of instruction within departments of education and between science and education departments. There was general agreement that this represents a major obstacle in our teacher education endeavors. Participants related experiences in which they had attempted to deal with this problem through team teaching and increased communication among college and university faculty. While this was only one of several issues raised in the presenter's paper, it apparently was of immediate concern to the session participants. On the basis of their response to this problem, it seems appropriate that AETS or other agencies study additional ways of planning and implementing more highly integrated programs.

Just as there were concerns relating to the implications of the original document, there will be similar questions related to the position paper. These questions primarily deal with the manner in which the document and position paper will be utilized. There should be concern with the validity of the findings on the basis of the number of contributions to the original document and the selectivity which was involved in submitting sample portions of teacher education programs. The position paper author recognized these limitations in his review. This is not meant to say that the document or position paper lack value, but that they should be interpreted with an awareness of the described limitations. Perhaps the most meaningful contributions of the paper will be the discussions which will evolve from points raised in the author's paper. Trends and concerns, such as the one previously mentioned, are identified in the paper which should give direction to future AETS study and action.

In a meaningful and commendable fashion, the author has condensed a large volume of material into a more manageable form. The author's opinions and reactions to the findings are quite candid and should be of concern to the membership of AETS.

PART II

HUMANISTIC EDUCATION

CHAPTER 6

SOCIAL PSYCHOLOGICAL CONSIDERATIONS FOR SCIENCE TEACHER EDUCATION

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Social psychology centers on the behavior of individuals, both their group and personal interactions. More specifically, it is concerned with individual beliefs, attitudes, values, perceptions, motivations and cognitions as these relate to and influence group and interpersonal dynamics. Many concerns of social psychology are also concerns of humanistic psychology [(3), (21)].

Since social psychology is directly related to the individual and to factors influencing interpersonal and group dynamics, and since science teachers continually function in situations requiring effective interpersonal and group dynamics, it seems that discussing the importance of social psychology for science teacher education programs would be like the proverbial carrying of coals to Newcastle. The question then is not whether social psychology is important, but how to include some aspects of this discipline in the education program for future science teachers.

The essay discusses several research studies have completed on perceptions of effective teaching in which social-psychological factors were ranked as important variables and specifically isolates factors perceived as most important. These factors were enthusiasm in teaching and adequacy of personal relations. The essay also presents some social-psychological implications for science teacher training.

Perceptions of Effective Teaching

Over the past five years I have sampled approximately 500 people from several populations, using a 50-item Q-sort designed to investigate perceptions of a good or ideal teacher. The results are summarized here; the studies have been reported elsewhere [(2), (4), (5), (6)]. These studies are also generally corroborated by the results of other investigations of related topics [(1), (11), (23)].

The populations sampled in this survey included: upper elementary students, disadvantaged, average and gifted secondary students, paraprofessionals, undergraduate education majors, elementary and secondary teachers and graduate students in education.

The 50 characteristics or behaviors of teachers examined through the Q-sort were classified into 5 major categories. The categories were: <u>knowledge and organization of subject matter</u>, <u>adequacy of relations with</u>

students in class, adequacy of plans and procedures in class, enthusiasm in working with students, and adequacy of teaching techniques and methods.

Analysis of the Q-sort items arranged the five categories in the following order.* (Category one was considered most important and category five least important.)

1. Adequacy of Relations with Students in Class

2. Enthusiasm in Working with Students

3. Knowledge and Organization of Subject Matter

4. Adequacy of Plans and Procedures in Class

5. Adequacy of Teaching Techniques and Methods

The first two categories involve the social-psychological dimension of teaching while the latter three concern the more impersonal dimensions of teaching. I think this is the important division and the one that constitutes the argument of this essay. When these results have been presented to various groups, the persistent question is, "How do you include enthusiasm or personal relations in a teacher education program?" This is a fair question, and this short essay is my attempt to answer. I plan then to discuss only the two dimensions closely related to social psychology: enthusiasm in teaching and adequacy of personal relations.

This discussion should not be perceived as an either/or dichotomy; either science education for knowledge, planning and methods or science education for enthusiasm and personal relations. I want to make it clear that my intent is not to dichotomize this issue. I am simply addressing myself to the issues that are perceived as important and seem to receive little emphasis. The results cited above are a relative ranking. All five categories are necessary for a science teacher, and no argument is made against the inclusion of Teaching Techniques and Methods because it is ranked last, nor for that matter am I arguing against programs which emphasize knowledge and planning. The argument that is developed in the remainder of this paper is basically that teacher education programs in science should also include the social psychological dimensions of teaching. Most teacher education programs in science presently emphasize competency of scientific knowledge, of planning science activities and of appropriate methods for teaching science. These conditions are necessary, but they are not sufficient. The personal and interpersonal dimensions of teaching are also perceived as important aspects of effective science teaching and thus should be given emphasis in the pre-service program.

*The arrangement cited here is a grand mean arrangement, that is, it is the ranking for all samples. For individual samples there was some variation between the ranking of the top two categories, i.e., whether adequacy of personal relations or enthusiasm in working with students was ranked first or second. Also, there was variation in the ranking of the remaining three categories

As an introduction to the sections on teacher enthusiasm and personal relations, I would like to relate an anecdote of a young woman just starting her teaching career. The anecdote points out the importance of all five components of teaching discussed above and gives particular emphasis to the humanistic dimension of education.

Kris was in a seminar I taught and seldom spoke unless she was asked a question, then she always replied politely and succinctly. One day Kris was in my office and I asked her to recall the most rewarding experience thus far in teaching. After a moment's thought a rush of energy came over her as she related her story. There was a juvenile delinquent, age 16, who had been truant for three weeks and was about to be expelled. The office had required his accountability during each hour of the day, and he was thus to report to Kris during an otherwise "free period." After several days she got to know a little about the young man; they talked about things of interest to both of them, he about hunting and cars, she about Soviet history. As she put it, "I showered him with enthusiasm for Soviet history." He has now read several books on Soviet history as well as authors like Dostoyevsky and Solzhenitsyn, books any teacher in school would have argued were beyond him.

Let me turn from the specific story to my points on enthusiasm and personal relations. I found out later Kris was a transformed person when she was teaching, whether it was in front of a class or with an individual. She loved Soviet history and projected this fascination through a teaching style that could only be described as enthusiastic. Her movements, her use of the blackboard, her animations and her eye contact all indicated enthusiasm, but most of all it was her face. One look and you just knew how excited she was about her subject.

Kris was also excited about her students. She knew what was important for her and recognized what was important for them. She dealt with the young man in a way that showed respect for him and his interests; she recognized the things that gave significance to his existence. Yet, she did not compromise her standards and values. The personal relations between Kris and the young man were good; she shared her ideas and herself at a time when he needed someone to listen and understanding him. The personal relationship took the student from the apathy of a truant to a position of enthusiasm for a new subject.

This young teacher knew her subject, planned well, and used appropriate teaching methods. She also had demonstrated enthusiasm for her subject <u>and</u> her students. In the past decade we have gained new information about the helping relationship in teaching. The areas of personal relations and enthusiasm are not as clearly defined as subject matter, but they are at least as important. The next sections describe some of the research in these areas.

Enthusiasm and Teaching

The enthusiastic science teacher seems to be immediately recognizable to most individuals; however, we have had some difficulty in describing the characteristics of these teachers and even more difficulty with the elusive problem of instilling enthusiasm in pre-service teachers. Let me turn to two difficult questions: "What is enthusiasm in aching?" and "What can be done in the teacher education program to make an individual enthusiastic?"

Enthusiasm in teaching science is observed in an individual's zeal, fervor and excitement. The teacher's behavior indicates an inspiration for teaching. I have also noted one further distinction, the enthusiasm is for the students and the subject.

It is possible to be more specific about teacher enthusiasm. Rosenshine has reviewed the research on enthusiastic teaching and described some specific qualities that contribute to understanding enthusiasm in teaching (25).

Rosenshine discussed studies that compared the cognitive gain scores of students and various enthusiastic teaching behaviors exhibited by the teachers with whom the students were studying. The review is divided between high inference studies and low inference studies. Rosenshine described the differences between high and low inference studies and the results of the studies in the following way. High inference indicated enthusiastic teaching in more general categories of teaching behavior such as: energy, dynamism, imagination and stimulation. Results of the high inference studies were very consistent. The results indicated that patterns of teaching behavior aligned with enthusiasm as described above are significantly related with student achievement.

Low inference measures used more specific teaching behaviors and generally positively influenced student achievement. For example, the teacher's use of questions which focus on interpretation of material, the teacher's use of a speaking voice which is not monotonous but which is conversational and relaxed, the teacher's use of praise and encouragement, and e teacher's use of non-authoritative, personal methods of control are more concrete than the high inference categories cited. Teacher beha rs such as gesturing, moving and animating also positively influer student achievement.

rch indicates that enthusiasm both broadly and narrowly defined does correlate with pupil achievement; fu er, some of the specific behaviors are identifiable and can be incorporated into teacher training. The studies reviewed by Rosenshine used cognitive growth as positive evidence that enthusiasm in its various forms is related to effective teaching. I would also posit the testable hypothesis that a teacher's enthusiasm, as described above, would have a positive influence on a student's self concept and attitudes toward the class. Implications of Rosenshine's research will be discussed later; first, however, is a discussion of personal relations and teaching.

Personal Relations and Teaching

Effective teaching is more than just enthusiasm; it also includes the whole range of the teacher's personal relations with students. There are two dimensions of personal relations that are important. The first is the personal attitudes and values of the teacher, for they have a definite influence on the interpersonal relations of the teacher. The attitudes, values and beliefs of a teacher can form a tacit dimension of teaching that, in my estimation, is often more important than other factors such as methods, materials or knowledge of subject matter. Research completed by O. J. Harvey, a social psychologist, has indicated a relationship between the teacher's belief system and classroom atmosphere and student behavior. Harvey's studies will be discussed in this section. The second aspects of personal relations in teaching is the actual interaction between the teacher and individual students or groups of students. The research of Arthur W. Combs has provided some information on the personal aspects of teaching; this too will be discussed in this section. It is first important to clarify the differences between attitude and value.

Attitudes are predispositions of behavior toward an object or referent in the environment. Attitudinal predispositions toward objects include enduring organizations of the perceptual, motivational, emotional and cognitive dimensions of the individual. The object can be almost anything; it can be either concrete or abstract, but is usually of social importance, e.g., education, science, minority groups, sex or oneself. For example, attitudes would influence a teacher's performance, perception, thinking and feeling toward ninth grade rural science students.

Values are culturally weighted preferences for some behavior, object, institution, person or group of persons. Values are the goods/bads, ought/ought nots, should/should nots toward the objects or referents in the environment. Values can be thought of as a positive or negative vector of an attitude. For example, the values a science teacher has toward ninth grade rural science students would reflect a cultural preference for what is desirable or undesirable for these students.

Belief Systems and Teachers

The work of O. J. Harvey has pertained to individual belief systems. Belief systems, as Harvey uses the term, are "deeply held attitudes or values" (15). He defines beliefs further: "A belief system represents a set of predispositions to perceive, feel toward and respond to ego involving stimuli and events in a consistent way" (16). The belief system acts as a psychological filter; it renders a perception of the world and, from the immediate environment, it selects what is attended to, what is discriminated against, and what is valued. Harvey has isolated several levels of belief systems in his studies. The following are the important aspects of four basic systems.

Beliefs of a System I level are characterized by concreteness, absolutism, simplistic analysis of problems and strong positive attitudes

Classroom Atmosphere

In the first study by Harvey and others (13) efforts were made to determine the effect of teachers' belief systems on the classroom atmosphere for pre-school children. There were 30 teachers in the study, 10 each of Systems I, III and IV. There were no teachers reported at the System II level. (This is not a fault of the research; Harvey has reported an absence of people with this belief system in education.) Classroom atmosphere was rated by two independent observers each visiting for approximately two and one half hours. The rating scale used items that reflected educationally desirable and undesirable behavior toward children. Abbreviated examples of the categories on the rating scale include: warmth, perceptiveness, flexibility, relaxed interaction, attention to individuals, consistency, punitiveness, anxiety, rule orientation, functional and unfunctional explanation of rules, ingenuity, creativity, and task effectiveness.

The initial hypothesis was that System IV teachers would score higher than System I teachers on all positive items and lower on the negative items, e.g., punitiveness. Further, System III teachers would score between the other two systems. Results indicated the hypotheses were correct; there was an overall statistically significant difference between teachers of different belief systems and ratings for their respective classroom atmosphere. Systems I and IV were significantly different on most dimensions. A cluster analysis also revealed differences in the extreme systems. System IV teachers scored high on fostering exploration and low on dictatorialness; this result was reversed for the System I teachers; they scored high on dictatorialness and low on fostering exploration. Harvey went further with studies of this nature; he investigated the influence teachers of different belief systems had on student behavior.

Student Behavior

The second study completed by Harvey and others (14) replicated portions of the study cited above and extended the design in an attempt to determine the influence of a teacher's beliefs on student behavior. The first portion confirmed the earlier study, demonstrating a correlation between the teacher's belief systems and the educational atmosphere. There were some modifications in the second study. Due to a small number of teachers (n = 90) and a reduced number of System IV teachers, two major categories were used. All System I teachers were in a group labeled more concrete and all System III and IV teachers were in a group of more abstract. Only one independent observer visited and rated both the teacher and student behavior. As it turned out there was higher reliability with this technique. The original teacher and student rating scales were later factor analyzed and reduced to a minimum of items. The teacher scale was discussed above (resourcefulness, dictatorialness, punitiveness); the collapsed categories on the student scale were: cooperation, involvement, activity, nurturance seeking, achievement, helpfulness and concreteness.

