1968 EDUCATION COMMITTEE REPORT

SUGGESTED CERTIFICATION REQUIREMENTS FOR SCIENCE TEACHERS

INTRODUCTION

The Education Committee of The Ohio Academy of Science has been considering criteria for the preparation of science teachers for a number of years. Its present membership was recruited at the behest of President Richard A. Popham in 1965 and has served continuously since that time. The Committee was interested originally only in the secondary school aspect of the problem, but one result of the present group's study has been the broadening of its base of concern to include the elementary school level as well.

The Committee is composed of (a) one or more college level teachers from each of the following fields: Botany, Chemistry, Geography, Geology, Physics, and Zoology, (b) four college specialists in Science Education, and (c) two secondary school men with extensive experience in science teaching. Several of the committee members have been associated with national panels investigating various phases of science teaching.

The college science specialists on the Committee were guided in their immediate approach to the certification problem by the results of a questionnaire, sent to every member of The Ohio Academy of Science, which posed the following questions: (1) What subject matter competencies do you feel a high school teacher in your field should possess? (2) For each competency you have listed, indicate the college course or courses which you would expect to supply it. The science education specialists and the secondary school representatives brought to the Committee's deliberations suggestions and judgments distilled from their total career experience.

The Chairman, despite a background of over thirty years of college teaching, is no expert either on teacher training or on science education. He feels most fortunate to have been able to recruit a number of "idea" men for committee membership and gratefully acknowledges that whatever of merit this Report contains is the result of their insights and perceptive proposals.

"Should" vs "Can"—The Importance of Attitude

There will probably never be a time when attempts to upgrade teacher training requirements *significantly* do not meet with a thousand and one objections. In its deliberations, the Committee tried to play "the devil's advocate," both in calling attention to objections to its proposals and also in giving them full consideration. No objection examined appeared to us to be valid in terms of lack of feasibility of the recommendation to which it was opposed. *Basically*, all reflected concern over the degree of commitment to quality education on the part of the profession and/or the public at large.

The various objections considered can be grouped around four ideas.

I. "We have a critical teacher shortage now. If you set up a more extensive or more difficult training program, you will only succeed in making it worse." The validity of this conclusion can be questioned and there is some evidence to refute it. More important, we think, is the fact that there has always been, and probably always will be, a shortage of teachers and if we concern ourselves only with body counts we will never accomplish any real improvement in the education offered the next generation.

II. "What you are suggesting as the proper preparation of today's science

teacher will require of him an inordinately long period of study, as well as a disproportionate amount of science course work, to the detriment of other aspects of his academic career." The Committee is quite aware of the problems presented by any marked increase in the number or extent of certification requirements. At several places in this report we offer general suggestions relative to newly structured courses, interdepartmental courses, etc., which would allow the prospective teacher to attain the objectives we seek more efficiently (timewise) than is possible under present curricular programs. However, we do not think it justifiable to postpone the increased requirements until that still-uncertain situation is finally realized.

III. "A number of Ohio institutions which presently prepare students for teaching careers do not offer work in enough science fields to provide the breadth of background you are prescribing as basic for all science teachers." This is true, particularly in the area of the Earth Sciences (Geology, Astronomy, etc.). Our suggestions for meeting this problem will be found in the "Basic Foundation for Scientific Literacy" section of this report. However, it might be remarked in passing that educational institutions on a space-age planet which is troubled by problems of natural resource utilization and waste disposal might well consider the establishment of Earth Science curricula for a number of academically valid reasons.

IV. "Students who could attain the unrealistically high preparation goals you are prescribing would very likely be immediately pirated away from Ohio teaching positions, either by industry or by other states having higher pay scales than Ohio has." The question underlying this objection is *the basic one*, regardless of what aspect of the educational endeavor we are trying to improve. "Do the people of Ohio really believe in education or do they merely pay lip service to it?" Specifically on the point under consideration, are they willing to finance competitive pay scales that will keep top-qualified persons in the teaching field? The evidence, both here and elsewhere, is not very encouraging. (News commentator David Brinkley ended a recent telecast with the information that the teachers of one of the richest school districts in the country (located near Washington, D. C.) were considering striking in an attempt to get their salary scale raised to the level already being enjoyed by New York's sanitation workers *prior* to their recent strike for higher pay.) However, we are convinced that no significant progress will be made on this or any other aspect of education until and unless the general public and the political administrations which serve it are challenged to attain higher worthwhile goals. We therefore feel that the following are valid assumptions for all concerned with the planning or administration of the educative endeavor. (1) They owe no responsibility to any adults (however influential) who have completed their formal education. (2) They owe every responsibility to children presently being, or yet to be, educated. (3) They are derelict in their duty if they temporize or compromise on matters affecting the quality of education. (4) The question basic to all their planning ought to be "What *should* be done in the interest of the best education for our children?", not "What *can* we get the public to buy or go along with?"

