SOME BASIC SCIENCE CONCEPTS OF PROSPECTIVE ELEMENTARY TEACHERS IN OREGON

by

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SOME BASIC SCIENCE CONCEPTS OF PROSPECTIVE ELEMENTARY TEACHERS IN OREGON

CHAPTER I

INTRODUCTION

In Oregon science in its various forms has long been a part of the secondary school curriculum, but in the elementary school only a limited amount of science was required. The "nature study" requirement was adhered to by many schools. Many others had a course of study of their own which attempted to broaden the field of science study, but not until last year did an integrated nine year program of science appear for the state as a whole.

The science program inaugurated in Oregon's elementary school curriculum in 1941 was evolved through the action of several factions. Most of the development in this field has come since the appearance of the Thirty-First Yearbook of the National Society for the Study of Education in 1932.[1] Another contributing factor was the appearance of articles and books written by such science leaders as G. S. Craig, W. C. Croxton, W. L. Beauchamp, S. R. Powers, E. L. Palmer, E. R. Downing, and many others.

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1. National Society for the Study of Education, A Program for Teaching Science, Thirty-First Yearbook, Public School Publishing Company, Bloomington, Illinois, 1932.

The fact that nature study alone was not broad enough to meet the needs of the child in a complex civilization was realized by many. Stevenson says:

> Still other forces have led to the development of elementary science. These include the meeting of two more or less well-defined movements--nature study and systematized science teaching, each of which had its weaknesses and strengths, the development of a new conception of elementary education, and the realization of the contributions of science to modern civilization and education.[1]

That science has a place in the early education of a child is expressed by Hudspeth when he says:

> Science and the social studies are the two main content subjects in the entire curriculum, and in the lower grades science is the more important because the child is more interested in and able to learn about himself and his surroundings than about government, history, and social institutions.[2]

That the various factors concerning science in the elementary schools was recognized by educators in Oregon was more or less well expressed by Rex Putnam, Superintendent of Public Instruction, when he wrote:

> Science is assuming a role of increasing importance in the life of every individual in America today. For those who are to engage in any kind of technical pursuit, specific science training has always been indispensable. But today, even though one does not

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1. Stevenson, E. N., Oregon's New Science Program, Oregon Education Journal, vol. 15, April, 1941, p. 7.

2. Hudspeth, Jack, Don't Forget Science in the Grades, Education, vol. 62, January, 1942, p. 302.

> engage in some occupation requiring specialization in science, to live at all successfully and happily he needs a broad experience in the sciences, a scientific attitude, certain skills and information that will enable him to be an intelligent consumer of science, and an appreciation of the function and place of science in our present culture. This obvious need points unmistakably to a responsibility of the schools to give instruction in science at all levels of the common school.[1]

The recognition of the needs for elementary science instruction culminated in the course of study which was released for use in Oregon schools in the fall of 1941. This guide draws heavily from the fields of physical science as well as from the field of biological science. This course of study is built around the major science concepts or generalizations.

The committee's point of view is expressed as follows:

> In recent years the numerous problems of civilization have become more and more associated with scientific knowledge and discoveries. In order to participate in this civilization and to cope with its problems, the educated individual must have knowledge of science and the ability to apply scientific methods to the solution of problems. With the issuance of this publication, Oregon joins many other states in adopting and putting into practice a sequential, unified, twelve-year science program.[2]

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1. Putnam, Rex, Tentative Guide to Science for Oregon Schools, State Printing Department, 1942, p. 2.

2. The Committee, Tentative Guide to Science for Oregon Schools, State Printing Department, 1941.

With the incorporation of science teaching in the elementary school curriculum the writer became interested in the problem of teacher preparedness in the various phases of science that were represented in the course of study. Croxton says:

> In every discussion of the improvement of teaching, whether from the standpoint of philosophy or of research, we always turn to the preparation of teachers.[1]

The Problem

Examination of the state course of study for elementary science reveals that the subject matter units range over five main fields of science: chemistry, physics, biology, astronomy, and geology. Only the simplest facts and concepts are used in elementary science, but since the nature of the units involved requires a good basic knowledge of the five afore-mentioned fields, this question arises: Are our teachers adequately prepared to present this very important phase of education? Powers states, "It is impossible to teach any subject well without an adequate background of subject

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1. Croxton, W. C., Science in the Elementary School, McGraw-Hill Book Company, Inc., New York, 1937, p. 113.

matter training."[1]

This study attempts to throw some light on the teacher preparation question by determining as objectively as possible the extent of the prospective teacher's grasp of certain basic concepts in the five main fields of science represented in the state course of study.

Method

From a study of the main fields of science represented in the state course of study, the writer has tried to assemble a group of statements or concepts which would be more or less basic to the various fields involved. These statements are all in agreement with the lists of basic science concepts set forth by Downing,[2] Craig,[3] and Croxton.[4]

The test devised was made up of 127 items all stated positively so as to cause as little confusion as possible in the minds of the subjects taking it.

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1. Powers, S. R., Programs for the Education of Science Teachers in State Teachers Colleges, Thirty-First Yearbook, Public School Publishing Company, Bloomington, Illinois, 1932, p. 333.

2. Downing, E. R., An Introduction to the Teaching of Science in Schools, University of Chicago Press, Chicago, Illinois, 1934.

3. Craig, G. S., Science for the Elementary School Teacher, Ginn and Company, Boston, 1940.

4. Op. cit., Croxton, W. C.

Furthermore, to eliminate guessing, a column marked "don't know" was included.

The items of the test were selected from a considerable number of questions that had been used by other investigators in the field. Sources from which selections were taken are as follows: (1) An Evaluation of Certain Popular Science Misconceptions;[1] (2) Some Significant Concepts and Beliefs in Astronomy and Geology of Entering College Freshmen and the Relation of These to General Scholastic Aptitude;[2] (3) A Study of Some Concepts and Beliefs in Chemistry and Physics;[3] (4) Mistaken Notions of Scientific Phenomena as They Now Exist Among Average Citizens;[4] (5) Some Misconceptions in Science Held by Prospective Elementary Teachers;[5] (6) items gathered from

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1. Hancock, Cyril, An Evaluation of Certain Popular Science Misconceptions, Science Education, vol. 24, April, 1940, pp. 208-213.

2. Ralya, L. L., and Ralya, Lillian, Some Significant Concepts and Beliefs in Astronomy and Geology of Entering College Freshmen and the Relation of These to General Scholastic Aptitude, School Science and Mathematics, vol. 40, November, 1940, pp. 727-734.

3. Ralya, Lynn L., A Study of Some Concepts and Beliefs in Chemistry and Physics, Journal of Chemical Education, vol. 18, August, 1941, pp. 364-367.

4. Bonnell, Clarence, Mistaken Notions of Scientific Phenomena as They Now Exist Among Average Citizens, School Science and Mathematics, vol. 25, October, 1925, pp. 737-739.

5. Ralya, L.L., and Ralya, Lillian, Some Misconceptions in Science Held by Prospective Elementary Teachers, Science Education, vol. 22, October, 1938, pp. 244-251.

a few professors of college physics, chemistry, and biology.

It should be stated that the test was not an achievement test but is concerned with the individuals' performances on single items or related items as an indication of their grasp of the specific concept or belief.

The gross total score that the subjects made on The American Council of Education Psychological Examination was used as a criterion for dividing the total group into a low and a high group, there being twenty-five in each. The percentage of error on test items for these two groups was figured to see if there was any significant difference in the two groups as far as performance on the items was concerned.

Scope of Study

The three Colleges of Education in Oregon where all of our elementary teachers are trained were the contributors to this study. It is regretted that a larger number of participants could not be obtained to take the test, but the war and defense jobs had so greatly decreased the enrollments that it was possible to secure only 126 subjects.

The students participating were all third-year students who at the end of the spring quarter would be

eligible for teacher certificates for elementary school work. Of this group 111 were women and 15 were men.

The science preparation required of students taking teacher training includes one year of biology, one quarter of physical science survey, hygiene--not classed as a science by some, and cadet teaching. Methods of teaching elementary science or nature study is included for a few but is not compulsory.

It was found, in this group, that a few more students came from rural areas to the teacher training institutions than came from urban areas. Also a larger number indicated their church preference as Protestant.

A group of twenty-five teachers who had taught during the past year were given the test to see how they would compare with the experimental group.

The number of participants and especially the small number of subjects in the high and low groups in the A. C. E. test were limitations. Also the ambiguity and chance of misinterpretation of some of the items in the test probably had some effect on the figures obtained. The figures can be regarded only as an index to the grasp of the concept. Even though a "don't know" column was included, there still exists the possibility of guessing.

