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THE SCIENTIFIC LITERACY OF SENIORS IN URBAN, SUBURBAN, AND RURAL HIGH SCHOOLS IN KENTUCKY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Nancy Barnett Hamilton, B.S., M.S.

* * * *

The Ohio State University
1965

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Studies in History of Chemistry, Professor Joseph F. Haskins
Studies in Recent Advances in Chemistry, Professor Alfred B. Garrett
## CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>THE PROBLEM</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Purpose of the Study</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kentucky's Educational Status Relative to High School Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need for the Study</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Definition of Terms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact of Science and Technology on Society Since World War II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need for a Citizenry Literate in Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outline of the Study</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>REVIEW OF PERTINENT LITERATURE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meaning of Scientific Literacy</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Findings on Scientific Literacy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Findings on Scientific Illiteracy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>History of Science Teaching with Implications Toward Scientific Literacy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>DESIGN OF THE STUDY</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Selection of the Sample</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>The Data-Gathering Instruments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handling the Data</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>ANALYSIS OF DATA</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Analysis of Variance</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Analysis of Covariance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summary of Results</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interpretation of Results</td>
<td></td>
</tr>
</tbody>
</table>
Chapter | Page
--- | ---
V. CONCLUSIONS AND RECOMMENDATIONS | 102
Scientific Literacy and High Mental Ability
Scientific Literacy and Urban, Suburban, and Rural Schools
Scientific Literacy and the Number of Science Courses Completed
Scientific Literacy and the Environment
Scientific Literacy and Sex
Scientific Literacy and the Size of the Graduating Class
Further Studies Needed | 111
APPENDIX | 131
BIBLIOGRAPHY | 131


<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rank of Kentucky Regarding Items Significant to Educational Status</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>Distribution of Scores from Tests on Understanding Science, Form W, of Urban, Suburban, and Rural Areas</td>
<td>79</td>
</tr>
<tr>
<td>3.</td>
<td>Analysis of Variance of Test on Understanding Science Scores of Urban, Suburban, and Rural Areas</td>
<td>80</td>
</tr>
<tr>
<td>4.</td>
<td>Distribution of Scores from Iowa Tests of Educational Development, Test 6, Interpretation -- Natural Sciences</td>
<td>81</td>
</tr>
<tr>
<td>5.</td>
<td>Analysis of Variance of Iowa Tests of Educational Development, Test 6 Scores of Urban, Suburban, and Rural Areas</td>
<td>81</td>
</tr>
<tr>
<td>6.</td>
<td>Distribution of Scores from Science Inventory of Urban, Suburban, and Rural Areas</td>
<td>82</td>
</tr>
<tr>
<td>7.</td>
<td>Analysis of Variance of Science Inventory Scores of Urban, Suburban, and Rural Areas</td>
<td>82</td>
</tr>
<tr>
<td>8.</td>
<td>Distribution of Scores from Sequential Tests of Educational Progress, Science, Form 2A</td>
<td>83</td>
</tr>
<tr>
<td>9.</td>
<td>Analysis of Variance of Sequential Test of Educational Progress, Science 2A Scores of Urban, Suburban, and Rural Areas</td>
<td>83</td>
</tr>
<tr>
<td>10.</td>
<td>Sex Distribution of Students Participating in the Study</td>
<td>84</td>
</tr>
<tr>
<td>11.</td>
<td>Number of Science Courses Completed in Grades 9-12 by Students Participating in the Study</td>
<td>84</td>
</tr>
<tr>
<td>12.</td>
<td>Socioeconomic Status of Parents</td>
<td>85</td>
</tr>
<tr>
<td>13.</td>
<td>Size of Graduating Class of Students Participating in the Study</td>
<td>85</td>
</tr>
</tbody>
</table>
Table of Contents

14. Range of I.Q. as Determined by Otis Test of Mental Maturity, Gamma, Form Em ............................ 86
15. Analysis of Covariance of Test on Understanding Science Scores ............................................... 88
16. Analysis of Regression on Test on Understanding Science Scores ...................................... 89
17. Analysis of Covariance of Iowa Tests of Educational Development, Test 6 ............................ 89
18. Analysis of Regression on Iowa Tests of Educational Development, Test 6 ............................ 90
19. Analysis of Covariance of Sequential Tests of Educational Progress, Science Scores .................. 90
20. Analysis of Regression on Sequential Tests of Educational Development, Science Scores ............ 91
21. Analysis of Covariance of Personal Inventory on Science Scores ...................................... 92
22. Analysis of Regression on Personal Inventory on Science Scores ...................................... 94
23. Regression Variables Significantly Associated with High Test Scores .................................. 95
24. Summary of Sex, Socioeconomic Status, Type of School Significant Variables .......................... 96
25. Table of Means ........................................... 97
26. Summary of Data for Personal Inventory on Science .................................................. 120
27. Educational Status of Fathers of Students Participating in the Study ................................. 128
28. Educational Status of Mothers of Students Participating in the Study ................................. 128
29. Favorite Subject of Seniors Participating in Study ........................................................... 129
30. Subject Liked Least by Seniors Participating in Study ................................................... 129
<table>
<thead>
<tr>
<th>Table</th>
<th>Vocational Plans of Seniors Participating in the Study</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td>32.</td>
<td>Educational Plans of Seniors Participating in the Study</td>
<td>130</td>
</tr>
</tbody>
</table>
CHAPTER I

THE PROBLEM

Introduction

Young people of today will live well into the twenty-first century. Within the lifetime of our present high school graduates our educational system will change as it has never changed before in such a short time. Industry, government, and our American way of life, will probably change beyond most predictions. Only those who have been and continue to be well educated will keep pace with the significance of the march of these events. High school graduation terminates formal education for the greater percentage of our high school students. Therefore, the type of education they receive must strengthen their ability to think, to assimilate new ideas, and to grow intellectually as the body of knowledge is enlarged and reshaped.

Since World War II, our Scientific Age has had two offspring: atomic energy and the space age. Our breath-taking movement into these new technological eras has brought about a critical situation in science education. This advancement of science and technology into a position of dominance in our culture has placed new demands on the secondary school science curriculum. Our very survival is dependent upon the quality of science instruction that our future citizens will receive.
Purpose of the Study

High school graduation terminates formal schooling for the greater number of high school students in Kentucky. These young people have reached voting age (18 in Kentucky) and have become policy makers in our democracy. This means that they are to help shape our future on a local, state, and national level. Many issues of the future will be of a scientific nature and will be of great social significance. It is imperative that our young people use intelligence coupled with scientific knowledge in making decisions about the problems of the future.

The purpose of this investigation was to make a comparative study of the scientific literacy of seniors from urban, suburban, and rural high schools in Kentucky. It was an attempt to determine whether these high school seniors have had sufficient scientific training to enable them to--

1. Read and interpret the vast quantity of scientific literature for the layman.

2. Have a positive attitude toward science.

3. Understand the scientific enterprise, the work of the scientist, and the methods and aims of science.

4. Have some measure of scientific achievement.

Kentucky's Educational Status Relative to High School Science

The NEA Research Bulletin, February, 1964, gave data for ranking states on how well they are educating their children by use of

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several items significant to educational status. This gives some indication of specific accomplishments. The rank of Kentucky in relation to other states is summarized in Table 1.

### Table 1

**Rank of Kentucky Regarding Items Significant to Educational Status**

<table>
<thead>
<tr>
<th>Item</th>
<th>Kentucky</th>
<th>Rank of State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated school age population (5-17) as per cent of total resident population, 1963</td>
<td>26.3%</td>
<td>23</td>
</tr>
<tr>
<td>Length of public-school term, 1961-62 (in days)</td>
<td>175.4</td>
<td>44</td>
</tr>
<tr>
<td>Public high-school graduates in 1963 as per cent of ninth-graders in 1959-60</td>
<td>58.2%</td>
<td>48</td>
</tr>
<tr>
<td>Average salary of public-school teachers, 1963-64</td>
<td>$4,400</td>
<td>46</td>
</tr>
<tr>
<td>Expenditures per pupil in public elementary and secondary schools, 1963-64</td>
<td>$300</td>
<td>45</td>
</tr>
<tr>
<td>Per capita personal income</td>
<td>$1,712</td>
<td>44</td>
</tr>
<tr>
<td>State and local tax collections as per cent of personal income</td>
<td>8.8%</td>
<td>34</td>
</tr>
<tr>
<td>Personal income per child of school age</td>
<td>$6,514</td>
<td>43</td>
</tr>
<tr>
<td>Per capita federal income tax collection</td>
<td>$157</td>
<td>44</td>
</tr>
<tr>
<td>Per capita federal income payments to states and local units and to individuals</td>
<td>$63</td>
<td>24</td>
</tr>
</tbody>
</table>

These figures indicate that Kentucky is in the lower 20 per cent bracket in length of school term, percentage of graduates, average
salary of teachers, expenditures per pupil, per capita personal income 
tax, and state, local, and federal income tax collections. The facts 
are indicative of public apathy toward education.

