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PROVIDED IS A COMPILATION OF PAPERS AND REPORTS WHICH WERE PRESENTED AT JOINT SESSIONS OF THE 1966 ANNUAL MEETINGS OF THE ASSOCIATION FOR THE EDUCATION OF TEACHERS IN SCIENCE (AETS) AND THE NATIONAL SCIENCE TEACHERS ASSOCIATION (NSTA). THE PAPERS DISCUSS (1) THE ENTRY INTO THE SCIENCE TEACHING PROFESSION, THE LEGAL VERSUS PROFESSIONAL CRITERIA FROM THE STANDPOINT OF THE COLLEGE DEAN, THE STATE DEPARTMENT OF PUBLIC INSTRUCTION, THE SECONDARY SCIENCE EDUCATOR, AND THE ELEMENTARY SCHOOL SCIENCE EDUCATOR, (2) RESEARCHABLE PROBLEMS IN SCIENCE EDUCATION, RESEARCH DESIGN AND OPERATIONS, AND (3) AUDIOTUTORIAL INSTRUCTION AS A VEHICLE FOR TEACHING SCIENCE. THE REPORTS DEAL WITH (1) PREPARING TEACHERS FOR THE JUNIOR HIGH SCHOOL, THE TECHNICAL SCHOOL AND THE JUNIOR COLLEGE, AND FOR TEACHING THE CULTURALLY DEPRIVED, (2) THE SCIENCE METHODS COURSE FOR SECONDARY SCHOOLS, AND (3) GUIDELINES FOR THE DOCTORATE IN SCIENCE EDUCATION. (DS)

ASSOCIATION FOR THE EDUCATION OF TEACHERS OF SCIENCE

1966 CONVENTION

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COMPILATION OF PAPERS AND REPORTS

from sessions held in conjunction with the convention of the

NATIONAL SCIENCE TEACHERS ASSOCIATION

ASSOCIATION FOR THE EDUCATION OF TEACHERS OF SCIENCE

TABLE OF CONTENTS

ENTRY INTO THE SCIENCE TEACHING PROFESSION: LEGAL VS. PROFESSIONAL CRITERIA

David S. Sarner
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The Dean's Point of View

For the past 12 years I have been dealing with the problems of Entry Into the Teaching Profession. As Director of Certification at Temple University, and now as Dean at Keene State College, the problems are generally the same - how can we in teacher education keep the standards up while the professionals in the field cry for teachers to fill the classrooms in their continually expanding schools?

In 1958, Jack Frymier and I did a study(1) which took a look at the requirements throughout the United States for certification in mathematics and science. We tried to ascertain what comprised adequate preparation for teachers of the subjects and we also attempted to determine what it was that made this preparation adequate.

Having no set, accepted standard against which to compare, we were then reluctant to say how much is enough. (I am pleased to note here that as a result of this study - the NASDEC Guidelines were eventually conceived). The data in the study, however, seemed to indicate that certification requirements for teachers of science throughout the United States are not generally agreed upon and not generally high. In other words, there seemed to be considerable lack of agreement among the states upon what constitutes acceptable minimal standards, although most states agree fairly well upon the amount of professional education required for certification.

Most of the states are vague in setting forth the specific subjects which a prospective science teacher must have before he can be certified to teach. Almost without exception no mention is made regarding the quality of this preparation. That is, a prospective teacher could complete the number of hours required for his teaching field of science with minimal grades, for example, all "D's" as long as he has maintained a grade point average satisfactory for graduation, and still be certified to teach in these particular subject matter areas.

It seems that many of the inadequacies which currently exist in various state certification laws can and should be remedied by teacher education institutions. The various colleges and universities can and must insist upon higher than minimal requirements in academic preparation. Obviously this is already being done in many places; all institutions engaged in preparing science teachers should consider the possibility of carefully evaluating their own institutional programs and minimum requirement.

During the past 8 or 10 years, thousands upon thousands of science teachers have availed themselves of the opportunities afforded them through the programs supported by N.S.F. funds. Surely this reinforcement of the science background of a large number of teachers presents an opportunity to enable the various states to strengthen or raise basic requirements for certification in the sciences.

In recent years the State of New Hampshire has made a strong effort to increase certification standards in the sciences. Although they have changed the regulations so that 30 semester hours are required in a major teaching area and that a minor teaching area requires 12 semester hours, they still allow a person with only 6 semester hours to teach in a subject. Therefore, any college graduate who satisfies the general education requirements for a baccalaureate degree - 6 to 12 hours of science - can qualify to teach a science course in the public schools of New Hampshire.

Obviously the training institution cannot fill in all the certification loop holes. They must, therefore, rely upon the state certification agencies to maintain high standards. Most state certification officers are trying to hold the line but what can they do when the hiring officials of the state's public schools clamor for teachers? Shall the superintendent close down a class? Theoretically we will answer, "Yes!" but practically we know he cannot do this. So, he looks around for almost any warm body to "hold the fort" until he can find an adequately prepared teacher.

A training institution can and does insist upon adequate standards. But it does face some problems peculiar to the State. New Hampshire, for example, has a large number of non-degree people who have been teaching for a number of years. Nothing can be done to force these people back for a degree. Fortunately, hundreds of them have returned for additional courses leading to a degree. With these teachers, it is possible to require content courses which will bring the subject matter knowledge up-to-date and build up a knowledgeable concentration.

There seems, then to be a definite need for some sort of uniform minimal code of requirements for certification throughout the United States. Perhaps the time has come to suggest support from a funding organization to support a series of meetings between the certification officers of the various states and representatives from A.E.T.S. which would prove instrumental in upgrading the current deficiencies. Out of such a meeting might come a program such as Watson(2) suggested in which full-year courses in biology, chemistry, mathematics, and physics totaling approximately 32 semester hours as a foundation program "for any prospective science teacher, irrespective of his special interests" would be required. As Watson pointed out, the Steelman report made such recommendations as far back as 1946, but so far these appear to have gone unheeded.

Let us then in A.E.T.S. continue in our slow progress toward the development of an acceptable program for the training of science teachers at both the elementary and secondary levels. A few regional sections have already started on this task. This convention will also consider the "Guideline for the Doctorate in Science Education." Isn't it time then, that A.E.T.S. assumes its role of leadership in Science Education? Why can't A.E.T.S. complete its recommendations for science teachers, then organize a series of regional meetings with the State Certification Officers of those regions, arrive at acceptable minimal standards, and then call for a nationwide representative conference which can develop a uniform minimal code of requirements for certification through the United States?

Dare we continue to ignore these recommendations? Is it possible that we can get more and better science teachers by having low minimum requirements? Can teacher's organizations observe the problem of inadequate standards without taking action and still profess professional status? Can state legislatures or education boards justify creating situations wherein prospective teachers spend two or more years in general education and sometimes less than one full semester in teaching field subject matter area preparation? Do states actually adhere to their written requirements, or do they sometimes "say one thing and do another?"

Questions such as these deserve serious consideration and then, vigorous action by any and all concerned.

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(1) Sarner and Frymier, "Certification Requirements in Mathematics and Science," School Science and Mathematics, June, 1959. 456-460.

(2) Watson, Fletcher G., "Course Requirements for Future Science Teachers," The Scientific Monthly, December, 1957, 32-323.

ENTRY INTO THE SCIENCE TEACHING PROFESSION: LEGAL VS. PROFESSIONAL CRITERIA

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The State Department of Public Instruction's Point of View

It is not necessary to review in detail the criticisms which have been leveled at state departments of education about arbitrary credit counting and inflexible certification rules. There are those who say state departments set the requirements much too low and others who say that state departments should not set standards at all. However, let us consider some of the practical and philosophical problems faced by an agency which must assume the responsibility for maintaining and enforcing a certification system.

In Pennsylvania, as in other states, a gradual transition is being made from the actual counting of credits and issuance of certificates to the "program approval" approach. This seems to be an admirable way to make it possible for teacher education institutions to provide and maintain well-planned, high quality programs for the preparation of new teachers. The outlook for the future supply of excellent teachers, under this plan, is promising.

We can, by this method, produce candidates who are highly competent, although still apprentice scientists and who also have a professional commitment to teaching. Other candidates, because they lack either the high competence in science or in teaching can be diverted from the teaching field. This, from our viewpoint, is fine. But, a state department certification officer is forced to face school superintendents who are unable to find enough teachers certified in science to meet the ever growing demand. In circumstances like this it is difficult for him to deny interim or emergency certificates to candidates who do not meet the minimum requirements.

When the state evaluation teams require an institution to provide science teacher education as described in the AAAS-NASDTEC Guidelines in order to get "program approval," the institutions are sometimes unable to hold enough students in the program to keep it going economically. Highly creative, imaginative students may well be interested in more than one discipline and will be lost to science if they can gain satisfaction in teaching another discipline which presently, at least, is not so rigorous and time-consuming in its preparation requirements. It seems obvious that we must compete with the other professions in attracting candidates from the top 5% (intellectually speaking) of our population. There is evidence that people from average intellectual levels may have a large measure of the compassion and empathy so essential for good teaching.

There is, however, another viewpoint from which we must look at this topic. The responsibility for maintaining a system of public education is delegated to the state governments. It is sometimes painful to remember this, because all of us, including state certification officials, like to attack the teacher certification and supply problems with a philosophical approach of mutual concern rather than by legislative decree. Teacher preparing institutions and state departments jointly share the responsibility for carrying out this public trust.

Liberal Arts and Education professors must temper their academic freedom with concern for the public good as they set about educating teachers. A state department official feels even more strongly the limits to the freedom he can exercise.

As he strives to increase and improve the supply of certified teachers available, he must constantly find a livable middle road through the maze of pressure upon him. Certification officers know that counting course titles and credits will not reveal the qualifications of the candidates. But, an objective line must be drawn and applied to all those seeking certification.

The battle is never ending to strike a balance between steadily developing certification requirements and too quickly adopting changes to reflect a short-lived trend in educational practice. When state boards of education move slowly and educational leaders jump onto bandwagons quickly, the certification official is caught in the middle.

Organizations such as AETS have a role to play in the support of state departments. Certification officers look to us for leadership in recommending needed changes and for support in getting these changes implemented. As staff members in institutions with "program approval," we can actually have the responsibility originally delegated by the state to the office of the certification official. There are those who question the legal right of a state department to delegate this authority, but inasmuch as it is being done, we cannot regard the responsibility given to us lightly. If we are preparing teachers, then we should perhaps accept the credits and hours available to us and use this time for teaching by example the nature of science, a love for it, and good ways of teaching it.

As long as state departments have authorities mandated by state constitutions, we cannot hope to brush completely away legal requirements for certification. Why not instead capitalize on the responsibility given to us by the "program approval" approach and make science and the teaching of it attractive to potentially good teachers. Then, we can prepare them to teach by using imaginative techniques and careful choices of content. This would leave the state certification official free to capitalize on the unique contributions which can be made by individuals and institutions to the science teaching profession as he fulfills his responsibility.

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ENTRY INTO THE SCIENCE TEACHING PROFESSION: LEGAL VS. PROFESSIONAL CRITERIA

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The Secondary School Science Educator's Point of View

"Entry into the Science Teaching Profession, Legal versus Professional Criteria" is an intriguing topic because the "Versus" implies an antagonism between the two. Obviously there is not. Professional requirements embodied the goal which is sought and the legal processes attempt to codify the achievement of this goal. Consequently, I should like to interpret the versus as distinguishing between the substantive aspects of entry -- the knowledges and skills which a professional science teacher should have -- and the process aspects of entry -- the path by which he finds himself labeled "certified."

I shall say only a very few words about the substantive aspects of certification although these are probably more troublesome than the procedural aspects. With knowledge growing explosively and our ideas about what constitutes good science teaching changing along with it, the skills and knowledges which we wish our teachers to exhibit change equally as drastically. The sad state of affairs of legal criteria can be illustrated by the recently adopted minimum certification requirements of New York State: "One year each in biology, chemistry, the earth sciences, mathematics and physics, and a second year in the science in which certification is sought for provisional certification (good for five years), and a third year in the science in which certification is sought for permanent certification (good forever)."

That this is a statement of <u>minimum</u> standards is self-evident; that it represents an improvement over previous standards is a tragic commentary on how realities have historically kept our aspirations low. Whatever the desirable level of competence in a science might be, I am convinced that in 1966 two years of study will not achieve it and I am even more convinced that a background of three years of study in a science is barely sufficient to maintain competence for even five years, let alone forever. But we could argue this point a long time. We are discussing criteria for entry, and I know of no way to make a candidate promise that he will keep professionally alive.