CHAPTER II

PREVIOUS STUDIES

Only recently, it seems, have the public schools awakened to the need for general understanding of science in the numerous problems of civilization. Ralya says:

> There are many scientific concepts, principles, and beliefs which are so relatively simple and so significant for lay thinking that they could and should become a part of the mental equipment of most people.[1]

Since science was incorporated into Oregon's elementary curriculum only last year, it has been such a new thing that teacher training institutions have had little opportunity to adjust their programs to fit the new needs. Under the old setup, however, courses in nature study were given to fill the teachers' needs. W. C. Croxton says:

> It is only recently in this country that elementary-school teachers generally have been required to prepare for science teaching. No adequate surveys of the training of elementary teachers in science have appeared.[2]

Part of the value of this study may be indicated by a quotation from a director of teacher training in this state.

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1. Ralya, Lynn L., A Study of Some Concepts and Beliefs in Chemistry and Physics, Journal of Chemical Education, vol. 18, no. 8, August, 1941, p. 364.

2. Croxton, W. C., Science in the Elementary School, McGraw-Hill Book Company, Inc., New York, 1937, p. 118.

> It is, of course, important that some one develop a pretty definite statement of the materials with which an elementary teacher ought to be familiar in the field of science, and then we should work out courses designed to assure that they would be familiar with this material.[1]

As has been previously stated little has been done concerning teacher training in elementary schools. Ralya, in his study of 130 women who were preparing for elementary teaching, concluded:

> A significant percentage of these prospective teachers exhibited ignorance or misconception of many simple and basic facts and principles, knowledge and understanding of which would be necessary for any adequate presentation of elementary science in the classroom.[2]

In a study to ascertain the extent to which certain superstitions, misconceptions, and scientifically unsound beliefs in the field of health were subscribed to by graduates from different types of teacher training institutions, Rhoton found that "in general, the number of health misconceptions held decreases slightly as the length of the training period increases."[3]

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1. Letter in the writer's files.

2. Ralya, L. L., and Ralya, Lillian, Some Misconceptions in Science Held by Prospective Elementary Teachers, Science Education, vol. 22, no. 5, October, 1938, p. 250.

3. Rhoton, Paul, Health Misconceptions of Prospective Teachers, Pennsylvania State College, State College, Pennsylvania, 1932.

In carrying on a study as to extent of teacher preparation to teach science, Palmer finds that:

> The diversity of the field of science is a factor which must be reckoned with when planning the training of a science teacher.
>
> To meet the situation arising from these diverse interests requires unusual breadth and some considerable depth of training.[1]

Studies of this kind are not abundant. A study having direct bearing on this particular problem has been made by Lynn L. Ralya and Lillian Ralya. This was made at The Citadel, Charleston, South Carolina, and is entitled "Some Misconceptions in Science Held by Prospective Elementary Teachers." In their study the courses of study analyzed by them contained agriculture, botany, zoology, forestry, chemistry, physics, astronomy, geology, geography, meteorology, physiology, and hygiene.

The true-false test devised by them contained subject-matter divisions as follows: The Heavens; Earth, Atmosphere, Weather, and Seasons; Chemistry and Physics Facts and Concepts; Food and Health; and Superstitions.

Conclusions drawn in the Ralya study were:

1. A significant percentage of these prospective teachers exhibited ignorance or misconception of many simple basic facts and

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1. Palmer, E. Laurence, What Constitutes a Desirable Program of Studies in Science Education for Teachers of Science in the Elementary School? Science Education, vol. 15, January, 1931, p. 104.

principles, knowledge and understanding of which would be necessary for any adequate presentation of elementary science in the classroom.

2. A significant percentage of these prospective teachers believed many folk superstitions, some of them harmful in themselves and others harmful in that they stand in the way of thinking and rational action.[1]

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1. Ralya, L. L., and Ralya, Lillian, Some Misconceptions in Science Held by Prospective Elementary Teachers, Science Education, vol. 22, October, 1938, pp. 244-51.

CHAPTER III

THE STUDY

Examination of the state course of study for elementary schools reveals the following content areas: the earth and universe; living things; energy and mechanics. When these content areas are broken down they fall into five science categories: physics, biology, chemistry, geology, and astronomy. These five fields contain many concepts.

A test made up of 127 items basic to these fields was given to 126 student teachers who would be eligible for their teacher certificates upon completion of the spring term. The test was given a week before the close of the spring term. Of the 126, 111 were women and 15 were men.

To obtain some idea of the science background of these teachers a check list of high school science subjects and college science subjects was put at the heading of the test. Of the high school subjects biology is the most popular with 71.5 percent of the 126 having had it. General science is next with 67.5 percent of the 126 having taken that, and chemistry is third with 24.6 percent having had that. In college subjects biology is again highest with 87.5 percent, hygiene next with 75.5 percent, and physical science survey third with 70.5 percent. Chemistry is not as popular with the college group

as it was in high school. Since the experimental group is small and the spread of science subjects is not great, it is not possible to make comparisons between members who have had more science courses and those who have not.

Table I represents a summary of the group's preparation in high school and college science. The high school and college preparation of the low aptitude group and of the high scholastic group is shown in Table II.

The high school preparation shows a little variation in some of the fields. General science was taken by an equal percentage, but in chemistry, 24 percent of the lower group had had it whereas only 12 percent of the upper group had. Physics shows somewhat of a reversal with only four percent of the lower group and 12 percent of the upper group having been enrolled in it. Biology with a large enrollment--60 percent lower and 68 percent upper--is next to general science in popularity as a high school course.

College preparation in science shows 80 percent of the lower group as having been enrolled in physical science survey for one quarter while only 68 percent of the upper group had been, but 16 percent of the upper group had enrolled in the course for three quarters. The entire lower group had had biology but only 96 percent of the upper group had, possibly because some of the upper

TABLE I

Showing High School and College Preparation of Subjects in Science

Amt. in yrs.	Subject	Number of total 126 taking subject	Per cent	Amt. in Qtrs.	Subject	Number of total 126 taking subject	Per cent
1	Gen. Science	85	67.5	1	Physical Science Survey	89	70.5
1	Chemistry	31	24.6	3	Physical Science Survey	6	4.7
1	Physics	14	11.1	3	Human Behavior (Biology)	110	87.5
1	Biology	90	71.5	1	Biology	4	3.1
1	Zoology	2	1.9		Hygiene	95	75.5
1	Physical Geography	1	.8	3	Chemistry	8	6.3
				1	Chemistry	2	1.6
1	Physiology	9	7.1	3	Zoology	2	1.6
1	Botany	3	2.3	1	Zoology	3	2.3
				1	Geology	8	6.3
				3	Geology	1	.8
				1	Physiology	5	3.9
				1	Botany	3	2.3
				1	Teaching of Elementary Science	5	3.9
				?	Nature Study	1	.8

TABLE II

Showing High School and College Preparation in Science of the Highest 25 and the Lowest 25 in the A.C.E. Test

High School					
Amount in yrs.	Subject	No. of lower 25	Per cent	No. of upper 25	Per cent
1	General Science	20	80	20	80
1	Chemistry	6	24	3	12
1	Physics	1	4	3	12
1	Biology	15	60	17	68
1	Physiology	1	4	0	0
1	Botany	1	4	0	0

College					
Amount in qtrs.	Subject	No. of lower 25	Per cent	No. of upper 25	Per cent
1	Physical Science Survey	20	80	17	68
3	Physical Science Survey	0	0	4	16
3	Biology (Human Behavior)	25	100	24	96
1	Chemistry	0	0	1	4
2	Chemistry	0	0	1	4
3	Chemistry	0	0	1	4
	Hygiene	17	68	19	76
1	Botany	0	0	1	4
1	Geology	4	16	1	4
1	Teaching of Elementary School Science	1	4	1	4
1	Zoology	0	0	2	8
1	Physiology	0	0	1	4

group were transfers and had had an equivalent course such as zoology, physiology, or botany. None of the lower group indicated having had any of the three latter courses mentioned.

The lower aptitude group had had no chemistry in college while four percent of the upper group indicated that they have had one, two, or three quarters of chemistry. Hygiene shows 68 percent of the lower group enrolled as compared to 76 percent of the upper group. Of the lower group 16 percent had had one quarter of geology, but the upper group showed only an enrollment of four percent.

Another indication of student background is religious preference. Of the 126, 40 gave an indication of being Protestants, whatever sect that might mean. Next in preference were Methodist with 29 and Presbyterian with 13. The others are scattered over a considerable range with eleven indicating no preference at all. The writer was at first curious about religious preference and its influence on certain concepts, but the number was so small that no conclusions could be drawn from the data.

TABLE III

Religious Preference Indicated by 126 Students Taking Science Test

Religion	Number	Percent
Protestant	40	31.7
Methodist	29	23.0
Presbyterian	13	10.3
Lutheran	3	2.4
Christ Scientist	1	.8
Catholic	4	3.1
Baptist	5	3.9
Christian	4	3.1
Latter Day Saints	2	1.6
Episcopalian	1	.8
No Preference	11	8.7

The science test given in the Colleges of Education was one continuous group of statements, but in Table IV the items have been divided into their respective fields for ease of interpretation and for greater clarity in reading. Read Table IV thus:

> "(1) A body once in motion continues to move until something stops it." In the first column 22.2 percent of the total 126 were in error; of the lowest 25, 24 percent were in error; of the upper 25, 28 percent were in error. In the "don't know" column, 2.3 percent of the 126 did not know; of the lower group, eight percent did not know; and 0 percent of the upper group did not know.