The committee has developed its recommendations under a commitment to those assumptions and we do not feel there is anything starry-eyed about the certification patterns we are suggesting. Of course, objections to some of our recommendations are to be expected and the careful reader will discover that we have inferred a step-by-step accomplishment of some of the objectives, thus giving the report a somewhat open-ended character. It would be false to assume, however, that we are anything but impatient to see the recommended objectives realized. We look forward eagerly to their adoption *in toto* at the earliest moment consistent with their proper execution.

The Competency Idea

It has been customary to state certification requirements in terms of credit hours of work in courses which are often very generally or even vaguely titled. This makes for ease in record keeping (recording and totaling). But the only assumption one can *confidently* make about the preparation of a candidate who, for instance, has completed "15 semester hours of basic courses in General Biology or Zoology and Botany (1963 Ohio Certification Laws and Regulations, p. 21)" is that he is presenting the required number of credit hours. In fact, examination of the 1963 Regulations shows that, in such fields as Art, Business Education, Health and Physical Education, Home Economics, Music, and especially in Industrial Arts, the need for specific stipulation beyond mere hour totals had already been well recognized.

From the beginning of our deliberations, we were committed to the idea of stipulating certification requirements in terms of competency in particular areas rather than mere hours of course work in the major field. However, our hopes of making really significant progress in that direction within the confines of this report have been frustrated, principally by two factors. For one, in suggesting patterns of certification requirements for *immediate application*, we have had to "begin where we are" in terms of available courses, even while questioning the degree of relevancy of some and/or the degree of common understanding relative to the constituent elements appropriate to them. Secondly, consideration of the relationships of various competencies to the re-structuring of traditional courses is not amenable to short-term efforts.

Thus, the suggested certification patterns presented later in this report represent only a first step toward a program of certification via competency. Fortunately, there is an increasing number of studies, some national in scope, directly concerned with the above-noted area of relationships between competencies and course re-structuring, and it seems to us that these studies could lay the groundwork for a more objective approach to certification via competency in the near future. The next step beyond the patterns recommended in this report could well be a fairly detailed understanding, between the State Department of Education and the institutions certified to train prospective teachers, of the specific competencies assumed (expected?) to be covered in the "typical" courses of certification sequences. There would remain the problem of variation in the quality of presentation of competencies and eventually a final step might be periodic checks of some sort by the State Department to keep such variation within reasonable bounds. *We hasten to add*, however, that the creation of any rigid, hierarchial straight jacket of tests and regulations, promoting conformity and hostile to innovation, would be worse than no regulation whatsoever.

College "Service" Courses and Teacher Preparation

In the science certification patterns now in effect in Ohio, introductory level courses comprise too great a portion of the total requirement. If the regulations being developed prove to be in tune with the times, this will no longer be true for science teachers at the secondary school level, but teachers at the elementary level will probably continue to get most or all of their science training from "beginning" courses. Our committee therefore asked the question whether, in light of the way they are often presented, college introductory science courses—serving non-majors as terminal requirements and prospective majors as departure points—are appropriate to and/or efficient in the training of a teacher of science, particularly at the elementary school level. At more than one point in the recommendations presented below, we have expressed the judgment that they are not. Although we have not had time to explore this matter in depth, it seems to us that at least two avenues of improvement are open: (1) selection of course content with the idea of science interpretation in mind, (2) interdepartmental courses.

At present we are far more positive as to what we do not want such teacher-oriented science courses to be; we do *not* want them to be "watered down" courses in any respect.

