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twenty–five points in their scores over the first testing period. The mean for the 245 students taking the first test was 49.1 while the mean on the retest was 55.5 which resulted in a net gain of 6.4 points.

Since this test did not include comparison norms for seventh and eighth grade students, the study will have to wait until next year before a comparison of this type can be made. Furthermore, one might assume that the entire critical thinking development of these students is caused by their courses in science alone, but we all should realize that all the subjects a student takes tend to contribute to the student's ability to think critically. Further studies and additional testing will be needed before a definite conclusion can be made. But from preliminary results of one year of testing, it appears that science teaching can and does develop the ability of students to think critically.

New Directions in Earth Science in Iowa Schools

SILAS W. SCHIRNER

Abstract: Earth science was a common part of the high school curricula fifty years ago. It dropped from about 30% to .4% of the total school enrollment from 1900 to 1949. The decline of earth science was paralleled by an increased offering of biology. In the modern high school curricula it is replacing general science, mostly at the ninth grade level. Earth science offerings are on the increase in Iowa from 7 districts in 1960 to 53 in 1965, an increase of 757%, which is roughly 10% of the schools. Other schools have plans for the adoption of an earth science course in the near future. It is taught 75% of the time at the junior high school level (grades 7, 8, 9). The size of the class is about 26-30 students taught by a married male with a BA degree and 4-7 years exeprience. Most states have no certification requirements specifically for earth science teachers. They are certified under general science or science in general. There are not enough qualified earth science teachers at present and as the growth continues the problem will become more critical.

INTRODUCTION

The purpose of this paper is to explore the past and present status of earth science in the secondary schools and from these try to predict trends in the future. It is the purpose of this paper also to explore some of the problems in staffing an earth science course with a well qualified teacher.

One of the major difficulties in such an undertaking is semantics. Earth science defined in an earlier paper by the writer as "an integrated course dealing with the study of the earth through astronomy, geology, meteorology, oceanography, and physical geography,"[1] is and has been called many things. It has been called physical science, general science, geology, astronomy, and others. The writer has used as data only those courses called earth science.

The Past

Geology and physiography were commonly taught in many high schools fifty years ago, although they are relatively new additions to modern secondary school curricula. These courses, which delt with geology, meteorology, climatology, physical geography and to some extent oceanography, served to introduce the student to the broad study of the earth. As time passed, these courses virtually disappeared from the public school curriculm. They were literally "shoved" out of the secondary school as a result of the rapid advances in the fields of biology, chemistry, and physics.[2]

From 1900 to 1949 there was a steady decrease in the per cent of total school population enrolled in earth science in the U.S.. At about this same time (1910 to 1957) there was a steady increase in the per cent of total school population enrolled in biology in the U.S..[3]

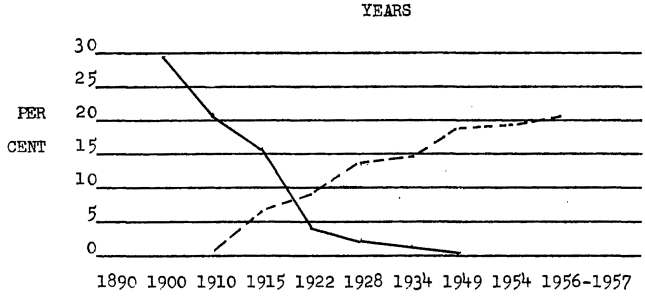

Figure 1. Comparison of earth science ——— and biology - - - - enrollment by per cent of total enrollment in U. S.

Although the school enrollment was increasing rapidly during these years the per cent enrolled in earth science decreased faster than the increased enrollment with a net effect of a decreased enrollment in earth science.

As recently as 1950 less than one per cent of the students in public secondary schools were enrolled in earth science courses.

Table 1. Comparison of number of students enrolled in earth science

Total enrollment	519,251	5,399,452
Per cent earth science	29.8	.4
Per cent total	154,736.8	21,597.8
Year	1900	1949

In that year, only New York and Oklahoma reported figures greater than one per cent.[4]

The turning point in the revival in the teaching of earth science came in 1949. At that time the New York State Education Department inaugurated an earth science course for gifted students. This course . . . proved so successful that the plan was soon adapted by other schools throughout the states. By 1962-63, 683 New York schools were teaching earth science courses to more than 42,000 students![2] Other states followed the lead with extensive programs in New Jersey and Pennsylvania.