TABLE IV

Results of the Basic Science Concepts Test Taken by 126 Subjects

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
Physics						
1. A body once in motion continues to move until something stops it.	22.2	24	28	2.3	8	0
2. It is more natural for a body to stop itself than to set itself in motion.	44.4	28	52	16.7	24	12
3. A uniform force acting constantly on a body tends to make the body move faster and faster.	33.4	36	36	16.7	20	20
4. The earth attracts a 10-pound body with ten times the force with which it attracts a one-pound body.	43.6	48	44	15.8	16	12
5. If it were not for the atmosphere a 10-pound body would fall twice as fast as a 5-pound body.	38.1	28	32	19	28	16
6. A given pendulum may swing through a larger arc in the same time it requires to swing through a smaller arc.	20.6	44	24	28.6	24	24

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
7. A floating body displaces its own weight of the liquid in which it floats.	11.9	0	8	8.7	8	4
8. A totally submerged body is buoyed up by a force equal to the weight of the liquid which it displaces.	11.9	16	4	20.6	20	6
9. The water pressure at a given depth in a large lake is greater than at the same depth in a small lake.	20.6	28	16	22.2	20	8
10. The pressure at a given depth in a liquid is the same in all directions.	19.8	12	32	25.4	24	28
11. The atmosphere exerts pressure only when the wind is blowing.	1.5	0	0	4.7	8	4
12. The pressure of the atmosphere against a square inch at sea level averages about 15 pounds.	6.3	0	12	25.4	32	16

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
13. The weight of the atmosphere above a square inch at sea level averages about 15 pounds.	26.2	32	8	36.4	44	20
14. A solid body weighs more when hot than when cold.	13.5	12	20	19	28	8
15. Ice possesses no heat.	7.9	16	4	9.5	12	12
16. At absolute zero all molecular action has stopped.	19.0	8	8	14.3	32	8
17. If air is warmed, its capacity to hold moisture is increased.	12.7	20	0	2.3	8	4
18. A compass needle is a little magnet.	16.7	12	16	7.1	12	8
19. The electrical generator causes electricity to move rather than creating it.	30.1	36	20	30.1	32	32
20. Lightning never strikes twice in the same place.	8.8	16	0	14.3	12	8

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
21. Radio waves travel at the same spped as sound waves.	22.2	4	16	23	28	28
22. Radio waves need air to travel on.	61	68	76	16.7	28	8
23. Sound is always produced by vibration.	5.5	8	4	3.9	0	8
24. Sound requires a solid, liquid, or gas to travel through.	13.5	12	12	13.5	24	20
25. A telephone message is conveyed by a current of electricity.	15	8	28	25.4	28	16
26. Light will travel through a vacuum.	22.2	16	28	31	36	20
27. We see an object because particles travel from the eye to the object.	20.6	32	24	19.8	16	4
28. The cat sees much better at night than do most other animals in the daytime.	33.4	56	28	12.7	12	8

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
29. The northern lights are the result of the sun shining on icebergs and the beams being reflected into the sky.	25.4	24	32	23.8	36	20
30. The voltage of an ordinary dry cell is six volts.	22.2	16	32	44.5	80	56
31. Man is able to manufacture or create energy.	50.6	56	60	7.9	0	0
32. Winds are due to temperature changes over the earth.	10.3	8	12	3.9	0	0
Biology						
33. If water is brought to a boil it is sure to kill all bacteria.	25.4	32	8	2.3	4	4
34. If drinking water is clear, cold, and excellent in taste it is always safe for drinking purposes.	.8	0	0	0	0	0

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
35. A man has one less rib than a woman since one of Adam's ribs was removed in creating Eve.	7.9	8	8	3.1	0	0
36. Human nature is determined entirely by heredity.	3.1	4	8	1.5	4	0
37. Two different kinds of food must not be eaten at the same meal.	0	0	0	0	0	0
38. Stewed tomatoes and milk should not be eaten at the same time.	3.9	4	4	3.1	4	8
39. Too much salt is the cause of high blood pressure.	11.9	8	16	19	32	12
40. It is necessary to take flowers out of the sick room at night because they use too much oxygen.	54.9	48	44	4.6	8	8
41. Yeast cells are sometimes created by the fermentation of sweet substances.	61.9	60	60	18.4	36	20

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
42. Fruit flies or vinegar flies are created by the decay of organic matter.	12.7	12	4	21.4	44	16
43. Life sometimes arises spontaneously.	11.9	4	20	15.8	24	16
44. The whale is the largest known fish.	21.4	12	20	11.1	12	16
45. Man is a direct descendant of the anthropoid apes.	6.5	16	12	14.3	12	20
46. The bat is one of several common night flying birds.	34.9	36	32	7.1	8	0
47. The clothes moth makes holes in fabrics during its flying stage of existence.	7.9	8	8	8.7	8	12
48. Horsehairs never develop into snakes.	3.9	8	4	3.1	8	0
49. All human beings begin life as fertilized eggs.	5.5	0	0	0	0	0

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
50. If a mushroom blackens a silver spoon, it is poisonous.	15	12	12	46.7	56	52
51. Fish are an especially good food for the brain.	12.7	16	8	10.3	16	12
52. Teeth that are carefully cleaned never decay.	3.9	4	12	.07	0	4
53. The green coloring matter (chlorophyll) in plants is essential to their growth.	15	16	20	0	0	0
54. Coal is made from plant material.	2.3	4	0	1.5	0	0
55. All material entering into the formation of a tree comes from the soil and water.	25.4	32	20	4.6	16	4
56. Protein foods are needed to build and repair the body.	2.3	4	0	1.5	0	4
57. Starches and sugars are good sources of energy and heat for the body.	2.3	4	4	0	0	0

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
58. Vitamins are needed for production of energy and building cells.	69	72	72	7.9	8	16
59. The coming of a severe winter can be predicted by early migrations of birds or thickness of an animal's fur.	46.9	52	48	16.7	12	12
60. Nerve impulses and electrical currents are closely related phenomena.	11.9	16	12	27	28	8
61. Only green plants can make their own food.	66.5	56	68	11.9	16	8
62. The four basic elements are fire, air, water, and earth.	29.3	32	32	15.8	8	24
63. Matter is electrical in nature.	27	24	32	42.9	56	40
64. There are smaller units than atoms entering into the make-up of matter.	27	32	12	9.5	20	12
65. Atoms are hard, solid, perfectly spherical bodies.	2.3	4	0	20.5	24	20

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
66. When a substance burns in air, it unites with oxygen.	4.6	8	4	6.5	8	8
67. Water is an oxide.	16.7	28	16	31	32	28
68. Iron rust is heavier than the iron from which it is formed.	31	32	20	46.7	48	52
69. When water evaporates it becomes air.	29.3	28	32	8.7	16	4
70. An explosion of coal dust is the result of rapid burning.	28.6	28	24	38.8	56	36
71. As much heat is produced by the log rotting in the forest over a long period of time as if one were to burn it in a stove.	26.2	24	12	27	24	24
72. If it were possible to collect all the materials formed when a stick burns, the total weight would be greater than the original weight of the stick.	31.8	20	36	31.8	32	24

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
73. Organic materials are ones which can be manufactured only by living things.	58.6	68	60	14.3	12	16
74. Combinations of elements go to make up the thousands of known compounds.	4.6	4	4	3.9	4	4
75. It is possible to destroy matter.	12.7	20	16	8.7	8	4
76. Air is a mixture of gases.	1.5	8	0	3.1	8	0
77. Beet sugar has a different chemical composition than cane sugar.	42.8	40	52	31	40	32
78. Some water is formed when most substances burn.	8.7	16	8	19	24	12
79. Living things undergo constant chemical change.	2.3	12	0	8.7	4	12
80. Plants and animals are both composed of similar compounds.	11.9	12	8	19	20	20
81. Molecules move about rapidly in gases.	5.5	8	8	14.3	12	8

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
82. Chemical energy can be transformed to electrical energy.	3.9	12	4	35.7	36	40
83. An increase in heat speeds up chemical reactions.	1.5	0	0	13.5	12	16
84. There is great chemical interdependence between plants and animals.	4.7	4	4	19.8	16	12
85. Oxygen and ozone are merely two different forms of the same element.	23.8	20	16	53.2	64	56
Geology						
86. The formation of stratified (layered) rock is going on today.	0	0	0	12.7	16	8
87. The center of the earth is a sphere of fire.	11.1	4	12	32.6	20	48
88. Fossils are the remains of animals drowned during "The Flood."	7.1	8	4	4.6	4	8