Elementary Education (Grades 1–3)

1. We feel the presently required 8 hours in science is insufficient preparation.
2. We recommend a *minimum* of three courses (10–14 semester hours), distributed among the biological sciences, physical sciences, and earth sciences.
3. We feel that investigative laboratory or field work in each of these areas is essential to meaningful preparation in it, and is especially so for the prospective teacher.

This is one of the places where we feel a need for the teacher-oriented courses noted above, for we agree that, as generally offered, the usual introductory courses designed for future science majors are not suitable, either in breadth or approach, for providing the experiences which will prepare the elementary teacher to interpret science meaningfully to children of this age group.

Elementary Education (Grades 4–6)

It is our feeling that this grade level represents a particularly critical period for influencing the attitude of the student toward science. Ideally, then, the science preparation of teachers at this level should be characterized by considerable depth as well as breadth. Because, without some reorganization and telescoping of the total elementary teaching requirements, this does not appear feasible at present, we suggest the following program as the next best thing.

1. Regular elementary teachers for Grades 4–6 would take the pattern recommended above—a *minimum* of three courses (10–14 semester hours) distributed among the biological, physical, and earth sciences, including laboratory or field experience in each of the areas.
   NOTE: As before, we feel that typical introductory courses for science majors, as they are often presented, are not suitable for this objective, either in breadth or approach.
2. We feel that the science program at this level would be significantly enhanced by authorization of the position of Science Specialist to coordinate the science program in somewhat the same way as Specialists in Music and Arts and Crafts now function. We have even suggested to officers of the Ohio Council of Teachers of Mathematics the possibility of a Science-Mathematics Specialist for the 4–6 Grade level. Those contacted evidenced some interest in the idea in principle, but indicated a need for much further study before any commitment on it could be considered.

We recommend that the certification program of this proposed Science Specialist consist of our proposed "Basic Foundation for Scientific Literacy" Core curriculum (see the following section). Here again, though to a lesser extent, we feel the need for a more appropriate approach and content than that found in introductory courses as usually offered.

The concept of the "Middle School" Division, now being considered in some quarters, may well prove to be the solution of the science teaching problem at this grade level, provided it faces up to the necessity of requiring some in-depth training in science.

"Basic Foundation for Scientific Literacy" Core Curriculum

We are convinved that, if there ever was a time when a person could teach adequately one branch of science without at least a basic knowledge of all branches of science (including mathematics), it has long since passed. The developments of recent years, which have witnessed the evolution of the natural sciences toward the quantitative approach of the physical sciences and the increasing inter-

dependence of all branches of science as a result of the molecular approach, make it absolutely essential that this situation be recognized and dealt within the preparation of science teachers at both the Junior High (Grades 7–9) and High School (Grades 10–12) levels.

We would be the first to admit that, under present science department curricular regimes, the block of course work necessary to acquire such a background is sizeable (although we have fitted it into some sample liberal arts programs). Since our concern is the objective, not any particular way of meeting it, we would welcome savings of time accomplished by restructured, interdepartmental, or integrated courses, provided the fundamental objective of a complete background is still attained. But we insist that the necessity for such a background is fundamental and that the problem it presents will never be solved by surgical treatment of any of the prescribed areas.

The Scientific Literacy Core, *as we envision it for all Junior High and High School teachers of science, is as follows:*

1 year (2 courses) in introductory Biological Science
1 year (2 courses) in introductory Chemistry
1 year (2 courses) in introductory Physics
1 year (2 courses) in introductory Earth Science[1]
Mathematics[2]

Explanatory Notes:

[1]The first course should be a Geology-oriented introduction to Earth Science, followed by an introductory course in Astronomy (preferably) or one among the following: Oceanography, Hydrology, Meterology or Climatology, Physical Geography.

[2]For teachers of Chemistry, Physics, and Earth Science, this should include an introduction to Calculus. For teachers of Biological Science, it should include college algebra, trigonometry, and descriptive and inferential statistics: the inferential statistics to include chi square, correlational analysis, and elementary analysis of variance techniques. For Junior High General Science teachers, it should include college algebra.