In an analysis among teacher behaviors and student performance, the following results were obtained. Teacher resourcefulness correlated significantly and positively with cooperation, involvement, activity and achievement by students. A negative correlation existed between teacher resourcefulness and concreteness of student responses. Dictatorialness by the teacher correlated negatively and significantly with student cooperation, involvement, activity, achievement and helpfulness. This was reversed for student's concreteness of response, that is, concreteness of student response correlated positively with teacher dictatorialness. Finally the teacher's punitiveness correlated significantly and negatively with cooperation, activity, involvement, achievement and helpfulness. Again, this was reversed for concreteness of student responses.

In summary, the first study indicates teachers with more abstract and open belief systems generate different atmospheres and manifest different approaches, at least at the pre-school level. The results of the study demonstrated that more abstract teachers "were clearly superior to the more concrete teachers in the extent to which they produced what are presumed to be educationally desirable atmospheres in their rooms" (14).

Replication of the earlier study, with similar findings, clearly demonstrates the relationship between the teacher's belief system and classroom climate. The latter study demonstrated a relationship between the teacher behavior and student behavior,* the important implication being in the correlation between the more open abstract beliefs systems of teachers and the more desirable student behaviors.

It would seem there are several social-psychological and educational implications of these studies. The first would be isolation of the causation problem. To what degree does the teacher behavior cause student behavior as outlined and described earlier?

The second level of implications would consist of those based on the assumption that teacher behavior does cause, to some degree, student behavior and classroom atmosphere. If this is true, teacher education programs should be concerned with the development of more abstract open belief systems with the characteristics of individuals as a goal.

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*Caution should be exercised in arriving at the most immediate conclusion. There is a correlation between teaching behavior and student behavior: however, this does not necessarily show causation. Student behavior could cause teacher behavior; a third factor, such as environment, could determine the behavior of both or, perhaps, an interaction of all could be the cause for the observed behavior. Harvey is aware of this and does address himself to the problem.

Perceptions of Effective Teachers

I think the research completed by Harvey can be extended in a further direction. If we can answer the question, "What are some of the desirable beliefs, attitudes and values effective teachers have toward self, other people and the teaching relationship?" then teacher educators will know a little more about some factors that influence the social psychology of the classroom.

Arthur W. Combs has been pursuing an answer to the above question [(8), (9), (10)]. Combs is a perceptual or phenomenological psychologist and uses this orientation as a basis for his studies. The perceptual orientation of an individual gives recognition to beliefs, attitudes and values, and the influence these have on behavior. The perceptual psychologist would also recognize situations occurring in the environment, an individual's knowledge and, in particular, the interaction of these factors that result in individual behavior.

The results of Combs' research show that effective teachers essentially have positive views of themselves. They have good self concepts; they identify with people; and they see themselves as able, worthy and dependable individuals. The effective teachers' perceptions of other people (including students) are that these people too are friendly, able, dependable and worthy. Central to these teachers is a concern for other people and the views and perceptions other people have of the learning situation. Perceptions of the effective teacher relative to the helping relationship is one of developing the student, not one of controlling the student: accepting rather than grouping or classifying the student; and concern for the discovery of personal meaning, new information or experiences of the student.

The dynamics of teaching include social-psychological factors as well as information, method and planning factors. Enthusiasm and adequate personal relations have been discussed in this essay as two important social-psychological components of teaching. The research concerning enthusiasm has isolated several factors that imply additions or modifications of teacher education programs. Research has also given some clarification of beliefs, attitudes, values and perceptions as these relate to the adequacy or inadequacy of the personal relations of a teacher. In the final part of the essay I will describe some suggestions and implications for teacher education.

Implications for Science Teacher Education

The research on effective teaching indicates a wide variety of methods, techniques, knowledge and skills; however, there seems to be two areas of commonality among the variety, enthusiasm and adequacy of personal relations. Enthusiasm and personal relations are probably both the most important and the most difficult aspects of teaching. It is for the first reason that they should be included in the education program for science teachers; because of the second reason they have not been emphasized in science teacher education.

Enthusiasm in Science Teacher Training

Most pre-service teachers are excited and enthusiastic about the possibility of working in a helping relationship. The first implication is to keep the enthusiasm fresh and continuing in the pre-service science teachers. I have seen, however, this enthusiasm reduced through pre-service experiences. As an illustration of this, I recently had a very capable young woman spend three hours grading papers in her first field experience in a local classroom. It took some encouragement to persuade her to return for a second day. Now I understanding that evaluating papers may be an important part of teaching, but certainly the introductory experience for a pre-service teacher could not have done much more to reduce enthusiasm. The structure of some programs is such that one's enthusiasm is diminished, if not extinguished, by the time the neophyte is ready for student teaching. We, as teacher educators, can prevent some of the reduction in enthusiasm by the evaluation of our present program. In designing the program of experiences for the pre-service science teacher, we should recognize the importance of enthusiasm and emphasize it in the program as much as subject matter, methods and planning.

A second suggestion is to let students experience role models of enthusiastic teachers. As I was entering education, this is the main lesson I learned in my methods course. The teacher had such fervor and zeal that I responded to it as well as to other basics such as using the overhead, giving a demonstration, and writing a unit plan. The observation of enthusiastic teaching could, hopefully, continue through the field experiences of the pre-service science teacher. One of the ways we learn is through imitation, and I suspect this is true when it comes to the acquisition of a syndrome of teaching behaviors. The continuous exposure of the pre-service science teacher to models of enthusiastic teachers will help develop some of the desired behaviors.

Third, during the methods course, importance should be placed on qualities of enthusiasm: the more holistic qualities such as zeal, surgence, stimulation and energy, and the more specific behaviors of asking questions, voice inflection, mobility, animation, praise, eye contact and gesturing. Again, let the science students know that enthusiasm is important and give feedback relative to their enthusiasm.

The specific implications for the education of science teachers are:

1. Recognize the importance of enthusiasm and attempt to maintain or develop enthusiasm of pre-service science teachers through continual emphasis.

2. Provide role models of enthusiastic science teaching through selective field placements and the science methods course.

3. In science methods and supervision of student teaching, place emphasis on the general qualities such as energy, dynamism, zeal and stimulation and specific qualities such as questioning, use of praise, eye contact, gesture, and movement.

Adequacy of Personal Relations - The Individual Science Teacher

Studies from individuals researching the influence of social psychological factors in the classroom have demonstrated the influence of attitudes, values, beliefs and perceptions on the teachers' effectiveness. It seems logical then to help the teachers clarify their attitudes, values, beliefs and perceptions relative to themselves, students and the teaching relationship.

Dr. Frances Fuller at the University of Texas at Austin has found that the concerns of beginning teachers form a hierarchy (12). As teachers gain experience their expressed concerns progress through the following hierarchy. First, teachers are concerned about themselves as teachers. My interpretation of this level is that the science teacher needs to develop a sense of esteem and personal adequacy as a teacher; the teacher is most concerned about the possibility of self fulfillment through teaching. At the second level, the neophyte teacher is concerned with the task of teaching; that is, he is interested in the methods, materials, techniques and procedures of the teaching task. Finally, at the highest level the teacher is concerned about the impact he or she is having on the students. The teachers at this level ask, "Is learning occurring?" "Are the students learning what they need?" and "How can I improve myself?"

If this is indeed a hierarchy and if science teacher education follows the old adage "start instruction at the student's level of need," then it becomes clear that some type of interaction that would allow the exchange of personal anxieties, development of confidence, and clarification of beliefs, attitudes and values would be helpful for the teacher candidate. One implication then is provision of opportunities for these processes to occur. The question then arises, "How can the opportunities be provided in the science education program?" It seems the issues of teacher needs could be approached in three ways: first, through a human relations seminar; second, as a part of science methods; and third, during the supervision of student teaching. It may be that other departments are providing the human relations seminar, in which case the science methods course and supervision are the primary areas of concern for the college science educator. I shall discuss the three areas in the remainder of this paper with the recognition that some of the human relations components might be included in another segment of the program. If this is true, the ideas should certainly be reinforced in the science methods course and, in particular, in the supervision of student teaching.

Group meetings that center on processes such as those described above are not to be thought of in the same manner as the use of the overhead projector. These groups are serious; they serve an important function and should occur after the candidate has made an initial commitment to becoming a science teacher. Specifically, these introductory groups, "human relations" courses, can include discussions of beliefs, prejudices, attitudes and values in science education and may use value clarification techniques [(18), (22), (26)]. Some role playing, psychodrama and other self awareness experiences, all centering on the individual as a science teacher, could be incorporated.

During science methods courses some of the following techniques could be used to further the new teacher's personal awareness: role playing teachers of the various belief systems described by O. J. Harvey; structuring some vague and ambiguous situations in which the individual can assume different teaching roles; observing science teachers using different approaches and then discussing personal reactions toward the various methods, attitudes and techniques.

At the supervision level obtain feedback from student teachers concerning problems encountered ruring their field experience (19). I suggest using a list similar to the following and asking the student teachers to indicate the degree to which the item listed is a problem and the degree to which they need or are getting help from someone concerning the particular problem. The items are listed below.

1. Adapting to the needs of students
2. Adjusting to deficiencies in school equipment
3. Budgeting time and controlling tempo
4. Evaluating pupil achievement
5. Handling discipline problems
6. Handling routine classroom duties
7. Keeping official records and reports
8. Lacking command of subject matter
9. Lacking an effective teaching voice
10. Lacking poise and self confidence
11. Motivating pupils
12. Planning and organizing lessons
13. Presenting lessons
14. Understanding special services of the school
15. Understanding my role as a teacher
16. Adjusting to the different situations encountered while teaching

Responding to these items provides feedback to both the student and supervisor concerning perceived problems. This is another example of a means of helping the individual teachers approach a level of adequacy of personal relations through first understanding themselves, their strengths as well as their weaknesses.

Adequacy of Personal Relations - The Science Teacher and Students

The interpersonal aspects of teaching vary from the common everyday encounters to actual crises in the classroom. There are some techniques and methods about which teachers in training can be made aware. The difficult question of "Where should these be included in the teacher education program?" can be answered by suggesting these ideas be incorporated at the levels discussed in the last section: first, an introductory seminar in "human relations"; second, the methods course; and finally, the actual supervision of student teaching. Some very elementary qualities that aid in developing an interpersonal relationship are discussed below. The theoretical orientation is attributed to individuals such as Rogers (24) and Carkuff (7).

Understanding the Student

In order to effectively help students it is first important for the teacher to understand the students' frames of reference. If the teacher understands the students, there will be clearer communication and understanding.

Attending to the Student

In class discussions or office conferences, personal relations are best when the teacher actively attends to the students: physically, such as sitting facing the students and maintaining eye contact; psychologically, such as communicating interest and observing cues that may help you become a better helper; empathetically, such as giving full attention and listening to other people and responding to them in ways that indicate you are crying to understand the situation as they see it.

Responding to the Student

When responding, science teachers interested in personal relations are aware of the many things to which they are responding. For example, a teacher might respond to behavior, feelings, meaning, or subject matter, all as a result of the same questions from four different people. It is through attempts to understand the students' perceptions and careful attendance to students' comments and discussion that the teacher can respond in a manner congruent with the actual needs of the student.

Adequacy of Personal Relations - The Science Teacher and the Group

Probably the area of neglect that can most influence and help the beginning science teacher is that of group dynamics. In many respects the students function as a group or groups: for example, during laboratory activities. Changing from individual activities such as reading or listening to the teacher to group activities such as working on a science laboratory are often times when discipline problems arise. It is definitely to the teacher's advantage to have some working knowledge and experience of group dynamics.

Concepts related to group dynamics and actual experience in conducting group activities can be emphasized in methods courses, supervision and other education courses. Other more specific suggestions include: the observation and analysis of group process in actual science classroom; allowing students to lead group discussions in science classes or as a part of science methods; introduction of students to materials such as Learning Through Discussion (17); completion of a group dynamics lesson plan as well as subject matter lesson plan; investigating the social structure of a science class through sociometric techniques (20).

To this brief comment on groups I would add that teachers can use group techniques to bring about manipulation for the fulfillment of personal needs; also, students can form group standards, beliefs and codes of behavior that lead to problems in the classroom. The reverse is also true; understanding group dynamics can eliminate the competition between teacher and students and through cooperation lead to the development of all individuals.

In summarizing the development of personal relations for the future science teacher the following implications seem appropriate.

1. The science education program should provide for the individual needs of the pre-service teacher. Specifically, this can occur through a special seminar; during methods courses, and through the supervision of student teaching. This sequence roughly parallels the developmental hierarchy of perceived student needs: first, a motivation to learn about self as a teacher; second, a motivation to learn about specific techniques of science teaching; and third, a motivation toward having an impact on a result of teaching.

2. The pre-service program should provide science teachers an introduction to techniques and methods that will aid in the development of good interpersonal relations with students. As a minimum the future science teacher should be able to understand student perceptions, listen and attend to a student's discussion, and finally respond to the student's needs as expressed and understood.

3. Pre-service science teachers should have had experience with and fundamental knowledge of group dynamics as these dynamics relate to the specific problems of the science classroom.