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
89. Promitive man was troubled a great deal by dinosaurs.	27.8	16	32	23.8	24	20
90. Man has been on the earth since it was formed.	9.5	8	4	15	16	20
91. The earth is at least one million years old.	1.5	0	4	18.4	12	24
92. Since the earth was formed there has been a wearing away of the mountains with no upward movement of the earth's crust which would tend to compensate for this wearing away.	11.1	16	4	6.3	8	0
93. The cause of the difference between our present animals and prehistoric ones is that the prehistoric animals were all killed off and a new race of animals placed on earth.	1.5	4	0	6.3	8	4
94. The land now exposed has never been under the ocean.	2.3	0	0	.8	0	4

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
95. Life probably began on the land.	21.4	28	24	15.8	20	16
96. Soil has been formed from solid rock.	8.7	4	4	9.5	12	4
97. During the age of the earth several mountain ranges have been built up and worn down.	2.3	4	0	4.7	12	4
98. Certain types of rock have been formed from soil.	7.1	12	16	9.5	8	12
<u>Astronomy</u>						
99. The stars contain few if any elements not found on earth.	11.1	24	4	37.3	44	36
100. Mars is a planet.	.8	4	0	.8	0	0
101. The earth is a planet.	.8	0	0	.8	4	0
102. The earth circles about the sun in a year.	6.3	8	4	1.5	4	0

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
103. The handle portion of the "dipper" points toward the North Star.	45.2	52	32	3.9	8	12
104. The northern hemisphere of the earth is tipped toward the sun during the summer.	15.8	24	20	7.9	20	4
105. The sun is a star.	38.9	48	36	5.5	8	4
106. The planets all circle about the same sun.	29.4	28	40	2.3	0	0
107. The moon circles about the earth in about a month.	7.9	8	4	14.3	28	0
108. The moon is largely responsible for the tides on earth.	2.3	0	0	2.3	0	4
109. The moon is always actually of about the same spherical shape.	14.3	20	8	12.7	20	12
110. The sun is much bigger than any other body in the heavens.	54	64	48	7.1	12	8

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
111. The solar system does not occupy a millionth of the space in the universe.	10.3	12	20	33.4	40	36
112. The earth is larger than any other body which circles about the sun.	12.7	20	16	6.3	12	4
113. The stars are much closer to each other on an average than the sun is to the earth.	24.6	32	32	27.8	40	32
114. The moon is closer to the sun than to the earth.	25.4	28	12	17.4	28	24
115. The stars shine because of the light they reflect from the sun.	49.3	56	60	10.3	8	4
116. The stars are not visible to us in the daytime because our side of the earth is turned away from the direction in which they are found.	15	28	12	5.5	16	0
117. The sun is made of approximately the same chemical elements as are found on earth.	16.7	20	20	33.4	36	32

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
118. The sun remains fixed in position in space.	40.5	40	56	7.9	12	16
119. The distant stars are fixed in position in space.	19.8	16	16	15	24	16
120. Stars fall through the sky rather frequently.	57.8	56	60	7.1	8	12
121. The so-called "shooting stars" that we see are composed of large pieces of matter which have reached incandescence through friction with the atmosphere.	71.4	68	80	19	28	20
122. The shooting stars or falling stars are at least a million miles from the earth when we first see them.	47.6	68	10	30.9	16	48
123. There are countless numbers of stars visible to the naked eye.	88.3	92	80	1.5	0	0
124. Scientists are unable to tell what stars are composed of because they can not obtain pieces for chemical analysis.	15	24	8	24.6	32	44

TABLE IV

Continued

Concept or Belief	Percent In Error			Percent "Don't Know"		
	All	Lower 25	Upper 25	All	Lower 25	Upper 25
125. If the sun were suddenly extinguished it would be several hours before we would be aware of it.	64.2	60	68	12.7	16	8
126. Man has never seen more than 57 percent of the moon's surface.	7.9	8	8	39.6	56	36
127. Stars give off heat.	23.8	32	20	18.4	28	44

Interpretation of Results Shown in Table IV

Physics

The fact that most phenomena are reducible to physical interpretations and are governed by laws certainly was not recognized concerning the laws of inertia when 22.2 percent were in error on (1) and 44.4 percent on (2). 33.4 percent did not realize that a uniform force would produce accelerated motion and 16.7 did not know whether it would or not. That a large number are not familiar with the laws of falling bodies is indicated by 43.6 percent being in error on (4); and 38.1 percent do not realize that Galileo disproved the idea that bodies fall with speeds proportionate to their masses, (5).

Most of the students are correct in their understanding of Archimedes' principle (7), (8); but their knowledge of liquid pressures at any given depth in various sized bodies of water seems meager as 20.6 percent of all were in error, 28 percent of the lower aptitude group and 16 percent of the high scholastic group were in error, and in addition quite high percentages did not know, (9). On item (10), concerning equality of pressure in all directions at a given depth, it is interesting to note that 32 percent of the high scholastic group were in error while only 12 percent of

the low aptitude group were; also a higher percentage of the high group did not know.

That the pressure of the atmosphere against a square inch at sea level averages about 15 pounds (12) is agreed by nearly all, but why a large percentage reversed their decision or marked "don't know" on the statement, (13), "The weight of the atmosphere above a square inch at sea level averages about 15 pounds," is beyond conjecture.

For the most part items (14), (15), and (17) are well understood, but a large percentage subscribe to (16), probably because nearly all elementary physics books state that at absolute zero all molecular motion has stopped or else the texts evade making any direct statement concerning it all.

Statements (18), (20), (21), (25), and (30) concerning electricity are all equally distributed as to error or lack of understanding, but items (19) and (31), concerning man's ability to create energy seem to be greatly misunderstood. Just what has happened to distort their concept of the law of conservation of energy is a matter that is indeed perplexing.

Item (21), concerning the speed of radio waves seems to be fairly well understood, for a rather low percentage, 22.2 of the total group, was in error on this question.

Item (22), the mode of travel of radio waves, is very greatly misunderstood when one notes that 61 percent of the total group, 68 percent of the lower group, and 76 percent of the upper group were in error. In addition 16.7, 28, and 8 percent of the total, low, and high aptitude groups, respectively, marked "don't know."

That sound is always produced by a vibration (23), is a well known fact but knowledge concerning the mediums that may transmit sound vibrations, (24), is lacking when 13.5, 12, and 12 percent of the total, lower, and upper groups were in error and 13.5, 24, and 20 percent of the groups respectively marked "don't know."

The concepts concerning vision and transmission of light must be vague as high percentages were in error and marked don't know on items (26), (27), and (28).

Another item (30), a very common one because practically all science teachers deal with dry cells, concerns the voltage of an ordinary dry cell; 22.2 percent of the total group, 16 percent of the low aptitude and 32 percent of the upper group were in error, and very high percentages, 44.5 of the total, 80 of the lower, and 56 of the upper group, marked "don't know."

One very common question that will be asked when children observe this phenomena is "What causes the northern lights?" Still about 49 percent of the total

group does not know or is in error on this question, (29), the low scholastic group has 60 percent that either does not know or clings to the old idea of the reflection of sunbeams off the polar ice.

Biology

Most of the concepts in biology are well understood and perhaps should be, for it is in this field that the students show the greatest amount of preparation. However, there are a few isolated items that are far out of line.

In the total group, 25.4 percent believe that if water has reached the boiling point all bacteria will be killed, (33), and 32 percent of the low scholastic group believe so; however, the high aptitude group was only 8 percent in error.

Items (37), (38), (56), and (57) concerning the physiology of nutrition are all well understood, but many believe that "too much salt is the cause of high blood pressure," (39); in addition, extremely high percentages have erroneous beliefs concerning vitamins (58).

It seems that a higher percentage should have been in command of a knowledge of the fundamental processes of plant respiration, nutrition, and photosynthesis, (40), (53), (55), (61).

Belief in the old theory of "abiogenesis" does not seem to run very high, (42), (43), but that yeast cells are sometimes created by the fermentation of sweet substances was held to by an unusually high percentage, running about 60 percent in all three groups, (41).

Considerable displacement of phyla occurred when 21.4 percent of the total group classed a whale as a fish and 34.9 percent classed a bat as a bird, (44), (46).

This group is quite free of the superstitions and health misconceptions mentioned in this section for all of the scores on items (35), (50), (51), and (52) were low. However, a high percentage do believe that a severe winter can be predicted by early migrations of birds or the thickness of an animal's fur, (59).

Chemistry

Teachers of science are very likely to need a knowledge of the fundamental nature of matter; yet nearly 29 percent believe that the basic elements are fire, air, water, and earth, (62), and a like percentage know little about the make-up of the atom, (63), (64). What the group's conception of the atom might be is unknown, but a very low percentage are sure that it isn't a hard, solid, or perfectly spherical body although a rather high percentage admit that they do not know what it is like, (65).