In the area of professional education we are perhaps in a better position. At least our critics say we are using too much of the college time for trivia. Our position probably would be better still if we knew specifically what we wanted. But it is nearly impossible to specify the behaviors of the good teacher, and it is more impossible to find the operational link between the courses in psychology and philosophy he takes and his ability to demonstrate these behaviors. But even if this were possible, we could not guarantee his having demonstrated competence in the behaviors on the basis of five or six observations during practice teaching under, to put it mildly, unsettling conditions. In this area, too, it is easier to specify what professional demands are insufficient than to specify those which are sufficient.

This brings me to consider the process by which certification is obtained. I shall make a suggestion for an alternative process that might serve as the basis for discussion.

Let me point out that certification is typically achieved upon the recommendation of a college or university after a student has passed a certain number of required courses and has demonstrated some proficiency in practice teaching.

In other words, the process of achieving certification is one in which the state sets certain criteria and the college recommends the candidate after he has met them. (Alternatively, the college does not recommend but the state looks over credits independently).

Now I think there are two things wrong with this process, quite aside from the substantive questions I have mentioned above. The first thing that is wrong is that the wrong agency makes the judgment of competence and the second thing that is wrong is that the judgment is made at the wrong time.

Most, if not all, other professions in which criteria for licensing must be met, have devised a process which separates the institutions that educate from the institutions that judge achievement of professional criteria. Typically a college or university educates and some committee of practitioners examines. There are many aspects of this that we could discuss, and I want to stress immediately that I have no great faith in single examinations. But I also think that there are at least two dangers in having the institution that educates be the sole judge of the adequacy of its program. The temptation to ignore deficiencies may be too strong. I wonder how many college faculties or administrations would admit that their product does not meet certification standards because of program deficiencies. At this point I tremble at the thought that Conant's recommendation from The Education of American Teachers should ever be implemented. I sincerely dread the thought of leaving entry criteria entirely to the judgment of college faculties. I reiterate that I think it is undesirable to have the college sit as the sole judge of the achievement of criteria.

There is an even more compelling reason for removing that judgment from the college. The short period of practice teaching is an opportunity to learn, not a time for judgment. If the college must attest competence it must also judge. I am convinced that the half dozen or so visits made to a student teacher's classroom during student teaching are times of utmost terror to him and that any judgment made by the college supervisor is a wrong judgment. The sampling is too brief; the conditions too artificial. Indeed the objectives of practice teaching are defeated by this. This point has been argued in the supervision literature for many years. I am astonished that it has received so little play in the context of student teaching.

Moreover, it has always seemed incredible to me that we can certify a teacher at the college and at the state capitol, and then deny him tenure on the basis of incompetence. Using practice teaching to judge competence immediately implies that the new teacher is indeed fully qualified when he has been recommended for certification. Nothing is further from the truth, as any first-year teacher will tell you. It is during his first year that he really learns to teach and that he can really demonstrate whether he has met entry criteria. This first year is a time when he still needs help and it is a much better time for review of competence.

Therefore, regarding the legal versus professional criteria of the process of certification, I would like to make a suggestion somewhat as follows. First, I would not certify either provisionally or permanently upon completion of a pre-service collegiate program. The program might still have certain required components but its completion would allow the teacher only opportunity to demonstrate competence in a classroom perhaps for one year. It would be the equivalent to the learners permit in driving. Second, I would appoint district or county supervisors of instruction whose sole function would be to work with first-year Teachers in their area of competence. These supervisors would pick up where the colleges left off. Their function would be to visit the new teachers on a regular basis and help them with curriculum planning, classroom problems, and the host of other matters that typically swamp them. I am convinced that this help is absolutely necessary for first-year teachers and I am furthermore convinced that it is not, and by and large cannot, be given by building principals or building supervisors. Third, this supervisor, who would probably visit each of perhaps twenty-five charges not less than twice a month and often as much as four or five times a week, would certify at the end of the first year that the teacher has the classroom skills necessary to pass certification. (You might notice a strong resemblance to another one of Conant's points here; namely, his recommendation for a "clinical professor.")

Is such a process realistic? I think so. It could reduce the frantic scurrying about I now see to visit practice teachers. Much of this, I think, is unnecessary because practice teachers are typically placed with competent practitioners. And where this is not the case, the college supervisor's effectiveness is much smaller because he is just not there most of the time and he frightens his charges when he is. The scurrying about is merely an attempt by the college to have a sound basis for judgment when it recommends for certification. I really believe we could save colleges hours and hours of supervision - a dull and unsatisfying job as those of you have done it must surely know - and reduce supervision to the number of visits needed to straighten out administrative factors such as clarifying roles.

The savings which would come from this reduced commitment by the college supervisor could easily be invested in paying the certification official an attractive salary to do his job well. Moreover, I feel he could help retain in the profession quite a few young teachers during those lonely first days and weeks and months when their dedication and energy are undermined by uncertainty, lack of attention, and ineptitude in minor situations. It is at this point that I feel professional criteria for entry differ most from legal criteria, and it is toward the rectification of this problem that I have directed my remarks.

ENTRY INTO THE SCIENCE TEACHING PROFESSION: LEGAL VS. PROFESSIONAL CRITERIA

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The Elementary School Science Educator's Point of View

Entrance into the profession of science teaching needs to be viewed from the perspective of both professional and legal criteria. The point of view expressed here concerning entry to science teaching in the elementary grades rests upon the idea that professional and legal criteria are interlocking and necessary aspects of making available teachers who are competent in guiding children in effective learning in science. Accreditation, approved programs of preservice and inservice education, certification with its provisional phase and then the more permanent aspect with emphasis on inservice learning and development need to be seen as "all of a piece." or should be made so in our educational planning. It is to our advantage to see what each aspect can and cannot do, and at the same time keep a perspective on the whole process of validating competency in teaching science in the elementary school. We have a tendency to bear down on some one or another aspect at various times in our efforts at reform, without enough consideration of the total matrix.

Entrance into the profession can be considered fait accompli upon the issuance of the provisional certificate. On the other hand, entry can be regarded as a developmental procedure from preservice education through initial certification to proof of competency during an initial period of full-time teaching experience and inservice education. Such a developmental consideration will depend upon substantially more cooperation and involvement among the institutions, agencies, and the local school systems concerned than we are now witnessing. However, such relatedness would seem no more difficult to achieve than trying to improve the situation from time to time by emphasizing first one set of criteria and then the other.

At this point, some general comments concerning science in the elementary school seem warranted as a background against which to raise some fundamental considerations in seeking to guarantee the entrance of professionally competent teachers to this area. First of all, we need to remind ourselves again, that as an area of learning and instruction in the elementary school, science is a relative newcomer. In comparison with reading, other language arts, mathematics, and some of the social studies, it is young indeed. That many of the professional pioneers in this field still are very much an active and contributing part of the educational scene today attests to the youth of the movement. When viewed from the social, cultural and economic realities of the times, the delay of the elementary schools response to so dynamic a force as science seems inexplicable. Such general apathy can account in part for the limited science requirements in the preservice program of the elementary school teacher, little recognition of it in elementary certification, and for the apparent lack of interest in childhood education on the part of the scholar in science. On the other hand, the relative newness of the ferment and emphasis on science in the elementary school means more flexibility in the situation. There are not so many hard and fast traditions to overcome. The high value that present society places on science and mathematics is encouraging a positive interest in science in elementary education among laymen, educators, and academic scientists. Considerable readiness for improvement is at hand.

Secondly, the critical significance of effective learning and teaching of science in the elementary grades has been propelled to the forefront within the past few years as a result of bringing the curriculum reform movement into the elementary schools. The participation of scientists and scholars in identifying some of the major integrating ideas and conceptual schemes in the content itself, in spelling out what science is and in describing how a scientist works has focused attention on what is important to learn in science. The much-quoted statement "---Any subject can be taught effectively in some intellectually honest form to any child at any stage of development," the reports of research on cognitive development and conceptualization, analyses of the will to learn and its dependence upon early childhood experiences are all contributing to the lifting of aspirations as to the goals to be achieved by children through learning in science and the professional competencies needed by the elementary school teacher in guiding and directing such learning. The need to bring the learning and teaching more in line with the true spirit of science, the need to upgrade curriculum offerings and to bring about some measure of universality of opportunity for learning in science for all children and teachers is immediately apparent.

Another factor to be taken into account is that while all teachers, in order to be liberally educated, need to know what science is, how it operates, and some of the major integrating ideas of science, most elementary teachers will not specialize exclusively in the teaching of science. Some will develop a content major in science. Only a few will elect at the preservice level to be specialists in science. Other areas of learning and instruction must be a part of their professional competency as well. The early years of schooling are regarded increasingly as the most favorable for learning and every discipline is knocking on the door of the elementary school for more time. Science courses offered at the college level as a part of the general education sequence bear great responsibility for exemplifying in both content and method contemporary knowledge and the processes of science. As matters now stand, this is not always the case.

Now, in light of the foregoing and mindful of the interdependence of the various facets bearing upon entry into the profession of science teaching, let us turn to the two areas of criteria - professional and legal - for further comment.

Professional Criteria

The profession is confronted with the necessity of being more contemporary and more explicit in the delineation of the specifics of competency needed for guiding children in a modern program of learning in science. This is the heart of the matter in establishing criteria for entry into the profession. If we put our minds to it we can come closer to describing good teaching in science in the elementary school than we have ever done before.

We are indebted to the national curriculum projects in elementary school science, to statements by practicing scientists, to documents such as the NASDTEC-AAAS Guidelines for Science and Mathematics in the Preparation Program of Elementary School Teachers, to the work of the NSTA Commission on the Education of Teachers of Science for stimulating higher aspirations for learning in science in the elementary grades. From such endeavors have arisen clearer ideas of the role of the teacher in helping children learn how to learn science through using the processes of inquiry, experimentation and discovery.

Some real problems arise as efforts are made to bring these aspirations and insights over into the main stream of general practice and to develop recognizable teacher competencies for selecting and maintaining appropriate teaching

Strategies in science. Structure, conceptual schemes, processes, inquiry, discovery as terms are easy to latch onto and their usage is high in current educational dialogue. Under the guise of these terms some of the same outmoded subject matter is being taught in the same old ways. It is easy to give the old wine new labels. It is much more difficult to be clear about what underlies these emerging ideas and to specify in behavioral terms what is implied. Total programs of teacher education in science for the elementary grades taking these ideas and behaviors into account are still to be designed and tried out. These are the tough problems into which we must sink our teeth.

Legal Criteria

The procedures used in certification and some in accreditation, although useful, are weak reeds to lean upon in vouching for competencies in teaching science to children. Administrative techniques that are simple to observe and easy to check, a filling of required slots with names of courses and hours of credit in academic science, in general professional education, in specialized methods may indicate benchmarks, but also may be only the husks of the real kernels being sought in the competencies needed. We need to be careful with demands for years of this or that science for elementary school teachers. It seems possible to make quite a collection of such requirements and in many ways not be assured of the competencies needed for guiding children in a modern up-to-date program of learning in science. Titles of courses tell very little about the character of learning opportunities provided therein. Somehow or other, we need to put more meaning into the shorthand of both certification and accreditation.

No one would deny the need for a "good" background in science, but just what is needed to begin on is not clear. Any number of the national curriculum projects in elementary school science are having considerable success using good elementary school teachers and providing them with intensive and expert inservice help. Additional depth in science sought by such experienced teachers would meet the need for continuing learning in the field and have a better chance of being related to their professional responsibilities than if all such was required of them before beginning full-time teaching.

The inservice aspect as an integral part of the total program in the education of teachers in developing higher levels of professional competency and as a basis for recommendation for licensure or certification is in need of considerable study. Providing knowledgeable assistance at the local school level in refining competency in science teaching and providing opportunities to continue learning in science are problems for the total profession, and have a good deal to do with developmental steps for entering the profession.

Many opportunities are before us as we continue to press forward to establish more defensible criteria for developing and vouching for professional competency. AETS in collaboration with NSSA is in a strategic position to make a unique contribution to the further clarification of entry to the profession through developmental procedures. We need detailed and specific reports from states and/or regions of emerging exemplary total programs. We need to give leadership in ferreting out and reporting forward-looking cooperative arrangements and significant learning and teaching experiences that seem to hold great promise for developing, evaluating, and rewarding professional competence. Perhaps a comprehensive publication is needed.

Certain opportunities afforded through the Elementary and Secondary Education Act of 1965 could be capitalized upon at the state level (or regional level within a state) in setting up truly innovative and experimental centers for making competency in the teaching of science more available at all levels and in establishing genuinely significant criteria for entry into the profession of science teaching. Such centers would involve university preservice and inservice programs, state department certification officers, state department supervisors of science, local representatives of professional science teaching organizations, local school system leaders and coordinators of inservice science and supervising teachers. Building appropriate backgrounds in science at the collegiate level, and developing and coordinating appropriate opportunities for classroom observations, participation, interneships, beginning teaching and the evolution of career teaching could be built together as an integrated whole.