In closing, I have developed an argument for two aspects of teaching that are, in my estimation, directly related to humanistic or social psychology. They are first, enthusiasm for teaching; and second, adequacy of personal relations in teaching.

Enthusiasm is an identifiable characteristic in both its larger, more general forms such as zeal, energy and vitality, and its more particular forms such as movement, pointing, animation, use of board and asking questions. These characteristics can be encouraged in teacher training as well as the attitudes and values that are a part of enthusiasm and personal relations.

Adequacy of personal relations starts with teachers understanding their own beliefs about themselves, students and teaching, and then includes working with students as individuals and students in groups. Again, teacher training has omitted some of these vital social psychological dimensions, and it is time they are included in the pre-service program.

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REACTION

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This essay is well written and documented. It offers an important contribution to teacher education. The author reports results of several research studies indicating that enthusiasm in teaching and adequacy of personal relations are perceived as more important qualities of an effective teacher than knowledge of subject matter and methods and techniques in teaching. Documentation of the author's thesis is provided by the results of his own research as well as that of others including O. J. Harvey, A. W. Combs and Frances Fuller.

I have no quarrel with the position the author has taken that enthusiasm and personal relations should be emphasized as a part of a science teacher education program. On the other hand, I think it should be recognized that these characteristics are equally important in any other profession that includes working with other human beings. Likewise, I think it should be recognized that none of these characteristics of a teacher: enthusiasm, personal relations, knowledge of subject matter, methods and techniques in teaching are mutually exclusive. Although the author's research shows that, in his studies, students ranked adequacy of teacher relations with students in class and enthusiasm in working with students ahead of knowledge and organization of subject matter, adequacy of plans and procedures in class and adequacy of teaching techniques and methods, I cannot help but wonder how these students would feel about a teacher who was enthusiastic about teaching a given subject but in fact knew very little about it. Perhaps we should ask the question, "To what extent are enthusiasm and knowledge of subject matter interdependent?" It seems to me hard to visualize a situation in which one would gain a reasonable knowledge of any subject matter without some enthusiasm for it and likewise, difficult to visualize how one could generate enthusiasm without adequate knowledge of subject matter. For this reason, I wonder how students would react if these different characteristics were posed in a circular arrangement rather than in a situation in which they were asked to rank most important to least important.

The second basic question which I would raise concerning this essay has to do with the mechanism by which enthusiasm and adequacy of personal relations could be built into the teacher education program. I think it is true that experts in the area of social psychology know a good deal about these characteristics. I also think that knowledge certainly is a prerequisite for building a teacher education program or any other program, for that matter, that will offer promise of improving these characteristics in the professional individual. Perhaps we need to concentrate more at this point in developing techniques for improving these characteristics rather than further justification of their importance. This position suggests that we may have sufficient research at this point (although I am not sure that we do) at least to begin development of techniques and materials for use in teacher education programs that will emphasize the important areas of enthusiasm and adequate personal relations. On the other hand, one of the questions we have to ask is "Will the techniques and materials developed actually improve enthusiasm and personal relations?" or "Are these characteristics so intimately tied to knowledge of subject matter and methods and techniques in teaching that we really cannot separate them out in a teacher education program?" If Professor Bybee's essay will trigger development of new techniques and materials in this area, I think it will have made an even more important contribution than it already has made in calling our attention to certain important characteristics of a good teacher.

CHAPTER 7

HUMANISM, SCIENCE AND EDUCATION

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Introduction

In recent years the concern for the experiencing individual has grown enormously. Countless articles, books and reports of various types have been written for various purposes, all of which can broadly be classified as dealing with humanistic psychology. A high proportion of the authors are in some way related to science or science education. In the wake of an antiscience climate, scientists and science educators have emerged on the forefront of what has become known as the "third force in education." The other two psychological forces are classical Freudianism and positivistic behaviorism. As was the case with the curricular movement of the 50's and 60's which upgraded the education of millions of young Americans, science education is again spearheading major reflective thought in education.

Perhaps the weakest link in the past decade of curriculum development was the inability of developers to successfully modify teacher education. It is hoped that members of the Association for the Education of Teachers of Science and others associated with curriculum development for teacher education will give serious attention to the third force movement when considering modification of teacher education programs to accommodate the future needs of science teachers and science teaching.

In this paper I hope to review the nature of humanism as evolving from the humanistic psychology movement, describe the nature of science as related to humanism, discuss the role of humanism in science education, and finally attempt to draw some implications for science teacher education.

Some Components of Humanism

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

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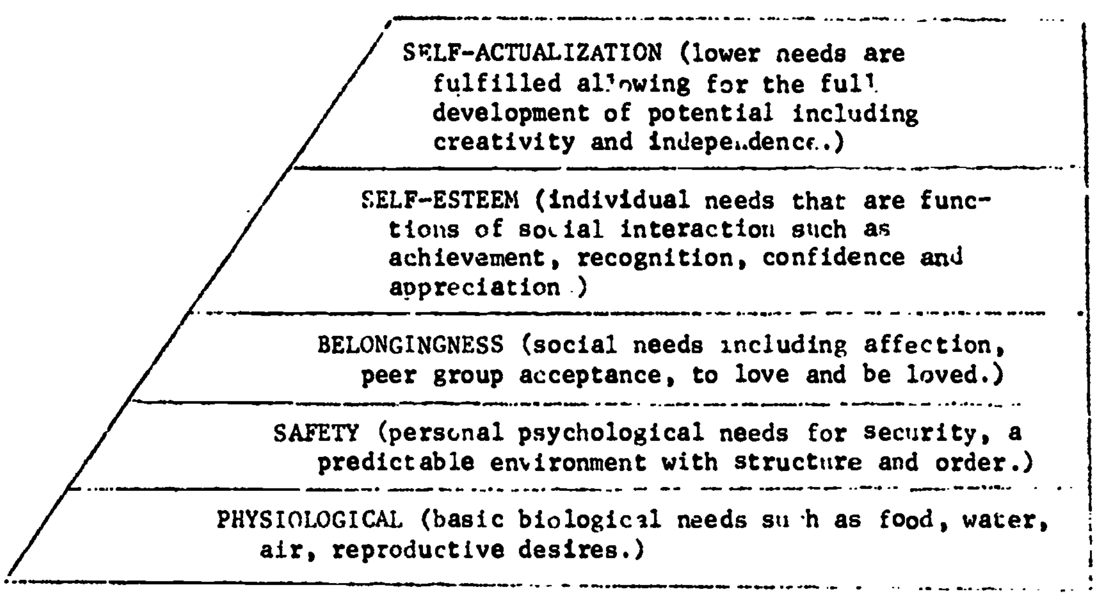
Basically the humanistic movement is an attempt to consider the individual as a unique person with the ability to experience and interact with reality. This uniquely human ability has resulted in the development of attributes which provide man with behavioral qualities that are the basis of cultural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

Perhaps the most basic theory of humanism is that the individual has internal components which affect perception, thought, feeling, and most importantly,action. Murray and Kluckhohn describe some internal components which might be classified as basic instincts (27, pp. 23-24). Maslow delineates a hierarchy of needs (23, pp. 107-155). Factors such as life styles also have causal influence upon perception, according to Maslow (24, pp. 300-302), Allport (2, pp. 266-267), and Murray (26, pp. 32-33), but must be learned. This is not to say that external factors, as ascribed to by behaviorists, are inconsequential, but rather that human interaction with the environment must be considered as a function of internal forces. Cultural and sociological forces, such as peer group and role pressures, do not exist outside the experiences of the individual but interact in a complex manner with the internal components.

It is impossible in the space provided here to review all of the aspects of humanistic psychology which have been emerging over the years. One of the most well known theories, and of special interest to educators, is the theory of the hierarchy of needs and subsequent forms of gratification developed by Maslow. An attempt will be made to present this theory as representative of a basic thrust of humanism and relate it to the nature of science, science education and teacher education.

Needs, as described by Maslow, can be illustrated by using a diagram such as that shown below.



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

Humanism is not merely a pleasure principle as Smaar and Escoll would have the public believe (33). It is not simply letting students have their own ways without discipline and structure. It contains many theories that would be useful in developing educational programs. Humanism can provide the science teacher a basis for better understanding the student. In addition humanism provides a basis for understanding the interaction of individuals and society with scientific knowledge and scientific processes. Perhaps self-actualizing science educators would be better equipped to provide the kind of education students will need to accommodate to a rapidly changing society largely influenced by science and technology.

The Nature of Science as Related to Humanism

Science is an intellectual tool created by man as a result of his interaction with his environment. It does not exist outside of the realm of man. Although it may be true that laws, concepts, and general understanding are results of science and are founded in reality, their interpretations are a function of the mind of man. Perhaps knowledge in books and other storage receptacles becomes humanized each time it is used. The humanist would suggest that man's preception, conceptual thought, and inferences are all a function of internal components which determine the individual's response.

The purist who rejects this position and maintains that science is completely autonomous is also saying that science is nonhuman, divorced from values, but also intrinsically worthwhile. This position is put forth to some extent by Jeffrey (23). A conclusion to be drawn from the rationale, of "basic research for the sake of research," is that even the most trivial research can be impressive when only methodological criteria are applied. This mind set states that value judgments lie outside the realm of science, outside the realm of knowledge and understanding. This mind set has fostered a public antiscience attitude.

Science may be objective, amoral, and self-correcting. The scientist and science educator, however, do operate within a value system which is neither objective nor self-correcting. Science is generally not considered humanistic; however, scientists and science educators can be (Woodward 36). A student of science can learn to base decisions on hard data but must also be aware of the significance of his own values in determining the subject under study, the type of data collected, or even the establishment of minimum probabilities for accepting or rejecting hypotheses.

Science offers the individual a systematic mechanism for objective analysis of reality, the reality of the individual as well as physical reality. For example, values of an individual are based in an ethical system. Personal use of science as a mental process could be a vital ingredient in value clarification. This should not be interpreted as drawing conclusions concerning the "correctness" of values but rather identifying the values that come into play under a specific set of circumstances. It is a naturalistic use of science. It is insufficient to simply ignore values. What is perceived and how it is interpreted are of importance to each individual and to his subsequent action.

To expand, if Maslow's theory of the hierarchy of needs is correct, one might test one's own action against the theory in a scientific manner. Such a systematic approach to introspection provides data for understanding self but also for the understanding of other persons. The needs are theoretically the same for everybody; the means of gratifying those needs may be different for each individual. The behaviors of the student of science. the teacher of science, the professional science educator, and the scientist are all functions of the hierarchy of needs and subsequent gratification.

Maslow (24, 25) and others [Barber (4), Bybee (7), Dewey (11)] have suggested that science can be a path to the greatest fulfillment and self-actualization for an individual. While it is true that science is only one means of attaining knowledge of the natural, social, and psychological aspects of reality, it is perhaps the one most potentially available to the masses. The public apparently conceives science as a large body of knowledge. It must be clarified that science is not only a collection of static intellectual constructs but also a dynamic method of understanding. This method of understanding is appropriate for understanding the perception of self.

There are many ambiguities of science which are significant, particularly as related to humanism. Although science is abstractly removed from values, it is a function of values -- if not itself a value system. Rationality, utilitarianism and meliorism are cultural values which have a positive congruence with the operations of science. In essence the position from which anyone operates is a priori, determined by a value system. This notion has been developed by individuals representing the sociology of science, psychology of science, and philosophy of science [Bronowski (5), Barber (4), Churchman (34), Maslow (24), Rudner (31)].

Another ambiguity of science is that characterized by Cohen (9) when he writes, ". . .it is not only analytic; it has a synthetic character as well." Science attempts to learn bits and pieces of reality through its analytic approach of the separate inquiry structures. At the same time science also is the process of synthesizing such bits and pieces into an objective picture of reality. It is this latter component of the nature of science which is most useful to the non-scientist. It is not enough merely to provide an individual the intellectual tool to dissect his life, to identify needs, drives, and other factors of self. One must also learn to assemble these bits of information into an acceptable, objective and holistic view. To be able to synthesize information in an objective manner is a significant scientific ability. Decisions can be made about the future in a more realistic objective manner if the individual has such skills.

In science, as well as in technologic studies, a basic skill is that of optimization. Frequently a decision must be made based on the data available. The researcher knows the theory or answer developed may not be correct or sufficiently refined; however, it does fit the data at hand. Therefore, a solution or theory is always open to refinement as new data become available. Optimization is part of the self-correcting aspect of science and allows for growth.

In humanistic terms optimization is also significant, particularly as related to the self. It is a unique sensation for members of the American public to believe that what one does is worthwhile. Acceptance of self is not easy. Glasser puts it very bluntly when he writes: "Therefore, all symptoms, psychological or psychosomatic and all hostile, aggressive, irrational behaviors are products of loneliness and personal failure" (16, p. 101). Although Glasser would deal with such problems through behavior modification techniques (15), it is also important to point out that for many individuals needs are unfulfilled. Such individuals must learn to deal with reality in an objective manner. Willers (35) has interpreted Glasser to mean that being human results in the rediscovery, redefinition, or reverification of what it means to be free and to work with, enjoy and cooperate with others.

The development of a strong self-concept is a prime goal among humanists. Self-concept is very important but it is a static concept. Singer (32) speaks of the "future-focused role image" which is somewhat similar to the self-actualizing concept of Maslow. Both ideas are predicated on the ability of the individual to assimilate new data and modify his position accordingly. This is optimization of solutions at the level of the individual. Persons who have learned this skill will be better prepared not only to accommodate to the future but make inferencea and predications as to their roles in the future.