It is a pleasure to note that the majority of the students are aware of the fact that compounds are made up of combinations of elements, (74).

Knowledge of the law of definite composition is certainly lacking when 42.8 percent of the total group, 40 percent of the low scholastic group, and 52 percent of the high aptitude group claim that beet sugar has a different chemical composition than cane sugar, (77). Perhaps this may be due to the old misconception held by their mothers that beet sugar, because of its larger crystals, did not make as good jelly as did the finer cane sugar. In addition, 31, 40, and 32 percent of the total, lower, and upper groups claim they do not know.

Oxidation is one of the fundamental processes to all life and is largely concerned in most other reactions, being especially important to us as a source of heat. All but 4.6 percent of the total group are aware that when substances burn in air they unite with oxygen, (66); but from there on their conceptions of oxidation are not very clear, for 16.7 percent fail to realize that water is an oxide and 31 percent do not know whether it is or not, (67). That iron rust is heavier than the iron--one of the original reacting substances--is not agreed to by 31 percent of the group while 46.7 percent do not know whether it is or not, (68). On item (70), a large per-

centage were not aware of the fact that oxidation may occur so rapidly as to assume explosive proportions, as 28.6 percent of the total group were in error and 38.8 professed total ignorance of the phenomenon. The low aptitude group also was quite unaware of this fact as 56 percent marked "don't know".

Item (71) is somewhat ambiguous since it does not state clearly that the log in the forest undergoes complete oxidation, but the phenomenon of slow and rapid oxidation should be so firmly fixed in the individuals' minds that a higher percentage than 75 should have answered correctly.

It is peculiar to note that such a large number should have been in ignorance concerning some of the afore-mentioned factors of oxidation and then to find that such a high percentage recognize the fact that some water is formed when most substances burn, (78).

The law of conservation of matter (75), as stated, is understood by the majority of the total group, but the low aptitude group is not so aware of the fact as 20 percent were in error and eight percent did not know. In considering item (72), the total group was not so aware of the law of conservation or of oxidation as 31.8 percent of the group were in error and 31.8 percent did not know.

That energy can be transformed, (82), was known by an extremely high number of the total group that attempted to answer the question, but it is disheartening to note that 35.7 percent of the total group marked "don't know."

The interdependence between living things and chemical reactions and compounds seems to be well understood, (79), (80), (84), for those items were correct for a very high percentage of answers.

Geology

Many of the questions that elementary teachers will be called upon to answer, by youngsters hungry for information concerning the earth, will have some connection with geology. It is surprising to note that very few of the group had had a course in geology; yet this particular field seems to be the one in which the group as a whole did very well. Not only were there fewer in error in this group, but there were considerably fewer items marked "don't know." This is probably because geology is so closely tied in with geography; in addition, physical science survey also touches on geology.

Not many were in error on item (87), "The center of the earth is a sphere of fire," but knowledge of theories concerning the earth's make-up must be limited, for high percentages marked "don't know."

A marked misunderstanding of geological time was exhibited by 27.8 percent of the entire group when they considered item (89). Perhaps this is due to the influence of a certain movie which was decidedly anachronistic in its setting.

The theory concerning the place and beginning of life, (95), is very hazy in the minds of many, as quite high percentages were in error or did not know.

Astronomy

In his book, Science for the Elementary School Teacher, Craig says:

> It should be borne in mind that children are able to secure comparatively few correct ideas concerning the universe by their own observation or by empirical reasoning..... It is imperative, therefore, that the teacher place in the children's hands reliable information concerning the universe.[1]

The state course of study has as one of its three major content areas "The Earth and Universe." A great deal of the field covered in the elementary grades concerns the evolution of the child's concepts of the solar system, expanding on to the galaxy to which it belongs.

An examination of the questions on astronomy in Table IV shows that, except for a few isolated cases, the

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1. Craig, G. S., Science for the Elementary School Teacher, Ginn and Company, Boston, 1940, p. 49.

prospective teachers' conceptions of this important field are very hazy.

Items concerning the earth and immediately related facts are quite well understood, (100), (101), (102), (107), (108), (111), (112), and (126); although a very high percentage do not know that the solar system occupies only a very small fraction of the universe, (111), and similarly high percentages do not know that man has seen no more than 57 percent of the moon's surface, (126).

Perhaps the fact that so many of the subjects were women who have never had the simple Boy Scout directions for finding the North Star accounts for 45.2 percent of the total group being in error on item (103).

Much concerning the sun is not understood by the group as 39 percent did not recognize the sun as being a star, (105), although only 14.3 percent did realize that it is not the largest body in the heavens, (110). Quite high percentages, about 34 percent of the three groups, did not know that the sun contained approximately the same elements as are found on earth, (117), whereas 40.5 percent of the total group thought the sun remained in a fixed position in space, (118). Item (125) shows an extremely great misunderstanding concerning the speed of light for 64.2 percent of the total group think it would

be several hours before darkness descended if the sun were suddenly extinguished.

Perhaps the most erroneous beliefs of all concern the stars, for examination of those items reveals some of the highest percentages of error found in the entire test. That space is vast has not been conceived by 24.6 percent of the entire group when they indicated on item (113) that the stars are closer to each other on the average than the sun is to the earth. The entire group's conception of a star must have been exceedingly vague when 49.3 percent indicated that a star shines by reflected light. Still worse was the like belief expressed by 60 percent of the upper scholastic group. It is a relief to note that low percentages of all except the low aptitude group are aware that the stars are all around us, (116), and that they are not fixed in space, (119).

Questions concerning the so-called "shooting stars"--meteors or meteorites--are numerous among youngsters, but their questions will be unanswered or answered unsatisfactorily according to the indications given on items (120), (121), (122), (123), and (127). About 57 percent of the three groups were in error when they indicated that stars frequently fall through the sky, and

still a higher percentage believe that "shooting stars" are composed of large pieces of matter. In addition, many think that they are at least a million miles from the earth when we first see them.

One great fallacy is the layman's calling any incandescent piece of matter a meteor, whether it is large or small, whether it is quickly consumed as it reaches the earth's atmosphere, or whether it reaches the earth. Craig says, "A meteor is what is known popularly as a shooting star;.....It is a meteor as long as it is out in space or in the earth's atmosphere. After it has fallen it is known as a meteorite."[1]

Acquaintance with the literature in this field seems meager, for 88.3 percent of the total group think that there are countless numbers of stars visible to the naked eye. Practically any general science text carries the information that researchers have established a fairly accurate count of the number visible at any one time.

That stars give off heat is not known by a fair percentage of the group and especially by the upper group

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1. Craig, G. S., Science for the Elementary School Teacher, Ginn and Company, Boston, 1940, p. 73.

when 44 percent indicated ignorance of the fact. 23.8 percent of the total group were in error on this item.

It is at least somewhat reassuring that only 15 percent of the total group were in error on statement (124), even though fairly high percentages did not know.

To summarize the findings in Table IV, the average number of errors and percentages per question for each group in each field was calculated. The average number of items marked "don't know" and the percentages were also computed. The results are shown in Table V, page 52.

The general degrees of understanding in the various fields, at least as far as the test items covered the fields, can be predicted when one notes that in the field of physics the average percent of error per question was 24 while an average of 17.7 percent did not know. In the field of biology the average percent in error was 18.8, and 9.1 percent did not know. Chemistry had an average of 18.3 percent in error, and 21.8 percent did not know. Geology had the least number in error with 8.6 percent per question and 12.3 percent marking "don't know." Last was astronomy which was also

the field in which the greatest deficiency was shown with an average of 28.2 percent in error and 14.1 percent marking "don't know."

Examination of the percent of error columns for the low aptitude and high scholastic groups shows little except that the high aptitude group shows slightly lower percentages of error per question in all fields except physics. The high aptitude group shows a lower percentage of questions marked "don't know" in all fields except geology where the low group had an average of 12.4 percent and the upper group 13.2 percent per question.

Twenty-five regular teachers--most of whom had taught science during the past year in elementary schools--were given the science test. The average number of errors per question was calculated and a comparison made with the highest scholastic group. The results are shown in Table VI, page 53.

The two groups rank very close together although the experimental group shows a tendency to be less sure of the answers. A comparison of the "don't know" columns shows a slightly higher percentage for the experimental group. Perhaps this is due to the prospective teachers'

lack of experience, or perhaps the experienced teachers do not like to admit that they do not know.

In physics the regular group shows slightly fewer errors per question, 22.0 percent as compared to 25.4 percent for the high aptitude group. Biology errors are nearly equal with 18.0 and 18.1 percent for the regular and high aptitude groups, respectively. Chemistry shows the two groups closely ranked with 19.2 percent for the regular teachers and 16 percent for the high aptitude group. Geology shows no difference in rank between the two groups with 8.4 and 8.0 percent for each group. Astronomy shows fewer errors for the regular teachers, 24.4 percent, than for the high aptitude group, 28.0 percent. Also, this field leads in the number of errors per question as it has with all other groups tested.