In the state of Iowa seven districts offered earth science as an elective course in 1960.[5]

In 1961 McGraw-Hill Book Company indicated that only " . . . 24 states reported having or planning an earth science course." Just one year later, the study by Coash revealed that 39 states were offering earth science courses. The number of schools teaching these courses in 1962 " . . . ranged from one in Nevada to 400 in Pennsylvania and 450 in New York. According to the later Shrum survey, 44 states offered separate earth science courses during the academic year 1962-63. A more recent survey (July 1963) by the ESCP staff indicated that schools in all of the 50 states and the District of Columbia planned to offer courses in earth science during 1963-64. The number of schools range from one or two in Mississippi to 683 in New York State.[2]

Present Status of Earth Science in Iowa

It is common knowledge to the science teachers in Iowa that units of study in meteorology, climatology, geology, astronomy and oceanography are included in most general science courses offered in the early high school years (7-9). There are other courses such as physical science courses that devote a part or all of the course to the study of earth science. In this study only those schools using the course title of earth science were considered.

From the State Department of Public Instruction's "Iowa Professional School Employee Data Sheet" (IPSEDS)[6] 64 teachers reported teaching an earth science course to 2831 students. These 64 teachers taught in 53 districts. This is an increase of 757% since 1960 when 7 districts offered earth science.[5]

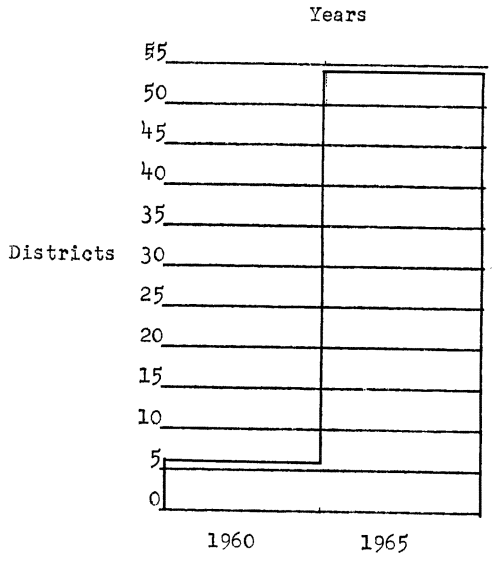

Figure 2. Comparison of Iowa School Districts offering earth science 1960 and 1965.

This is a larger per cent increase in earth science offering in Iowa (757%) than in New Jersey (600%)[2] during the past five years. However it should be noted that New Jersey has a well established program in the majority of schools[2] and Iowa is just starting to move in this direction.

Data from a personal survey conducted by the writer indicated 15 additional schools not reported in IPSEDS survey as having a course offered at present called earth science. This added to the 56 schools reported in IPSEDS survey would bring the total number of schools teaching earth science up to 71. The writer is confident that this figure is a minimum number and not the true or maximum number of earth science courses taught in the state at present. No attempt was made to determine the number of students in earth science in the 15 schools not reported in IPSEDS.

The per cent of schools in Iowa teaching earth science is roughly 10%. Despite the rapid growth, comparatively fewer students take earth science than take biology, chemistry, or physics.

When earth science is taught in Iowa it is taught over 50% of the time at the ninth grade level (the level for which the new ESCP material have been developed). It is taught over 20% of the time at the eighth grade level. Whenever the course was taught to combinations of grades including the ninth grade the number of ninth grade students far exceeded the students at

other grade levels. The writer took the liberty of using these combinations to arrive at the per cent given (over 50%-actually 54.7%). The only other significant level was an earth science course taught at the eleventh and twelfth grades (9.4%). It was indicated by one school that those students not enrolled in chemistry or physics. This may indicate a course of lower calibre and would point to a need for a science curriculm composed of more than one track. Perhaps one track for the future scientist and another for the non-scientists.

Table 2. Grade placement of earth science for 1964-65 in the State of Iowa by per cent

Grade level	7	8	9	10
Per cent	7.5	22.7	43.3	3.8

Table 3. Combination of grades

Grade level	9-10	9-10-11	9-11	10-11-12	11-12
Per cent	3.8	3.8	3.8	1.9	9.4

Table 4. All combinations involving ninth graders

Combinations	9	9-10	9-10-11	9-11	
Per cent	43.4	3.8	3.8	3.8	
Total					54.8

The grade level at which the course is taught indicates two things. First the disenchantment of Iowa science teachers with general science courses in the upper junior high school years is reinforced by the number of schools teaching earth science at the 8th and 9th grade level. Second the impact current earth science curriculum study groups have had on the thinking of secondary school teachers and administrators is shown by a major offering in the ninth grade.