The Role of Humanism in Science Education

The Curricula

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

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

Along with the current interest in problem-centered teaching, increased attention has been given to humanism and the science curricula. The Environmental Studies Program and the Earth Science Teacher Preparation Project are but examples of attempts to explicitly deal with humanistic theory and its relationship to the teaching-learning environment. Concern is exhibited throughout the materials for the individual and his experience. The project gives attention to needs of the teacher as well as of the student.

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

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

Teacher Education As It Stands Today

It is difficult, if not impossible, for teachers and college professors to assist students in fulfilling their various needs when the instructors have not yet attained gratification of their own lower level needs. The teacher who still needs respect through authority, the professor who is not secure in what he is doing or why he is doing it, certainly will have difficulty in creating learning environments which will encourage growth in students. Attention has been given to this problem with the development of programs and ideas aimed at fostering the teachers' ability to identify and subsequently deal with their individual needs. The reader is referred to previously cited references (6, 13, 30) as sources for materials, techniques, and models which have been developed and tested to help teachers deal with their own needs, as well as develop skills which will be usable with students.

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

> Teacher education programs should provide experiences that foster continuous growth in those human qualities of the teacher that will enhance learning by his students.
> A. A teacher should show sensitivity to students.
> B. Teachers should have self-esteem and confidence.

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

The relation of self-actualization to teacher characteristics is an active area of research. It has been shown by Murry that self-actualizing teachers demonstrate more concern for students (28). Self-actualization as a teacher attribute has been related to critical thinking done by students [Coble (8), Drews (12)]. Teacher behaviors of various types have been related to self-actualization [Dandes (10)]. Most researchers seem to suggest that a change in teacher selection and education is in order. Factors related to humanism are significant and should be given serious thought.

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

Schools, Humanism and Barriers

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

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

These same pressures mitigate against widespread success of "third force" objectives. Hunt (21) has predicted that responses to such pressures will include: a lengthening of the school day; decreased teacher-student interaction; extension of school years, both downward and upward, with an increase in structured preschool programs and the addition of grades thirteen and fourteen, to list just a few. Keeping a student in school a greater proportion of the day or year decreases his interaction with the world around him. Decreased opportunity for a teacher to get to know a student decreases the probability of providing learning environments which match the needs of the student. Increased structure decreases the chances of students to experience, to find their limitations and strengths, or to assess their own needs.

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

> "Since the jail function (of schools) is not a humane function and works against the humane task of helping learning and growth, since we cannot at the same time and in the same place be in the jail business and in the learning business, we must get ourselves out of the jail business" (20,p. 246).

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

Although such pressures and forces do exist it should be remembered that the function of schools is to educate. Although schools are frequently used as tools, as pawns, to bring about social reforms, the primary charge to the schools is to prepare our youth for their life as the next generation. Schools, curricula, and administrative decisions should be in response to the needs of youth, not the problems of adults.

Implications for Science Teacher Education

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

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

Science and humanism can be the prime vehicles for assisting future science teachers accommodate to change. If the science teacher uses what Dewey describes as a scientific habit of mind (11, p. 191) to view himself, he likely will be in a better position to optimize about self and even predict his role for the future. An understanding of needs will foster his own growth thus enabling him to better work with students and their needs. The self-actualizing future-role-oriented science teacher will be a vital ingredient of education in the future.

Although specialization is perhaps biologically, socially and intellectually necessary, it is not known at what level or to what degree specialization should occur. Should science teachers be trained only to canalize youngsters into specific disciplines of science? Should science teachers be trained to function only as science teachers? I believe that the answer to both questions is: positively not! Even though one becomes a specialist he should retain or attain the capacity to function as a generalist. The needs of society are changing, the future of schools is in question, and certainly the role of the science teacher will be modified. The Association for the Education of Teachers in Science might heed the words of John R. Gardner, ". . .in a world of change the versatile individual is a priceless asset" (14,p. 26). The difficulty is, of course, in educating the "versatile individual."

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

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

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

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REACTION

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Teachers and innovative teaching are central to effective science experiences for students, and it is essential that we develop more effective teacher education. As was stated in the AAAS Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics, there are certain aspects of science that can probably only be conveyed by a living breathing model -- the science teacher. For example, how can we lead students into becoming more curious about the universe in which they live? Or, how can we teach youngsters to consider different points of view and to seek evidence that supports or rejects different positions? Probably, these behaviors can only be taught by teachers acting this way themselves and serving as models. To develop such teachers is certainly a challenge to teacher education.

Certainly, it is important to stress that science is a human undertaking. There is science in books in the Library of Congress, but they are of little moment until someone knows that they are available, understands them, and uses them. We, of course, are also concerned that there be a continuing group of people who can and want to investigate our universe, interpret their findings, and help all of us to understand ourselves and the world we live in a little better.

Certainly, the stress on the individual is important. It is well to be reminded that it is for the student that we as teachers, schools and all our instructional paraprofessionals exist.

However, I do believe that society has a stake in education beyond the development of individuals. Most of our education is "public"education, and the public has a critical stake in the nature and quality of the education that children and young people receive. Our most critical problems cannot be resolved without a critical educational input. For example, consider population education! The population of the world is increasing at a rate of two per cent per annum. Most students of the problem agree that it would be desirable to at least stabilize population size. How can this be done? There probably will be ways that many will find morally reprehensible. I believe we should do our utmost to help students to study such a problem situation, become aware of possible consequences of different courses of action, and decide what courses of action they as individuals and as groups wish to take.

We could name many other critical problem areas in which education is perhaps our best hope for some kind of resolution. Our students have a stake in this, and a central purpose of education may be to help students prepare for life today and tomorrow. But, the broader public also has a stake, and hopefully they will insist that education meet these obligations to the public.

One of the strong arguments for an education that stresses humanism leading to "self-actualized" individuals is that these ar[illegible] kinds of individuals who may be best prepared to deal with import[illegible]ietal problems. In fact, it was suggested that this may be a p[illegible]uisite to effective individual and societal action with regard to imp[illegible]ant problems.

It was suggested that one of the important prerequisites for effective teaching for self-actualization was that teachers first become self-actualized. This supports the thesis that teacher education is of critical importance in curriculum improvement. Teacher education programs that are "open," problem-oriented, in which future teachers have some voice in determining the nature of the program, may be the best approach to preparing teachers who can work in the same way with their students.

How can some of the self-actualization procedures be introduced into programs? The "wedging" approach was suggested. Attempts to completely revolutionize programs seem not to have been very effective. Small changes, amplified when opportunities arise, may be the most effective ways of bringing about real change. When people in leadership positions find that they have teachers anxious to be innovative, it is critically important that they be given support and encouragement. This kind of teaching is precious; when it occurs it should be encouraged and nourished.

Apparently, much of the most innovative work in education toward self-actualization and consistent with humanistic psychology has occurred in science education. It was suggested that this was because science teachers brought with them the analytical processes that they used in their work in science. Science people may also bring to their teaching the value structure that is inherent in science.

The importance of science teachers providing models of the kinds of self-actualization that they stress in their own teaching was stressed. While it may take time to develop these abilities; there seem to be no inherent reason why young teachers cannot do it as well as those who are older. While this can be done within the traditional subject matter areas, there are less inhibitory factors when boundary lines are dimmed and more of an integrated approach is taken.

The desirability of developing some kind of an instrument to assess progress toward self-actualization was suggested. While very difficult to develop, it could be quite useful.

PART III

OTHER ISSUES

CHAPTER 8

A PSYCHO-EPISTEMOLOGICAL MODEL FOR TEACHING SCIENCE AND ITS ARTICULATION WITH CLASSROOM ACTIVITIES

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> . . .Words come out in single file, one at a time; there's no other way to talk or write. So, in order to talk about it, we cut the real, undivided world into little pieces, and make these into strings of talk, like beads on a necklace. But we must not be fooled; these strings of talk are not what the world is like. Our learning is not real, not complete, not accurate, above all not useful, unless we take these word strings and somehow convert them in our minds into a likeness of the world, a working mental model of the universe as we know it. Only when we have made such a model, and when there is at least a rough correspondence between that model and reality, can it be said of us that we have learned something.
>
> What happens in school is that children take in these word strings and store them, undigested, in their minds, so that they can spit them back out on demand. But these words do not change anything, fit with anything, relate to anything. They are as empty of meaning as parrot-speech is to a parrot [(Holt, 4, p. 106)].

The ring of truth in Holt's words cannot be denied by anyone who has been deeply involved with schools and who has taken the time to seriously appraise what happens there. Furthermore, the problem exists at all levels of schooling. It is quite obvious that students do learn abstract models and they do learn to operate logically with abstract symbols, the more successful students spiraling higher and higher within the educational structure. It is also quite obvious that students perceive and learn to deal with concrete phenomena, simply out of the necessity to function in a real world. They develop their own personal frames of reference by interweaving experiences unique to them with ideas acquired from others.

Ideally, one would hope that personal frames of reference actually used to interpret and deal with natural phenomena would contain concepts from the sophisticated bodies of knowledge called physics, biology, psychology, etc. Too often, however, students are unable to interpret concrete situations in terms of abstract models they have learned supposedly so they may deal with particular aspects of the world. In other words, the models they learn in school are not "working" models -- working models usually evolve from some other set of experiences. As a consequence most students, many adults, and too often professionals can talk a great game but perform in a seemingly unrelated manner. In science it is not unusual for students to defer articulating abstract models with concrete phenomena until they have begun their doctoral research. In education, articulation may not occur even at the graduate level.

Revision of the programs and conditions which have led to this apparent schism between the abstract knowledge one acquires and the way he actually operates seems to be the only viable solution. If revision is necessary, what programs and conditions need changing? What suggestions can be made for improvement? Are the proposed changes possible within the present institutional structure, given the currently held values of the established academic community? While the author would be the first to admit that he cannot offer definitive answers to the above questions, he does feel that there are potentially fruitful directions that deserve consideration and exploration; that through a skillful combination of concrete experience with intellectual activity, a student can acquire abstract concepts and use them to interpret and deal with the natural world.

Where do we begin? How can we improve an educational system that at times seems incomprehensible because of its size and complexity? We start by trying to improve the parts of the system which fall within our realm of influence and which potentially can lead to improvements in other parts of the system. Teacher education programs obviously fall into this category.

Few people would question that science teachers should have thought about and come to some personal conclusions about the kinds of knowledge <u>in</u> science and <u>about</u> science that their students should have. This implies that the teachers themselves must have a pervasive understanding of science. One would also assume that teachers should be adept at designing and employing teaching strategies and techniques that are conducive to developing the types of knowledge they are trying to engender in their students. This implies that they must develop a comprehensive understanding about how people acquire certain types of knowledge.

In short, what is needed is a well-articulated theory of science education that would provide science teachers with a comprehensive and coherent framework for interpreting what is happening in the classroom and for making prudent decisions about what should be done next. Not only is such a theory necessary for the development of coherent personal frames of reference but it would provide teachers with a basis for meaningful communication within the teaching community.

In the first section of this paper, the author describes a psycho-epistemological model which he believes would be a viable paradigm for science education. He feels that this model provides a way of looking at knowledge and the way knowledge is acquired that may help bridge the gap between abstract knowledge and concrete experience. The model integrates the development of a personal knowledge with the development of cultural scientific knowledge. In this sense it is a <u>genetic</u> psycho-epistemological model of knowledge. The ideas presented here are not intended to be an advancement of learning theory nor of epistemology but an attempt to take some of the ideas presented by psychologists, scientists and philosophers of science and integrate these ideas into a conceptual model that a teacher can use.

In the second and third sections some of the major problems in science education and teacher education are considered in the light of the model described in the first section. In these latter sections the model is used to interpret and to suggest solutions to problems found at various levels of our educational system. Despite the obvious interdependence among sections, each section was written to stand on its own and the reader is urged to begin with or to consider only those sections which interest him.

A Paradigm for Science Education

> How seldom do we find intellectual leaders in the humanities recognizing that contemporary science is essentially a symbol system which enables men to develop postulates and assumptions with which to observe, perceive and interpret events. Nor have we yet persuaded the nonscientists that we recognize that the scientist-observer is himself in the picture and that whatever he observes and interprets is patterned by his own basic conceptions and criteria of credibility [Brown, 3, p. 14].

The ultimate source of all scientific activity is natural phenomena; that is, objects and events (interactions among objects). One need not be a scientist to recognize that some objects have striking similarities and that under similar conditions these objects appear to interact in similar ways; in fact, our modes of behavior from moment to moment are based upon concepts and structures which reflect deeply seated or internalized assumptions about the manner in which objects interact.

People with little science background have internalized assumptions about the interaction of objects that are often independent from one another and apply only to very specific situations. Moreover, it is not uncommon for such assumptions to be based upon or influenced by social, religious or cultural experience acquired through communication with other people rather than through direct experience with the objects themselves. As a consequence, people often harbor notions founded on superstitions, faulty advice and inadequate observation as opposed to notions abstracted from and verified by direct encounters with natural phenomena. When confronted with problems originating in the biological or physical worlds, their actions are often inconsistent from one situation to another. This reflects a mode of behavior which tends to be ineffective, inefficient and somewhat less than satisfying when dealing with these problems.