Under the existing wartime conditions it was possible to secure only twenty-five regular teachers who had been teaching science. This number is small, and the results shown are not large enough to be significant. Many had been teaching for several years and had forgotten what science courses they had had. For that reason it was impossible to make comparisons as to the science

TABLE V

Showing Average Number of Errors Per Question and Percent of Error in Each Section of Science Test

Section	Average No. Errors, Total Group	Percent Error	Average No. Errors, Lower Group	Percent Error	Average No. Errors, Upper Group	Percent Error
Physics	30.2	24.0	6.1	24.4	6.4	25.4
Biology	23.8	18.8	4.7	18.8	4.5	18.1
Chemistry	23.0	18.3	5.1	20.4	4.0	16.0
Geology	10.8	8.6	2.0	8.0	2.0	8.0
Astronomy	35.5	28.2	8.1	32.4	7.0	28.0

Section	Average No. Don't Know, Total Group	Percent	Average No. Don't Know, Lower Group	Percent	Average No. Don't Know, Upper Group	Percent
Physics	22.2	17.7	5.5	22.0	3.5	14.0
Biology	11.5	9.1	3.1	12.4	2.3	9.2
Chemistry	27.5	21.8	6.1	24.4	5.1	20.4
Geology	15.5	12.3	3.1	12.4	3.3	13.2
Astronomy	17.7	14.1	4.7	18.8	3.9	15.6

TABLE VI

Showing A Comparison Between the Highest 25 of the Experimental Group and 25 Regular Teachers

Section	Regular Teachers				Experimental Group			
	Average Number of Persons in Error per Question	Percent	Don't Know		Average Number of Persons in Error per Question	Percent	Don't Know	
			Number	Percent			Number	Percent
Physics	5.5	22.0	3.7	14.8	6.4	25.4	3.5	14.0
Biology	4.5	18.0	1.3	5.2	4.5	18.1	2.3	9.2
Chemistry	4.8	19.2	4.3	17.2	4.0	16.0	5.1	20.4
Geology	2.1	8.4	1.3	5.2	2.0	8.0	3.3	13.2
Astronomy	6.1	24.4	2.2	8.8	7.0	28.0	3.9	15.6

preparation of the two groups with the meager data available.

To summarize, it seems that there is little difference between the regular teachers and the high aptitude group in performance on this test. Experience in the field still has not led to any great increase in knowledge along these lines.

As a further indication of their background, the students were asked to indicate the type of area, rural or urban, in which they had been raised. The following table shows that a larger number of students, of this particular group at least, came from a rural area. The findings here are in accord with Stevenson who found that "agricultural pursuits are predominant in families sending students to Colleges of Education in Oregon."[1]

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1. Stevenson, E. N., Biology Populations in Oregon Normal Schools, Oregon Education Journal, vol. 13, November, 1938, p. 22.

TABLE VII

Showing the Number and Percent of 126 Students Taking Science Test Who Were Raised in Rural Or Urban Areas

Location	Number	Percent
Rural area	59	47.8
Urban area	43	34.2
Grew up in both	8	6.3
No report	16	12.7

To see whether there was any difference in abilities in science between the prospective teacher from a rural area and one raised in an urban area, the writer compiled Tables VIII and IX. Table VIII shows the subjects and the amounts taken in high school and college.

In high school 83 percent of the rural students had had general science as compared to 74.5 percent of the urban students. One explanation may be that in larger schools there is a greater choice of subjects; thus, some students chose other fields. Chemistry, as might be expected, was taken by 30.2 percent of the urban students and by 15.2 percent of the rural students, possibly because many of the smaller schools cannot afford chemistry

equipment. Courses in physics had been taken by about equal percentages of each group, 11.9 and 11.6 of the rural and urban students, respectively. Biology was taken by 69.5 percent of the rural students and 76.6 percent of the urban group. It might be that some of the smaller schools had substituted physiology or zoology for biology, as more rural students reported having had those two subjects.

College preparation of the two groups was as follows: 83 percent of the rural group had had physical science survey as compared with 79 percent of the urban group; 95 percent of the rural group and 90.5 percent of the urban group had biology; hygiene was taken by 79.7 percent of the rural group and by 69.8 percent of the urban group. Other subjects are indicated by sporadic cases for each group, but in all the tendency seems to be for the rural group to have had more science, as can be seen through examination of the following table, page 57.

Table IX, page 60, summarizes the results of the rural and urban groups on the test.

In the physics section 23.2 percent of the rural group were in error per question as compared to 27.4 percent of the urban group. The "don't know" replies on the physics section amounted to 17.1 percent per question for

TABLE VIII

Showing the Amount of Science Preparation of Prospective Teachers from Rural Areas and Urban Areas

		High School			
Amount in Years	Subject	Rural Area		Urban Area	
		Number Taking Subject	Percent	Number Taking Subject	Percent
1	General Science	49	83.0	32	74.5
1	Chemistry	9	15.2	13	30.2
1	Physics	7	11.9	5	11.6
1	Biology	41	69.5	33	76.6
1	Physiology	5	8.5	2	4.6
1	Zoology	1	1.7	0	0.0
1	Geology	1	1.7	0	0.0

TABLE VIII

Continued

		College			
Amount in Quarters	Subject	Rural Area		Urban Area	
		Number Taking Subject	Percent	Number Taking Subject	Percent
1	Physical Science Survey	49	83.0	34	79.0
3	Physical Science Survey	1	1.7	0	0.0
3	Biology	55	95.0	39	90.5
3	Zoology	3	5.1	0	0.0
1	Chemistry	2	3.4	2	4.6
3	Chemistry	1	1.7	2	4.6
	Hygiene	47	79.7	30	69.8
1	Geology	3	5.1	1	2.3
1	Botany	4	6.8	0	0.0
1	Teaching of Elem. Science	4	6.8	0	0.0
1	Physiology	0	0.0	2	4.6
1	Nature Study	0	0.0	1	2.3

the rural group and 16.4 percent for the urban group.

17.3 percent of the rural group was in error on each question in the biology section as compared to 19.0 percent of the urban group, while 9.1 and 8.8 percent of the rural and urban groups, respectively, marked "don't know."

In the field of chemistry 17.6 percent of the rural and 20.1 of the urban group were in error, but rather high percentages did not know, when 21.8 percent of the rural and 18.8 percent of the urban group marked in that column.

Geology is the field best known to the rural group as only 6.8 percent were in error as compared to 10.0 percent of the urban group. The percentage of questions marked "don't know" is about equal for each group.

Astronomy again has the highest number of errors of any field, as 28.0 percent of the rural group and 30.2 percent of the urban group were in error. The percentages marking "don't know" were not so high with 14.0 percent of the rural group so indicating and 16.5 percent of the urban group expressing that deficiency.

TABLE IX

Showing a Comparison Between the Average Number and Percent of Persons in Error Per Question of 59 Rural Students and 43 Urban Students

Section	Raised in Rural Area				Raised in Urban Area			
	In Error		Don't Know		In Error		Don't Know	
	Average No. of Persons per Question	Percent	Average Number	Percent	Average No. of Persons per Question	Percent	Average Number	Percent
Physics	13.7	23.2	10.1	17.1	11.7	27.4	7.5	16.4
Biology	10.2	17.3	5.4	9.1	8.2	19.0	3.8	8.8
Chemistry	10.4	17.6	12.8	21.8	9.1	20.1	8.1	18.8
Geology	4.0	6.8	7.5	12.7	4.3	10.0	5.1	11.8
Astronomy	16.5	28.0	8.3	14.0	13.0	30.2	7.1	16.5

CHAPTER IV

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Summary

The state course of study for elementary school science was analyzed to see what fields of science were represented in it. Five main fields of science were found, namely: physics, biology, chemistry, geology, and astronomy.

A true-false test covering the main basic concepts in the five fields was made. This consisted of 127 items, stated positively to avoid confusion in the minds of the subjects taking it. To help eliminate guessing and the "chance factor" in true-false tests, a column headed "don't know" was included.

During the last week of school the test was given to 126 students in the Colleges of Education in Oregon. These students were all eligible for elementary school certificates upon completion of the term. In addition, the test was also given to twenty-five regular teachers who had been in service the past year. Participants in the regular college group were asked to check religion, to state whether they were raised in a rural or urban area, and to indicate their high school and college science courses. The regular teachers were asked to indicate only their high school and college science

courses. This many failed to do.

Comparisons were made between the scores of the top twenty-five and the lowest twenty-five ranking students on the American Council of Education Psychological Examination. Scores and percentages of error were also calculated for the entire group's performance on the science test. Likewise, a comparison was made between the regular teachers and the top twenty-five students to see if there was any difference between the scores they made on the science test. Last, the science test scores of the students raised in a rural area and those from an urban area were compared.