Approximately two and one-half million dollars was expended by 
Kentucky school districts for equipment in fiscal 1960, with over 75 
per cent of the money going for science equipment. The State Depart-
ment of Education designates courses in chemistry, biology, and physics 
as "Specific Laboratory Courses." The graduating class of 1964 was re-
quired to have two units in science for graduation. These facts are 
indicative of progress toward a better science program.

Possibly the most influential report on Kentucky's educational 
program was the one made by the Kentucky Curriculum Study Committee in 
1961. After visiting forty-seven high schools and fifty-seven junior 
high schools in the state, the Committee made reports and recommenda-
tions in various subject-matter fields. Regarding science, the 
Committee stated:

The purpose of teaching science at all levels in our public 
schools should be two-fold: to make a knowledge of the mater-
ials and methods of science an integral part of our daily 
lives, and to seek out and encourage at an early age those who 
will be our scientists of tomorrow.²

The Committee found that there was duplication and overlap of 
content within the grades themselves and with grades above and below. 
Some Kentucky schools offer a full year of general science in each of 
the junior high school grades. Others offer one-half year of science

²Report of the Curriculum Study Committee to the Commission on 
Public Education (Lexington, Ky.: Bureau of School Service, University 
of Kentucky, October 1, 1961), p. 121.
in grades seven and eight and a full year of science in grade nine. These courses are usually non-laboratory courses.

The senior high school science program consisted chiefly of biology in the tenth grade, chemistry in the eleventh grade, and physics in the twelfth grade. In 1960-61 there were 30,244 students enrolled in biology, 9,053 in chemistry, and 4,452 in physics; a ratio of 6.8:2:1. Some schools offered a course called Senior Science or Advanced Science, mostly warmed over versions of General Science. Some courses were offered with no laboratory work whatsoever or an occasional demonstration by the teacher. Some schools have laboratory facilities, but not the teachers. There was evidence that N.D.E.A. funds were not being wisely used.

Recommendations eleven through eighteen relate to the science program in the senior high school. They are as follows:

**Grades 10-12. The Curriculum Study Committee Recommends that:**

11. As many schools as possible should offer at least one course in each of the fields of biology, chemistry, and physics. These courses should be rigorous laboratory courses and should have provisions for at least one double laboratory period per week.

12. The teacher should have a major in the subject that he is teaching. For teachers in the smaller schools this requirement might necessitate a dual major (thirty semester hours in the first major and twenty-four in the second) in order that they might qualify to teach a full load. If the teacher training program is properly planned, no hardship should result from this requirement.

13. No school should be accorded the "comprehensive" or "standard" rating unless recommendations 11 and 12 are fulfilled.

14. The class size for these courses should be limited to twenty-four students and no teacher should be required to teach more than four classes per day if all are laboratory courses.
Properly conducted, these courses could challenge the ablest students and thus eliminate much of the need for second year courses.

15. No school should attempt to offer second year courses in chemistry, physics, or biology or participate in advanced placement programs until all the above recommendations have been complied with.

16. Aviation Education and Introduction to Chemistry-Physics should be eliminated from the science curriculum. In 1960-61 there were only 154 students in the state enrolled in Aviation Education and no high school offered Introduction to Chemistry-Physics. The principle learned in Aviation Education can be more effectively presented by a good course in physics, and Introduction to Chemistry-Physics would be replaced by the ninth grade Physical Science course.

17. The course designed as Advanced Physical Science but which in many places is nothing more than a repetition of general science should be eliminated. The grades 7-9 science sequence would include the material presently included in this course.

18. The practice of allowing units in agriculture and/or home economics to satisfy the science requirements for graduation should be stopped.

Need for the Study

A review of Science Education, School Science and Mathematics, Dissertation Abstracts, and the Review of Educational Research for the years 1946-1964, revealed that no studies had been made regarding scientific literacy. Though many writers stress the need for a scientifically literate population, no attempt has been made to set up a criterion for making a quantitative determination of scientific literacy.

As shown previously, Kentucky ranks low among the states in factors that would contribute to a favorable climate for excellence in

\[3\text{Ibid.}, \ p. \ 129.\]
science. Too, urban and suburban schools generally have more expenditure per pupil, and are thought to have science programs superior to those of the rural schools. Possibly the teacher and the pupil contribute more to the acquisition of a scientific background than material devices.

This study was undertaken for the following reasons:

In Kentucky,

1. There is a lack of any assessment or evaluation of science teaching.

2. There has been no measure of the scientific literacy of secondary school students.

3. There has been no measure of the attitude of students toward scientists and the scientific enterprise.

4. There has been no evaluation of the outcomes of scientific achievement as measured by standardized tests.

5. No relationship between the socioeconomic conditions of students and their scientific literacy has been established.

6. No study has been made of scientific information in regard to interest, need, or abilities of students.

It is hoped that this study may help, in some small way, to determine the quality of science education in Kentucky's schools and that this might be a stimulation and a pattern for similar studies.

Definition of Terms

There are as many ideas concerning the meaning of scientific literacy as there are writers on the subject. A compilation of definitions found in the literature was used throughout this paper for reference. Scientific literacy implies familiarity with the
development, methodology, achievements, and problems of the scientific disciplines. A scientifically literate person must be able to read widely with an understanding of science. This reading would include the historical development of science with insights into the work done and the conditions under which it was carried out. He understands that science is both a process and a product. He has a knowledge of his natural environment and the forces that make up this environment. His attitude is that of a scientist: openminded, critical, questioning, intellectually honest, and skeptical. Other facets of the layman's scientific literacy include a variety of general scientific information, understanding of the inter-relation of science and other disciplines, realization of the contribution of science to human welfare, and an appreciation of the work of the scientist.

The term scientific attitude as defined by Good in the Dictionary of Education is "a set of emotionally toned ideas about science and the scientific method and related directly or indirectly to a course of action." He adds, "in the literature of science education the term implies such qualities of mind as intellectual curiosity, passion for truth, respect for evidence, and an appreciation of the necessity for free communication in science."^4

This study was concerned with students from urban, suburban, and rural schools. It was necessary to set up a frame of reference for each of these areas. In his book, Analytical Sociology, Carr said:

Local urban communities in America are normally marked by seven

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distinct characteristics: (1) symbols of continuous identity; (2) centralization of population; (3) nonagriculture occupations; (4) separation of residence from occupation; (5) permanent patterns of motility; (6) definite ecological patterns of development into diverse areas of advantage and disadvantage; and (7) local self-government.

In The Encyclopedia of the Social Sciences Douglas defined a suburb as "one of a cluster of communities immediately surrounding the central city." In contrasting the suburbs with the urban areas the following distinctions are made:

The urban core is a limited area occupied by many people. The most conspicuous characteristic of the suburban zone is that fewer people occupy much more land. All the suburbs combined decentralize only a fraction of the city's total functions and thus remain fragmentary and dependent communities. They have fewer major institutions because the city performs part of their community functions.

In the same reference Zimmerman compares rural society with urban. He said:

RURAL SOCIETY as compared with urban society is marked by a relative predominance of the agricultural occupations, by closeness of the people to a natural as contrasted with a human environment, by the smallness of its communal aggregates, by a relatively sparse population, by greater social homogeneity. The individual in rural society as a whole has fewer contacts with others, he associates with people from a smaller geographic and social area, a greater proportion of his social contacts are face to face and his relationships with any particular individual tend to have longer duration.

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7 Ibid.
What Is Science?

There seems to be widespread public misunderstanding of the term science. Our culture is built on technology and technology depends upon science. Most people confuse technology with science. They think that in supporting projects aimed at practical results they are supporting science. The report of the Conference on the Planning for Excellence in High School Science of the National Science Teachers Association defined science in terms of a process and a product:

Science, . . . is a human enterprise including the ongoing process of seeking explanations and understanding of the natural world, and also including that which the product produces—man's storehouse of knowledge. Science is a process and product.

In his book Science and Common Sense, Conant discussed the importance of science to the general public. He then gave his definition of science:

My definition of science is . . . somewhat as follows: Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observations . . . . Science is a speculative enterprise. The validity of a new idea and the significance of a new experimental finding are to be measured by the consequences—consequences in terms of other ideas and other experiments. Thus conceived, science is not a quest for certainty; it is rather a quest which is successful only to the degree that it is continuous.

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Merrifield added another facet to the scientific enterprise as stated by the National Science Teachers Association. He said:

But when we speak about science, as such, it is well to remember and keep clearly in mind what it is we mean. It means at least three things. Science is a way of making inquiry into change. It is also a method which has products; that is applications like the compass, or the printing press, the adding machine, television and nuclear power. And, it is also a philosophy, a view of the world in which we live using basic assumptions about reality and knowledge and human nature which are different in kind from those of the most of the intellectual tradition.