Scientists, on the other hand, have not been content to operate with a set of assumptions obtained in such a nebulous way (at least within their own fields of study). They assume there is a better way to deal with the biological and physical worlds. An integral aspect of this assumption is the scientist's faith in the consistency he perceives in the world -- that the structure of objects and occurrence of events are not capricious but occur in a manner that is susceptible to systematic organization. Science encompasses the activities of those engaged in this attempt to articulate natural phenomena with some systematic scheme that can be used as a framework for perceiving, organizing and dealing with these phenomena. Scientific knowledge is the fruit of this effort.

Because science is a human activity, scientific knowledge is a human creation. So that it may be communicated to other persons or stored for future reference, scientific knowledge is expressed in symbols. Because it can be communicated and stored, it becomes a part of our cultural heritage -- to be used, abused or ignored, depending upon the frame of reference of the potential consumer. Studying how this knowledge evolved until it became part of our cultural heritage is a genetic, developmental or historical approach to the epistemology of science. In contrast to this approach is logical empiricism, which might be likered to taking a "snapshot" of the scientific enterprise at some moment in time and then analyzing how the various elements are logically interrelated. The genetic approach, best exemplified by Kuhn (1962) and Bohm (1965), is a dynamic analysis of the activities of scientists and scientific knowledge. It is concerned not only with how different ideas are related, but how they came to be as they are and how they change over time. No implication is intended that one approach is right and the other wrong. Actually they address themselves to different problems. A dynamic model of scientific knowledge is particularly well suited to deal with the dynamics of teaching science to children.

During early stages of development in any field of science, categories of objects and events and classification systems are formulated. Once objects and events have been classified into types then one can look for consistency in the types of interactions that occur among a selected set of objects under a given set of conditions. Such a consistency when found is interpreted as a relationship among classes of objects under certain conditions and may be thought of as an empirical law.

Though everyone engages in abstracting and generalizing, it only becomes a scientific activity when a decided effort is made to: (1) explicitly state the characteristics that are abstracted; (2) designate the conditions under which they apply; and (3) continually check the resulting generalizations against new observations. A set of generalizations formed in such a manner provides us with a basis for effectively predicting events under specified conditions. Such a set of generalizations may consist of an extensive accumulation of seemingly independent statements about what to expect in very particular situations. To commit such an extensive set of statements to memory would be an overwhelming task, and, needless to say, would be an extremely tedious activity.

Therefore, a major quest of scientists is an abstract set of relationships which will provide some pattern or order for empirical generalizations. It is these logically consistent abstract patterns of relations that make it possible for scientists to deal so effectively with problems that arise in the natural world, that provide science with its aesthetic value, and that point toward potentially fruitful avenues of scientific investigation. Such a set of explanatory principles is commonly called a theory.

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

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

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

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

As earlier stated, some elements of a theory must be articulated with empirical evidence. However, some theoretical constructs do not have articulated counterparts in the natural world. Yet, these theoretical constructs are used to perceive and interpret natural phenomena. This is usually accomplished by associating these constructs with a counterpart in a physical model. It is often much easier for a person to visualize a physical image than a set of symbols; hence he is able to manipulate these concepts more easily (8).

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

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

Since theories in vogue at the time usually have the cumulative support of many prestigious scientists, anomalous results obtained by only one scientist are not apt to be received favorably by his peers. Therefore, "successful" solutions to scientific puzzles are solutions that add credence to the theory, not doubt. Anomalous results are more apt to reflect upon the ability of the puzzle solver than upon the credibility of the theory. When such results are obtained, the tendency of the scientific community is to question the validity of the experiment -- the scientist's argument linking his experiment to the theory, the design of the experimental apparatus, or even the construction of this apparatus are all potential targets. The scientist's interpretation of the results can also be questioned -- experimental results can often be made to fit a theory by organizing the experimental data that has been collected.

Therefore, scientists are not prone to claim "disproof" of a theory on the basis of singular anomalous results obtained in an experiment designed to articulate that theory. Instead, they will go to great lengths to make the results fit the theory or look for ways they could have misinterpreted the theory. The experimentalist will recheck the assumptions and logic of his experimental design, the design and construction of his instruments and equipment, and the interpretation of his results. If none of these reviews succeed in locating an explicable source of error, then the theorist may be persuaded to reappraise some minor assumptions, recheck some of his derivations and reassess the implications he has drawn from these derivations.

If this relatively minor internal tinkering, which could lead to minor revisions of theory or experimental design, is unable to square theory with experimental results, then the results are usually set aside as irrelevant or anomalous incidents to be attacked at some later time when the theory has become more fully articulated. In this case the scientists who are aware of the anomaly would feel they had encountered something that they had failed to resolve, but the failure was not convincing enough to shake their faith in the paradigm. All these maneuvers are characteristic of those employed by scientists engaged in what Kuhn calls "normal science," which he suggests includes nearly all scientific activity.

It is only when a substantial number of anomalous results accrue to a theory, some of which raise fundamental questions within the theory, that a few scientists begin to lose faith in the explanatory power of that particular theory and begin to search for entirely new schemes for perceiving the natural phenomena that the old paradigm has been concerned with. If a scientist with a good reputation among his peers is able to formulate a new theory which accounts for most of the anomalies accruing to the old theory, explains the important generalizations that were explained by the previous theory and discounts anomalies with the new theory on the basis that they are irrelevant, then professional support for a new theory becomes a possibility. In the event that enough professional support can be marshalled in support of one of these new ideas then the foundation has been provided for what Kuhn calls a scientific revolution, whereby the science community rejects the old theory as a paradigm for research (puzzle-solving) and adopts a different theory in its place. The transition is usually neither rapid nor smooth. Some scientists are able to make the shift -- others are not. It may take a generation before the shift is complete -- that is, until the vast majority of the science community uses the new theory as the accepted paradigm for research.

The period of transition from one paradigm to another is a time of instability and unrest for many of the scientists in that field. To keep pace in the field requires a complete mental restructuring and a mental substitution of new structures for old conceptual schemes to which the scientists had been deeply committed for many years. To be faced with such a shift can be traumatic. Kuhn (5, p. 22, 25-26) cites the internal turmoil encountered by Wolfgang Pauli just prior to Heisenberg's paper on matrix mechanics which led to a new quantum theory. Pauli had written to a friend, "At the moment physics is terribly confused. In any case, it is too difficult for me, and I wish I had been a movie comedian or something of the sort and had never heard of physics." A few months later Pauli wrote: "Heisenberg's type of mechanics has given me hope and joy in life. To be sure it does not supply the solution to the riddle, but I believe it is possible to march forward."

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

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

Some ways that a scientist might interact with other scientists, contribute to or draw upon the cultural knowledge pool, assimilate new concepts or ideas into his existing frame of reference and accommodate these ideas with natural phenomena are outlined in Figure 1. Each segment in this diagram is influenced directly or indirectly by each of the other segments. For example, the characteristics of objects and events that occur as the result of human activity are to a large extent determined by the thought patterns or mental structures that have evolved in other segments.

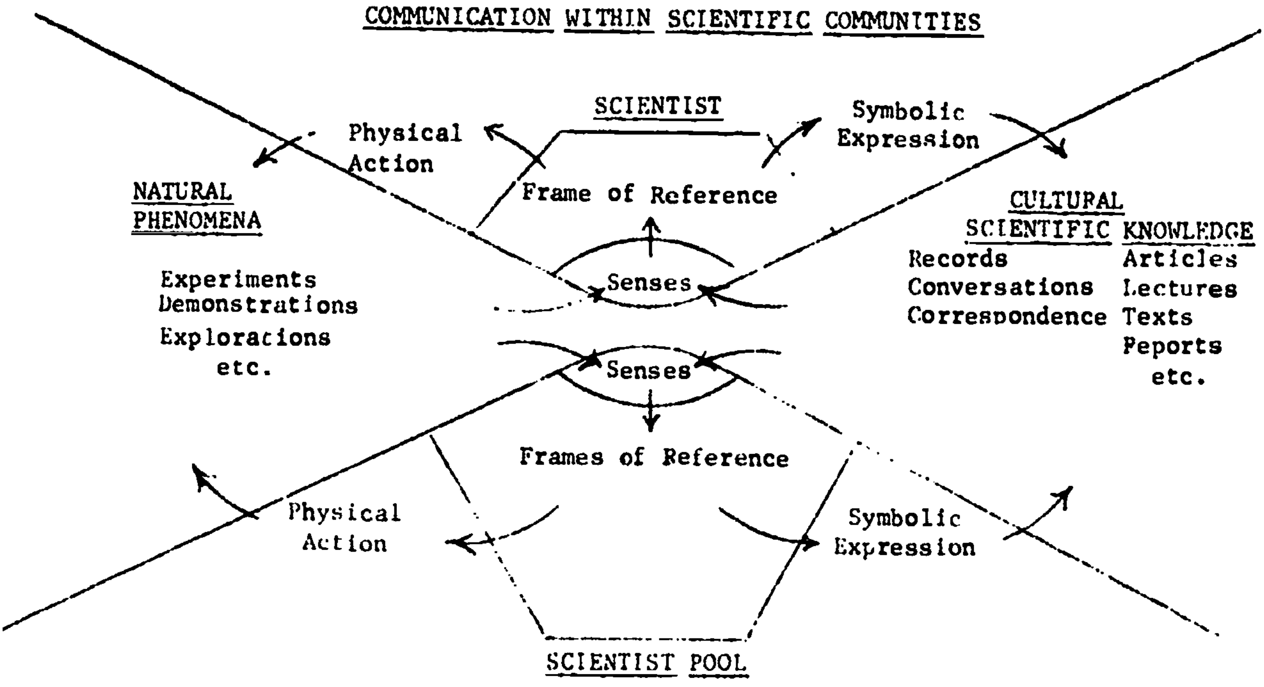

Figure 1

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

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

During this dialogue, an experimental scientist who has been reading these various comments may have some idea about how this slightly modified version of the theory can be tested or articulated. The experimentalist undoubtedly perceives what has been written with a frame of reference that is in fairly close agreement with the frames of reference of other scientists within that particular field, but he would be expected to have some unique interpretations. To test or articulate the theory he must develop an argument that ties some aspect of the theory to a specific phenomenon in the external or natural world. This means that he must employ or design some device or instrument which he can use to demonstrate the phenomenon which he has predicted. The argument that he develops must employ a language and follow a logical structure that his peers understand

and that his peers will consider a valid and legitimate argument. Also, his experimental devices and instruments must be of such a nature that his peers consider them valid instruments for this particular demonstration. Both the argument and the devices that are constructed, however, will reflect this particular scientist's individual prejudices or preferences, which in subtle ways influence the way that the results are organized and accumulated. In this sense, he introduces his own idiosyncracies into this particular aspect of the scientific activity or investigation. His argument underlying this experiment, a detailed description of the instruments used in the experiment, and a report of the results obtained in the experiment all may be organized and published. This publication will be within a framework that is understood by his peers in his particular field. But it too will carry the stamp of his idiosyncracies. The publication will be read by his peers and hence the cycle continues. The overall effect of this type of interaction is the generation and evolution of a body of cultural scientific knowledge.

The individual bits of information, in the form of symbolic statements, that are fed into the pool of information labeled public knowledge are fed through the frames of reference of practicing scientists -- in effect, a filter system. Therefore an individual scientist can influence the development of a theory and many theories carry such marks of scientist's idiosyncracies. The extent to which individuality is permitted in articulating any given theory is controlled in subtle ways by consensus among one's peers in regard to the criteria of credibility which are imposed upon work within the field. By controlling the publication of articles and the selection of speakers at various conventions, the practicing members in a given field can successfully control the direction that a given paradigm will take. This control makes it a stable conceptual system. Because of this stability practicing scientists within a relatively narrow field are usually able to communicate quite freely with one another.

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

Continued communication and common experience among communities of scientists are necessary not only for the training of new scientists but also for the very survival of cultural knowledge. There is no way of attaching common meaning to symbols other than through the commonness of experience that resides in the minds of humans who provide interpretive and creative meaning to what is contained and expressed in symbols. Implicit in cultural knowledge is this commonness of experience though it is rarely stated. People who have acquired the interpretations common to the community of scientists (or scholars) who generated this knowledge or are keeping it alive will understand it and will be able to communicate with each other -- those who have not, will not.

Implications for Teaching Science

> . . .When I say teach, I mean an active teaching method and not just a verbal transmission (7).

If we expect students to be able to communicate meaningfully in terms of scientific models, and it is a major assumption here that this is desirable, then they must acquire the concepts and understand the models used by the scientific community. The level of sophistication at which they learn concepts and models, however, will vary with the student population. These are not new ideas. In fact, for generations they have been among the premises upon which the teaching of science has been based. It might help to clarify matters if we briefly explore some of the ways that people learn concepts and models and then consider some of the ways concepts and models have been commonly presented to students in school.

The most critical concepts in anyone's frame of reference are those abstracted from direct encounters with objects and events. For example, suppose that each child in a classroom is given a dry cell, a wire, and a bulb and is instructed to see how many ways he can arrange the three items so that the bulb will light. Experience indicates that after a short initial period of exploration and frustration the children do discover and identify different arrangements in which the bulb will light. From these arrangements they are able to abstract what is common to each case where the bulb lights but is not found in the cases where the bulb does not light. The idea abstracted is that there is a continuous loop of metal that goes from one pole of the dry cell to one contact on the bulb and from the other contact of the bulb to the other pole of the dry cell. This closed loop, commonly called a closed or completed circuit, is a concept that they have abstracted from a set of experiences with concrete physical phenomena. In the following discussion, a concept that has been abstracted from experience with objects and events will be called an intuitive concept.