The high school science subjects that seemed to have been most popular with the prospective elementary teachers were biology, general science, chemistry, physics, and physiology, ranking in order as named from most popular to the least.

College subjects taken by these prospective teachers seem to be limited largely to three with biology being first, hygiene--which perhaps should be classed as applied science--second, and one quarter of physical science third. Chemistry seems to be largely neglected with only 7.9 percent of the total group having had it. More than one quarter of physical science survey seems to be shunned, since only 4.7 percent of the group had had more.

Teaching of elementary science--although new and not required--should have great bearing upon their science teaching; yet it was taken by only 3.9 percent of the total group. Astronomy, another subject of value, seems to be neglected entirely as a formal course, although the students do get some in connection with physical science survey.

The general degrees of understanding in the various fields, at least as far as the test items covered the field, can be predicted when one notes that in the field of physics the average number of persons making errors per question was 24 percent, and an average of 17.7 percent did not know. In the field of biology the average percent in error was 18.8, with 9.1 percent marking "don't know." Chemistry had 18.3 percent in error per question, and 21.8 percent did not know. Geology is the field in which the group as a whole is best informed, for 8.6 percent were in error per question and 12.3 percent did not know. Last was astronomy, the field in which the greatest deficiency was shown, with an average percentage of error per question of 28.2 and 14.1 percent marking "don't know."

Whether there was any significant difference between the low aptitude group and the high scholastic group could not be determined from this study. It does seem,

however, that the high scholastic group had less tendency to mark "don't know" for on examining these columns one finds the following percentages: physics, low 22.0, high 14.0; biology, low 12.4, high 9.2; chemistry, low 24.4, high 20.4; geology, low 12.4, high 13.2; and astronomy, low 18.8, high 15.6.

The regular teachers show a slightly lower percentage of error per question and also less tendency to mark "don't know" than the upper twenty-five of the experimental group. The differences in figures on the two groups are not great enough to be significant. From the data it seems that perhaps the experience of teaching has led the regular teachers to be more sure of themselves as to what they know and do not know.

More students going to Colleges of Education--at least of this group--are from rural areas than from urban areas.

More urban students had had chemistry than rural students. This is probably because smaller schools do not have facilities or the money for chemistry equipment. That urban students did no better on the chemistry section of the test can be ascertained from the following data: average percent in error rural, 17.6, urban, 20.1; average percent "don't know" rural, 21.8, urban, 18.8. The two groups were about equal on other fields in the test.

Conclusions

From the results shown in the study it may be concluded that the prospective teachers have a lack of general information in the science field. Particularly are they weak in chemistry, physics, biology, and astronomy.

The regular teachers are about on a par with the prospective group and lack science information which would be necessary for teaching elementary science in the classroom.

As far as performance on the science test was concerned, the low aptitude group and the high aptitude group showed little variation.

A comparison between the rural and urban students on the test shows about equal performance of the two.

Recommendations

The high percentage of error and the high percent of items marked "don't know" in the science test lead the writer to recommend the following program.

1. A general survey course of nine quarter hours should cover the fields of astronomy, physics, chemistry, and geology. In view of the findings, the least emphasis could be placed on geology.

2. The biology course as now given should be continued and more emphasis given to the fundamental principles and generalizations of the field. Physiology, botany, and bacteriology should be stressed.

3. Since the physical science and biological science courses as now given have general demonstrations and laboratory work, the student should enter one field for special contact. This might be zoology, botany, physics, or chemistry. The student will thus experience the method, content, and laboratory manipulation used in the sciences. In addition, this will give the student a special knowledge beyond apparent needs and much satisfaction and confidence in his teaching.

4. A. Presenting science materials and drawing attention to the significances attached to them would be a problem for these teachers. A final course in methods dealing with the demonstrations of simple scientific facts, materials, and laws usable in the elementary classroom would be valuable.

B. Ample opportunity to have experience in science teaching during the supervised teaching should be made.

A survey in physical science and biology, along with some study in a special science, plus methods and actual experience in science teaching during the supervisory period will undoubtedly lead to better comprehension of

the basic science concepts and more adequately prepare the prospective teacher to teach elementary science.

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APPENDIX

BRIEF COMMENTS ON QUESTIONS IN THE SCIENCE TEST

Question 6, "A given pendulum may swing through a larger arc in the same time it requires to swing through a smaller arc." This question is somewhat ambiguous but is sufficiently definite for the purpose.

Question 15, "Ice possesses no heat." Under ordinary conditions this is false; however, at absolute zero it would be true.

Question 16, "At absolute zero all molecular action has stopped." This was marked true, for the average textbook evades or fails to comment on this point; however, rotation may exist at absolute zero.

Question 32, "Winds are due to temperature changes over the earth." It is recognized that this is not the only cause of winds.

Question 33, "If water is brought to a boil it is sure to kill all bacteria." In this case it was assumed that normal atmospheric pressure prevailed.

Question 35, "A man has one less rib than a woman since one of Adam's ribs was removed in creating Eve." This question is made definite by the instructions at the beginning of the test to use scientific criteria.

Question 53, "The green coloring matter (chlorophyll) in plants is essential to their growth." In this question it was assumed that <u>their</u> refers to plants that have

chlorophyll.

Question 62, "The four basic elements are fire, air, water, and earth." This is made definite by the instructions to use scientific criteria.

Question 75, "It is possible to destroy matter." It was assumed in this case that teachers answering this question had not had contact with conversion of matter into radiation.

Question 83, "An increase in heat speeds up chemical reactions." This would have been more definite if the question had read <u>temperature</u> in place of <u>heat</u>.

Question 121, "The so-called "shooting stars" that we see are composed of large pieces of matter which have reached incandescence through friction with the atmosphere." Perhaps a comparison should have been introduced to indicate the size of <u>large pieces</u>, but it was assumed that ordinary pebbles would be regarded as small.

PLEASE FILL OUT ALL ITEMS TO THE BEST OF YOUR ABILITY

NAME_____ AGE_____ SEX_____

RELIGION_____ Grew up in rural and or urban area (underline)

Science courses and amounts taken in

High School
- General Science_____
- Chemistry_____
- Physics_____
- Biology_____
- Physiology_____
- Botany_____
- Geology_____

List any additional

College
- Physical Science Survey____
- Biology_____
- Zoology_____
- Chemistry_____
- Physiology_____
- Bacteriology_____
- Hygiene_____
- Botany_____
- Geology_____

List any additional

Following are many science concepts. Please indicate as accurately as you can your belief by marking in the proper column with a check mark.

	True	False	Don't Know	
1.	( )	( )	( )	1. A body once in motion continues to move until something stops it.
2.	( )	( )	( )	2. It is more natural for a body to stop itself than to set itself in motion.
3.	( )	( )	( )	3. A uniform force acting constantly on a body tends to make the body move faster and faster.
4.	( )	( )	( )	4. The earth attracts a 10 pound body with ten times the force with which it attracts a one pound body.
5.	( )	( )	( )	5. If it were not for the atmosphere a 10 pound body would fall twice as fast as a 5 pound body.
6.	( )	( )	( )	6. A given pendulum may swing through a larger arc in the same time it requires to swing through a smaller arc.
7.	( )	( )	( )	7. A floating body displaces its own weight of the liquid in which it floats.
8.	( )	( )	( )	8. A totally submerged body is buoyed up by a force equal to the weight of the liquid which it displaces.

	True	False	Don't Know	
9.	( )	( )	( )	9. The water pressure at a given depth in a large lake is greater than at the same depth in a small lake.
10.	( )	( )	( )	10. The pressure at a given depth in a liquid is the same in all directions.
11.	( )	( )	( )	11. The atmosphere exerts pressure only when the wind is blowing.
12.	( )	( )	( )	12. The pressure of the atmosphere against a square inch at sea level averages about 15 pounds.
13.	( )	( )	( )	13. The weight of the atmosphere above a square inch at sea level averages about 15 pounds.
14.	( )	( )	( )	14. A solid body weighs more when hot than when cold.
15.	( )	( )	( )	15. Ice possesses no heat.
16.	( )	( )	( )	16. At absolute zero all molecular motion has stopped.
17.	( )	( )	( )	17. If air is warmed, its capacity to hold moisture is increased.
18.	( )	( )	( )	18. A compass needle is a little magnet.
19.	( )	( )	( )	19. The electrical generator causes electricity to move rather than creating it.
20.	( )	( )	( )	20. Lightning never strikes twice in the same place.
21.	( )	( )	( )	21. Radio waves travel at the same speed as sound waves.
22.	( )	( )	( )	22. Radio waves need air to travel on.
23.	( )	( )	( )	23. Sound is always produced by vibration.
24.	( )	( )	( )	24. Sound requires a solid, liquid, or gas to travel through.
25.	( )	( )	( )	25. A telephone message is conveyed by a current of electricity.
26.	( )	( )	( )	26. Light will travel through a vacuum.
27.	( )	( )	( )	27. We see an object because particles travel from the eye to the object.
28.	( )	( )	( )	28. The cat sees much better at night than do most other animals in the daytime.
29.	( )	( )	( )	29. The northern lights are the result of the sun shining on ice bergs and the beams being reflected into the sky.