RESEARCHABLE PROBLEMS IN SCIENCE EDUCATION: DESIGN AND OPERATIONS

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Last year Phi Delta Kappa published the book, "The Training and Nurture of Educational Researchers" containing the papers and ensuing discussions of the sixth annual symposium on educational research. The volume is very interesting reading for seeing the various conceptualizations of what educational research is, could be, or should be. Perhaps one of the more intriguing comments in the volume is the following, extracted from a paper by Carl Bereiter. "The proper question to ask in evaluating a field of applied research is, What changes have been brought about because of it? Applying this question to educational research of the last 30 years leads directly to an insight into its basic failing: The only major changes brought about have been changes in education research itself - new measuring devices, new statistical techniques, and a general refinement in research methodology. One looks in vain for discoveries that have had any impact on the enterprise which educational research was intended to serve." Bereiter adds that such innovations as educational television, teaching machines, and new curricula did not come about from educational research discoveries. I highly recommend to you Bereiter's provocative analysis of education research contained in his paper, and the printed transcript of the spirited discussion following his presentation. In the discussion one of the participants, Harry Levin, speculated as follows: "Suppose there had never been an enterprise called educational research. Suppose that there wasn't this activity we call educational research, or a lot of people who call themselves educational researchers for one reason or another. Would educational practice be very much different at this point from what it is now?"

This morning I should like to consider my task "Design and Operations" within the context of taking seriously the comments of Mr. Bereiter and Mr. Levin. I interpret "Design and Operations" as falling into the domain of "how to do it," and will center comments around three subanalyses. First, how research has been conducted in the past and to what this appears to have led. Second, some of the present and developing means for conducting research. Third, I should like to suggest an alternative mode of conducting research, one that may be ultra-conservative or just plain old-fashioned heresy.

I

Joseph Rice is often considered as the individual who started educational research, as distinct from psychological research, when he administered a spelling test to 30,000 children in 1897. In a series of articles in the Forum, which he edited, Rice showed that the results fell far below the claims being made for the teaching of spelling. Between the late 19th century and the early 1930's educational research and research methods developed at an astounding rate, evidently grounded on two fundamental beliefs. First, it was held that if just about anything and everything having to do with schools were measured there would develop rapidly a science of education with unlimited implication for practice. Secondly, it was believed that beneath the apparent complexity of educational phenomena there lay a basic simplicity, presently hidden from view. One finds in the literature of various fields, in curriculum, supervision, administration, and teaching, these two assumptions serving as postulates upon which design and operations of research were based.

Consider, for the moment, how well suited such a statistic as one-to-one correlation fits these two notions. Let us take, for an example, the relation between teacher characteristics and pupil achievement. If one holds to the belief in simplicity then there must be a simple relation between what pupils learn and characteristics of teachers. The earliest education study I know centered on this particular problem was done in 1902, where IQ scores of teachers were correlated with a measure of pupil achievement. The correlation was essentially zero. If the simple relationship is not between teacher IQ and pupil achievement, then the relation must be between some other characteristic of the teacher and pupil achievement. Surely, one trial is not sufficient to shake the foundations for this assertion. In the thirty-year period between 1900 and 1930 there were conducted hundreds of correlational studies searching for some kind, any kind, of relationship between teacher characteristics and pupil achievement. However, it would be unwise to lapse into cynicism at this point. After all, had not the physical sciences experienced enormous success by holding the view that behind the buzzing confusion of natural occurrences there was an order, a simplicity, a beauty graspable by man, and this beautiful simple order emerged by exercising ingenuity, patience, and skill in measuring? In truth, rather than cynicism we should express admiration for this period of hard work because it was a good first approximation of how to go about making sense of educational phenomena. Who knows, it might have worked.

But there grew gnawing doubts that it was not working, and furthermore, that it might not ever work out. Under the leadership of Ralph Tyler and others, fundamental assumptions were re-examined in the early 1930's. Rather than simplicity, it might just be that educational phenomena are complex. If there is an order, then the order itself might be complex. It is easy to say this in 1966, but one has to examine the research literature of the 30's and early 40's to see how slowly, how very slowly, researchers began to design and carry out studies as if they really believed in the complexity of the phenomena. It is possible to point to the Eight Year Study as a towering example reflecting these new sets of fundamental beliefs. Unfortunately, even today this research study is too little known and appreciated, and it is only 30 years later that some of the ideas about evaluation used in the Eight Year Study are beginning to show up in some current course developments in Science and Social Studies.

II

About fifteen years ago, designs and operations for handling complexity slowly became better known to educational researchers. I would guess that by now it is generally believed that matters of concern to educational researchers are indeed viewed as being complex. Perhaps this view is now so widely held that one might be led to comment, "Alright, alright, things are complicated. . .so what?" I would insist, however, that this was not the view 40 years ago, and the shift in belief is of enormous importance for the design and operation of educational research, indeed one must grasp this change to understand much of what is currently going on, and many of the plans being proposed. Time permits only a few general comments on the current situation.

First, new modes of research design and statistical operation are increasingly being used in educational research. The sheer technical prerequisites for just reading the literature, in say science education, have taken a formidable leap. There are a number of reasons for the rather sudden appearance of new designs and statistical operations in research. While the notion of educational phenomena as complex rather than simple has been long "agrowing," the technical tools for measuring complex systems and for making sense out of masses of data has been slower to become known and used. Surely one breakthrough has been that marvelous computational serf - the computer, but in addition, thanks to some ingenious people, it is now possible for awestricken individuals like myself to baby-talk to an ever increasing number of gadgets. Emerging from studies using these newer modes of research are more powerful statements about events of educational interest. It remains to be seen whether in time there will become available sets of relational statements enabling us to make sense, to understand, and explain with greater depth, curriculum, teaching, learning, supervision, teacher education and so on. Today one is reminded of the optimistic mood of a half-century ago, but our mood should also be cautious for we are ill advised to forget that the optimism of the past was followed by disillusionment.

But there are other developments than design and statistics. There is also evolving, not only a technology for dealing with complexity, but also a "science" for dealing with complex systems. Other people might prefer to say there is a developing "pseudo-science," so I shall play it safe and simply say that there is a developing "rationality" for dealing with complex systems. Increasingly the means used to conduct and conceptualize educational research look more and more like the means used by the psychologist, the sociologist, the economist, the political scientist, and even the analytic philosopher. Recently I received a book entitled, "Cybernetic Principles of Learning and Educational Design" which deals not only with the very apparent hardware of the "Buck Rogers School of Thought" but in addition with the general rationale behind the hardware.

Lest these matters appear over mystical let me provide a more specific illustration. Behind the incredibly rapid evolution of programmed instruction from modest beginnings, to pompous hucksterism, to disillusionment and despair, the fundamental rationality behind programmed instruction still remains. Further, while the school market for essentially poor programs has rightfully dropped out, programmed instruction is increasingly being used in industry. It remains to be seen whether the new wave of complex hardware, like computer-linked program systems, will become a reality. The mounting pile of books and articles on the computer in education may turn out to be prophetic or merely amusing. In terms of research, however, we must note that the ideas on which programmed instruction is based are also very powerful ideas for research, and may be considered both as a rationale and a method for investigation. The methods may be used to alter an organism's behavior, but may also be used to study the behavior of the organism. In the decade ahead we may see these instrumentalities flourish as research <u>means</u>.

I should like to pass on to a quite different aspect of the current scene dealing with research people, places to work, and money. I refer to "Research and Development Centers" and to "Regional Educational Laboratories." As a means for conducting research they may in some aspects resemble the "Educational Research Bureaus" of the past, few of which survived. But there are sufficient differences, for example, general "climate" and available resources, to warrant the assertion that these are indeed new operational means. I wish here only to point out that there is the potential for an enormous range in educational research endeavors, for example, the potentials for longitudinal studies, systematic programs of research, replications in different settings, multiple-discipline research, and so on.

Other than technical developments and new educational research organizations, there is yet a third area which deserves consideration as a new means of operation. However, here I am at a total loss to even speculate what might happen. As I am sure you are aware, such large industrial organizations as General Motors, Xerox, Raytheon, IBM, and others, have been purchasing publishing houses, equipment supply houses, private educational research organizations, audio-visual manufacturers, and a host of other small outfits. I leave it to you to wonder what may be done in educational research by these large industrial organizations with enormous resources of talented people, a history of valuing Research and Development, and an unimaginable production capacity.

These three on-the-scene matters, new technical means for handling complex systems, new educational research organizations, and the entering of corporate organizations into the educational domain are my personal candidates for what may have great impact on design and operations of future research. Perhaps you have a different set of candidates.

III

There is yet another factor I wish to mention, but it is a bit heretical, and may cross into the areas discussed by Drs. Atkins and Suchman. Returning once again to the beginning of the century we can see that there was an intricate relation between the research questions asked, the technical means then available for designing studies to grapple with research questions, and the concepts (the ideas, the current state of knowledge) applicable to educational concerns. Today research questions deal with more variables, techniques of design and analysis are increasingly able to cope with multiple variables, and a staggering number of concepts, relations, and theories can be borrowed or modified from other research areas particularly the behavioral sciences. I have already expressed the belief that these are signs for renewed optimism. Nevertheless, I cannot help but feel, and it is a feeling, that what slips through all our research network is the ultimate concern of all of us - the student, at whatever level. At the moment I can only comment briefly on two matters.

Despite all our complex research machinery we know precious little about what happens to Billy or Janet in school, whether in pre-school or in graduate school. Equally disturbing, particularly to those working in curriculum, supervision, and teacher training, we know very little about what happens, even descriptively, in the classrooms, any level classroom. This is quite strange. It is as if there existed a gigantic medical research complex, and rarely did anyone look at the patient, and then only to see if he lived or died. Somehow we must find ways of returning to the phenomena - the students. I do not mean that we should look at students with a misty sentimental glaze. But I do mean that we have such a wide variety of sets of glasses for observing, that we may have a limited and quite distorted view of what happens to students in school. We view them with the foggy glasses of one psychological theory, the finely etched glasses of a test, questionnaire, or scale, or as teachers (at any level) we can put on our super-glasses covered with painted letter "K's", each letter standing for "Knowledge." These are all helpful I have no doubt, but what would we see if we used the naked eyeball, even myopic eyeballs? Again I border on mysticism. Stated less mysteriously, our research networks may be so highly developed that the questions we pose, the ways we examine, the ideas we use, may form a closed system of attack on educational problems. There is, however, remote, the possibility that a naive but rational looking at and listening to students may be yet another way of having an impact on research designs and operations.

Trying to look at what happens in classrooms, particularly what happens to students (all the students, not just the enthusiastic five of thirty) and subsequently attempting to make sense out of observations is a very difficult task. Promising beginnings have taken place in the work of Flanders, Amidon, Smith, Hughes, Medley and Mitzel, Withall, and many others, but these are nets with a very large mesh and catch only the large global phenomena. Still this is a beginning. What is needed in re-examining students and classrooms are means that will capture those matters that escape our notice. This could lead to a better understanding of the fine structure of students and classrooms with subsequent implications for curriculum, teaching, supervision, teacher training, - in brief, in understanding our work world.

AN AUDIO-TUTORIAL APPROACH TO TEACHING BOTANY

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I would like to divide my talk into four parts: First, I will discuss the history of the audio-tutorial system; second, I will show you a film of scenes from our learning center; third, I will discuss the audio-tutorial system as we currently operate and some of the results; and fourth, I wish to summarize with some of the educational concepts which have emerged as a result of our experience.

1. The audio-tutorial system began approximately five years ago as an attempt to make some adjustment for the diversity of backgrounds of students in a freshman botany course. The course involved 380 students and was a four hour credit course. It mainly served freshman students in the Schools of Pharmacy and Agriculture. These students have attended a great variety of kinds of high schools so that some had received very excellent training and others relatively poor training. Students with equal capacities could not perform equally well because of this difference in background. To assist the students with poor background, it was decided to make a special lecture on tape each week and file this tape with the language tapes in the Audio Visual Library. Students who wanted could go to this facility and hear the supplementary lectures and thus enable them to compete more effectively. During the course of preparation of these lectures, it occurred to me that the student might well bring their text book along and open it to the appropriate pages so that the subject matter in the text could be related to the subject matter covered by the tape lecture. Later it seemed logical to add the use of their laboratory manual in the same pattern so that the subject matter in the laboratory manual could be related to the subject matter in the text and to the subject matter on tape. Still later, it seemed feasible to provide the student with plants and experimental materials so that these too could be related to the laboratory manual, text book and tape lecture. Ultimately the discussion on the tape was no longer a lecture but rather was a discussion on a one-to-one basis, one teacher-one student, in which I was tutoring the student through a

sequence of learning events. The tape was prepared by arranging the various items which I felt would contribute to the student's learning on a table before me and talking into the tape player as if I were visiting with a friend helping him study. Learning events included a great range of experiences such as reading from the text, doing an experiment, collecting data, analyzing data, manipulation of a microscope, watching a time lapse movie, observing plant specimens, charts, diagrams, photographs, and listening to brief lectures or discussions as appropriate. The success of the initial tapes encouraged me to run an experiment of 36 students for one semester which further confirmed the potential of the audio-tutorial system. At the end of the second semester of experimentation, I met with these students to restructure the botany course, disregarding all traditional limitation and placing total emphasis on student learning. All busy work would be eliminated and an attempt would be made to adapt the method of presentation to the nature of the objective. The first restructured course included the following study sessions.