Impact of Science and Technology on Society Since World War II

Addressing the Montana State College Conference, Chemistry for Non Science Majors, Sears stated, "Among the sins of the American people today is the fact that they're virtually scientific illiterate." This is a resounding statement when our youth today, already having experienced an Atomic Age and a Space Age, finds itself on the brink of a new age--the Leisure Age. They have been cognizant of the forces of science in raising the life expectancy of man: antibiotics to combat diseases, elimination of childhood diseases by vaccines, wonder drugs, organ transplants in the human body, all helping to create a comparatively new socioeconomic problem--the Golden Age.


"Wash and wear" fabrics possible through the development of synthetic fibers, every type of gadget and machine, easy process and storing of food have made more time available to the housewife. The age of automation and mechanized farming makes it possible to predict that, within twenty-five years, 2 per cent of the population will be able to produce the food and goods needed by the remaining 98 per cent. This will give billions of hours of leisure time to our citizens.

Since the dropping of the atomic bomb which brought about the end of World War II, modern atomic physics has delved into the structure of the very atoms that make up every scrap in the universe. Because the explosion of uranium is controllable the supply of electricity yielding energy is enough to last at least one hundred thousand years. Man has truly traveled twenty thousand leagues under the sea by atomic submarine. Radioisotopes have been used in medical research in diagnosis and therapy, and in industry and agriculture. They have improved man's health and have given him better material products.

Science and technology have brought all parts of the world closer together by improved communication and transportation. Communication by mass media brings the launching of a man into space, or a TV program from France into one's own living room. Automation has made possible a telephone call to any part of the continental United States for one dollar. We now have the push button dial system and picture-phone service. In a few short hours one travels to the remote corners of the globe, made possible by today's modern jets, being entertained
en route by a movie. Superhighways and modern cars and buses speed this generation to school. Surely the modern frontiers are the frontiers of science.

On the other side of the ledger, science has created problems which may or may not be solved during the lifetime of today's graduates. There is the ever-threatening danger of man's annihilation by nuclear weapons. High altitude nuclear tests may or may not have fouled up our space communications. They may or may not affect unborn generations. The problem of increasing population demands an increased use of consumer goods. This raises the questions, "Will there be enough food, water, clothing, and shelter?" and "Shall religious groups reexamine their stand on birth control?" Controversies rage over conservation of our natural resources, water and air pollution—problems to be solved in the future. Pesticides, "hard detergents," food additives, and the growing narcotic problem are only a few more areas of science affecting youth's future. The recent reports on the harmful effects of tobacco and the rise of alcoholism among both sexes give sensible young citizens thoughts to ponder. DNA, the stuff of genes which controls one's heredity, can be isolated, made artificially, and its control over life partly understood. Should scientists determine the whole story, they would be able to control the heredity of plants and animals; able to design them. This would be a social power at once more beneficial and more dangerous than atomic energy. Intelligent decisions must be made in a world dominated by science.
Need For a Citizenry Literate in Science

The scientific enterprise has become so much a part of our culture that it touches the life of every man, woman, and child daily. Only a minority of these citizens have any scientific training and few are expert in scientific matters. Many take pride in their ignorance of science and deem it too difficult a subject to be learned by the nonscientist. Others appreciate the comforts, conveniences, and luxuries offered by science but have no desire to know the processes which brought them about. The results of scientific research penetrate our lives faster than the method of thinking.

It would be foolish to make professional scientists and technicians of everyone for we would then truly have a lopsided world. But with science increasingly shaping the affairs of men at the government level, shaping our thoughts and beliefs, it behooves every citizen to know a modest amount of science. He needs some acquaintance with the principles of science, some understanding of the methods of scientists, and some knowledge of how these are related to our daily life. He needs to know the power of science and also its limitations. Conant realized the importance of science to the average citizen when he said:

How can a man without scientific training know whether the enthusiastic chemist, doctor or engineer is talking sense when he urges the investment of money in this or that adventure? This query is relevant to decisions made almost daily by boards of directors of all manner of business undertakings, by trustees of hospitals and universities, by federal and state officials and by members of Congress.\(^\text{13}\)

\(^{13}\)Conant, *op. cit.*, p. 2.
Pauling was aware of the great importance of an understanding of science by the citizen of a democracy when he wrote:

The citizen who is trained in science may . . . be expected to exercise his political rights more effectively than one not trained in science, both because of his greater understanding of the nature of the modern world and because of his understanding of the scientific method, the way in which conclusions can be drawn from facts.14

Though one scientific achievement after another revolutionizes our way of life, we have a public showing disinterest, distrust, and often even hostility toward science and scientists. In writing of the relation of people to science, Lonsdale said:

The general public thinks of science in terms of its frontiers, telescopes rather than spectacles, nuclear energy rather than coal, H-bombs rather than bows and arrows, penicillin and cancer research rather than bicarbonate of soda. They think of science . . . as moving in the direction of limitless power and of scientists as men . . . having or likely to have, unlimited power. Knowledge is power and "power" said Alfred the Great, "is never a good except he be good that has it." They are not quite sure of the scientist's goodness.15

In his article "Are You Illiterate About Science?", featured in *Vogue*, Ubell wrote of the anti-scientists thus:

. . . the anti-scientists have refused to put on "scientific spectacles" to see the new beauty in nature, being content, perhaps, with the brazen yellow of Wordsworth's daffodils and averting their eyes from the fine structure of life and matter as seen with microscopes, atom-smashers, x-rays and other powerful extensions of our senses.

Maybe science has scared the anti-scientist. They see only the glowing, five mile fireball of the hydrogen bomb, the threatening, blunt upward cylinder of the intercontinental

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rocket, the insipidities of television, and the incomprehensible chicken tracks of the modern mathematician who to them must be a modern cabalist.\textsuperscript{16}

The tragic consequence of a public illiterate in science is forcefully expressed by Rotkin as he said:

We simply cannot afford to have a public indifferent, perhaps even hostile, to science. This has now become not merely a matter of choice or taste, but a matter of survival. Our survival as leaders of civilization certainly is at stake. Even our physical survival may be.\textsuperscript{17}

\noval{Outline of the Study}

\noval{General Design of the Study}

This study was an effort to compare the scientific literacy of Kentucky high school seniors in selected urban, suburban, and rural schools. Mr. Marvin Dodson, Executive Secretary of the Kentucky Education Association, aided in the selection of the schools. An attempt was made to obtain a wide geographical distribution. Tests were selected which would measure the following as accepted qualifications for scientific literacy:

1. Ability to read and interpret scientific literature of a general nature.

2. Knowledge of the scientific enterprise and the work of scientists.

3. General scientific achievement.

4. Positive attitude toward science and scientists.


Information concerning socioeconomic status of parents, parent's education, student's educational and vocational plans, and his science training in secondary school was obtained from a personal data sheet. An intelligence test was administered to each participant. The results were tabulated and treated statistically. From these data some conclusions were drawn concerning the scientific literacy of the sample.

Groups Involved in the Study

The testing program was administered to a sample of at least thirty high school seniors from the participating schools. Five urban, five suburban, and five rural schools made up the sample. The testing was done during April 1964.

Summary

The great urge today is for the elimination of scientific illiteracy in our democratic society. There is little doubt that there is a need to be certain that our future citizens are scientifically literate. The purpose of this study was to compare scientific literacy of students in a selected sample of urban, suburban, and rural schools in Kentucky. This study attempted to give an insight into the science background of high school seniors as measured by specific tests. It may serve as a catalyst for similar studies in many other areas.
CHAPTER II

REVIEW OF PERTINENT LITERATURE

Meaning of Scientific Literacy

In 1957, the year of the first Sputnik, many writers deplored the nation's scientific illiteracy. Others were vehement in their declaration of the need for a scientifically literate population. However, it was not until 1962 that the first statements were made answering the question, "What is Scientific Literacy?"

In January, 1962, Johnson and Obourn made the first statement concerning the developing of scientific literacy:

In developing scientific literacy, two aspects of science merit attention. Knowledge outcomes, which might be regarded as the product side, have always appeared in the objectives of science teaching. Less obvious but even more important is the process side—the methods and attitudes of the scientist. These processes of inquiry are essential to the development of a feeling or sensitivity for science. While facts themselves change and their applications are continually altered, the processes remain more or less constant. Unless they are taught intertwined with the product, the true nature of science will ever remain elusive, and whatever gap may exist between the scientist and society will be perpetuated.¹

The December, 1962, issue of Theory Into Practice was devoted to trends and issues in school science. In relating the goals of science education to the present need for developing scientific literacy Johnson said:

The concept of scientific literacy must be based, first of all,

on knowledge—a kind of knowledge that is much broader than mastery of detailed information. It suggests also the qualities of curiosity, accuracy of observation and interpretation, and open-mindedness.

The person who is scientifically literate will be curious about the how and why of materials and events. He will be genuinely interested in hearing and reading about those things that claim the time and attention of scientists, and his interest will not be lessened by unwelcome ideas and events. He may never create any ideas pertaining to science, but he will be conversant with the ideas that are being considered in the intellectual marketplaces of the world.