	True	False	Don't Know	
30.	( )	( )	( )	30. The voltage of an ordinary dry cell is six volts.
31.	( )	( )	( )	31. Man is able to manufacture or create energy.
32.	( )	( )	( )	32. Winds are due to temperature changes over the earth.
33.	( )	( )	( )	33. If water is brought to a boil it is sure to kill all bacteria.
34.	( )	( )	( )	34. If drinking water is clear, cold and excellent in taste it is always safe for drinking purposes.
35.	( )	( )	( )	35. A man has one less rib than a woman since one of Adam's ribs was removed in creating Eve.
36.	( )	( )	( )	36. Human nature is determined entirely by heredity.
37.	( )	( )	( )	37. Two different kinds of food must not be eaten at the same meal.
38.	( )	( )	( )	38. Stewed tomatoes and milk should not be eaten at the same meal.
39.	( )	( )	( )	39. Too much salt is the cause of high blood pressure.
40.	( )	( )	( )	40. It is necessary to take flowers out of the sick room at night because they use too much oxygen.
41.	( )	( )	( )	41. Yeast cells are sometimes created by the fermentation of sweet substances.
42.	( )	( )	( )	42. Fruit flies or vinegar flies are created by the decay of organic matter.
43.	( )	( )	( )	43. Life sometimes arises spontaneously.
44.	( )	( )	( )	44. The whale is the largest known fish.
45.	( )	( )	( )	45. Man is a direct descendant of the anthropoid apes.
46.	( )	( )	( )	46. The bat is one of several common night flying birds.
47.	( )	( )	( )	47. The clothes moth makes holes in fabrics during its flying stage of existence.
48.	( )	( )	( )	48. Horsehairs never develop into snakes.
49.	( )	( )	( )	49. All human beings begin life as fertilized eggs.
50.	( )	( )	( )	50. If a mushroom blackens a silver spoon, it is poisonous.
51.	( )	( )	( )	51. Fish are an especially good food for the brain.

	True	False	Don't Know	
52.	( )	( )	( )	52. Teeth that are carefully cleaned never decay.
53.	( )	( )	( )	53. The green coloring matter (chlorophyll) in plants is essential to their growth.
54.	( )	( )	( )	54. Coal is made from plant material.
55.	( )	( )	( )	55. All material entering into the formation of a tree comes from the soil and water.
56.	( )	( )	( )	56. Protein foods are needed to build and repair the body.
57.	( )	( )	( )	57. Starches and sugars are good sources of energy and heat for the body.
58.	( )	( )	( )	58. Vitamins are needed for producing energy and building cells.
59.	( )	( )	( )	59. The coming of a severe winter can be predicted by early migrations of birds or thickness of an animal's fur.
60.	( )	( )	( )	60. Nerve impulses and electrical currents are closely related phenomena.
61.	( )	( )	( )	61. Only green plants can make their own food.
62.	( )	( )	( )	62. The 4 basic elements are fire, air, water, and earth.
63.	( )	( )	( )	63. Matter is electrical in nature.
64.	( )	( )	( )	64. There are smaller units than atoms entering into the make-up of matter.
65.	( )	( )	( )	65. Atoms are hard, solid, perfectly spherical bodies.
66.	( )	( )	( )	66. When a substance burns in air it unites with oxygen.
67.	( )	( )	( )	67. Water is an oxide.
68.	( )	( )	( )	68. Iron rust is heavier than the iron from which it is formed.
69.	( )	( )	( )	69. When water evaporates it becomes air.
70.	( )	( )	( )	70. An explosion of coal dust is the result of rapid burning.
71.	( )	( )	( )	71. As much heat is produced by the log rotting in the forest over a long period of time as if one were to burn it in the stove.
72.	( )	( )	( )	72. If it were possible to collect all the materials formed when a stick burns, the total weight would be greater than the original weight of the stick.

	True	False	Don't Know		
73.	( )	( )	( )	73.	Organic materials are ones which can be manufactured only by living things.
74.	( )	( )	( )	74.	Combinations of elements go to make up the thousands of known compounds.
75.	( )	( )	( )	75.	It is possible to destroy matter.
76.	( )	( )	( )	76.	Air is a mixture of gases.
77.	( )	( )	( )	77.	Beet sugar has a different chemical composition than cane sugar.
78.	( )	( )	( )	78.	Some water is formed when most substances burn.
79.	( )	( )	( )	79.	Living things undergo constant chemical change.
80.	( )	( )	( )	80.	Plants and animals are both composed of similar compounds.
81.	( )	( )	( )	81.	Molecules move about rapidly in gases.
82.	( )	( )	( )	82.	Chemical energy can be transformed to electrical energy.
83.	( )	( )	( )	83.	An increase in heat speeds up chemical reactions.
84.	( )	( )	( )	84.	There is great chemical interdependence between plants and animals.
85.	( )	( )	( )	85.	Oxygen and ozone are merely two different forms of the same element.
86.	( )	( )	( )	86.	The formation of stratified (layered) rock is going on today.
87.	( )	( )	( )	87.	The center of the earth is a sphere of fire.
88.	( )	( )	( )	88.	Fossils are the remains of animals drowned during "The Flood."
89.	( )	( )	( )	89.	Primitive man was troubled a great deal by dinosaurs.
90.	( )	( )	( )	90.	Man has been on the earth since it was formed.
91.	( )	( )	( )	91.	The earth is at least one million years old.
92.	( )	( )	( )	92.	Since the earth was formed there has been a wearing away of the mountains with no upward movement of the earth's crust which would tend to compensate for this wearing away.

	True	False	Don't Know		
93.	( )	( )	( )	93.	The cause of the difference between our present animals and prehistoric ones is that the prehistoric animals were all killed off and a new race of animals placed on earth.
94.	( )	( )	( )	94.	The land now exposed has never been under the ocean.
95.	( )	( )	( )	95.	Life probably began on the land.
96.	( )	( )	( )	96.	Soil has been formed from solid rock.
97.	( )	( )	( )	97.	During the age of the earth several mountain ranges have been built up and worn down.
98.	( )	( )	( )	98.	Certain types of rock have been formed from soil.
99.	( )	( )	( )	99.	The stars contain few if any elements not found on earth.
100.	( )	( )	( )	100.	Mars is a planet.
101.	( )	( )	( )	101.	The earth is a planet.
102.	( )	( )	( )	102.	The earth circles about the sun in a year.
103.	( )	( )	( )	103.	The handle portion of the "dipper" points toward the North Star.
104.	( )	( )	( )	104.	The northern hemisphere of the earth is tipped toward the sun during the summer.
105.	( )	( )	( )	105.	The sun is a star.
106.	( )	( )	( )	106.	The planets all circle about the same sun.
107.	( )	( )	( )	107.	The moon circles about the earth in about a month.
108.	( )	( )	( )	108.	The moon is largely responsible for the tides on earth.
109.	( )	( )	( )	109.	The moon is always actually of about the same spherical shape.
110.	( )	( )	( )	110.	The sun is much bigger than any other body in the heavens.
111.	( )	( )	( )	111.	The solar system does not occupy a millionth of the space in the universe.
112.	( )	( )	( )	112.	The earth is larger than any other body which circles about the sun.
113.	( )	( )	( )	113.	The stars are much closer to each other on an average than the sun is to the earth.
114.	( )	( )	( )	114.	The moon is closer to the sun than the earth.

	True	False	Don't Know		
115.	( )	( )	( )	115.	The stars shine because of the light they reflect from the sun.
116.	( )	( )	( )	116.	The stars are not visible to us in the daytime because our side of the earth is turned away from the direction in which they are found.
117.	( )	( )	( )	117.	The sun is made of approximately the same chemical elements as are found on earth.
118.	( )	( )	( )	118.	The sun remains fixed in position in space.
119.	( )	( )	( )	119.	The distant stars are fixed in position in space.
120.	( )	( )	( )	120.	Stars fall through the sky rather frequently.
121.	( )	( )	( )	121.	The so-called "shooting stars" that we see are composed of large pieces of matter which have reached incandescence through friction with the atmosphere.
122.	( )	( )	( )	122.	The shooting stars or falling stars are at least a million miles from the earth when we first see them.
123.	( )	( )	( )	123.	There are countless numbers of stars visible to the naked eye.
124.	( )	( )	( )	124.	Scientists are unable to tell what the stars are composed of because they can not obtain pieces for chemical analysis.
125.	( )	( )	( )	125.	If the sun were suddenly extinguished it would be several hours before we would be aware of it.
126.	( )	( )	( )	126.	Man has never seen more than 57 percent of the moon's surface.
127.	( )	( )	( )	127.	Stars give off heat.