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

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

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

There are myriad concepts, especially in science, which can be described in terms of specific relationships among other concepts. For example: <u>displacement</u> may be described as a change in <u>distance</u> in a given <u>direction</u>; <u>velocity</u> may be defined as the rate of change of <u>displacement</u> with respect to <u>time</u>; and <u>acceleration</u> may be defined as a rate of change of <u>velocity</u> with respect to <u>time</u>. A concept that is described or defined on terms of other concepts will be referred to as a <u>formal</u> concept. When trying to teach the above concepts to students, it has been common practice to assume that distance, direction, and time are intuitive concepts in the students' frames of reference and displacement, velocity and acceleration are acquired as formal concepts by learning definitions similar to those above. When a student has learned these definitions, it is assumed that he understands them. Often, nothing could be further from the truth.

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

A second assumption implicit in the above practice of teaching formal concepts is that a child's intuitive notions are identical with those held by the instructor. Such commonality is rarely the case. Referring to the previous example, a child's early notion of velocity is not a distance/time relationship but "is bound up with that of overtaking, i.e., with a purely spatial intuition involving a change in the respective positions of two moving bodies" (6). In a similar vein, children can have an intuitive notion of acceleration before they have a formal understanding of velocity. They can associate it with forces exerted on their bodies and changes in speedometer readings when a car they are riding in "speeds up" or "slows down." To suggest that their intuitive feeling for acceleration is the same as a physicist's formal concept would be delusionary. Whereas it is a serious mistake at times to assume that children have no notion about some aspect of the world in front of us, it is an equally serious error to fail to recognize that children's words are often associated with different notions from those that we possess. Commonality of concepts within a community cannot be assumed as a starting point but as a goal to be pursued.

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

Therefore, the above practice, which assumes that students apply commonly understood rules to combine commonly held intuitive notions to arrive at commonly held formal concepts, is delusionary. It is more often the case that students apply misunderstood rules to combine vague or ambiguous intuitive notions to arrive at even more vague and ambiguous formal concepts. The point to be emphasized here is that we cannot understand formal concepts semantically until we have established a common base of intuitive concepts. We may establish verbal or symbolic connections between symbols representing higher and lower level concepts but that does not imply understanding in the sense that we perceive and assimilate natural phenomena in terms of these abstract symbol systems.

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

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

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

<u>Urg-Jos-Fap System</u>

The elements of the system are: <u>urg</u>, <u>jos</u> and <u>fap</u>.

The relationships among the elements are: $\vdash$ and $\dashv$.

Rule 1: If <u>a</u> r <u>b</u> and <u>b</u> r <u>c</u>, then <u>a</u> r <u>c</u>; and

Rule 2: If <u>a</u> $\vdash$ <u>b</u> then <u>b</u> $\dashv$ <u>a</u>, where <u>a</u>, <u>b</u> and <u>c</u> represent elements of the system.

Given relationships:

Rel. A: urg $\vdash$ jos, and
Rel. B: jos $\vdash$ fap.

<u>Questions</u>

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

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

<u>Answers</u>

1a. urg $\vdash$ jos
b. jos $\dashv$ urg

2a. jos $\vdash$ fap
b. fap $\dashv$ jos

3a. urg $\vdash$ fap
b. fap $\dashv$ urg

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

It is one thing to learn and operate within a closed logical symbolic system and quite another to use that system to interpret or deal with some aspect of the world external to the system. It would seem that being able to use a system to interpret and deal with that aspect of the world for which the system was designed is as important as is learning the elements and operations permitted in the system. This is especially true if we expect the learning of such systems to be more than a sophisticated game with little relevance for dealing with problems or interpreting situations or phenomena that one encounters. Especially in science, the theories and ideas about the natural world have been developed in accordance with actual physical and biological phenomena. These theories have been developed to interpret and deal with these phenomena.

A system (model, scheme, etc.) that is learned in isolation from other systems -- symbolic or natural -- may be thought of as an <u>encapsulated</u> system and the only time that it would be used to make decisions would be when direct reference is made to some aspect or element of the system. Similarly, the only output that would result from mental manipulation of the system would be expressions or statements in terms of symbols contained within the system. Unless some verbal or phenomenological cue from outside the system can trigger one to think in terms of that system, then the system is encapsulated for that person. If models, schemes, theories, etc., are to be useful to the person who has "learned" them, then he must respond to cues in other situations that indicate an appropriate application of these models, schemes, or theories.

It seems that it has been a basic assumption of educational institutions that if theories, schemes, models and so forth were taught per se to students that the students would be able to develop appropriate applications of these systems. The thesis here is that this is not the case. If systems are taught in an abstract and closed manner, that is, if they are not linked in meaningful ways to other aspects of a person's frame of reference and concrete referents (if any) then these systems will exist as encapsulated systems. The only time they will be used is when a person is asked a question or hears a statement directly related to elements or aspects of the system. Yet much of a student's time in school is spent "learning" symbolic systems which for the most part remain encapsulated. The teacher talks about the model, the teacher has students read textbooks about the model -- in short, the entire classroom activity is carried on in an abstract manner. These symbol systems are not linked with their referents -- the real objects and events that are necessary precursors to a semantic understanding of the models. Consequently, students assimilate only the symbol systems and later are able to apply them only in formal instructional contexts. Tests are designed to determine not if the student can apply the system but to determine if he has memorized the important elements and can operate according to the rules.

When a student is confronted with a real life situation in which a model that he has learned is relevant, he does not perceive the situation in terms of the model. Therefore, he cannot use the abstract manipulations provided by the model to make a decision for action which would be effective in that particular situation. Certainly in science, where the goal is the development of models to interpret and organize natural phenomena and to explain generalizations about these phenomena, it makes little sense for the lay person to learn the models unless he is able to relate these models to actual objects and events with which he is confronted. If someone is expected to learn and apply symbolic systems that have been developed within a culture, then acumen with the system is necessary, but not sufficient.

At this point someone may ask: "But are not the scientific disciplines -- physics, for example -- such abstract systems? And if so, isn't it appropriate to learn physics as an isolated system?" Certainly physics is an abstract system -- the degree of abstractness determined primarily by the level of sophistication of the mathematics involved. For those few theoretical physicists whose work consists of operating entirely within a closed symbolic system there may be some justification for learning physics isolated from other aspects of the world. For someone who is not going to make theoretical physics his life work, such isolation becomes very difficult to defend.

Unless a student is able to use the concepts and models of science to interpret, organize and deal with phenomena which he encounters outside the classroom there seems to be little more justification for teaching science in school than there is for teaching any other intellectual game, such as chess. This suggests that what happens in a science classroom should have some effect on a student's decision-making processes and hence his mode of behavior outside the classroom.

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

Since learning is influenced by reference frames, it is crucial that a teacher assess his students' frames of reference as quickly as possible. This assessment cannot be accomplished simply by written or verbal diagnostic tests. One of the best ways to probe into a student's frame is to have him interact physically with some set of objects and to have him describe what he is doing while he is doing it. When a teacher has formed some ideas about how his students perceive and organize phenomena related to a certain field of science or even phenomena in general, then he is in a position to begin helping his students acquire working scientific models.

If a teacher finds that a student has not encountered phenomena related to a certain field of science, has not begun to develop a reference frame for perceiving and thinking about these phenomena, or has not articulated a rotely learned model dealing with these phenomena, then direct experience with the phenomena should be the starting point.

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

When students are confronted with unfamiliar situations (assuming they do not just ignore them), their frames of reference must be accommodated so that various aspects of the situation are perceived and assimilated. Accommodation may be accomplished by reorganizing only what resides already in one's frame of reference or it can be influenced by communication with someone else. For the latter to occur assumes that the frames of reference of the communicants have enough elements in common so that when one describes an idea in his mind, the other is able to recreate that idea on the basis of the first one's description. Too often, however, teacher and student have quite different frames of reference regarding specific aspects of the world. Formulating an idea into words is essentially a coding process. For someone to decode those words and arrive at nearly the same idea implies that encoder and decoder have essentially the same coding devices, i.e., frames of reference. But, in teacher-student interactions, the teacher is often trying to help the student acquire a working model where there is none to begin with. If the student does have a working model it may be so different that there is no basis for communicating about it with mutual understanding. A student often finds himself in a dilemma trying to create an unfamiliar mental model from verbal descriptions provided by a teacher or text. However, to interpret the words used in the description requires the previous existence of a mental model similar to the one he is trying to formulate.

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

To what extent should a student be encouraged to develop a model which is different from the one that is a part of the paradigm in vogue at the time? As long as his interest holds and he appears to be gaining experience, he should be encouraged to probe and express his ideas about what he sees and believes. Unless there is some illogical step in the student's argument, he should not be discouraged from continuing his own way of organizing his thoughts. If a teacher feels that a certain line of theorizing is going to be unproductive, it is usually because he is aware of phenomena that are anomalous to the theorizing that the student is doing. If this is in fact the case, then the teacher should be able to create a situation whereby the student is confronted with the anomalous phenomena. If he is asked to explain them in terms of his ideas, then he will have to face up to the anomaly and there is a greater chance that he will recognize that the direction he is taking may be unproductive.

To encourage a student to pursue his own way of conceptualizing certain phenomena does not preclude encouraging him to look at the phenomena in a different way. For a student to see that there is more than one legitimate way of perceiving and organizing some aspect of the world is in itself an insight that is foreign to many people. However, before a teacher can suggest an alternate way of perceiving and organizing something, he must have considerable insight to the student's frame of reference.

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

To help a student learn a scientific model -- not at a scientist's level of sophistication but at least at a descriptive level -- the teacher must be in close communication with the student. He must know what the student is thinking, what his symbols represent when he uses them, what his experiences have been so that he (the teacher) can try to determine what physical referents the student has for the symbols and ideas that he expresses verbally. The teacher must do this on an individualized basis. He must play an active role in the student's learning process. The role, however, is not one of a dispenser of information. It is a role of analyzer and assesser of what the student knows. It is a role of determining what kind of action taken at this time will help the student acquire understanding that the teacher is helping him to develop. In this role, the teacher has to be sensitive and creative. He must also be flexible and able to take into account any new evidence which may suggest a change in approach or modification of immediate plans.

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

Many of the ideas suggested above have been designed into the materials produced by some of the recent science curriculum development projects. At least two projects, the Science Curriculum Improvement Study and the Elementary Science Study, were based upon psychological and epistemological frameworks not that different from the one presented here. However, the extent to which certain approaches to the teaching of science have been developed and promoted in the form of curricula is not the writer's primary concern. What is of concern is the way these and other materials are used by teachers in their classrooms. It is one matter to develop materials to be used with a particular teaching approach in mind; it is quite another to have those materials used in a classroom in a manner which reflects this approach.

There is no questioning the fact that the new curriculum materials have proven to be a valuable resource for those teachers who understand and are sympathetic to the psychological-philosophical basis underlying their development. On the other hand, if a teacher does not have the proper orientation there is little hope that he will or even can use the materials in the way intended by the developers. The curriculum developers themselves were among the first to recognize this problem. Some projects provided special courses, institutes or workshops to help the "trial teachers" develop the "necessary" outlook. In any event, the number of teachers who are able to function in an enquiry-oriented environment without some continuing in-service course or workshop is relatively small. This seems to be true for elementary as well as secondary school teachers and for recent graduates as well as experienced teachers.

Implications For Teacher Education

> . . .science sought originally to give man a wholeness of knowledge and understanding, but ended up fragmented into countless separate fields each of which can overwhelm the student in a flood of specialized information (2, p. 12).

Faced with an increasing demand for teachers who are prepared to teach in open and enquiry-oriented school environments, we must create programs that will help them develop the qualities required for a successful performance in that role. There are at least two sets of desirable qualities, though the sets are not independent from one another. The first set includes the feelings that one has for himself, for others, and for his work. The second set consists of the special capabilities or competencies that one needs to cope with a particular school environment. The first set of qualities are primarily affective, the second set primarily cognitive. Neither set is offered as an exhaustive list but as a set of representative examples.

Among the first set of qualities is commitment to the open enquiry-oriented mode of teaching and confidence in its long range benefits to students. Another quality is a willingness to recognize and tolerate other ways of viewing the world -- an openness to new or different ideas. Also, the teacher should be internally secure; that is, he knows who he is, likes what he is and is not trying to present some unreal image of himself to the students. He should be approachable to the students in the sense that they feel at ease when they are talking with him. Last, but certainly not least, he should have an abundance of patience.

First among the cognitive abilities, a teacher should have a working knowledge of a psychological-epistemological model for teaching science. It is this model which provides meaning and organization for him in what otherwise might prove to be a hopelessly confusing and directionless set of activities and events. It allows him to place what he and his students are doing in some overall framework and thereby into some perspective. This perspective allows him to help students plan strategies and make moves that will take them from where they are at that moment to some more comprehensive level of understanding. In addition to the natural phenomena which serve as foci for student investigations, the model must account for individual student's reference frames, the interaction and communication among a community of students engaged in scientific activity, and the cultural scientific knowledge which bears on the problem in hand. Moreover, the model must deal with the interrelationships among these various parts.