One hour per week--General Assembly Session (GAS); 1 hour per week--Small Assembly Session (SAS); and 2 hours per week--Independent Study Session. The Independent Study Session was the modification of the original audio taped tutorial. The ingredients of the course perhaps will be best communicated to you through the use of a movie film showing scenes from our classroom. This film follows the activities of a student through one week's work. I would emphasize at this point that several changes have been made since the film was produced. These changes were based on our experience and constant brainstorming with teaching assistants and students; however, the basic outline provides a good background for the remainder of my discussion. At one point in the film where the student is asked to use an 8 mm Technicolor projector, there will be spliced in some work prints of the kinds of learning events we would expect to be presented through the single loop film medium. I will show you the film now and discuss some changes we have made immediately after the viewing. Let us now go to the film.

2. SHOW FILM -- "A Multi-faceted Approach to Teaching Botany"

3. I am stopping the film before it discusses the Small Assembly Session because we have made several changes in this session, and I don't want to take up time with the outdated information. Two Sessionswe have already discussed -- the Independent Study Session which remains the same except for some minor changes such as the increased use of 8 mm film and improved arrangements of furniture in the learning center and the General Assembly Session which was discussed on film remains essentially the same.

An Integrated Quiz Session (IQS) has been substituted for the Small Assembly Session. The IQS is a modified seminar and oral quiz. It involves eight students seated informally around a table with one instructor. The instructor is supplied with the various items which were included in the learning center the preceding week, and these items are used as a basis for student discussion. All students are asked to discuss items in their turn and are asked to do so in a specified pattern or format. First, the item is to be identified; secondly, the student is to tell its role in the week's work or objectives; and thirdly, the student is to explain how it fulfills this role. These items include a great variety of materials such as plant specimens, a microscope, 2 X 2 slides, diagram or chart, a time lapse movie, all or parts of experimental equipment, or any other materials which have been used as a subject of study during the proceeding week. The student's performance is evaluated immediately on the basis of 0-10 points. If the instructor is much impressed, the student is placed in the category of excellent and receives a score of 9. If the instructor is not impressed, the student is placed in the category of mediocre and receives a score of 7. If the instructor is depressed, the student is placed in the category of poor and receives a score of 5 or less. Six is a passing score, and all scores are subject to change as the discussion continues. Each student has an opportunity to add comments concerning any item which he thinks may enlighten the group. The instructor will then raise his score as seems to be appropriate. The items are distributed to the students in a sequenced fashion so that the theme or themes of the week are clarified and where experiments lead progressively from experiment "A" to experiment "B" to experiment

"C", etc., this progressive relationship is retained during the session. This session has been an effective feedback mechanism for informing us of the success or failure of any program sequence of experiments and often provides clues for improving our approach. It also helps to clarify the appropriateness of the communication vehicle used in attempting to achieve the objective. It turns into a miniaturized seminar and thus enables many students to see relationships and concepts which were not evident from the Independent Study Session earlier. The IQS is also an effective tool for preventing procrastination on the part of the students.

Two questions most commonly asked concerning the system are as follows: 1. Have we not now eliminated the personal contact important for motivation? 2. Is this not now a "spoon-fed" type operation in which there's not opportunity for student discovery or inquiry? In answer to the first question concerning personal contact, is that we find personal contact is actually enhanced. We now have relegated much of the routine of teaching to a routine vehicle and teacher's time now can be devoted to meaningful personal contact. The opportunities for personal contact are as follows:

1. As in the conventional lecture system, the senior instructor is available at the General Assembly Session for this kind of personal contact such as it is.
2. In the Independent Study Session an instructor is available to give direct attention to individual needs on a one-to-one basis for any problem requiring instructor assistance. Also in this session students may visit with instructors about any additional aspects of the subject matter which they find interesting.
3. The IQS provides an opportunity for every student to become well known by at least one instructor in the course, and every student to know at least one instructor very well. Additional opportunity is available for every student to know many instructors well but there is no alternative but to become well acquainted with at least one instructor.

The second question concerning inquiry is also answered in the affirmative. First, may I define levels of inquiry. Inquiry occurs at various levels with the maximum or first level of inquiry represented by research. The second level of inquiry is the type of experimentation which can be completed in the span of a three-hour laboratory. The third level of inquiry is one in which the busy work of doing the experimentation is completed by the instructor and the student is asked to collect data from the results and analyze these data. The fourth level of inquiry is to provide the student with data and ask the student to analyze these data. The fifth, of course, would not be considered real inquiry but merely a demonstration. All of these levels of inquiry are feasible under the audio-tutorial system. At the first level of inquiry, our students are asked to do two miniature research projects, the first of which we provide guidance throughout the project and the second is left totally to the initiative of the student. In the first project the problem is defined, the materials and methods are described, the student is told what data to collect and asked to analyze these data and write up the project in the format of a scientific paper. The second project is completed by those students who hope to make an "A" in the course and here the student is restricted only by the materials available to him. He defines the problem, decides on the experimental procedure, what data to collect, analyzes these data, and writes up his project in the form of a scientific paper.

At the second level of inquiry, a problem is defined for an experiment requiring two to four hours and is done in the ISS as well under the audio-tutorial system as under the conventional system. The subsequent levels of inquiry are also handled effectively in the ISS. The results of the A T system have been positive from every point of view. Better instruction can be given with equal or less staff and space. Grades and student interest have improved at all levels. Costs are reduced for equivalent levels of instruction.

4. Now may I take a few moments to discuss the philosophy of the audio-tutorial system as I see it in retrospect after five years

of experience. It is sometimes said that "teaching is an art". This may be true however, "education" should be a "science". The scientific method demands that one begin by defining the problem first. The "problem" in education, simply stated, is "learning must be done by the learner". While this is not a very profound observation, it stands to reason that if "learning is done by the learner", the educational system should provide activities which require student involvement. Both teacher and student alike should be concerned with the kinds of activities and situations which contribute to learning. If these activities and situations can be identified, the teacher is obligated to provide a course structure which will permit the student to engage in these activities and the student is obligated to perform them conscientiously. I would like to list some of these activities and situations as I see them.

1. Repetition.--There is little question but that the nature of many objectives require repetition for their achievement. However repetition ought to be engaged in an intelligent fashion and adapted to the individual needs of a particular student. For example, a student who has learned about the Krebs cycle in high school biology has little need for extensive repetition of this study in a college biology course. On the other hand, a student who is encountering the Krebs cycle in his college biology course for the first time may find it necessary to repeat this study or certain portions of it, a great many times. In a course with 500 students the teacher cannot possibly make the adjustments in repetition for individual student needs. Only the student can determine intelligently how much repetition is necessary.

2. Concentration.--Most classrooms are not organized to permit students to concentrate during their study. Students are distracting to one another and other disassociated events which may be occurring tend to divert the student's attention from the subject at hand. The audio-tutorial system permits the student to isolate himself from the surrounding environment through the covering of his ears with the earphones and the use of booths to reduce his awareness of his surroundings.

3. Association.--In a study of plant science the major objective is to learn about plants. It makes sense therefore, that a study of plants should be conducted where plants are available for observation. Diagrams, charts, models, photographs, and other such devices should be a "means to the end" that students' attention is directed to the literal plant itself. The audio-tutorial system provides an opportunity for the student to have a plant available at the time he reads about it, does experiments, etc.
4. Appropriate sized units of subject matter.--People vary considerably in the amount of subject matter than can be grasped in a given amount of time. Programmers have demonstrated that most people can learn almost anything if it is broken into small enough units and the student can take time to become informed about each unit before proceeding to the next. Any program of study therefore should provide each student an opportunity to adjust the size of the unit to his own ability to assimilate the information so that those who can absorb large quantities of information may do so in an unrestricted fashion whereas others who must proceed more slowly, the course structure should permit them this opportunity to do so. The audio-tutorial system allows the student to proceed at his own pace and to break the subject matter into units commensurate with his ability. This is especially important where the learning events are sequenced with subsequent events dependent on a mastery of proceeding ones. The human mind with its limited attention span frequently is distracted during the presentation. If this distraction coincides with a point which is particularly critical to subsequent units of information, when the subsequent units are presented the student's deficiency may frustrate the learning experience. Presentation of material over a long span of time may result in progressively increased frustration such that the student assumes the attitude that the subject matter is too difficult for him. In order to maintain status with his peers, he may develop an attitude of "I don't want to learn this material"

simply as a defense mechanism. Experiences such as this throughout several years of exposure to formal education may cause many educatable people to develop mental blocks which are difficult to overcome. The same information presented to the same student in a setting where the student can make each foundation idea firm before proceeding to the next can result in successful learning. "Success begets success" and successful experiences will tend to encourage the student to greater achievement. The educator could well afford to learn from a successful construction engineer who pours a concrete foundation carefully shaped and positioned to support the future structure and then permits this foundation adequate time to become fixed or firmed before placing on it the subsequent materials. Bricks and mortar are laid alternately with each brick and measure of mortar carefully placed to provide a bed for the positioning of the next bricks to be laid. Only in education do we pour forth the units of subject matter along with the cementing materials at a fixed rate, mixing together the bricks and mortars without regard to the many other factors which may affect the resultant organization.

5. Adapt the nature of the communication vehicle to the nature of the objective.--Botany is a "complex" of subject matter and requires a great variety of learning experiences. These may include the handling of a plant specimen, watching time lapse film, viewing photographs, reading from textbooks, Scientific American articles, listening to a discussion by the senior instructor, visiting with colleagues, etc. It is logical then that no single vehicle such as lecturing or a text book can achieve the full spectrum of objectives for this complex subject. The student's experiences should not be confined to any particular vehicle such as 8 mm film, audio tape, text book, or any other of the great variety of communication devices which are now available to us. In cases where the development of a procedural skill is necessary, there is no substitute for the student doing this procedure himself. A properly structured course, therefore, would

carefully define objectives and not try to mold objectives to fit a favorite medium (lecture, for example) but instead would use the medium best adapted to the nature of the objective. The audio-tutorial system permits this kind of student participation and enables one to bring to bear the correct medium commensurate with the objective.

6. The use of multi-media.--Individuals differ in their responsiveness to different kinds of communication devices. Some people learn well through reading, some can learn best by auditory communication, and others can learn best by literally handling specimens and doing of experimentation. While some of my colleagues think that intellectual achievement is accomplished only through reading, it is my opinion that many poor readers are as intelligent as good readers and may literally become more knowledgeable than good readers if they are permitted exposure to subject matter through a communication vehicle more suited to their receptiveness. The audio-tutorial system thus provides an opportunity for subject matter to be covered in a great variety of ways with the student exploiting that medium which communicates most directly and effectively for him.

7. Finally and most important of the learning activities and situations.--The significance of integrating learning events was brought abruptly to our attention by an accidental positioning of two experiments. Subject matter from experiment "A" was necessary for understanding the subject matter of experiment "B". For a number of semesters the students had had little or no difficulty of transferring information from experiment "A" to experiment "B". One semester, however, I noticed that more students were having difficulty with this transfer of information. In tracing the possible causes for the difficulty, it was discovered that during the preceding semesters experiment "A" and experiment "B" had been sitting in close proximity. Some new materials inserted in the course had forced the placing of experiment "B" on the opposite side of a demonstration table from experiment "A". Although this distance was a little more than three feet, the

disassociation in space resulted in less students being able to transfer information from experiment "A" to experiment "B". It stands to reason then that if this disassociation is extended in space by an even greater distance, still fewer students will be able to make the transfer of information. One can extrapolate further and assume that if the disassociation is not only in space but in time as well, still less students will be able to transfer the information. While the proximity of positions of materials is not a very intellectual challenge to a teacher, this experience has served to emphasize to us that many of the students' problems are not caused by the difficulty of subject matter, but rather by these relatively simple factors. It stands to reason that if learning events are to be complementary and to have some relationship, they should be brought into close proximity and properly sequenced. The conventional structuring of a lecture, recitation and laboratory does not take this into consideration but rather may expose a student on Monday to a lecture concerning a given subject, perhaps on Wednesday the student does experiments related to that subject, on Friday a recitation will involve the student in some exposure to the subject and then on Sunday night, late, the student may read on this subject from his text. The audio-tutorial system permits the student to bring all of these learning experiences into an integrated sequence so that each learning event may enhance or complement the adjacent ones and thus result in a synergistic effect. One might compare this analogously to an orchestra. Many musical instruments making sounds in a random fashion, result in noise or cacophony; however, these same sounds, if given timing and placed in an appropriate sequence or relationship one to another form a melody. I am suggesting that there is a melody of learning and that teaching is, indeed, an art. It is the art of sequencing learning events into a meaningful experience for students.