Perhaps one of the most important evidences of scientific literacy is the desire to determine the true quality of an idea, to be open-minded about one's own ideas and those of others. A scientifically literate person will try to be as accurate as possible in his observations and descriptions. His first expression of an idea, whether given that name or not, will be his hypothesis. When his further studies and the critical observations of others confirm earlier ideas, he will be ready to adjust his thinking in terms of the new information. Most important, too, he will require painstaking accuracy in others, and he will insist on being given the basis for making a judgment about the quality of ideas. This attitude will carry over into all areas—philosophy, foreign affairs, etc.

Scientific literacy is, to a large extent, a matter of feelings and values, but these must be founded on knowledge, which, in most cases, starts in the classroom. Thus, the goals for science instruction in the elementary and secondary schools are most important. For example, we must consider the kinds of knowledge that should be presented and the specific attitudes and skills that should be instilled in students. A brief summary of the historical development of various goals in science education should be useful in helping us to understand the issues confronting science educators today in their effort to develop scientifically literate individuals.²

The editors of the NEA Journal sought to obtain some suggested procedures and resources to improve general understanding and appreciation of science and to enable nonscience teachers to see better the

relationships of science to the subjects they teach. Some of the nation's finest scientists and science educators contributed to the symposium, On Scientific Literacy, published in the April, 1963, edition of the Journal. They made the following statements:

Richardson, professor of education, The Ohio State University:

The scientifically literate person has a knowledge of science adequate to an understanding of his environment. This knowledge helps him examine the world about him with respect to its rational explanations and to the processes by which the explanations have been derived.

The scientifically literate person also possesses objectivity; he is open-minded, critical, and skeptical to the degree that he questions the validity of even his own conclusions.

Scientific literacy requires an awareness of the separate, identifiable entities in the universe--matter, energy, and life, and of the essential relationships among the three. The scientifically literate person thus must be able to read and to discuss scientific information found in common literature and to interpret common scientific phenomena with facility and confidence. He must also be able to interrelate and to differentiate between science and applied science.

Science is a creation of man's intellect. Scientific literacy is based upon a growing understanding of the relation of man's intellect to the structure of those processes and products of thinking which constitute science.

Holton, professor of physics, Harvard University:

There are two facets to scientific literacy: (1) some narrow-area contact-knowing and keeping up with at least one chosen, even though small, part of science, and (2) range contact-trying to keep in touch with a variety of other scientific developments.

To gain some narrow-area contact, an individual takes on, as he would a hobby, one subject in which he already has some natural interest. An example for a teacher might be the behavioral psychology of children. Note that this example is

more in the field of "pure" science than "applied" science. Telescope making, electronics, photography, and other interesting technical hobbies have their rightful place, but in a context other than scientific literacy.

While he is achieving some narrow-area contact, the teacher who wants to be scientifically literate should keep his reading eye open for any overlap or link between science and his own teaching field.\textsuperscript{4}

Evans, formerly of Teachers College, Columbia University:

Modern life places a premium on the mastery of extensive bodies of scientific knowledge and techniques by the largest possible number of citizens. Therefore, one of the greatest social needs today is to effect a sharp rise in scientific literacy among the general population.

Scientific literacy, however, does not require a survey and understanding of the whole of science and technology. A relatively small number of fundamental scientific concepts and conceptual schemes can be identified and, when understood, can form a firm foundation for understanding the nature of the sciences and scientific work and for interpreting the newer developments as they come along.\textsuperscript{5}

Beadle, president, University of Chicago:

Everyone--layman and teacher alike--who claims to be broadly informed about our culture knows that some understanding of science is essential. But no one can know all of science in any detailed way. Even professional scientists cannot possibly keep up with new developments except in a few areas. So the teacher--whether professionally trained in science or not--may regard with deep despair the problem of acquiring and maintaining some sensible literacy in all of science.

How does one find out about broad and simplifying concepts without an elaborate scientific background? It is not so difficult. Witness the increasing numbers of nontechnical books on science and the growth of magazines designed for the nonspecialists. In particular, those who learned their science

\textsuperscript{4}Gerald Holton, \textit{ibid.}

\textsuperscript{5}Hubert M. Evans, \textit{ibid.}
twenty or thirty years ago would be encouraged to sample such literature and to discuss the new science with younger colleagues so that they may discover the extent to which once separate spheres of science have been drawn together within the past two decades.6

Odishaw, executive director, Space Science Board, National Academy of Science:

Scientific literacy can be defined as a comfortable familiarity with the development, methodology, achievements and problems of the principal scientific disciplines. A thoughtful reading of some fifty books could establish such familiarity. . . . In addition, I recommend that each person become familiar with at least one branch of science. . . . Some depth in a single field is better than superficial gleanings in many, and will afford a meaningful foundation for general reading and insight into other fields.7

Meyerhoff, chairman, Department of Geology, University of Pennsylvania:

Scientific literacy does not imply omniscience, which even the professional scientist cannot claim. Rather, it calls for familiarity with scientific methods and for sufficient knowledge in the several fields of science to understand reports of new discoveries and advances.

Virtually every teacher has taken a college course in at least one science. This training should be adequate to absorb the principal facts, theories, and principles in other scientific disciplines. . . . The teacher should make a persistent effort to read current reports on scientific developments and engineering achievements in the press and in reputable magazines. With this kind of program, scientific literacy will come, not only painlessly, but pleasurably.8

Pierce, director, Electronics Division, Bell Telephone Laboratories, Inc.:

By literacy we mean more than mere ability to read words; we mean having read widely with understanding. Further, we think of a literate man as being generally informed. The latter criterion may not, however, carry over into the field of science.

6George W. Beadle, ibid., pp. 33-34.
7Hugh Odishaw, ibid., p. 34.
8Howard A. Meyerhoff, ibid., p. 34.
because science understands only a minuscule fraction of the world about us. Nonetheless, our wealth, our comforts, and our way of life have all been brought into being through that small understanding.  

Hurd, professor of education, Stanford University:

A scientifically literate person has a precise understanding of some of the key concepts, laws, and theories of science. He can relate these concepts, laws, and theories in a logical and coherent manner and can appreciate their significance.

The laws of science are based upon disciplined observation and careful experimentation, and the scientifically literate person sees science as a process by which new knowledge is discovered and a man's understanding of the world expanded. The process is an intellectual one; it should not be confused with its tools or the applications of the knowledge it reveals.

New terms are sometimes coined to represent more precise answers, but knowing terminology does not reveal the meaning of science. To be scientifically literate is to understand the place of the individual in the process of discovery and to recognize the limitations of science and know about its many unsolved problems. Most of all, they appreciate how the use of intelligence in inquiry and experimentation has advanced man's understanding and influenced the course of society.

Trytten, director, Office of Scientific Personnel, National Academy of Sciences:

To me, any discussion of scientific literacy should differentiate between knowledge about science and understanding of science.

The person who seriously wishes to understand science should look for materials that bear upon science's nature and functioning. He should seek, for example, to understand the basic principles and unifying concepts of science in their simplest operations. It is better to have a thorough understanding of Newton's laws in physics or of the role of the cell in biology than to know the galaxy of space vehicles.

9 J. R. Pierce, ibid., p. 34.
10 Paul DeH. Hurd, ibid., p. 34.
11 M. H. Trytten, ibid., pp. 34-35.
Waterman, former director, National Science Foundation:

The problems of communicating science are possibly more complicated than those of other fields. Science is technically difficult for many, and its language is not understood; science is confused with technology, and scientists are confused with inventors.

What elements in scientific knowledge are most important for the layman to know? My own list might begin with an exposition of what science is, especially science as distinguished from technology; this to be followed by an understanding of the aims of the individual research scientist and something of his characteristic methods of working and his philosophy, insofar as such things can be generalized.

Also, I would examine the historical development of science as exemplified by the work of leaders in a given field, together with some exposition of the conditions under which their work was carried on. I would look at the current state of knowledge and ignorance about the field; at the cultural, social, and economic environment in which the field developed; and at the growth of the experimental method and the systematic use of observational data where experiment is not feasible.

Further, I would study the philosophy of science, which demands that conclusions and observations must be subject as far as possible to objective criticism, analysis, and review by the entire scientific community; the major generalizations or laws as found in the sciences, with examples of their confirmation in a variety of phenomena; the usefulness of such generalizations in predicting or identifying promising areas for further research; and finally, some attempt at incorporating the ideas of science into the history and philosophy of mankind.

Shamos addressed one of the major sessions at the Forth-Seventh Annual Convention of the National Association of Secondary School Principals on the topic, "The Price of Scientific Literacy." This speech is reproduced in the April, 1963 issue of the Bulletin. He said:

What do we mean when we speak of a common literacy in science? We obviously do not mean competence in science to the extent of solving problems independently; this is the task of the specialist. Nor do we mean an encyclopedic knowledge of scientific facts. We mean, as Wilbur Schramm put it "... that

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12 Alan T. Waterman, ibid., p. 35.
an educated man should know science in a humanistic way." He should know it for his general good and because it is part of his culture, just as he is expected to know history, philosophy, or literature. He should have a certain sophistication in science. He should feel comfortable when reading or talking with others about science on a non-technical level. Hopefully, he should be able to distinguish between scientific argument and dialectic.