Approx. credit-hour equivalent (27–30 semester hours)

Two of the objections which will be raised immediately against the adoption of this recommendation deserve specific comment. I. "Such a program cannot be required because a number of Ohio institutions presently preparing teachers do not offer course work in the Earth Sciences (Geology, Astronomy)". Our answer to this is that Ohio, blanketed as it is with institutions of higher education, is in a unique position to promote the universality of such training through a program of inter-institutional visitation, either of faculty or involved students. It is our understanding that some institutions in the state are already considering this type of pooling of academic interests. II. "How can already certified, practicing teachers of science possibly upgrade their background to meet the standards inherent in a program such as this?" Our answer is that the various nationally sponsored Summer and In-Service Institutes are showing the way and it can be claimed that it is part of the state's responsibility to broaden these efforts.

Certification Pattern For The General Science Teacher in Junior High School (Grades 7–9)

A. "Basic Foundation for Scientific Literacy" Core Curriculum (approx. 27–30 sem. hrs.)
B. Additional Preparation for the (Junior High) General Science Specialty: Six courses (approx. 18–24 sem. hrs.), distributed as follows:
   Two additional courses (a total of four courses) from each of two of the following areas:
   a. Biology
   b. Chemistry
   c. Earth Science
   d. Physics

Two additional courses in science relevant for teaching pupils at the Junior High School level. Some examples of desirable courses for this category are:

History of Science
Philosophy of Science
Conservation of Natural Resources
Meteorology
Scientific Photography

C. Professional Competency (see Section on Professional Competency near end of Report)

Certification Pattern For The Teacher of Biological Science in High School (Grades 10–12)

A. "Basic Foundation for Scientific Literacy" Core Curriculum (Approx. 27–30 sem. hrs.)

B. Additional Preparation for the Biological Science Specialty:
For a *Four Year Program* of Preparation:

One course from each of the Four Areas[1] listed below, plus a year (two courses) of Organic Chemistry (which may include Biochemistry). (approx. 18–24 sem. hrs.)

Area I The Structure of Organisms[2]
Area II. Regulation and Maintenance in Organisms[3]
Area III. Continuity and Variation in Organisms[4]
Area IV. Diversity and Inter-relationships of Organisms[5]

Explanatory Notes:

[1]Certain "traditional existing courses" address themselves to the competency areas listed. However, since we do not wish to "freeze" thinking about possible, more efficient approaches (reorganization, integration, inter-departmental), such courses are noted below as—perhaps—temporary "means" to achieve the competency "end" stated above.

[2]Through taking a course such as Comparative Anatomy, Comparative Morphology, or Plant Anatomy. A course in Human Anatomy would not properly achieve this competency, but would be a very appropriate second course taken in the area.

[3]Through taking a course such as General or Cellular Physiology, Plant Physiology, or Animal Physiology. A course in Human Physiology would *not* properly achieve this competency, but would be a very appropriate second course taken in the area.

[4]This competency is attacked from different angles by courses in Genetics (Plant and Animal), Embryology, and Evolution. Integrated courses in this area are already offered in some institutions.

[5]Through taking a Taxonomic course or a Field course in Botany or Zoology or a course in Ecology. A course in Conservation would *not* properly achieve this competency, but would be a very appropriate second course taken in the area.

For a *Five-Year Program* of Preparation: See Section on Five-Year Program near end of Report.

C. Professional Competency: See Section on Professional Competency near end of Report.

Certification Pattern For The Teacher of Earth Science in High School (Grades 10–12)

A. "Basic Foundation for Scientific Literacy" Core Curriculum (approx. 27–30 sem. hrs.)

B. Additional Preparation for the Earth Science Specialty:
For a *Four Year Program* of Preparation:

1. A total of six courses from the Five Areas[1] listed below, distributed as follows: 2 courses from Area I, 2 from Area II, & 2 from Areas III, IV, and V combined (18–24 Sem. Hrs.)

Explanatory Note:

[1]Certain "traditional existing courses" address themselves to the competency areas listed. However, earth scientists are at present concerned with new approaches (restructuring, integrated, and interdisciplinary) and the examples noted below should be considered "temporary" means to competency "ends."

Area I. The Solid earth; materials, structure, processes and landforms[2]
Area II. Earth history and paleobiology[3]
Area III. The Atmosphere[4]
Area IV. The Hydrosphere[5]
Area V. The earth's environment in space[6]

Explanatory Notes:

[2]Traditional courses concerned with this Area are: Physical Geology, Geomorphology, Common Rocks and Minerals.