Education is a science so that one must define the problem first and then go about logically developing a procedure which permits a student to engage in those activities which result in learning. It may require a total restructuring of courses and reorganization of approaches. Teaching is an art but the artistry comes not through the use of the teacher as a communication device but rather in his skill in determining objectives and developing the materials and sequences which will enable the students to achieve those objectives in the most efficient and effective manner. Many of us find this approach to education a little difficult. Teachers and educators are the most tradition-bound group of individuals I know. This happened in a logical evolutionary sequence, the explanation of which is relatively simple. In the days of Aristotle, the source of information was the scholar and he was the communication vehicle. It was logical that contact between the student and the educator was through lecturing. It is amazing that many of us still teach in this fashion feeling that our contribution is to expose to the student our knowledge of the subject matter, and many people who want to become teachers do so merely because the lecture is an ego-inflating device. We find it an exhilarating experience to stand before 500 people and to mystify them with our great knowledge of a given subject. In this age there are many communication devices more effective than the human being and ego-inflation of scholars is not a worthy objective for an educational system. We lost sight of the basic purpose of education a long time ago. When the situation was such that there was one teacher and one student, the teacher focused on the individual needs of that particular student, but when the teacher had two students, the focus was changed then to the needs of the teacher and the two students must then assemble at the convenience of the teacher. When the situation expanded to involve so many students that two teachers were necessary, one teacher then became senior and a new group of individuals with individual problems was evolved, the administration. It is logical that for administration one would select the most aggressive and most skillful individual at problem solving. It is logical also that such an individual would solve the problems which were close at hand. During the years divergent evolution has occurred to produce a community of individuals who are concerned with problems of constructing buildings, obtaining funds, etc. and learning problems are given lower priority. With our administrators preoccuppied with these problems, only lip service is given to such mundane things as the proximity of experiment "A" and experiment "B". Such small insignificant items are cast aside in favor of the more challenging and interesting activities associated with the vast numbers of students and big time education. I would like to cite just one example in support of my position. A certain university begins its semester with the first classes meeting at 11:30 AM on Wednesday. I challenge educators at that institution and at any other institution to show me a course for which good pedagogy dictates 11:30 on Wednesday as the appropriate time to begin the semester. I know of many courses, multiple section courses, for which this timing clearly is a disadvantage. Multiple sectioned courses which meet on Monday, Wednesday and Friday will have some sections which will have been exposed on Wednesday afternoon, Friday afternoon and other sections which will have been exposed only on Friday so that the subsequent week's work will be totally out of synchrony. As a result, both instructors and students recognize the impossibility and impracticably of this situation so that students do not show up on Wednesday afternoon and if they did they would find a sign on the door saying "No class today". For all practical purposes, it is impossible to start course work until Monday morning of the subsequent week.

Now I ask you if good pedagogy does not dictate that classes begin at 11:30 on Wednesday what criteron then is used to establish the starting time? The answer is simply that this is an administrative convenience and that administrative convenience is taking precedence over sound pedagogical procedure. This is merely one example and if time permitted I could cite you many more.

One more thought. It was suggested to me that if one wishes to attract outstanding faculty to a University today, it is necessary to provide ideal teaching conditions. I should like to analyze this statement for you. What is meant by outstanding faculty? Outstanding faculty on most campuses are Nobel prize winners or those which have demonstrated competence in research activities. Secondly, what is meant by ideal teaching conditions? The answer is, few hours in the classroom and highly selected students who will learn in spite of the instructor. It is a truth that we have come to the point where instructors consider it a promotion when they are given the best students in the university or high school. I am suggesting to you that this is not a professional attitude. What would you think of a doctor who wished to take only those cases which could be cured by merely dispensing aspirin. Most of us would say that this is non-professional, and we would not want a doctor of this kind. We want a doctor who would like to concern himself with the hard-to-get-well cases and those cases which are challenging. If this be true, and teaching is a profession, a professional attitude would demand that we too would find the hard-to-get-well cases most challenging. Humbling as it may be, self-examination may be in order for us to determine whether we really and truly fulfill our role in the educational process. Are we succumbing to the ego-inflating exercises which display our great knowledge of the subject matter, or are we willing to accept that it is our responsibility to provide the facilities, provide the guidance and direction, and provide motivation to help students learn. Let us be honest with ourselves and true to our commitment.

Thank you very much.

6/17/66/MB

REPORTS OF CONCURRENT SESSIONS

Session A: PREPARING TEACHERS FOR THE JUNIOR HIGH SCHOOL

Chairman: Alfred D. Beck, Teacher of Science, The Dalton School, New York City

Panel: Isidore Bogen, Examiner, Board of Education, New York City

Frances L. Behnke, Instructor in Science Education, Teachers College, Columbia University in the City of New York

John R. Logsdon, Science Teacher, Horace Mann School, New York City

Louis Teichman, Principal, James H. Kieran Junior High School, New York City

Isidore Bogen discussed the problem of preparing teachers for the Junior High School from the point of view of recruitment and selection. Among the recruitment problems that are specific to science teachers in the Junior High School, he mentioned (1) general competition for persons trained in science, (2) inadequate training of those science persons available for teaching, (3) difficulty of locating persons with "generalist" as opposed to "specialist" training, and (4) difficulty of recruitment of science specialists who have kept up with recent curricular developments. Teachers must be selected for knowledge and for skill in both science and pedagogy. There is also the problem of marginal persons when the supply of teachers is inadequate. Among his suggestions for the future are early recruitment, examination of requirements, salary and working conditions, and pre-service and in-service training programs.

Frances L. Behnke discussed problems which have arisen from the changing nature of the curricula of the general science programs in the Junior High School, and suggested concerted efforts to alleviate the contrasts existing in the training of Junior High general science teachers. For example, the development of a professional sequence of courses related specifically to the teaching of science and improved college teaching. Recommended college courses would include behavioral sciences, courses on the nature of learning and on the nature of science, and training in the newer curricula, both in the updated content and in the redirected philosophy. The Introductory Physical Science Project and the Earth Science Curriculum Project incorporate teacher training programs into their plans.

John Logsdon discussed classroom procedures and included the following remarks: What a new teacher needs to know on the day that he meets that first class is how to develop mental activity. A good class meeting is one in which each student is put on the defensive - forced to fall back on his basic life experience in order to contribute effectively to class discussion. A thesis is proposed by the teacher, an antithesis is forwarded by a student. The synthesis of the two is achieved by developmental questioning and "stage directing" on the part of the teacher. By exploring possible antitheses to the bitter end - that is, by having various members of the class criticize each other's contributions on the basis of common sense, experience, and text readings, a healthy spirit of intellectual competition can be maintained for the duration of the period.

Louis Teichman presented the principal's view of what seemed needed in preparation of Junior High School teachers, covering the following and other points: Assuming that junior high, or intermediate, or middle school science will continue to cover a range of science areas, teachers will need training in each of the major science disciplines. A full year each of college biology, chemistry, physics, and earth science seems minimal.

Knowledge of the content areas is, by itself, sterile. The teacher must understand science - its conceptual scheme, its methods, its impact on technology and society, its promise and its limitations. He must know the processes of scientific thought, so that he can use the bread and butter of facts to nourish and develop critical thinking.

The teacher should have something to communicate. This something should be factual, inspirational, scientific, entertaining, up to date, applicable, and appropriate. For this, the teacher needs a repertoire of techniques, methods, and materials. Emphasis in methods courses should be on types of lessons, on lesson planning, on the art of questioning, on means for eliciting and for developing pupil participation, as well as on classroom routines.

The prospective junior high school teacher of science should be able to communicate, at the level of his pupils for understanding, and above their level for inspiration and growth.

Session B: PREPARING TEACHERS FOR TECHNICAL SCHOOLS AND JUNIOR COLLEGES

Chairman: Nathan S. Washton, Professor of Education, Queens College of the City University of New York

Panel: George Alterman, Director of the Evening Division, Queensborough Community College of the City University of New York

Irving Allen Dodes, Professor of Mathematics and Chairman of the Division of Mathematics and Science, Kingsborough Community College, New York City

In his introduction, Professor Washton described the framework of education, of which the community college is an integral part, and pointed up the functions served by it in our civilization, with the following remarks.

Junior or Community Colleges came into existence in the twenties and thirties primarily as terminal institutions with the major function of training young people for specific vocations or semi-professional or technical jobs. A few students transferred to the four-year colleges. Today the number of students transferring from community colleges to four-year colleges in increasing to the point where the terminal function or vocational function is now in the secondary position. Hence, in many institutions, the first two years of instruction in junior or community colleges resembles the lower division in most liberal arts colleges. The role of the junior college becomes more difficult in that a minimum of two tracks may be needed for almost each type of curriculum.

The highly varied and specialized curricula in the community colleges demand technically trained teachers who also must have the know how of imparting information to set the stage for learning to take place. Particularly in the teaching of science, the junior college instructor can never be overprepared. Research in the many areas of science produce a quantity of knowledge that requires one to devote himself full time merely to keep up with the advancement of scientific information. In addition, the instructor of science in the community college is expected to give advice and guidance to young adults who need assistance in job selection. We need a dedicated scholar, technician, and most important a sympathetic teacher, all wrapped in an aura as a director of learning. The training for this type of teacher has not been fully designed as yet.

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George Alterman discussed the preparation of science teachers for two-year colleges, stating first that the role of science in the two-year college is determined by the multiple objectives of this type of institution. The science offerings must, therefore, include (a) basic science for training of technical personnel; (b) general education science for the non-science major; and (c) science for potential science and engineering majors.

He further said the major emphasis of the faculty in these science courses must be on teaching. The selection of faculty must, therefore, be based upon (1) the ability to communicate ideas, to guide the development of understandings and the organization of inquiry, (2) knowledge of the principles, ideas and understandings of the specific discipline, and (3) the ability to instill enthusiasm and inspire curiosity.

To process such an individual he proposes the following as a hypothetical model of a Ph.D. program that will more adequately serve our objectives.

Undergraduate. A major in one science; a minor in a second; basic courses in other sciences and mathematics through statistics and calculus; the usual liberal arts background including basic courses in psychology, sociology, and logic.

Graduate. The course equivalent of a master's degree in one science; one full year course in a second science; statistics; history and philosophy of science; psychological and sociological foundations of education and pedagogical considerations as it relates to the teaching of science and one discipline specifically. For those who are not engaged in teaching - an apprentice or intern program in a two-year college; for those already teaching - a program of intervisitations and supervision.

For all. A thesis - one that employs all the valuable features of a scientific endeavor (but not necessarily involving original research) and "indicates scholarly skill and promise rather than one that contributes to human knowledge."

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Irving A Dodes discussed what we want in a community college teacher and listed the following four basic requirements: 1) asuitable knowledge of CONTENT; 2) a satisfactory TEACHER; 3) participation in college ACTIVITIES; 4) a combination of rare PERSONAL CHARACTERISTICS. Using slides for illustration, Dodes amplified these four categories.

With the slide on CONTENT he displayed the general courses with their bordering subjects offered in New York City Community Colleges - such as Statistics, Calculus, etc., under Mathematics; Botany, Embryology, Anatomy, etc., under Biology; Inorganic, Organic and Physical Chemistry; Nuclear and Atomic Physics; and the various technologies - and emphasized the need for the teacher to be able to "fill in" on any course in their main field.

With the slide on TEACHING he explored a) an understanding of general education as related to community college problems; b) certain essential pedagogical theory; c) a certain amount of job skill in actual practice; and d) the out-of-classroom teaching activities. He described examples and improvement techniques.

With the slide on ACTIVITIES he listed some of the areas such as Budget, Syllabus, Curriculum, Space Planning, etc. in which the teacher is expected to participate.

With the last slide on PERSONAL CHARACTERISTICS he listed traits such as poise, tact, courtesy, patience, and good relationships as essential for the success of a community college teacher.

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Discussion at the end of the presentations centered on the graduate training offered by NSF institutes and other graduate courses that do not grant credit towards a doctorate because of great variations in requirements for transfer credit from institution to institution. A special type of doctorate for science teaching or for teaching was suggested in which both depth and breadth would be achieved.

In his closing comments Professor Washton stated that we need a nationwide survey to determine curriculum and instructional developments in junior colleges to distinguish their unique problems from the four-year colleges. He said we also need to take the recently proposed doctoral program by AETS, implementing it for use for this type of teacher as well as for supervisors in science education.