It is not necessary that he understand in detail the functioning of the telephone or the automobile, but that he know the difference between science and technology, and that he realize that Henry Ford and Alexander Bell, however great their achievements, should not be numbered among this nation's most distinguished scientists.

Must he know any facts of science? Should he know, for example, that the Earth is round (or nearly so) and that it spins on an axis and rotates about the sun? Should he know that warm air rises, or that oxygen is needed to support combustion? Of course he should—and more. He should know these facts of nature just as he knows various facts of history or literature or geography. They are a part of his environment, both real and intellectual. This sort of knowledge is natural history, not science as we shall understand it.

More important, he should understand how these facts are determined and how they are used in the development of major conceptual schemes. In short, he should develop a feeling for the nature of the whole scientific enterprise, for its strengths and its limitations, and for its influence on man's intellectual development.

It must be granted that we are nowhere near this kind of sophisticated scientific society, and that general education in science has been in the past a rather dismal failure. What kind of problems stand in the way of achieving such literacy? For the most part, the problems are linked with the nature of science, or, what is almost the same thing, the difficulty of teaching it. 13

Wittlin described scientific literacy in relation to all active citizens with the following comments:

When we claim the need for a general scientific literacy of all active citizens in an environment molded by the second industrial revolution-in-process, we are asking for more than

a levelling up with respect to factual information. It begins with an informed awareness of significant samples of two kinds of phenomena—of matters of nature, be they atoms or stars, animals or volcanoes, rain or gravity, and of man-made things, be they toasters of cyclotrons, insecticides or vaccines. Together these two categories make up man's environment. In addition there is man's intangible internal environment including those attitudes which prompt scientists to do their jobs. To qualify for full-fledged scientific literacy the non-scientist may be reasonably expected not merely to be aware of such attitudes and to appreciate them, but in some measure to share them: curiosity and freedom of prejudice; imagination coupled with patient observation and disciplined reasoning; tentativeness of judgement and readiness to change it in the light of fresh evidence.¹⁴

In his article "Science Education Under Challenge," Jacobson said:

But scientific literacy involves more than learning how to understand the words that scientists use... Scientific literacy involves using science as well as understanding it. This broader definition of scientific literacy raises the sights of science education and suggests a more significant role for science education in the life of everyman.¹⁵

Defining scientific literacy in an address at the National Science Teachers Meeting in March, 1964, Branson said:

You are literate in science when you understand some of the facts of science and how they are related to each other, when you understand how science is related to the objects in our physical world and finally, when you have some real understanding of the image of science in your mind and in the public mind.¹⁶

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Findings On Scientific Literacy

Though the goals for science teaching have implicated for many years the development of scientific literacy, it was not until 1952 that the term appears in the literature. In writing the foreword for the book, *General Education in Science*, Conant used scientific literacy to describe the expert on judging experts. He said:

The wider his experience, the greater would be his scientific literacy. For what blocks the inexperienced person who attempts to examine critically proposals advanced by scientific experts in his ignorance of the way such experts think and talk.

Formal education can be only a first step in reducing ignorance and illiteracy . . . . A major educational problem that now confronts those concerned with teaching science is how to start the student down a road that will insure his arriving at some degree of scientific literacy.  

Other writers expressed their opinions in this volume. Sears said:

Now, how do we know that all is not well with the supposedly educated man who is not, professionally, a scientist? First, there is still too low a level of scientific literacy among the lay public. This charge is true in spite of the popularity of certain types of scientific literature and the widespread interest in certain fields of applied science, whether as hobbies or as an adjunct to vocation . . . . it is more difficult than it should be to secure enthusiastic and popular support for the intelligent application of science in many matters of public welfare.

In stating the need for scientific literacy if we are to develop

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18 Paul B. Sears, "Assimilation of Science into General Education," *ibid.*, p. 36.
public policies that will contribute to the greatest good for the greatest number of people Fuller stated:

While we are schooling our students to assume their responsibilities as the future middle class in science and reducing scientific illiteracy among our contemporaries, we must make special efforts to see that our political leaders are well informed concerning the scientific and technological aspects of governmental policy and action under consideration.¹⁹

According to Richardson, today's unprecedented impetus for teaching the sciences derives from three main sources, one of which is scientific literacy. He wrote:

Scientific literacy is needed, first of all, by each member of a culture such as ours that is so thoroughly based upon technology and scientific endeavor. We believe that in order to make effective decisions in personal, civic, and national affairs, the citizen must have some knowledge of the processes and products by which he is fed and clothed, entertained and inspired, and defended from enemies foreign and domestic.²⁰

After stating the other two sources as the momentum of technological development and the habit of critical thinking he summarized:

The keystone of this threefold goal is scientific literacy. It would seem that only as all people are more broadly educated in science can we hope that science will make its maximum contribution to critical thought among all people, and to their effective and happy living through intelligent interaction with the living and inanimate world. Only thus will there be an adequate supply of scientists and engineers, as well as a widespread understanding and intelligent use of the products of scientific and technological activity. And from this broad base of scientific literacy will come our continuing growth of scientific knowledge and its application to human concern.²¹


²¹Ibid., p. 2.
Another science educator, Barnard, stressed the role of the school science program in developing a scientifically literate citizenry:

Under our system of self-government citizens must make many decisions related to science—for instance, on the financial support of scientific research and the use to be made of technological developments. A scientifically literate citizenry is needed if intelligent decisions are to be made on such matters. Developing such a citizenry is a responsibility of the schools and primarily a function of science programs in schools.22

In the same year, 1957, Smith indicated that research had shown the conviction that citizens must be literate in science:

The inescapable reality that the children of this generation will live in a scientific world is reflected in much educational research. Research for many years has demonstrated the existence of an abiding conviction that citizens must be scientifically literate.23

After Sputnik, alarmists were concerned over the crisis in science education and our need for an ample supply of high calibre scientists. A profound statement is found in The Pursuit of Excellence:

There is a danger of training scientists so narrowly in their specialties that they are unprepared to shoulder the moral and civic responsibilities which the modern world thrusts upon them. But just as we must insist that every scientist be broadly educated, so we must see to it that every educated person be literate in science. In the short run this may contribute to our survival. In the long run it is essential to our integrity as a society. We cannot afford to have our most highly educated people living in intellectual isolation from one another, without even an


elementary understanding of each other's intellectual concerns. Such fragmentation must lead to a loss of social purpose.  

The following year, 1959, the President's Science Advisory Committee's report on science and engineering education in the United States was issued. The report elaborated on the personal satisfaction of being scientifically literate thus:

As the musically literate gets more enjoyment out of music, so the scientifically literate can derive far more personal identification with and satisfaction from rapid technological change if he understands the fundamental scientific principles on which the new technology is based. His knowledge helps to bridge the dangerous gaps of misunderstanding which sometimes exist between scientists and non-scientists and gives him a better appreciation of what his colleagues in other fields are doing.

Regarding improvement in our American educational system the committee stated:

Our changing civilization will demand in the future an even greater devotion to learning and a greater pride in intellectual achievement. The profound effects of recent advances in science and technology demand that scientific literacy be far more widespread among the American people if we are to solve the problems of this age.

The same year Brand Blanshard edited a book which was a searching examination of American education by professionals. The contributors were a group of eminent teachers and critics who have been

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26 Ibid., p. 30.
leaders of American educational philosophy. Mead discussed the gap be­
tween scientists and others. She stated:

At present there is a growing effort to identify those
children who display a particular type of intellectual ability
and to provide a special education for them. This is as neces­
sary in the clinically oriented human sciences as in the physi­
cal sciences. But this effect ought to be complemented by an
effort to teach as fully as possible the advances in any field
to other young children and adolescents and educated adults as
well, so that we may have scientifically literate citizens and
parents.27

Roucek edited a volume, The Challenge of Science Education,
aimed at synthesizing the cross-currents of thinking and the evaluation
of educational practices in the field of science by the distinguished
specialists in this field. Relative to our progress in science
Killian said:

Our progress in science will be greatly affected by our
achievement of a high degree of scientific literacy among the
rank and file of Americans. A man cannot be really educated
in a relevant way for modern living unless he has an under­
standing of science. Our young people, whether they become
scientists or not, need some of the intellectual wealth of
science, some its excitement and adventure, some of its
special vision for interpreting nature--some of the under­
standing which our citizens should have if they are to deal
intelligently with the great issues of our time arising out
of science.28

Fitzpatrick emphasized the fact that the sciences are not easy
and that scientific literacy requires hard work. He said:

If our young people are to possess any marked degree of
scientific literacy they must exert themselves and not take

27 Margaret Mead, "The Gap Between the Scientist and Others,"
Education in the Age of Science, ed. Brand Blanshard (New York: Basic

28 James R. Killian, Jr., "Problems of Science Teaching in the
United States," The Challenge of Science Education, ed. Joseph S.
refuge in elective courses in which the standard of mental effort is minimal. There is no Santa Claus in the learning situation. We will reap just about what we sow. We need a public attitude which makes ignorance unfashionable and holds the acquisition of knowledge in esteem.  