The average class size of the earth science classes taught in Iowa is 25. Classes over 32 are very few. The most frequent size being from 26 to 30 students per class. However there are more smaller than this number than there are larger as shown by the graph included below.

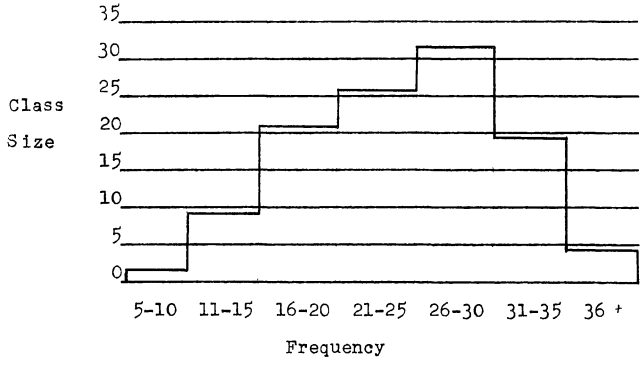

Figure 3. Size of earth science classes in Iowa, 1964-65.

Generally the length of the class is 55 minutes and the course is taught 5 days a week for two semesters.

The Earth Science Teacher

The IPSEDS survey indicates that most of the earth science teachers in Iowa have less than seven years experience. The graph below will give a clear picture.

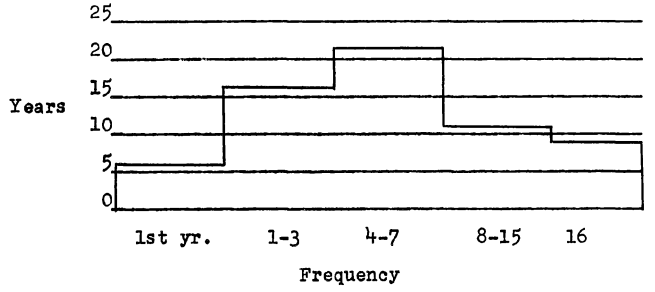

Figure 4. Number of years experience of earth science teachers in the state of Iowa 1964-65.

The following tables will indicate the highest degree held by earth science teachers, their salary, tenure, age sex and marital status, and total semester hours of college credit.

Table 5. Iowa earth science teachers—highest degree held

Per cent	3.1	84.4	12.5	0	0
Frequency	2	54	8	0	0
Degree	No Degree	B.A.	M.A.	Specialist	Ph.D.

Table 6. Iowa earth science teachers salary

Yearly salary	Below	4800	5100	5600	6100	6600	7100	Over
dollars	4800	5000	5500	6000	6500	7000	8000	8000
Per cent	1.6	13.1	29.5	16.4	23.0	6.5	8.2	1.6
Frequency	1	8	18	10	14	4	5	1

Table 7. Iowa earth science teachers tenure at present position

	1st yr.	1-3	4-7	8-12	13-14	15-19	20 & over
Per cent	24.1	46.8	19.4	0	4.8	0	4.8
Frequency	15	29	12	0	3	0	3

Table 8. Iowa earth science teachers age

Age in years	21-25	26-30	31-35	36-40	41-45	46+
Per cent	26.2	27.9	18.0	11.5	1.6	14.7
Frequency	16	17	11	7	1	9

Table 9. Iowa earth science teachers sex and marital status

Status	Single fem	Married fem	Single male	Married male
Per cent	4.8	4.8	11.3	79.0
Frequency	3	3	7	49

Table 10. Iowa earth science teachers total semester hours all college credit

Hours	Below 130	131-150	151-170	171-190	191+
Per cent	5.1	42.4	18.6	13.5	20.3
Frequency	3	25	11	8	12

The number of semester hours college credit in the fields of

earth science as reported by IPSEDS survey was obviously in error. Teachers teaching in several fields reported the same number of hours credit in all fields. This was interpreted by the writer as being the total number of hours in science and not as earth science. Since confidence in the data was in doubt it was deleted from the paper.