Session C: PREPARING TEACHERS FOR THE CULTURALLY DEPRIVED

Chairman: J. Darrell Barnard, Chairman of the Department of Science & Mathematics Education, New York University, New York City

Panel: John C. Robertson, Professor of Secondary Education and Chairman of New York University's Project APEX, New York City

Roscoe Brown, Professor of Education, New York University,

Virgil A. Cliff, Professor of Education, New York University,

Edward E. Henderson, Professor of Education, New York University,

Patricia C. Sexton, Professor of Education, New York University,

All four above on administrative staff of Project APEX

PROJECT APEX*
(A Program For Excellence In Teaching)

Project APEX is an experimental program at New York University, School of Education, sponsored by the U. S. Office of Economic Opportunity. Its purpose is to demonstrate that low income youths of promise but untapped potential can profit measurably from experience in a special five year university program and that some, perhaps all, can complete college and become teachers with specific competence to educate children in depressed urban areas.

Project APEX differs from other kinds of college programs for low-income youth in that the youth selected for the project usually would not be able to gain admission to college. Project APEX aims to serve some of the many youth in disadvantaged areas who have the ability to benefit from college and have been overlooked by the traditional means of selection for college.

An important contribution of the project will be the identification, use and evaluation of criteria that are different from those usually used in selecting college entrants from the disadvantaged segment of the population. The selection will be based on the following criteria and information will be obtained through interviews, taste and attitude, and adjustment scales.

a) academic performance - position relative to other students in the general curriculum.
b) personal and social adjustment.
c) demonstrated ability as a leader or participant in a group activity.
d) aspirations.
e) commitment to a goal of service.
f) relationships with peers and family.

The sixty students in this program will be selected from two New York City high schools which serve students from low-income neighborhoods. They will be male graduates of the general curriculum and will live near New York University in housing approved by the University. The college program for the first three years of the Project will involve both remediation of the students, academic weaknesses and introduction to the areas of knowledge usually covered in the liberal arts program in the first two years of college.

The structure of the program will revolve around four basic core areas of academic work. These are: 1) language arts and the humanities; 2) social sciences; 3) science; 4) mathematics.

In each area the academic program will begin with the diagnosis of students' specific strengths and weaknesses in each content area. The curriculum that is developed in each of the areas will be based on these diagnoses and the rates at which the students gain competence in the areas. Students' academic study will be coordinated with work in a Work Study program which will involve part-time work at New York University. Information about the students' attitudes, personal and social adjustment, and their academic performance will be used to evaluate the Project. Periodic assessments will be made to determine the extent to which the objectives of Project APEX are being achieved.

As an adjunct to Project APEX, plans are being developed to recruit an additional sixty young men from middle class backgrounds who will be trained in conjunction with the APEX students. These students will be academically able college freshman who are committed to learning how to work and teach in disadvantaged areas. Funds are being sought to support this part of the program.

*A Research Report on PROJECT APEX with a fuller discussion of aims and intentions can be found in THE MARYLAND TEACHER, Volume XXII, May 1965.

Session D: THE SCIENCE METHODS COURSE FOR SECONDARY SCHOOLS

Presiding: Dr. John J. Montean, Associate Professor of Science Education, University of Rochester, Rochester, New York

Presentation of Questions: Dr. Matthew H. Bruce, Jr., Assistant Professor of Science Education, Cornell University, Ithaca, New York

Panel: Dr. Stephen S. Winter, Associate Professor of Science Education, State University of New York at Buffalo, New York

Dr. T. Reginald Porter, Associate Professor of Science Education, University of Iowa, Iowa City, Iowa

Dr. Ernest Burkman, Associate Professor of Science Education Florida State University, Tallahassee, Florida

Dr. Leslie W. Trowbridge, Assistant Professor of Science Education, Colorado State College, Greeley, Colorado

Dr. Milo K. Blecha, Professor of Science Education, University of Arizona, Tucson, Arizona

Ten questions were edited from the report of a meeting of science educators held at Skaneateles, New York, in June, 1965. Each of the five panelists were asked to respond to two of the ten questions, dealing with the sub-questions as well.

RESPONSE: Dr. Stephen S. Winter

Question 1: Where should the responsibility for the instruction in science teaching methods reside?

a. Can it be divided?
b. What sort of person(s) should teach the course(s)?
c. How can more interaction be developed between those concerned with methods instruction and/or practice teaching and those whose concern is with the academic departments?
d. Can the laboratory phases of methods instruction best be taught by the academic departments?

In trying this, that, and other things in an attempt to develop a satisfactory methods course, I have convinced myself that there is what might be called a theoretical aspect to methods, For instance, the student should know that a lecture is and does, what its limitations are, and how it can be organized for maximum affect. He should and must know the characteristics of a good discussion, when to use it, and when not. He should know various ways in which a demonstration can be used; for instance to initiate a topic, to confirm, to summarize. He should also know what characteristics of a demonstration are likely to enhance its effectiveness and what characteristics of a demonstration tend to make it useless as a learning experience. He must know how to test, etc., etc.

Now these things a good teacher does implicitly and naturally; a poor teacher likewise performs them, inadequately, in an unconscious manner. Consequently, I feel that the person who teaches a methods course must not only be experienced but must also have the opportunity to think about methods and to analyze them. This suggests that a college person from the education department would be more likely to have had the interests needed for my concept of a good methods course. At this level of concern, the academic area probably has little to offer except to exemplify good use of their methods.

In the laboratory phase, on the other hand, academic department has much to offer because it is there that a student can get insight into the dozens of responsibilities that go into making a good student laboratory. The academic department can be of great help by employing future teachers as laboratory assistants in positions where they can see the problem of setting up a laboratory, getting materials together, setting the stage for the student experiment, etc.

Question 2: What patterns of placing methods instruction in the sequence of professional preparation are most effective for prospective science teachers?

a. How much relative time should be devoted to methods instruction?
b. Where should methods instruction be placed with relation to the clinical experience for optimum effectiveness?
c. What role, if any, should the practice teaching experience have in evaluating methods students and courses?
d. What should be the role of personnel from the academic departments in supervising practice teaching?

The kinds of concerns of a methods course which I mentioned in answer to the last question must be presented before the student goes out to practice teach since he must have this knowledge at his command. But it is less than half of the overall concern with methods. There is the question of analyzing one's behavior - excellent though it may be from a theoretical point of view - in a live classroom. This can take place only when the student teacher is actually responsible for carrying out instructions.

Consequently I feel that a methods course might well be divided into two parts. A one-semester two-credit course dealing with the theoretical aspects of teaching which precedes student teaching; a one-credit seminar dealing with methods at the same time that he student teaches. In the latter, then, he can see how methods must be changed in response to student behavior as one conducts a full 45 or 50 minutes lesson.

Both of these courses I see as being preparatory, limited, and in a sense rather dogmatic. While the student learns to fashion a pattern of behavior for effective instruction, he is not yet concern with overall curriculum objectives and broader philosophical and methodological concerns. He is still learning to identify his role in a predescribed context. But the good science teacher eventually must move from this self-centered stage to the stage of considering the science curriculum as a whole. This, in my experience, does not come until much later after he has solved his initial personal concerns. Consequently, I feel that a second methods course, perhaps under a more sophisticated title, is needed. In this course, the student can evaluate his actions in relation to full-year or full-program objectives, rather than in relation to tomorrow morning's lessons. I think that an attempt to do this in the initial methods course is largely unappreciated because the student is not yet free enough from immediate concerns to make sense out of such long-range objectives.

Regarding the evaluation of the student on the job, I feel that the main function of the supervisor is to assess whether the school and classroom is satisfactory from the point of view of the university, and to assure that practice teacher and teacher are working harmoniously. I feel that any direct assessment of the student teacher by the supervisor is a very poor procedure because it is the supervisor's function to help this young person to develop into a good teacher. Evaluation, at this point, will tend to create a gap between the two as has been extensively discussed in the supervision literature.

RESPONSE: Dr. T. Reginald Porter

Question 3: How can methodology taught in the science teaching methods course be made to reflect more accurately and at the same time influence more effectively the actual classroom practices of science teaching?

a. How can we better exploit the potential to be found in observation of actual teaching as part of methods instruction?
b. In what ways can practicing classroom teachers most effectively be brought into the methods instruction?
c. Is the current stress on teaching science as inquiry tending to lose effect because it does not reflect the major direction of actual practice?

The science methods course is most apt to reflect actual classroom practices in science teaching if it is taught in a secondary science room (or a reasonable facsimile) and each student has an opportunity to participate in some science lessons (especially if the methods course is taught before student teaching). If the methods course is to have an influence on science teachers and their teaching, there should be every possible opportunity for the students to become familiar with reference books, visual aids, special techniques and programs.

Observations of science teaching are most effective if discussed candidly both from a positive and negative point of view. Nor is it necessary for students always to observe good science teaching. Practicing classroom teachers will be most effective as resource persons, consultants, and demonstration teachers.

In any event, if the true inquiry teaching approach is used, the actual practice is not lost because it keeps pace.

Question 4: What role should the methods courses play in training prospective science teachers to teach science as inquiry?

a. Should the methods course be expected to develop this? Should the science course sequence be expected to develop this? Is it a joint responsibility, and if so, how can it best be coordinated?
b. Can specific techniques be developed for use in preparing prospective science teachers for teaching science as inquiry?
c. What steps can be taken in methods instruction to evaluate the student's possession of this ability?
d. Is this aspect of the methods instruction already emphas emphasized heavily, with no real evaluative criterion upon which to base the emphasis?

The science methods course will have to take the leadership in showing prospective science teachers ways to teach science as inquiry because most college or university courses are service courses and not planned to be taught in a specific way.

By example, specific techniques can be set up to illustrate ways of teaching science as inquiry. It will be difficult to evaluate a student's ability to teach in this way, but it is possible. If the student is assigned (or chooses) a specific topic to develop and teach by the inquiry approach, his progress and results can be evaluated.

We cannot really "teach how to teach." We can only provide good examples of teaching and make resource materials available. The individual will formulate his own approach and philosophy as he teaches because teaching is a creative activity.

RESPONSE: Dr. Ernest Burkman

Question 5: How can students in the methods courses best be evaluated? How can the courses themselves be evaluated?

a. How can we best determine whether the student has developed a consistent and logical model of the manner in which learning takes place in science?
b. What practical means can we employ to insure that there is a continuous, reliable feedback from teachers to methods instructors regarding what their courses do, do not do, or should do?

The basic question to be answered by the evaluation of courses in which methods of science teaching are dealt with is: "How well has the student integrated all of the knowledge and skills he has learned into operational terms?" In short: "In what way does the individual perform differently as a teacher as a result of the instruction which he or she has received?"

If one views the evaluation problem in these terms it means that we must somehow measure both the specifics of the skills and knowledge which we hope we are conveying, and good teaching performance as well. At Florida State University we are attempting to evolve an evaluative scheme which takes into account both of these kinds of measures.

An attempt has been made to identify the <u>specific</u> skills which a teacher of biology, chemistry, physics, or junior high school science should be able to perform. These include such things as making up solutions of different types, ability to connect up correctly and read a voltmeter, ability to carry out certain photographic skills, ability to use an overhead projector effectively, preservation methods for biological specimens, maintaining cultures of living organisms, etc. To evaluate whether or not the student possesses such specific skills, we simply ask him or her to perform them at the end of the course.

The faculty of the Florida State University Department of Science Education has devised separate check lists for each of the sciences and these are being expanded as we include other kinds of skills and techniques. Knowledge of specific content is handled by objective and subjective examinations of a fairly traditional sort. Each student is expected to be familiar with the specifics of the organization of the various new curricula, the general aspects of the theories of such men as Piaget, Bruner, Gagne, etc., principles involved in organizing teaching laboratories, etc.

The problem of checking the students' ability to incorporate specific skills and techniques into a teaching situation is a more difficult one to handle. At this point, the best approach seems to be that of utilizing systematic classroom observations. The staff is currently at work on developing a scale, patterned after the Flanders approach in interaction analysis. When developed the scale will differ from the Flanders scheme in that it will include other aspects of teacher behavior than the verbal, and will deal specifically with those aspects of teaching which are somewhat peculiar to science.

When this scale becomes available in polished form we plan to observe all prospective teachers in classroom situations looking particularly for evidence that the methods course has affected teaching performance in a positive manner. Some work of this sort is going on presently with preliminary scales, particularly in the area of elementary science.

Question 6: Relationship of the methods course to other facets of the professional sequence. What proportion of the professional sequence should be given over to special methods instruction?

The experience of the group at Florida State University has led to a situation in which the amount of general professional education work required of the undergraduate has been drastically reduced, and the special methods portion of the sequence has increased greatly. At the present time, more than two-thirds of all of the professional work taken by the prospective science teacher is taught and controlled by the Department of Science Education.