He further stated:

The ultimate fate of the scientific enterprise is in no small degree dependent upon establishing a species of scientific literacy in the general population. To this end we should engage in further experimentation designed to produce acceptable physical science courses for the large numbers of students who will end their formal education in the senior high school.  

In relating science to total process of education Kusch surmised:

... every man with a serious pretension to having been educated should have made the attempt to acquire an understanding of science. The attempt, honestly undertaken, almost certainly will lead to scientific literacy if not to profound knowledge. It may lead to a high respect for the methods, the integrity, the spirit, and the results of science. The citizen who respects the structure of science ... is to my mind, better able to participate effectively in the conduct of our national and international affairs--indeed, in every respect of life--than is the man who is totally ignorant of the spirit of science.  

In criticizing the teachers and administrators he stated:

Those who have been concerned with the problem of increasing scientific literacy among laymen since World War II and in the post Sputnik days, with the added problem of enlisting a greater fraction of the best brains into scientific and technological fields, sometimes have given only lip-service to these objectives ... those that have been responsible for organized


30 Fitzpatrick, op. cit., p. 169.

instruction at all levels have often failed to acquire a scientific literacy of their own.

... faculty and administration lack any kind of scientific sophistication and are not driven by belief of importance to acquire it. This is poor leadership and poor education, and scientific literacy hardly will rise to new heights if those who pay lipservice to its importance do not, on their own initiative, make the serious attempt to understand science.

It is almost valueless to discuss the details of any pedagogic program for an increase in scientific literacy without a prior vigorous attack on the boundary conditions that limit the practical effectiveness of a program that has, in the abstract, a great value . . . the problem is intimately related to the patterns of American life, to the values of our culture, to the standards that we have set for ourselves. 32

In the opening address at a symposium on the Life and Physical Sciences Schenberg stated the three goals that science educators must keep before them:

We science educators must keep three goals before us. We must contribute to the aims of general education in a democratic society, assure the preparation of scientifically literate citizenry and stimulate an adequate number of our talented and interested young men and women to enter the scientific professions. We believe that the attainment of the third objective . . . cannot be realized unless the second goal is attained, for we must first provide the environment and climate in which these youngsters can be nurtured. 33

The conference which resulted in the publication Planning for Excellence in High School Science, had some pertinent remarks to make

32 Ibid., pp. 199-201.

concerning scientific literacy. Regarding preparation of citizenry the report said:

Readying the citizenry for life in our society is the function of the educational enterprise. Within the last decade, the educational enterprise has come under close scrutiny in terms of its adequacy to prepare scientifically literate citizens. The question has been repeatedly asked whether science is being properly taught in our schools.  

Regarding the process of science in relation to the product:

The latter (process) is extremely important, not only for the training of future scientists, but also for the production of a scientifically literate citizenry capable of applying broadly the modes of scientific thought and sympathetic to the scientific endeavor. Consequently, there is a need for a re-examination of the aims, content, and methodology which form the larger part of the complex that is science education.

The importance of a scientifically literate citizen is emphatically stated:

A scientifically literate citizen is essential to safeguard the national security, to assure advances in basic science and to maintain our standard of living. Because the place of science in the culture of our times and its impact on the personal lives of people, it becomes imperative that science have a prominent place in the educational enterprise at every level of teaching.

Regarding the role of science education it said:

Science education does have an obligation to serve not only individuals, ... but also society as a whole. It is assumed that society is served by providing it with a scientifically literate citizenry and with technically prepared scientific manpower in sufficient quantity and quality to serve whatever needs and demands a society seeks.

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34 Planning for Excellence in High School Science, op. cit., p. 4.

The conditions of modern life clearly make it imperative that the lay citizen achieve a relatively high level of scientific literacy. Yet the difficulties which stand in the way of achieving and maintaining an adequate public understanding of the scientific enterprise are formidable . . . . Perhaps one of the most serious mistakes which has been made in formal schooling was to underestimate the time required for the achievement of literacy in science, thus delaying serious study of the scientific disciplines until the upper years of the school program . . . .

In hoping for an improvement toward scientific literacy he further stated:

It is hoped that more and more competent scientists will join those already working through the mass media and the schools to raise the level of public literacy in matters technical and scientific, an essential condition for the victory of wisdom and knowledge over stupidity and dogma. Such a victory, it is now clear, is a straightforward prerequisite to human survival.

Johnson and Obourn contend that the two problems to be faced if science programs are to make a contribution to society are (1) the need for excellently trained young people to constitute our scientific manpower pool and (2) the need to raise the scientific literacy of our entire citizenry. They said:

Raising the general level of scientific literacy may be even more crucial than the manpower situation. Over the past decade science and technology have played an increasingly important role in our way of life, and there is every reason to believe that this trend will continue.

Concerning evaluation they said:

These two broad, problems, scientific manpower and

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39 Ibid., pp. 78-79.

40 Johnson and Obourn, loc. cit.
scientific literacy, provide the frame of reference for a modern science program. The experiences which we propose for our pupils must be evaluated with respect to their contribution to both goals.  

Philip G. Johnson carries the same idea one step further in saying: "Most leaders in science education today agree that the overarching goal is the development of a scientifically literate citizenry."  

In the same issue of Theory Into Practice Shannon writes about general and special education in science stating:

Our society cannot afford to sacrifice the general education of all persons: scientific literacy is a paramount goal. Nor can we neglect the specialized education in science of those who will help extend the literacy to the total population or of those who will expand the horizons of science.  

Patton has written a brief textbook for non-science majors. It was designed to meet the needs of certain students who will not become scientists, technologists, or engineers but who need to know something of what science is about in order to become intelligent citizens in this age. Patton said:

Nowadays to be an educated person one must be literate in science. Every educated person needs to have at least an elementary understanding of the concerns of his compatriots in other areas of knowledge and culture.  

The year, 1963, brought similar comments from those in leadership positions in science and science education. Blackwood stated:

Perhaps more clearly than in the past, science education

\[41\text{Ibid., p. 234.}\]

\[42\text{Philip G. Johnson, loc. cit.}\]

\[43\text{Henry Shannon, "General and Special Education in Science," ibid., p. 258.}\]

is expected to contribute to national goals of security and welfare. The study of science at the elementary and secondary school levels is expected to build a scientific literacy among all citizens. Such study is expected to lead indirectly and directly to an increasing reservoir of scientifically competent manpower. These overarching national purposes are influencing the nature of current science curricula.\textsuperscript{45}

Dr. Glenn T. Seaborg contributed to the \textit{Chemical and Engineering News}'s section on Career Opportunities in January, 1963. He stated that this country has had two earlier revolutions--the Political Revolution of 1776, and the Industrial Revolution. Our Third Revolution is that of science and technology. Concerning this revolution he said:

The Third Revolution is creating a society and a world based largely on science and technology, a society in which individuals will have a responsibility to be scientifically literate . . . . In addition to a minimum literacy in science for the general public, the emerging scientific age requires more people of deep scientific training, for it will be scientists and engineers who will be called upon for many, if not most, of the significant contributions.\textsuperscript{46}

Shamos points out that the rapid growth of science has outpaced public understanding and outmoded much of the current science education. Concerning the pressure for educational reforms he stated:

The pressure for educational reforms in science is now very great, as are the opportunities for carrying these out. But the responsibility for avoiding misjudgements is correspondingly heavy . . . . The danger lies in possibly deluding ourselves into believing that certain changes will necessarily achieve a given set of objectives. It may be, for example,


that the price of scientific literacy is simply too high—not in dollars but in the possible sacrifices of other intellectual values.\footnote{47}

He then classified our knowledge of the natural world into three categories: natural history, science, and technology. After defining natural history as largely observation and description and technology as the products of science, he then defines science as the activity by which we seek a better understanding of nature. Mathematics is necessary to discuss the simplest concepts in meaningful fashion and this is one of the major obstacles in the path toward a common literacy in science. A second obstacle is that basic concepts defy common-sense understanding. He drew these conclusions:

Without a major and dramatic change in the over-all structure of science education it seems unlikely that the problems we have mentioned can be solved and a scientifically literate society be evolved. An exposure to natural history in the primary and junior high-school grades, plus one or two courses in secondary school and college . . . cannot possibly achieve this goal . . . Hopefully the high school curricula will soon be integrated so as to present a unified spectrum of science . . . What is needed is a comprehensive program in science beginning in the primary grades and covering the youngster's entire school.