[3]Traditional courses concerned with this Area are: Historical Geology, Paleontology, Stratigraphy.

[4]Traditional courses concerned with this Area are: Meterology, Climatology, Physical Geography—Weather.

[5]Traditional courses concerned with this Area are: Oceanography, Hydrology. It may also be considered in some Geology and Physical Geography courses.

[6]The traditional course concerned with this Area is Astronomy, but it may also be included in introductory Geology or Physical Science courses in some institutions.

2. Laboratory work of an investigatory nature is to be undertaken in *at least three* of the five Areas listed above.
3. Junior-Senior level work is to be undertaken in one of the five Areas.
4. At least one course should be structured to demonstrate the *interdisciplinary nature* of Earth Science.
5. Four weeks of *Field Work* in Earth Science should be undertaken. It can be in one of the Areas, or in two or more combined.

For a *Five-Year Program* of Preparation: See Section on Five-Year Program near the end of the Report.

C. Professional Competency: See Section on Professional Competency near end of Report.

Certification Pattern For The Teacher of Physical Science in High School (Grades 10–12)

A. "Basic Foundation for Scientific Literacy" Core Curriculum (approx. 27–30 sem. hrs.)

B. Additional Preparation for the Physical Science Specialty:
For a *Four Year Program* of Preparation:
The prospective high school Physical Science teacher should attain competence in the following fields—
A. Atomic and molecular structure and chemical bonding
B. Chemical calculations
C. Organic chemistry, theoretical and descriptive
D. Analytical techniques and theory
E. Introductory kinetics and thermodynamics
F. Inorganic chemistry, theoretical and descriptive
G. Electricity, magnetism, and electronics
H. Mechanics, simple vibrators, waves in simple mechanical media
I. Geometric and physical optics
J. Heat, introductory physical thermodynamics
K. Quantum theory

To implement the above, the prospective teacher should take *three courses in chemistry and three courses in physics* (approx. 18–24 sem. hrs. in addition to the Basic Foundation for Scientific Literacy courses—Item A above). Traditional existing courses which can provide the required competencies are the following:

1. Organic chemistry. (A requirement) The course should cover the whole field of organic chemistry. If no such course is available, two courses should be taken.
2. Physical chemistry (calculus based)

3. Analytical chemistry
4. Inorganic chemistry
5. Intermediate classical physics. If no such course is available, two or three intermediate courses should be selected from Electricity and Magnetism, Intermediate Mechanics, Optics or Heat, and Thermodynamics
6. Modern Physics
7. Advanced Physics laboratory, if not included in #5.

A prospective teacher *who desires to specialize in either chemistry or physics should take two extra courses in his special field* so as to improve the competencies listed above.

For a *Five-Year Program* of Preparation: See Section on Five-Year Program near the end of the Report.

C. Professional Competency: See Section on Professional Competency near end of the Report.

THE TEACHING MINOR

Our Committee is convinced that it is no longer possible for a person to do an adequate job of teaching in any branch of science without possessing a well-rounded knowledge of the field involved. We therefore do not feel that any teacher should be certified to teach in a field until he has completed our full prescribed Specialty Preparation in that field.

PROFESSIONAL COMPETENCY COURSES

The professional competency requirement should consist of the Student Teaching course, together with a Methods or Practicum course, to be taken immediately prior to or concurrently with the Student Teaching.

The Methods course would concern itself with the teaching and learning of the particular science Specialty in which the student had chosen to work and it should (1) include an analysis of the philosophy and rationale for teaching that Specialty in the secondary school, (2) develop the ability to utilize various strategies of teaching that Specialty, (3) develop knowledge and skill in using basic laboratory techniques in secondary school teaching of the Specialty, (4) develop knowledge and understanding of techniques utilized in evaluating learning outcomes in the Specialty, and (5) develop knowledge and understanding of materials and apparatus appropriate for teaching the Specialty at the secondary school level.