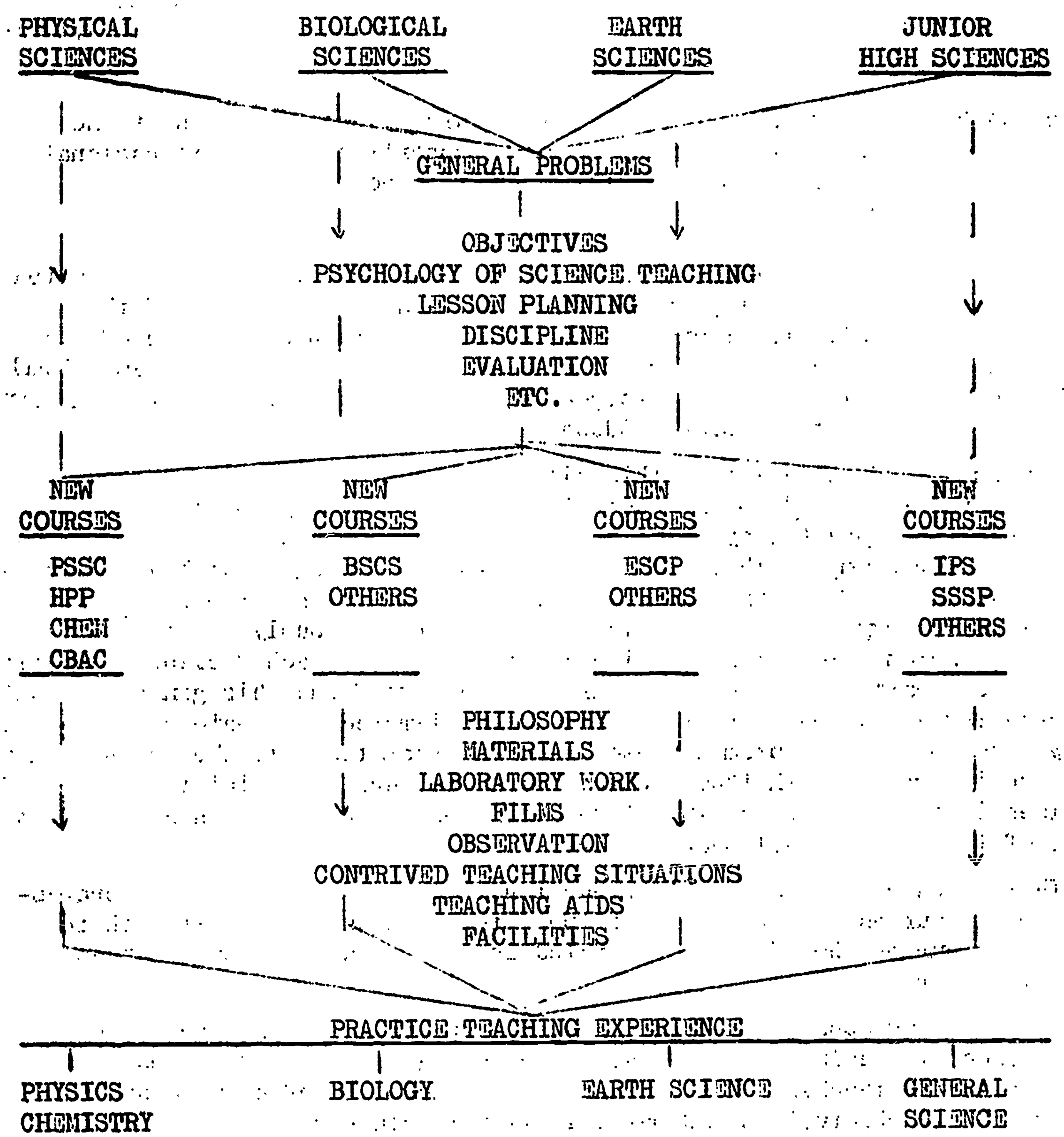
The basic belief which led to this situation is that there is a special history, philosophy, psychology, and social basis for science teaching and that general treatments of educational psychology, etc., do not provide the kind of training required. We have found, for example, that upper class students coming to us have never heard of Piaget despite the fact that they have typically taken one or more courses in educational psychology. Since Piagetian concepts are obviously of interest to those concerned with science teaching, we find it necessary to teach "Science Educational Psychology" as a part of our methods courses. We have found this general situation to be increasingly true over the years and have attempted to create courses in which psychology, sociology, measurement, etc., are incorporated into the science education sequence and integrated with those topics which are purely special in nature. The key premises in this way of looking at the relationship of the methods course to the remainder of the professional sequence are:

A. There should be considerable reduction in the number of general professional courses and that much of the material presently dealt with in these courses should be incorporated into a "package" with a subject matter core.

B. To relate as much of the content of the special methods course (as expanded to include the general topics alluded to above) as possible directly to teaching. This leads to the inclusion of heavy doses of systematic observation and participation in classroom situations.

To carry out a program of the sort outlined above, obviously requires time. Furthermore, such a program requires large blocks of time since it is necessary for the student to spend consecutive hours in the laboratory, teaching situation, etc. The Florida State University group has solved the time problem by setting aside one full six-week period during which the student takes nothing but science education work. The instructor of this course is free to arrange flexible schedules to include teaching practice at the University High School, reading in the content which appropriate, previewing of appropriate films at the University film center, and working in the laboratory on teaching experiments and demonstrations, etc.

SECONDARY SCIENCE METHODS CLASSES



Dr. Trowbridge's suggestions for the new science methods courses appear here in outline form.

The basic pattern has been considered as successful by all concerned although we do not have hard data to prove the point. As more and more information becomes available we plan to continue the rather substantial modifications which we have begun to date.

RESPONSE: Dr. Leslie W. Trowbridge

Question 7: Is the conventional science methods course - encompassing all sciences and levels of secondary science teaching - adequate for both junior high school and subject area specialty teachers?

a. Do we downgrade junior high school science teaching by default in emphasizing special preparation in the special subject area?
b. Is there really any identifiable difference between the preparation appropriate for junior high school science teachers and senior high school science teachers?

I believe the general science methods course encompassing all sciences and levels of secondary science teaching is rapidly becoming out of date - if ever it was adequate for the task. The practitioners of science teaching in junior and senior high schools are specialists in their respective fields. Prospective teachers in these fields deserve the greatest possible attention to the problems and methods which are appropriate for their specialty.

Development of the new courses in physics, chemistry, biology, earth science, and general science increases the need for special methods courses. While it is true that many similarities in philosophy and approach exist among the new courses, the fact remains that methods students cannot grasp the full implications of these courses with superficial treatment. It is not sufficient merely to name the new curriculum projects, display some of their materials, and discuss some of their common goals. Students must have opportunities to work with the materials, do representative problems and experiments, write some of the tests, and observe high school students at work in these courses. Only in this way will they be able to say, when interviewed for a job, "Yes, I am able to teach PSSC physics" - or BSCS biology - or whatever the superintendent is looking for.

The next few years are likely to show a change in the preparation of science teachers. I do believe the NSF is gradually going to get out of the business of retraining experienced science teachers. It will be up to the colleges and universities to modify their programs in such a way as to prepare teachers to teach the present new courses or others which will develop in the future, as part of their <u>undergraduate programs</u>. Please note outline attached herein.

There is nothing in the subject matter of the new courses which is not capable of being taught by up-to-date academic departments. The undergraduate teaching majors in physics, chemistry, biology, etc. will be prepared adequately to teach the appropriate subject matter. It is vitally necessary that the professional education of the prospective teachers be upgraded accordingly. The methods course which is required for certification must give sufficient time to philosophy, materials, and objectives of the modern science courses to make the student truly competent to teach them. This can only be done in a special methods course.

I might add that it is highly important that prospective science teachers get the opportunity to practice teach in one of the new courses as a follow-up to the type of methods course described above. It is quite likely that unless this opportunity is afforded, the emphasis on new curriculum developments in the special methods course will be largely wasted.

Apart from the emphasis on the new courses, which may be an arguable point for many of you, the special methods course offers an additional advantage. This is with respect to the background preparation and competencies of the methods instructor. It is a rare person, in my opinion, who is adequately prepared both from the standpoint of training and experience, to do justice to all the sciences in one methods class. While it may not be possible in a given situation to provide a methods instructor for each discipline, certain judicious groupings can be made, such as physical sciences, biological sciences, earth sciences, and junior high school sciences. At Colorado State College, provision is made at present for separate methods courses in the first three of these areas. These are one-quarter courses carrying three quarter hours of credit. Enrollments range from five to twenty students per quarter.

With reference to subhead (a) of the question, I would reply that we probably downgrade it more by not providing a special methods course for the junior high school teacher. Junior high school teachers and the junior high school program in general have suffered for many years by the absence of identification, exprit de corps, and a clear sense of responsibility for this level of science teaching. I think there is no single effort that could have a more unifying and salutary effect than a well-taught methods course designed specifically for the prospective junior high school teacher.

With reference to subhead (b) of the question, I interpret this to mean difference in methods of teaching and professional training. I think it is obvious there are differences in subject matter background. I believe there are differences. The impact of new programs at the junior high level is beginning to be felt. Increased emphasis on inquiry, investigation, and laboratory experiences demands teachers who are alert to the manifold opportunities here. The junior high school science program is gaining prestige as courses become more clearly delineated and responsibilities within the framework of the total science program become better identified. Differences in age level, maturity, mathematics background, motivation, energy, and interests combine to make the junior high school group unique in the school system. It has been a neglected group. Junior high teachers have not been a cohesive group. It is time a sense of unity and purpose was developed in order that this very important level of science teaching be strengthened. The special methods course can help do this.

Question 8: What should be the role of demonstration teaching in the methods class? Who should do it - instructor, students, practicing experienced teachers?

I believe there should be not only demonstration teaching but actual "contrived" teaching and "capsule" teaching by students in the methods class. I am a firm believer in the maxim, "Learning by participation." I do not see how one can learn as complex an art as teaching merely be watching, reading, and listening. It is true we provide a practice teaching requirement which may follow the methods course, but the first tentative dips into the "cold water" of teaching should be made in the methods class. In this situation, the duration is shorter, the control is firmer, and the feedback is immediate. Other students in the class can play the role of pupils, comments and reactions can be solicited, and a fruitful critique session can be held immediately following the teaching. If tactfully handled, this can be the most effective learning situation in the entire methods course.

Demonstration teaching by the instructor or practicing experienced teachers is certainly to be desired. Such occurrences should be built around specific types of classroom situations such as handling a discipline problem, introducing a unit, initiating a discussion, or beginning a laboratory experiment. Use of the micro-teaching technique, employing small groups of pupils and focussed on short-range objectives, is to be encouraged. Closed circuit television, using live or taped lessons from high school classes in progress should be incorporated into the plans. Films, film strips, tapes, and other audio-visual aids should be employed. But actual participation - running the gamut from lesson planning to teaching to evaluation and critique should be the privilege of all prospective science teachers in the methods classes.

RESPONSE: Dr. Milo K. Blecha

Question 9: How can we best select persons for eventual admission into practice teaching?

a. What is the role of personality factors in the teacher's capacity for teaching science effectively, and how can this be dealt with in the methods course?

b. What part of methods instruction should be devoted to encouragement of creativity and the ability to recognize it in children?

c. What stress should be placed on innovation in the preparation of the science teacher?

This reporter in his search for information concerning this question found practically nothing in the review of educational research. However an assessment of what is available would seem to indicate that some common screening practices come to the forefront more than others. These mainly include:

a. Screening all candidates prior to student teaching for speech deficiencies. These tests are usually administered by the speech departments.

b. In many colleges, students are asked to take and pass an English proficiency test.

c. Although less reliable, some schools administer personality tests to students before they enter student teaching. Such personality traits which reflect people orientation, teacher warmth, and intrinsic motivation rate high on this scale.

d. Better subject preparation with a grade of "C" or "3" are being required in many schools because studies continue to reveal the lack of adequate preparation in content areas.

e. Perhaps the most difficult area to assess is that of psychological maturity. When emotional physical and psychological difficulties are suspected which might impede teacher effectiveness, a screening board should be asked to make a final decision.

Finally, it must be pointed out that teacher competence is an elusive complex that seems to defy the gross measures of analysis. Perhaps there is a dire need to develop, with the aid of NSF funds, a theoretical framework which would clearly establish strategies for teacher preparation and the measurement of them.

Question 10: Are modern methods courses and content preparation planned and designed in terms of what we know about adolescent behavior?

In science we seem to be so preoccupied with science phenomena that there is a good chance we may have lost sight of the learner which in turn could bring about diminishing returns. For example in 1961 there were ten percent fewer graduates in science teaching than in 1950. Modern science curricula was developed without educational objectives formulated beforehand. Much of this material is based on learning theories that have been demonstrated to be untenable.