The task is clearly enormous, and the price is high in human energy and in time that must be taken from the youngster's other activities. Whether a common literacy in science . . . is worth the price is a question that our society must judge. It is my conviction that the cost is trivial when compared with the potential benefits.\footnote{48}

Several speakers at the twelfth annual convention of the National Science Teachers Association made reference to scientific literacy. Branson had pertinent remarks to make on the topic:

\begin{quote}
I think that the image of science in our minds, but
\end{quote}

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\begin{itemize}
\item \footnote{47} Shamos, \textit{op. cit.}, p. 43.
\item \footnote{48} Shamos, \textit{op. cit.}, pp. 50-51.
\end{itemize}
especially in the minds of our students, and the people at large, the laymen, is the most neglected aspect of scientific literacy . . . the role of science in modern society especially as it relates to what is possible for man on this earth must be considered as the most important problem of scientific literacy for the future.49

Another who spoke of scientific literacy was Mayor, who said,

Many agree that the major purposes of science education are to teach an understanding and appreciation of what science is and what a scientist does, and to teach scientific literacy. These broad purposes are endorsed alike by those with a responsibility for leadership in science and science education and also those interested in science as a part of liberal education.50

Though the tasks in science education are never finished Jacobson said "One of the laudable movements in science education is the drive to develop scientific literacy."51

Findings on Scientific Illiteracy

Volume four of the report to the President on "Science and Public Policy" is entitled "Manpower for Research." It dealt with the shortage of scientists, the implications of this shortage, and the steps that must be taken to relieve it. According to the report, science teaching from the elementary school through the secondary and collegiate levels involves several problems, one of which concerns scientific illiteracy. Steelman stated a third problem:

3. While the majority of our youth is exposed to general science and life science in some form, only a small fraction

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49Herman Branson, op. cit., p. 12, 14.


51Jacobson, op. cit., p. 630.
is encouraged to study physical science. High school graduates may have little or no education in the physical sciences—the basis of our engineering technology. Even the minority which goes on to college may graduate and yet remain scientifically illiterate—so inadequate is the science requirement for the general student. On the other hand the science specialist may go through college without becoming aware of the social implications of science.\textsuperscript{52}

For more than a decade following World War II, criticism of science arose in new and powerful quarters. Speeches, articles, and books showed the growing distrust of science and scientists. Some of the causes for the adverse developments were stated by Quimby in his discussion of the topic "Unpopular Science." He gave many reasons for the unpopularity of science; among them was ignorance: "The extraordinary scientific illiteracy in America even among intelligent, educated people—ignorance of the basic precepts without which there would be no science at all."\textsuperscript{53}

In his article, "Science—the Endless Adventure," DuBridge discussed the fun of understanding the marvelous adventure stones in science. He then said, "We spend strenuous efforts in this country to reduce illiteracy, to make it possible for every man, woman, and child to read and write."\textsuperscript{54} Next he pointed out a new type of illiteracy:

We succeeded—but we face a new type of illiteracy today in which citizens are unable to read and understand the things


about which they must make decisions, all the way from spend­ing billions on nuclear energy to investing a few thousand dollars in a new chemical company; decisions as to what to do about smog; about putting fluorine in drinking water; about paying higher salaries to teachers of science. The ability to understand the adventures in science has a real practical value in addition.55

During the Post-Sputnik years several scientists and science educators have been cognizant of the problems brought about by our scientific illiteracy in America. Hurd said: "The immediate problem is one of closing the gap between the wealth of scientific achievement and the poverty of scientific literacy in America."56

The September, 1959, issue of Education featured a group of especially written articles to bring to readers a well-rounded discus­sion of the all important problem of providing science education in elementary and secondary schools. Mallison brings to attention the panic brought about by scientific illiteracy. He said:

It is reasonable to state . . . that the scientific illiteracy of the lay population has produced an atmosphere of panic that is both unscientific and indefensible. The solutions proposed to many of the issues are ample evidence of the myth-mindedness of many persons. Consequently, the rational efforts of those who are aware of the true impli­cations of the present situation have often been frustrated by a disorganized determination to "do something about it."57

Weaver was emphatic in saying:

The essential fact is that many Americans are scientific and democratic illiterates. Although they may have an ele­mentary, secondary, or even college-university training, they

55 Ibid.
can only recite the science facts which they have memorized or mouth the slogans and protestations which are traditionally associated with the American way of life. Today too many Americans (a) are woefully uninformed about the new meanings of democracy in a scientific, technological, urban, industrialized society; (b) are sadly undisciplined in the actual practice of the human relations required in a modern democracy; and (c) continue to believe that the American way of life can be preserved by chauvinistic devotion to traditional and conventional institutional practices. 58

In *Rethinking Science Education* Carlton expressed a similar view:

Although a large proportion of the citizens in our society have been exposed to science in the schools, the scientific illiteracy of the public mind is appalling. The products of science-teaching, as represented by the average citizen are indeed disappointing. 59

In setting forth the purposes of the Science Manpower Project, Fitzpatrick recalled events before sputnik. He described the situation thus:

Even in 1956, which was a pre-sputnik year, it had become apparent that the national output of new scientists, technologists, and technicians—not to mention science teachers—was inadequate in terms of a modern economy. Equally obvious was the conclusion that many public officials who had little real familiarity with science were being called upon to resolve problems involving a variety of scientific factors. In general, it was becoming evident that a species of scientific illiteracy was widespread. The nation which operates under such a handicap is poorly prepared to survive in the modern world. 60

After his well written discussion of five of the revolutions in


Science; biochemistry, the atom, archeology, astronomy, and mathematics, Ubell concluded:

Life is more intricate than a simple superstitious demon theory. The universe has grown big and roomy, peopled—perhaps—with other "people-like beings." The atom itself has become a busy, boiling place with uncanny laws of behavior. While the history of man has become less mythical, the story of his adaptation to his environment becomes arresting.

Of all this, one can choose to be illiterate. But in that case, one chooses narrowness of vision.61

History of Science Teaching With Implications Toward Scientific Literacy

Period from 1750 to 1920

Instruction in the sciences in this country had its real beginning in 1751, with the founding of the Philadelphia Academy by Benjamin Franklin. Franklin believed that young people should read the "histories of nature" if they intend to become merchants, so that they might better understand the commodities they sell; if they intend to become craftsmen, in order to learn how to use new materials; if they intend to enter the ministry, in order that they might understand the proofs of the existence of God. Science was also considered a good topic of conversation. He proposed that the study of science be accompanied by practice in gardening and visits to farms.

More than one hundred years later, in 1854, Thomas Huxley delivered an address on the educational value of the natural history

61Ubell, op. cit., p. 183.
sciences. One of the points he made was regarding the now so-called scientific method:

The man of science, in fact, simply uses with scrupulous exactness the methods which we all, habitually and at every moment, use carelessly; and the man of business must as much avail himself of the scientific method--must be as truly a man of science--as the veriest bookworm of us all; . . . . If, however, there be no real difference between the methods of science and those of common life, it would seem, on the face of the matter, highly improbable that there should be any difference between the methods of the different sciences; nevertheless, it is constantly taken for granted that there is a very wide difference between the Physiological and other sciences in point of method.62

A few years later, in 1869, he made an after-dinner speech at the Liverpool Philomatic Society on scientific education. He expressed viewpoints held today. Concerning the value of scientific training he said:

The introduction of scientific training into the general education of the country is a topic upon which I could not have spoken, without some more or less apologetic introduction, a few years ago. But upon this, as upon other matters, public opinion has of late undergone a rapid modification. Committees of both Houses of the Legislative have agreed that something must be done in this direction, have even thrown out timid and faltering suggestions as to what should be done; while at the opposite pole of society, committees of working men have expressed their conviction that scientific training is the one thing needful for their advancement, whether as men, or as workmen.63

Concerning the value of a knowledge of physical science he said:

Now the value of a knowledge of physical science as a means of getting on is indubitable. There are hardly any of


63 Ibid., p. 101.
our trades, except those merely huskstering ones, in which some knowledge of science may not be directly profitable to the pursurer of that education. As industry attains higher stages of its development, as its processes become more complicated and refined, and competition more keen, the sciences are dragged in, one by one, to take their share in the fray; and he who can best avail himself of their help is the man who will come out uppermost in that struggle for existence, which goes on as fiercely beneath the smooth surface of modern society as among the wild inhabitants of the woods. 64

In 1892 the Committee of Ten, under the Chairmanship of Charles W. Eliot, was appointed by the National Education Association. This committee organized conferences on nine subjects, three of which related to science. One opinion on which the members unanimously agreed was:

... that every subject which is taught at all in secondary school should be taught in the same way and to the same extent to every pupil so long as he pursues it, no matter what the probable destination may be, or at which point his education is to cease. 65

One conference felt it urgent that the study of simple natural phenomena be introduced into elementary schools and that one period a day from the first year of primary school be given to such study. It was recommended that the sciences be pursued chiefly by means of experiments and practice in the use of simple instruments for making physical measurements. Another conference recommended that botany and zoology be introduced into primary schools at the very beginning and pursued steadily, no less than two periods per week throughout the course below high school. Again the necessity for laboratory work was stressed.

64Ibid., p. 103.