A second important characteristic in this set is sensitivity to various aspects of the student's world. On the basis of what a student says and does, the teacher must be able to weave together some "picture" of the student's frame of reference, that is, to see what the student sees. He also should have some notions about the influence of motivational and physiological changes on a student's behavior as well as the influence of the social milieu.

A third desirable capability is to be able to communicate with other teachers or educators concerned with similar problems. It is important that teachers feel they are a part of a concerted effort to solve problems with which they are confronted. This can only be accomplished if they share experiences, insights and whatever other resources are at their disposal. To be able to do this, they have to "talk the same language."

A final characteristic, implicit in the ones described above but worth stating explicitly, is that he has had considerable practical experience interpreting real situations with students in terms of the psycho-epistemological model.

If we assume that possession of these two sets of characteristics is necessary for a teacher to perform successfully in an open, enquiry-oriented environment, how do we help teachers develop these qualities? As for the first set, which are essentially personality characteristics, it would probably be overextending the role of a teacher education institution to attempt to change them in a direct way. We might, however, expect some change in personality as the students develop a better understanding of the role for which they are preparing and as they gain confidence in their ability to perform in that role. Publicizing the desired traits and providing feedback to students about the traits they seem to be projecting might also help them modify their personalities to some extent, but it does not seem feasible to build mechanisms for changing personality into any teacher education program. Therefore, our efforts should be directed toward building a program designed to help teachers develop the cognitive traits found in the second set of characteristics.

Implicit in this discussion is the assumption that teacher education programs following present practices cannot provide prospective teachers with the experience and comprehensive understanding that is necessary to cope with an enquiry-oriented school environment. Today, a typical prospective teacher's educational experience can accurately be described as fragmented and compartmentalized. A close look at present practices suggests there are at least two assumptions upon which these practices are based which serve as obstacles to the integration of knowledge and experience.

The first assumption is that if students are told something or if they read it, especially if a change in their verbal behavior is detected afterward, then this information automatically becomes part of their functional frame of reference (i.e., they use this information later in decision-making and interpretative processes). While this assumption may be valid in some areas of study, though even that is doubtful, it certainly cannot be defended in science or in education if one expects the decision-making and interpretative processes to extend beyond term papers, final exams and cocktail parties.

Change in verbal behavior does not necessitate change in other forms of behavior. Yet, nearly all our educative efforts are directed toward changes in verbal behavior with the implicit hope that other behavior will change as well. Why has this practice continued for so long if it has not been successful? The answer is obvious -- even though teachers have extensive interaction with students, this interaction is almost exclusively verbal -- often limited to a closed abstract system. This is especially the pattern among college teachers. Furthermore, changes in verbal behavior can be detected and quantified under classroom conditions -- hence effectiveness in verbal learning can be demonstrated and measured with relative ease.

Teachers should take a close look at how their students perform in circumstances other than those in their own classroom. They have been operating in a closed system, judging success by measurements made within the system, but assuming that what is learned will be applied to circumstances outside the system. Our teacher education programs have become encapsulated. Unquestionably there is a dearth of feedback loops from teaching performance to preparatory programs. As a consequence, success within a program often proves to be a poor indicator of success later in a real teaching situation. The criteria for success have been weighted too heavily on willingness and capability to manipulate symbols and not enough on the ability to use these symbols to interpret and deal with concrete aspects of the world.

The second assumption is the "pieces of a puzzle" assumption. Each course taken by a student is supposed to represent a different piece in a puzzle. By the end of his college career the student is expected to have fitted each of these pieces together to form a "big picture" -- a comprehensive and coherent frame of reference including social, political, philosophical, and professional elements. What the student does not realize, and it seems as if we sometimes go to ridiculous lengths to conceal it from him, is that the pieces are usually from different puzzles. It is the rare individual who is able to modify, transform or reject pieces until he has developed an internally consistent and functional big picture. It is the tragic individual who attempts to fit the pieces together just as he received them and thinks that he has the big picture. What we usually have is a great number of students who are confused, frustrated and even angry but often they do not know why and more often do not know what to do about it.

Presenting students with a unitary point of view which would preclude any contradictions would certainly be an undesirable solution to the problem. Exposure to diverse points of view is one of the most important and highly cherished functions of a university, and this is as it should be. On the other hand, exposure to ideas in the seclusion of classrooms, where the range of experiences provided for the student is rigidly controlled and where a student's behavior must conform to the expectations of a single instructor, has the effect of glossing over any incompatability that these ideas may have with other ideas. Students get in the habit of operating in tight little boxes -- they quickly find out what each teacher wants them to do and then they try to do it. If they took time to scrutinize what they were doing, they would often find that their performance in one class is at odds with their performance in another. In the present system there are few rewards for undertaking such an analysis. Many instructors are reluctant to praise students for pointing out ideas that are incompatible with the ones they are trying to promote. If a student recognizes contradictions but he suppresses any urge to comment on them or to alter his behavior, this does not do much for his self-image. Therefore, one is not encouraged to dig too deeply. Rather than try to eliminate diversity or to ignore it as is done now, we should recognize that it exists and help students deal with it.

What elements should be included in a teacher education program? How might these elements be organized to reduce fragmentation and provide concrete experiences? The fundamental concept around which such a program should be organized is the concept of community. This implies that there should be continuing communication among all participants in the program and the communication should be conducted in an environment common to all. The community should consist of prospective teachers, master teachers and specialists. All members of the community would not be together all the time, nor even most of the time, but would be expected to meet on some regular basis as a group, and would be engaged in similar activities when they were not together as a group. The size of the community should be large enough to provide a critical mass but not so large as to be unwieldy.

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

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

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

Finally, provision should be made for individual planning and programming within the broad guidelines set out here. A prospective teacher should be allowed to choose the type or types of teaching roles he wants to be prepared to fulfill.

To describe in general terms the broad outlines of a proposed program is one matter, but it is quite another to put these ideas into practice, especially if one must operate within the framework of an established institutional structure. Whether or not it is possible to successfully carry out such a program under present conditions requires an empirical test. However, some speculation about how a specific teacher education program might be modified to incorporate the desired characteristic described above would provide at least a basis for further discussion.

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

If we modified our program at the University of Illinois by pooling all the education courses and twelve hours of the science or science related courses, we would obtain a block of time equivalent to thirty-two semester hours or one-quarter of a student's undergraduate program. A block of time this size would give us the time and flexibility needed to create an integrated program of scholarly activities and concrete experiences. Spread over a two-year period, a participating student would concentrate about half his total study time during that period to the integrated program.

All the basic ideas covered in the pooled separate courses could be covered in the new program but they would be integrated into a unifying framework -- the psycho-epistemological model. Although the same idea might be covered in the integrated program, the new program would not be an amalgamation of separate courses under the direction of single instructors. Instead, being constructed around the concept of community, the new program would be a dynamic activity involving professionals and scholar-apprentices working on common problems within a common theoretical framework. A continuing seminar and concrete experiences with children, schools and materials provide a focus and a realistic base for this activity.

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

The seminar would meet for two to three hours at least twice a week for the duration of the program. Each member of the staff would be expected to attend at least one general session each week. The seminar would provide a forum for both students and staff to present and compare points of view and to discuss teaching experiences within the context of the underlying model. Each specialist would interpret experiences common to the group using models characteristic of his particular discipline or specialty. The similarities and differences among the various interpretations and the compatibility of a particular interpretation with the psycho-epistemological model being developed would be pointed out and discussed. Even though the community is committed to a particular model and specialists would have been selected on the basis of having expressed sympathetic views about the model, we would expect to find considerable disagreement among these "experts" with regard to particular interpretations or applications of the model. These differences would be discussed in the presence of the students who are encouraged to participate in the discussion. Under these conditions, a student would find it very difficult not to recognize contradications among viewpoints. He would have to judge the various interpretations and assimilate those ideas that are consistent with other views that he holds. In the process of judging and organizing these various thoughts he might even recognize that some fundamental ideas pervade many different fields or that other people might hold equally valid points of view different from the one he holds.

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

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

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

During the second semester of the program, students should have organized and articulated their ideas to the point where they can anticipate what is apt to happen in a particular classroom with specific children given certain conditions. When they reach this point, students should have the opportunity to create their own mini-classroom environments with groups of four or five children. In these mini-classrooms they should have the opportunity to experiment with their own teaching strategies and styles. This type of teaching experience should continue and expand under the supervision of master teachers and other specialists until students are able to manage twenty-five to thirty children at one time.

Where does one find the children and different school environments to carry out these activities? The writer has found that if school administrators and teachers are directly involved in the planning of activities, if their suggestions are listened to and given serious consideration and weight, then facilities and children are usually available. The master teachers in the program are the teachers who provide the children and classroom facilities. Their participation is an essential aspect of the program.

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

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

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

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

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

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

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

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

The hypothetical program just outlined was designed with secondary science teachers in mind. A similar model would be just as appropriate for elementary teachers preparing to teach in open classrooms, open schools or in individualized programs. The concept of community and the psycho-epistemological model are just as valid for preparing elementary teachers for these roles as they are for preparing secondary science teachers.

The writer does not suggest that educational institutes should rush to adopt the program outlined here. He is expressing a sincere concern for the apparent lack of viable alternatives offered to prospective teachers in our educational institutions today. His only appeal is that alternatives should be initiated and given a fair trial.

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REACTION

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Dr. Weller's paper is informative and stimulating. Its imaginative and creative thrust is found, in my estimation, in the last section entitled "Implications for Teacher Education." This part, in turn is based on carefully stated and clearly developed assumptions, theses, and discussions which are persuasive and hardly deniable. In some instances the assumptions and theses need to be tested and validated by some means, but if the opening arguments are granted, the conclusion, the "Implications for Teacher Education," seems reasonably to follow.

In light of the present state of the art in teacher education and secondary school science teaching, I simply accept without serious question most of what Dr. Weller proposes. The statements below are offered more as limited and selected commentary than as challenge or criticism.

The "epistemological" half of Dr. Weller's psycho-epistemological model is interpreted by this reviewer to be a description of (to state the nature of) cultural scientific knowledge and its relation to personal knowledge. This section of the paper properly should be reviewed by a scholar in the field. Based on my limited reading in this area, I believe that Dr. Weller has written clearly and accurately on the topic. He has written of a modern view of science knowledge and how it is generated, and in my estimation these are understandings of which too few classroom science teachers are aware. And I am convinced that a teacher's performance would be enriched if he had at his command the insights which Dr. Weller describes. Such knowledge could have an important impact on both curriculum and methodology.

A key position, appearing repeatedly in the paper and related to the psycho-epistemological model, is the statement that, for secondary students to develop a comprehensive working knowledge of science, he must, in turn, have a working knowledge of the "models" which guide the work of the scientist. This proposition should be debated. The concept of models in science has a great appeal for the science teacher who is himself an advanced student of science. Graduate students in science education who first encounter the concept are stimulated by it and wonder why their university professors hadn't exposed them to it before! Enthusiasm and excitement for any idea is a good basis for teaching. But we should weigh carefully this interesting and rather sophisticated idea as one which should become the content of our own secondary science teaching. (Any such debate will probably include the reaction that the concept has already been successfully introduced to high school students.)

The critical portion of the paper comes in the final discussion of the elements to be included in a teacher education program. Among these elements <u>community</u> may well be the most important. As an integrating base the concept of community is imaginative, is a fitting extension of ideas developed earlier in the paper, and is pleasantly idealistic. I have the feeling that Dr. Weller's community turns out, in fact, to be more inclusive than the prospective teachers, master teachers, and specialists whom he lists. Rather, it would also include the children in the public schools where the prospective teachers are to spend much of their time and would include the environment of those schools. The community approach suggested is much like field-based programs many teacher education institutions are developing, but in a very important way it goes beyond such innovations by including specialists from the academic disciplines in the teams or community. In order to implement the psycho-epistemological model the author desires, none of these persons may be omitted from the community of his proposal.

Someone has said that politics is "the art of the possible." It may be politics in its broader and more creative sense that would be needed to implement Dr. Weller's rather radical proposal. Certainly a reader can readily see that fundamental changes in institutional traditions, modes of operation, organization, and expected roles would be needed to bring the show off. On the basis of the field-experience emphasis being tried in our institution (Oregon State University), I am confident that teachers in preparation would welcome the community concept enthusiastically. Master teachers of the public schools would soon be sold on the plan. But the two groups of the community who would be hardest to change are the professional teacher educators and the academicians in the specialized science disciplines. If someone can persuade all parties of the worthiness of the goals, provide the leadership, secure the cooperation, find the financial support, shift the priorities, and develop the commitments and contracts, then one of the truly fundamental changes in teacher education in the Twentieth Century could become a reality. I would concur with Dr. Weller's closing statement, that his psycho-epistemological model is an alternative which should be initiated and be given a fair trial.

CHAPTER 9

A CHECK ON INTUITION

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For whatever reason, the bulk of the decisions science educators make regarding most everything, but especially related to our own day-to-day approach to teaching, are based on intuition -- our own or someone else's. Some intuitive decisions take the form of gut-level or top-of-the-head responses, whichever you prefer. They seem to appear from nowhere, but we all believe they must surely be the natural, sometimes subtle, result of experiences one has had, some fresh in memory, others mere feelings - perhaps the leftovers of an internal synthesis of past happenings.