The Committee is concerned over the road-block in the way of effective teacher training that results from lack of cooperation between the faculties of Education departments and those of science-content field departments. This may result from a simple failure to communicate, or from lack of mutual respect, or even from antipathy. Whatever the cause, the immediate sufferer is the unfortunate student teacher, but only a figurative step away is the "bleat" of the non-cooperating faculties about "the poor quality of teaching at the lower levels". The first-degree criminal in this regard is the college science teacher who persuades a good student interested in teaching to abandon it in favor of a more lucrative career in some other line of endeavor. In all justice, such a character should never again have the privilege of working with any well qualified student.

To regard training for professional competency (methods) and content acquisition as inherently different is another of our artificial distinctions. They are but two phases of the same endeavor and the accomplishment of that endeavor should be recognized as the responsibility of the Institution, not merely of one department within it. If institutions insisted that the professional training of prospective teachers called for a cooperative program involving both the Education department and content field departments; if the Educational people granted that professional training is a means to an end, not an end in itself, and thus not to be unduly

proliferated; if the faculties of content field departments realized that genuine creation and innovation in the area of professional training is intellectually significant; only then we could proceed, in mutual respect and trust, with the development of outstanding teacher-preparation programs.

Cooperative programs are essential and innovative programs should be continually encouraged. Cooperation could be attained through team teaching or, where the setup warrants, dual (departmental) appointments would be both highly desirable and effective. In a sense, however, the department affiliation of the person or persons involved in "training teachers" is not important. What is important is that such persons bring to the task (1) a continuing and direct experience with the teaching situation to be faced by their students on entering the profession, and (2) a thorough background in some science content field.

THE FIVE-YEAR PROGRAM OF TEACHER PREPARATION

Some fifteen (15) or more states now require the prospective teacher to complete a five-year (Master's Degree or Equivalent) preparation program in order to qualify for a Professional Certificate. It appears to us inevitable that Ohio will follow suit in the near future and we heartily endorse such a move.

As inferred in the foregoing recommended Certification Patterns for the Biological, Earth, and Physical Science Specialties, we feel that *complete* preparation to teach one of these fields requires a five-year program. *The Fifth Year should be specified as follows:*

1. A Master's Degree or its Equivalent.
2. Two-thirds (⅔) of the work or twenty (20) semester hours (whichever is larger) to be taken in the candidate's Teaching Field or Fields.

On completing the Four-Year preparation program, the candidate would enter the profession with a Provisional Certificate. He would be required to complete the "Fifth Year" within seven (7) years after entering the profession and, upon completion of it within this period, would be granted a Professional Certificate. One of the secondary school science teachers on our Committee has suggested that, in light of the continuing explosion of scientific knowledge and the ever-increasing sophistication of its techniques, all science teachers should be periodically re-examined throughout their careers, but the Committee has made no judgment on this point.

We do have a very positive opinion about one aspect of the Fifth-Year course work and that is that an undergraduate level course should not be barred, *per se*, from inclusion for credit in that year, particularly if the student has not had previous work in the area involved. Several of us know, by experience or professional shop-talk, how the fetish of "graduate level courses only" has made a farce out of work in some Summer Institutes, etc. As an example, the committee chairman two summers ago had a good, conscientious student who politely complained about the difficulty and exam pressure of his NSF Institute course and informed him that, in the (far western University) Institute she had attended the previous summer, the class had been informed at the beginning of the course that, since everyone registered was a graduate student, there would be no examinations and everyone would be graded B or better. It is our opinion that the indiscriminate application of "graduate level only" regulations effectively serves to aid and abet such educational hoaxes as the foregoing. Is that to be preferred over the acceptance of some honestly earned credits in significant undergraduate courses?

ADDENDUM: STATE SCIENCE SUPERVISORS OR SPECIALISTS

The following was submitted by two of the science education specialists on the Committee too late to be considered in full Committee sessions. Because,

taken at face value, it appears to be an eminently logical move, the chairman has exercised his prerogative by including it in this final Report.

Their comments read: "We strongly recommend the clear identification of elementary and secondary state science supervisors as positions that should be established in the State Department of Education. Such persons should have professional preparation in the field of science education and experience as teachers and supervisors. These positions have been needed for a considerable period of time to aid many schools which desire assistance. It is especially important at this time due to the changing procedures for providing federal funds to states. These persons are needed to help make state plans and to seek the counsel of other appropriate persons concerning the improvement of science education within the state and the support of science education programs."

Respectfully submitted,

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