In content new curricula are designed primarily for the college bound student who has demonstrated an interest in science as a career.

Most promising of the recent innovations seems to be the switch away from rote learning to the stressing of skills and the processes of science. Much more emphasis needs to be focused on the learner and how science literacy can be inculcated in youth.

GUIDELINES FOR THE DOCTORATE IN SCIENCE EDUCATION

April 1, 1966

With the advent of large-scale secondary school curriculum projects, the growth of NDEA support, and the recent activity in science curriculum improvement at the elementary school and college levels, the need for strong leadership in all aspects of science instruction has become apparent. To date leadership has come from many sources, including scientists in academic departments as well as science educators. Nevertheless, the only acknowledged and long-term sources of persons explicitly trained to provide continuing leadership in pre-college science instruction are the many doctoral programs in science education. Many universities are now in the process of modifying their programs in this field or of establishing new ones. The task of designing suitable doctoral programs in science education has been made difficult by the absence of accepted guidlines. Hence, at the present time there is wide variation in content and quality among programs leading to the doctorate in science education.

The Association for the Education of Teachers in Science is committed to the improvement of science curricula and of program for teacher education and, consequently, it is directly concerned with standards for doctoral study in science education. Therefore, in March 1964 the president of AETS, acting in accordance with recommendations of the Executive Board, appointed a committee to identify the essential common elements of doctoral programs in science education. The resulting committee report was presented to the membership at the March 1965 annual meeting. A modified report was then circulated widely to persons directly concerned with science education, and their criticisms were sought. The committee has considered all responses carefully in preparing this final document.

The program outlined below represents the thoughtful and informed response of this committee to the charge given it. Nevertheless, the report should be clearly understood to be <u>not a mandate but a guide</u>. The intent was to provid (1) a standard which universities could use to evaluate their existing programs in order to decide what changes, if any, should be made, and (2) a model which universities could refer to when trying to decide whether or not to institute a doctoral program in science education, and which in the affirmative case, could be used as a guide to the design of the program.

Many institutions may wish to initi te or sustain a program which demands more of the candidate; however, it is doubtful that any institution should long permit itself to have standards lower than those suggested here.

The report is divided into four sections: the first discusses the occupational niches for which doctoral programs in science education can be expected to prepare candidates; the second deals with the prerequisites for admission into such programs; the third describes the model program itself, and the final section presents some of the rationale undergirding various features of the program.

THE JOB OF THE SCIENCE EDUCATOR

It is manifestly clear that there are several functions commonly performed by persons designated as "science educators." These may be organized into three categories, each of which delineates (albeit with some overlap) a kind of recognized position. These are:

I. The college or university science educator.

This person usually finds himself doing several, and sometimes all, of the following: teaching science methods courses, supervising student teaching in science, directing or supervising and/or teaching in-service training programs for science teachers, participating in local, state or national science curriculum projects, consulting with schools or school systems on science instruction, analyzing research for its relevance to science instruction guiding the study of graduate students in science education, and carrying on research.

II. The supervisor, coordinator, or director of science instruction in a school system at local, county, state, or national levels of responsibility. The work usually involves the design and implementation of science programs, the provision of services and materials to facilitate the work of science teachers, and liaison between science teachers and leaders in the schools and persons in other agencies concerned with science instruction. Classroom science teaching at pre-college levels is sometimes involved, as is the teaching of occasional science education courses at nearby universities or extension division centers.

III. The research specialist on programs of science instruction. Like the science educator in Category I, a person in this category is usually located at a university; however, unlike the teacher or practitioner the focus of his attention is on, and the bulk of his time and energy is devoted to, research and the guidance of others in research on aspects of science instruction. He may also have some of the duties listed in Category I.

It should be noted that the category "teacher of college-level science" is not among the functions in this list, despite the fact that, at the present time, some persons trained as science educators devote most or all of their time to the teaching of science rather than to methods of teaching science, to supervised practice, or to research in science education. The committee felt that the proper training for a college science teacher or a research scientist should be quite different from that for a science educator and felt that responsibility for the training program of science professors must reside with scientists and their professional societies. Therefore, the discussion that follows focuses on doctoral programs whose purpose is to prepare teachers, practitioners, and research specialists in science education.

PREREQUISITES FOR ADMISSION

General Admission Standards. These should be not less than those required for admission to the graduate school of arts and sciences at the same institution by whatever measurements are ordinarily used. That is, GRE scores or GPA or other devices used in making admission decisions throughout the university should also be applied to decisions about those seeking admission to the doctoral program in science education.

Age. For candidates in Categories I and II, the doctorate should normally be completed before age 35, even though time is needed for gaining actual experience in school teaching and for obtaining an up-to-date knowledge of a science before embarking on a doctoral program. In general, candidates for doctorate degrees in science education should be given less and less encouragement to undertake a program if the projected completion date would take them past that age. Those persons who expect to devote their energy to science education research that is, those in Category III, should be encouraged to complete the degree before the age of 30. The maximum starting age should be adjusted accordingly. This recommendation can be met only if there is a concomitant emphasis on early identification of, and ample financial support for, potential candidates.

<u>Mathematics</u>. Because science is so closely related to and dependent upon mathematics, it is necessary that workers in the field of science education have an adequate background in mathematics. It is recommended that, before beginning a doctoral program, a candidate should have at least one year of college mathematics, preferably calculus.

<u>Classroom Experience</u>. Persons entering programs leading to positions of types I and II should have two to four years of teaching experience in elemenatry and/or secondary school, but longer classroom experience increases the candidates's age without adding compensating insights. For those going into research one or two years of experience may be sufficient, and not much more than this should be encouraged so that the candidate can complete his doctoral work at an early age.

THE DOCTORAL PROGRAM

The following statements indicate the main features of an acceptable program leading to a doctorate in science education. Note that the details and implementation are left to the individual universities.

1. <u>Depth in science</u>. At the time of completion of the doctoral program the candidate should have the equivalent of a contemporary master's degree in an area of science. This means that if he earned a master's degree in an area of science some years earlier, he should, during the period of his doctoral studies, take enough additional graduate courses to bring himself up to date.

2. Breadth in science. For Categories I and II the program should insure that the candidate has at least a one-year course with laboratory in each of the usual school sciences, namely, biology, chemistry, physics and earth science. While this requirement may in many cases be fulfilled prior to admission to the doctoral program, courses or other means should be used to insure that the candidate is knowledgeable about modern content and emphasis in these basic areas.

3. <u>History and/or philosophy of science</u>. While ideally a full-year course in each of these two subjects might be desired, there are many practical difficulties in fitting them into a program. However, the candidate should be expected to complete no less than a year's study in one or the other of these subjects, a year of study divided between them, or a year course encompassing both.

4. Science education. By whatever means, the candidate should become well informed about past advances in science education and reach the forefront of curricular and other developments in this field. An advanced course or substantial seminar should be the minimum, but a large number of courses in science education should not be required.

5. Psychological, sociological and philosophical foundations of education. An advanced course or seminar based on each of these disciplines should be expected. The candidate should have an up-to-date knowledge of role orientation, group dynamics, child development, cognitive and personality psychology and of the school as a social institution.

6. Statistics. No less than one full year of study which would carry the student through experimental design and covarient analysis or the equivalent should be required. A knowledge of some computer techniques would be desirable. Category III candidates should be expected to acquire the more advanced statistical skills.

7. Mathematics. Candidates should take one year of college mathematics in addition to the year required for admission. This should be calculus unless the candidate has already taken it.

8. Dissertation. A dissertation should be required so that the candidate can demonstrate his capability to plan and carry out a significant independent study. While the study should be restricted in scope so that the candidate can complete the dissertation in a reasonable time, it should nevertheless be significant enough and of such quality that it can serve as the basis for a report to the profession. The report will ordinarily take the form of a paper delivered at a conference, a published article, or preferably both.

9. Professional involvement. During his period of residency the candidate should be actively engaged in experiences pointing directly toward his career goal. For example, with counsel and criticism of his performance by staff members in science education he might teach portions of a methods course or participate in supervision of science teachers.

10. Research involvement. During his residency the candidate should be involved in some aspect of research in science education. This is to be expected especially of those candidates who are not going to be primarily research workers. In order to meet this standard the institution must have adequate research facilities and suitably staffed on-going research activities, including research in science education.

11. Doctoral committee. The doctoral committee which supervises the work of a candidate in science education should contain representatives from relevant academic areas (science disciplines, psychology, statistics, etc.) and from education. History and/or philosophy of science are accepted as appropriate disciplines.

12. Residency. The program should require at least two years, preferably consecutive, of full-time residency. In some cases one year of residency obtained during a recently completed master's degree program may be included, but in no case should a candidate be permitted to obtain the doctor's degree without spending one academic year in full-time residence on campus.

13. Time limitation. The requirements listed above can form a unified and purposeful program of study only if they are completed over a relatively short period of time. For candidates in Categories I and II, the interval from admission to completion of the program should not exceed seven years, while for candidates in Category III the interval should not exceed five years.

RATIONALE

A complete argument in behalf of each feature of the model program just outlined cannot be given here. However, a brief statement of the assumptions made and the reasoning involved may do since it has been shown elsewhere that the science education profession accepts such a program in principle.

The numbers identifying the following statements refer to the similarly numbered features of the model in the preceding section.

1. The future of science instruction in the elementary and secondary schools will be best served by the continuous and cooperative efforts of science educators and scientists working together on problems of teacher preparation and on science curriculum. It is important, therefore, that science educators have a sufficiently deep knowledge of science based on advanced study in some field of science; similarly, of course, scientists who agree to work in the realm of science education ought to be expected to acquire more than superficial knowledge of educational theory and practice. Given this considerable overlap in their training, the scientist and the science educator can discuss problems of curriculum and science instruction for the elementary and secondary schools on a basis of mutual respect and support.

2. In addition to having some depth in a single science, a science educator must be competent enough to help science teachers in biology, chemistry, physics, and the earth sciences. He must have a minimum competence in these fields. The committee feels that for Categories I and II its recommendation here is an absolute minimum, and a second year of study in each of the fields would be highly desirable.

3. Work in curriculum design requires that science be seen in perspective and understood in both its historical and contemporary aspects. An understanding of the history and philosophy of science is essential to the development of such perspective.

4. A science educator can hardly be competent unless he is aware of the current developments in his field. Science instruction has been radically altered in the past decade by a series of events and developments. Whether he is teaching undergraduates, supervising prospective science teachers, working in the graduate program, or whether he is employed as a science education expert by a local school district, a science educator must be familiar with current curriculum developments and he must understand the philosophy which gave rise to their development. Furthermore, he should be well acquainted with the current research in science education and understand the trends and issues of science instruction at the present time.

5. The specialist in science education is also an educator. He must be able to communicate effectively in the field of professional education, as well as in a field of science. Improvement in science instruction, as in all education, calls for an understanding of the sociological and psychological factors involved in learning. The science educator needs to have a suitable mastery of the problems of curriculum development and supervision. He should be competent to a degree which will permit him to make contributions to general educational theory. He should not be insulated from the general problems of education in other academic areas.

6. Every science educator should have command of statistical theory which will permit him to interpret and to evaluate current research. Those in Categories I and III should reach a level sufficient to permit them to direct graduate study and do original research.

7. Mathematics is a basic and fundamental tool of modern science and it is required to understand much of the research both in science and in education which is being reported in the journals. Calculus is an important tool for work in any area of science as well as in education.

8. The dissertation or its equivalent is still the best vehicle for focusing the work of a doctoral study. However, many of the studies now being completed are not well designed and are often too long and too diffuse. If there is a substantial science education research program at an institution, it should be possible to pattern a series of related research studies which will be suitable as dissertation topics and which will, collectively, result in a unique and substantial contribution to the field of science education.

9. and 10. The need to be directly involved as an apprentice in the kind of work one will ultimately do requires no defense. It is merely a belated recognition in education of a practice in graduate study which has long been accepted in medicine, law, science and other fields.

11. The work of science educators has both academic and professional dimensions. The individual science educator must serve as a link between scholars in different disciplines as well as between them and teachers. Consequently, it is appropriate for the doctoral committee to be comprised of representatives from the candidate's science area as well as from the field of professional education. Such a provision may help insure that the candidate's science background will be adequate and that his knowledge of science is both sufficient and contemporary. Furthermore, scientists are more likely to cooperate with science educators if they are given some responsibility in their training. Similar arguments hold in addition for psychology, sociology, or whatever other academic field the candidate studies in a major way.

12. Full-time residency is essential if the candidate is to become immersed in his discipline. He must be at a place where he can work with other graduate students in the same field, as well as with academic leaders in his own and related fields, where he can participate in seminars, formal and informal, and in research. Full-time residency is much more likely to insure this kind of experience than work taken sporadically or on a commuter basis.

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