Whatever may be the specific character of our internal chaining of cognitive and affective experiences, it is of less importance than the fact that most of our actions are intuitively based. And to recognize this bothers us. To be labeled "intuitive" insults our scientific pride. Such a label smacks of subjectivity, irrationality, a shortage of empiricism. Both men and women are made to feel uncomfortable by the word "intuition," as each automatically thinks of it as immediately preceded by the word "woman's." This word pairing denigrates the concept of intuitive thought because our chauvinistic past has reinforced the notion that men think rationally, whereas women operate on the basis of visceral level hunches called "woman's intuition." Thus, the internal reflex response to the word "intuition" is likely to be a feeling of insult for the man and embarrassment for the female -- either one resulting in contempt.

Though we prefer not to be reminded of it, the fact remains that, as teachers and teachers of teachers, we demonstrate daily through our various modes of instruction a tacit confidence in our own intuition. It is a human confidence. It demonstrates our anxiousness to move ahead, to act, to achieve the objectives and goals of our instructional efforts.

Let me hasten to admit that I strongly support intuitive decision making. I make many intuitive decisions each day, and so do you. We depend on them. Surely such decisions are often our very best, and frequently they provide the quickest and best way to handle certain problems. The questions are: Why have we developed such an implicit trust and dependence upon intuition? and What effects is intuition having on the education of science teachers and the students they teach?

Introspectively recalling our own personal educational experience may help in our understanding of why we are as we are. Perhaps it may help to consider the differential value which experience has placed on intuitive decision making versus empirical decision making. Think of your own experiences and then think about your contemporaries in science education.

Although each person has a different set of educational experiences, surely there are many common elements in these sets. In fact, it is highly probable that, with regard to decision making, our educational histories are much more alike than different. All of us have had eleven to thirteen years of precollege education, four to six years of undergraduate, two to eight years of graduate. Think about how that educational experience has likely affected your own attitude toward decisions based on intuition and those which are empirically based.

During your precollege instruction, how many times did you engage in any kind of research activity designed to get an answer to a question or to evaluate an intuitive judgment that you had made? What kind of emphasis did your teachers place on an empirical evaluation of ideas or actions? At the precollege level, which kind of decision making came out on top - intuitive or empirical?

As an undergraduate, how many of your professors asked you to research the result of intuitive decisions? I don't mean writing a term paper that pooled information about some topic; I mean assignments given you by your undergraduate professors requiring you to engage in following up an idea or a decision for action that was intuitively based by conducting some kind of empirical evaluation. As an undergraduate, was your confidence in research and your ability to carry it out increasing faster than your willingness to make and accept intuitive decisions?

Now then, recall your experience in graduate school. I suspect that if it was like most, the emphasis on research-based decisions didn't really begin until you and your advisor began to plan the master's thesis or the doctoral dissertation. Did graduate instruction give research the edge over intuition, or even an equal weighting?

The emphasis on intuitively-based decision making, common to our educational experience, must be the primary reason for our implicit trust in intuition and the reason we exercise it so readily. We have seen the process in action more or less continuously throughout our total educational experience. The educational time given to learning how to make empirically-based decisions, how to read and evaluate research reports, and how to set up and carry out simple evaluative efforts represents only a small fraction of our total educational experience. Our teachers have not demonstrated their active concern for emphasizing the intuitive decision-making process. They have not exemplified the critical need to balance good intuition with good evaluation. Are we copying the behaviors of our teachers? Are we behaving in the same fashion by approaching problems in about the same way as they did? I believe the answer to both questions is yes.

It would be convenient to blame all our shortcomings on past experience, on the contingencies that mold us, on the educators who have stimulated or who, more often than not, have bored us. But, of course, it isn't that simple -- we contribute our part as well. We seem to possess somewhere in our chromosomes an "excuse gene." I can't think of any other living creature which has such a gene. But surely we must. I never met a human being who didn't demonstrate the phenotype. Let's look at an example of the excuse gene at work.

Suppose you pose a question to yourself or to a colleague. The question relates to some intuitively-based instructional activity you or he is doing or planning. Here's the question: "How will you empirically evaluate your idea?" Will your colleague's response be something similar to one of the following? "There just isn't enough time for that." "I'm really interested in getting only a rough idea of whether or not this will work." "I was forced to start teaching before I had a chance to plan any evaluative research." "What I'm doing is really too simplistic to warrant an evaluation." "It's just a hunch; I'll evaluative it intuitively."

The ease with which such excuses are made indicates how our reliance on intuition seduces us away from empirical evaluations of our own educational decisions. Though we talk about the importance of research findings, read about them in professional journals and in dissertation abstracts, and stress in our seminars the importance of basing instructional activities upon research, we seldom demonstrate through systematic evaluations conducted in our own classrooms and laboratories the importance of checking up on our intuitive decisions.

I know as well as you the rationalization for moving ahead on the basis of intuition. We have a job to do and too little time to do it. Who has time to look at research data? When we do look, the research is often trivial or the findings irrelevant to the problems we face. Or we can't trust the findings because the design is poor or the statistical treatment ambiguous. All of these reasons, or, if you wish - excuses, can be justified. But even if they can, how can we as scientists, teachers of science, teachers of science teachers, and masters of instruction disregard our responsibility to check up on the intuitively-based instructional efforts in our own classrooms, particularly when the opportunity to do so is continually present?

Whatever our reasons or excuses, they say the same thing. It's easier to behave unscientifically. Behaving the way an educational scientist should is tough. It takes resources of time and energy and, more often than not, money. More than that, it takes planning. And it requires a willingness on our part to open up our intuition for autopsy, to maintain a tentativeness about our own judgments, and to strive for objectivity. That's expecting a lot of anybody.

And I suspect that there is at least one other reason that we neglect or even resist a research check on our intuition. It is a reluctance related to our being bent out of shape, so to speak, by our unrealistic perceptions of the relationships between instructional evaluation, research design, and statistics. Perhaps because we are in higher education, we think all evaluative research must be sophisticated by clever and profound statistical treatments. We act as if the whole world will break down the door to get at the results of our meager effort and therefore that it is incumbent upon us to engage in research that is not only statistically sound, but earthshaking in its potential. This unrealistic view of research produces a "scaredy-pants" reaction on our part. It intimidates us and those watchful bystanders, our students, and thus gives us yet another excuse for failing to balance intuitive judgments with empirical ones.

Let me summarize what I've said thus far. We all act upon intuitive decisions. Because of past educational experiences, we are likely to be overconfident regarding our intuitive judgments, giving much less attention to empirical justification. We resist engaging in evaluative research because it's more difficult to act like a scientist; we don't seem to have the time or the energy for it, we don't know exactly how to do it, we don't have a great deal of confidence in research findings anyway, and we are afraid of our critics.

Whether we accuse history or our own personal characteristics for the position we occupy in our private evolution, it is indisputable that we are nonetheless responsible for the teachers of science and the teachers of science teachers emerging from the institutions we represent. We must remember that our students are more likely than not to follow our behavioral example. This is particularly true should we be so fortunate or unfortunate, as the case may be, to gain their confidence.

Our guidance through our example is crucial. Thus, our first obligation to our students and our profession is to exemplify a scientific and objective behavior -- an overtly open-minded instructional approach guided by systematic evaluation of intuitive decisions. In other words, we must develop each of our own instructional schemes so that a means of checking up on its intuitive elements is part of its basic design. This responsibility carries with it the prerequisite of knowing where are are going, how we plan to get there, and what objectives we will have achieved on arrival.

If we are to encourage students to transcend the level of intuitive classroom behavior, we must also accept the responsibility for engaging them in empirical, evaluative studies or at least in their design, whether the students be undergraduates or graduates. Through the assignments we make and the expectations we display, they should perceive that good teaching demands checking up on their intuitive actions. Traditional activities in methods courses should give way - concede equal time, so to speak - to the development of evaluative competencies. Lesson plan development should incorporate simplistic empirical means for judging instructional effectiveness. The testing devices it includes must focus on the action and outcome of instruction, whether it be group-oriented or individualized.

An important part of motivating students to engage in empirical testing of intuition is to make sure that in conducting and discussing evaluation research, we emphasize the importance of simplistic design. We should urge our students to view empirical payoffs as generating primarily from step-by-step efforts. We should encourage them first to establish their instructional goals, objectives, and the methods to achieve them; second, to think through the evaluative questions they wish to answer; and third, to conduct studies based on the simplest first step, rather than attempt to tackle a whole research domain in one fell swoop.

We have the responsibility to provide undergraduates and graduates with experience in our classrooms that will help them to evaluate instruction relative to both the affective and cognitive domains. And we should feel some responsibility for helping them learn to apply simple statistics. This would serve to increase their own confidence that they can design and conduct simple studies, investigating those factors of most interest or urgency to them. At the same time we need to emphasize that the best research experience is that which grows out of real problems - ones they now face or will be facing in instruction - once again emphasizing that simplicity in design is the key to successful evaluative efforts.

We can discharge our responsibility to motivate teachers, especially in-service ones, to check up on their intuition by emphasizing the relevance of such inquiries. They present an opportunity for studying ideas and actions in the privacy of one's own classroom. We need to remind in-service teachers that their continuous contact with students gives them a great advantage in conducting empirical studies. Their classroom is their laboratory. We should encourage the classroom teacher to engage in short-term and in longitudinal studies. And we should stress the notion that engaging in instructional evaluation studies in his own school is the most relevant demonstration to his students and colleagues of his own belief that science teaching itself employs inquiry and research. We can further encourage participation in research by pointing out its benefits for the classroom teacher - the integrity it brings to his instructional efforts, the opportunities it offers in evaluating his progress toward his own educational goals, and the arguments it can provide in support of his own intuitive decisions in this era of accountability.

As members of an organization for the education of teachers of science, we should think of ways to encourage teacher-conducted classroom research and evaluation. We should investigate means of coordinating our research efforts with those of our colleagues in the public and private elementary and secondary schools. Surely, we can learn as much from them as they can from us. We should develop a means of rewarding good efforts in order to raise the prestige of the teacher. We should consider ways to improve communication between teachers who are engaging in evaluation of their instructional schemes. As part of our own instruction, we need to search out, find, and provide for our pre- and in-service teachers examples of the research efforts of other classroom teachers. There are exciting studies being done by classroom teachers. We must think of ways to identify and publicize them. Perhaps one way to achieve this is to establish a journal exclusively for teachers to which they could submit reports of studies conducted in their own classrooms.

What payoffs might we achieve from this individual and corporate emphasis on checking up on intuitive decisions? First, it should produce a sensitivity on the part of all of us and all our students to the need for continuous evaluation of our instruction. Second, it should stimulate greater interest on the part of classroom teachers in the evaluative research of others, primarily in finding out if, and, if so, how, one's own instructional problems are being tackled by others. Third, it should focus attention on the issue that is of specific relevance to teachers -- how to improve their teaching in their particular setting. A fourth benefit should be the development of a greater receptivity on the part of teachers to innovation in instruction. Having had the opportunity to look at their own efforts in the nonthreatening, protected environment of their own classrooms, teachers should be less defensive, more realistic, and more objective about their own ideas and innovations and, therefore, more receptive to those of others. A fifth and more subtle benefit for the classroom teacher who checks up on his intuition is the pride and confidence of knowing that he has made an honest effort to evaluate his own attempts at instruction critically.

Perhaps the most important payoff of a check on intuitive decision making is the production of a more efficient and logical instructional process. The quality of intuitive decision making should improve. And that is important because all of us will continue to forge ahead day-by-day on the basis of intuition. By checking up on our intuition, what we know about the instructional process and the application of theories of instruction and learning has got to increase.

By now it should be clear that the bulk of what has been offered in this paper is based upon intuitive judgment. No references have been made to research studies which support the points put forth. No quotations from reputable science educators have been included. No attempt has been made to suggest a way of evaluating the comments or ideas. Even so, perhaps some of the propositions may have found agreement with your own intuition. Certainly most of them come from mine. I suspect we had better check up on both mine and yours.

REACTION

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I agree with many of the thoughts Dr. Snyder presents in his paper on intuition. Much of the agreement comes from using my own intuition since there were no empirical studies cited in the paper.

It is sometimes difficult to ascertain whether our decisions are based on empirical or intuitive judgment. That is, how much evidence must be available to call it an empirical judgment? Is it intuition if only one study is used or if the study is only somewhat related to the problem? I agree wholeheartedly that we as science educators should strive to lean more heavily on data rather than intuition and that we should set an example for others to follow. It is not enough to point the finger at others. In fact, this practice might be counter productive if pre-service or in-service teachers hear us saying one thing and practicing another. My own intuition tells me that they will be influenced by what we do rather than what we say they should do.

One small ray of hope is found in some of the "new" science programs. For example, in the SCIS program one of the key questions for teachers is "What is your evidence?" If this type of thinking could permeate the teaching techniques in science courses K-12 and college science and professional courses, it would provide a tremendous impact on the type of learning that takes place in these classes.

The suggestion of Dr. Snyder concerning the teacher's role in self-evaluation is noteworthy but very difficult to implement. This difficulty is especially easy to understand with teachers in K-12 schools who probably teach from 25-35 hours/week when we observe how much self-evaluation takes place with college teachers who teach from 6-12 hours per week.

As Dr. Snyder has stated, it is very easy to fall into the rut of relying heavily on intuition. For example, I have written this short response without citing a single empirical study. The point is not whether we use intuition or not, but how can we keep from continuing to exclude meaningful data in the basic process of decision making. Dr. Snyder states that by checking on our intuition, it will improve our intuition. This conclusion is the best example of using intuition to arrive at a profound conclusion. Somehow I cannot get too excited about an intuitive judgment about intuition.