Earth Science Teacher Certification

At the present time the State of Iowa certifies the earth science teacher under the requirements for a teaching certificate in general or physical science.[7] This is unfortunate indeed. A person with hours only in biology, chemistry, and physics can be "qualified" to teach earth science in Iowa. This means that a subject centered around geology, astronomy, meteorology, oceanography, and physical geography can be taught by a person with no training in any of the fields of the discipline.

In 1963 there were 15 states that had or were planning definite academic requirements for certifying earth science teachers. At the same time 14 states included earth science certification under the requirements for a teaching certificate in general or physical science. Iowa was one of these states. There were 20 states that had no certification requirements for earth science teachers, and one state where no information was available.[7] With the rapid growth of earth science in the secondary schools there is a great need for certification of the teachers to guarantee the young people of our state a qualified teacher in the classroom.

Eight guidelines proposed by the Teacher Preparation-Certification Study (NASDTEC-AAAS) will be helpful to any study group. The college program for teachers of earth science should include:

1. A thorough college-level study of the material also offered in the high school curriculum.
2. Observation of the sequential nature of the subject to be taught, including appreciation of the concepts offered in high school courses.
3. A major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.
4. Sufficient preparation for the later pursuit of graduate work in one of the earth sciences.
5. Availability of a fifth-year program emphasizing courses in science.
6. Work in areas relating to earth science.
7. A course in earth science teaching methods.

8. Observation of curriculm improvement recommendations made by various national groups.[7]

The writer has spoken to several of the science representatives from the State Department of Public Instruction in Iowa about certification for earth science teachers. They indicate and recognize a need for requirements, but no action has been taken to date. The State University of Iowa has at present a five year masters degree program for the training of earth science teachers. The State Department of Public Instruction should be guided in their efforts by this program, the program in other colleges and universities in the state, and the eight guidelines proposed by NASDTEC-AAAS.

Indications of Future Trends in Earth Science

It is clear from the data of this study that earth science teaching in the secondary schools of the state is and will continue to increase. There are several reasons for the revival and continued advancement.

1. The impetus by Mohole Project and International Geophysical year and the rebirth of interest in the earth and its environs.
2. Most of the material presented in the "old" general science course is now being taught in the lower grades. There is a distinct need for a somewhat more advanced science course for the beginning high school student and resulted in the disenchantment of most scientists and science educators with the general science courses.
3. Need for a course to introduce the student to the basic methods of scientific inquiry and investigation at an early age.
4. The need for a medium through which to illustrate the interdependence of the various basic sciences.
5. The rapid advance in scientific knowledge, technology and the vast accumulation of facts dictates a need for the understanding of broad concepts that have and are standing the test of time through inquiry.
6. The effects of curriculm study groups on science teaching in the secondary schools of the state and nation.

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Experimental Studies on the Dispersal of the Frog, *Rana Pipiens*

RICHARD V. BOVBJERG[1]

Abstract. Massive emigrations of the frog *Rana pipiens pipiens* Schreber have been recorded from large sloughs in northwestern Iowa. To investigate the possible ecological causes for this movement, two sets of laboratory experiments were done. A simulated slough was constructed in a large concrete tank and stocked with vegetation and a population of maturing tadpoles. As the time came for the emigration in the field, the experimental population, under the regulated laboratory conditions, had matured and emigrated in a way parallel to the natural situation. In other experiments, emigrations were determined for populations of juvenile frogs, one of which was five times the size of the other. The rate of movement was almost identical in the two groups, suggesting that population pressures do not stimulate movement. The precise correspondence of activity in the artificial slough with that in the field, as well as the apparent density-unrelated response to population density, indicate that the stimuli to this emigration behavior are internal rather than environmental.

In a previous paper (Bovbjerg and Bovbjerg, 1964), crash emigrations of the frog *Rana pipiens pipiens* Schreber were described. Over a three-year period, mass midsummer movements were observed at Garlock Slough, immediately south of Lake West Okoboji in northwestern Iowa. These seasonal movements all started early in July and essentially emptied this large body of water of the juvenile frogs within several days. The emigrating frogs were at, or just prior to, the stage of complete metamorphosis. It was suggested that the stimulus for the emigration behavior was not related to specific environmental factors such as temperature, rainfall, food, or predation pressure. Prior to the movement, density at the margins of the water was very high, which did suggest local, high density as a possible stimulus to emigration.

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