The conferences on Physics, Chemistry and Astronomy, Natural History, and Geography were combined for one session when they passed a resolution that "one-fourth of the whole high school course ought to be devoted to natural science." It was thought, then as now, by many, that the secondary school course was of a very feeble and scrappy nature.

At the turn of the century, the United States had a population of 76.1 million. There were 15.4 million in the 5-13 age group; 6.1 million in the 14-17 year group. The secondary school enrollment for the school year 1899-1900 was 700,000, with the population of public high schools 519,251, and the total number of high school graduates in 1900 was 95,000. This means that only about eleven and one-half percent of the high school population was in school.

Any formal science education the greater percentage of children received at this time had to be in the primary grades. The popular course was nature study with its great proponent--Wilbur Jackman. In writing the third yearbook for the National Society for the Scientific Study of Education, Jackman said:

The study of nature ultimately resolves itself into a study of energy. The great aspects under which energy may be observed--color, form, and force--are presented to the children through an inquiry into their functions.

In nature-study as in everything else, the work must begin with what the individual has already acquired, and it should proceed from this according to the natural laws of

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66 Ibid., p. 39.

mindgrowth. The pupil's knowledge of nature, . . . has been gathered by a more or less careful observation of his surrounding landscape . . . If properly conducted, the study will lead to a fuller recognition of natural laws which are simply the statement of the sequences of phenomena, that, so far as observed, remains constant. 68

By 1915 the total enrollment in public high schools was 1,165,495. With the shift from emphasis in formal values of subject matter to increased emphasis on functional value new courses indicative of this changing character made their appearance. Biology, having first been introduced in 1907, was gaining in popularity and botany and zoology were gradually declining. General Science which came into being in 1899, also had a rapid growth. Its aim "was to bring together science from various areas into one course such that the student could gain a general understanding of science and use the content to help solve his problems." 69

In 1913, the National Education Association appointed a commission on the Reorganization of Secondary Education. In 1918, this commission published a report in which it listed the seven "cardinal principles" to serve as a guide for redirecting high school education: health, command of fundamental processes, worthy home membership, vocation, civic education, worthy use of leisure and ethical character. This document proposed that each subject field be reorganized in terms of its potential contributions to the objectives specified in the seven cardinal principles.


69 Richardson, op. cit., p. 12.
The Commission on Reorganization of Secondary Education ap­
pointed a sub-committee known as the Sub-committee on Reorganization of
Science in Secondary Schools. After carrying on its work for seven
years the committee made its report in 1920. The report urged that
sciences be organized and taught so as to contribute to the "Cardinal
Principles." Science instruction was considered valuable in realiza­
tion of six of these objectives. The report stated the specific values
of science study: (1) The development of interests, habits, and
abilities; (2) teaching useful methods of solving problems; (3) stimula­
tion; (4) information values; (5) cultural and aesthetic values. 70

The Committee held the following point of view concerning
science:

Neither in common life activities nor in research is the
artificial stratification of the sciences maintained in solv­
ing problems. Not only is science organized and tested
knowledge, which in the process of testing has become highly
classified, but true science includes the process of organiz­
ing, testing, and determining the effectiveness of knowledge. The common method of science teaching too often has been
that of presenting the so-called essentials with their defi­nitions and classifications and of subordinating or omitting
the commonplace manifestations of science in home, community,
civic, and industrial situations which make it most easily
possible for the learner to practice science. 71

In 1927, a special committee of the American Association for
the Advancement of Science prepared a report entitled "On the Place of

70 National Education Association, Reorganization of Science in
Secondary Schools, A Report of the Commission on the Reorganization of
Secondary Education, Bulletin 1920, No. 26, Bureau of Education

71 Ibid., p. 16.
Science in Education." The report emphasized a growing awareness of the importance of scientific method as an objective of instruction:

This period is distinguished from preceding ones by the fact that it is an age of applied science. Practical science has completely transformed our manner of living. On the liberal side this period is not clearly distinguished from others which have preceded it. The mass of our population is still victim of traditions, prejudice, and superstition and unmindful if not unconscious of the methods of working which scientists have developed and employed in their research to reveal truth. Neither the methods of scientific study nor the personalities of those who apply them have been objectified with sufficient clarity to make them functional in general education... It is a common charge and it cannot be denied that science teachers generally are failing to transmit to liberal education any clear understanding of the scientific methods of work and study or of the scientific attitudes.72

The Committee also commented that "A voting majority in a democracy is a serious menace unless it is an educated citizenry" and "Probably each great scientific discovery would have been voted down if its case had been left to popular vote."73

The year 1929 brought the great stock market crash and subsequent years of depression. The writings of the times do not seem to reflect the distress abroad in our land.

Delivering the Commencement Address at Boys High School, New York City in 1929, Fish spoke of the scientific spirit:

Adherence to facts, restraint and control in the use of the imagination, caution in forming conclusions—these common sense procedures constitute the method of science; add to these, courage of conviction, and you have the impelling force known as the scientific spirit... The true scientific spirit knows no national bounds. The results of its work are for all

72 American Association for the Advancement of Science, "On the Place of Science in Education," a report by the Special Committee, School Science and Mathematics, XXVIII (June, 1928), p. 661.
73 Ibid., p. 644.
humanity. The scientific spirit and its products, by bringing men of all nations into closer touch and into better understanding, is the greatest force for the prevention of war that the world has today. Science has given much of material value to men, but the message that the scientific spirit carries to humanity is of infinitely greater value—it is the message of open-mindedness—the willingness to set up new ideas and then to try them, then to question them, to alter them and finally to reject or accept them as evidence warrants. The true spirit of science brings with it integrity of thought, which means honesty; open-mindedness, which means tolerance; and action based on these two, which means justice. Honesty, tolerance and justice—all products of the scientific spirit—these three constitute the very safeguards of our nation and of civilization itself.\(^7^4\)

The American Association of University Women has long been interested in bridging the gap between the scientist and the layman. An article in the Association's Journal in January 1929 gave reasons for the vague notions people have regarding science—strange language of the scientist and the indifference of the scientists. Relative to bridging the gap in our democracy Stafford writes:

Bridging the gap between the viewpoints of scientist and layman requires much more than a translation of words and simplification of terms.

By studying the latest developments of science, the habit of scientific thinking may be acquired. This ability to distinguish between genuine scientific studies and fakes, between the man who knows and the man who pretends to know, is more important in a democracy than anywhere else.\(^7^5\)

The great philosopher, Whitehead, published a collection of his addresses under the title The Aims of Education in 1929. Many of his


statements are as relevant to science today as they were then. Concerning the problem of education:

The problem of education is to make the pupil see the wood by means of the trees.

The solution which I am urging is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum. There is only one subject-matter for education, and that is Life in all its manifestations. Instead of this single unity, we offer children—Algebra, from which nothing follows; Geometry, from which nothing follows; Science, from which nothing follows; History, from which nothing follows, a couple of Languages, never mastered; and lastly, most dreary of all, Literature, . . . Can such a list be said to represent Life, as it is known in the midst of living it?76

Concerning a scientific education:

A scientific education is primarily a training in the art of observing natural phenomena, and in the knowledge and deduction of laws concerning the sequence of such phenomena. But here, as in the case of a liberal education, we are met by the limitations imposed by shortness of time. There are many types of natural phenomena and to each type there corresponds a science with its peculiar types of thought employed in the deduction of laws. A study of science in general is impossible in education, all that can be achieved is the study of two or three allied sciences. Hence the charge of narrow specialism urged against any education which is primarily scientific. It is obvious that the charge is apt to be well-founded; and it is worth considering how, within the limits of a scientific education and to the advantage of such an education, the danger can be avoided.77

Millikan, great American physicist and Nobel Prize Winner, wrote of the place of science in the modern world:

. . . any effort to suppress or impede the growth of science, which means to the scientist merely the growth of man's understanding of his world, and hence of his ability to live wisely

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77 Ibid., p. 59.
in it, is to him an unpardonable sin, or at least not the work of an understanding mind.

If we are to be asked deliberately to shut our minds to the truth, or to be deterred by fear from searching for it, we might as well, so says the scientist, give up the effort at intelligent living altogether and go back to savagery. Furthermore, the whole history of man's age-long rise from superstition and ignorance up to his present estate seems to the scientist to be a practical demonstration of the essential soundness of this view.78

In 1930 the National Society for the Study of Education adopted a plan for a yearbook on the topic, "A Program for Science Teaching." In the report the committee gave special attention to the contributions of science to general education, the aim of which was described as life enrichment. The thirty-first yearbook reinforced the definite organization of science instruction from the first through the twelfth grades. It advocated the organization of content around broad concepts or generalizations derived from specifics.

Writing for the yearbook Powers stressed the importance of the major generalizations:

The major generalizations of science and the associated scientific attitudes are so important and so extensive in scope that the student may live with them throughout his life. Definable educational values from science teaching will have been obtained if students acquire (1) An ability to utilize the findings of science that have application in their own experience; (2) An ability to interpret the natural phenomena of their environment; and (3) An appreciation of scientific attitudes through an understanding of, and ability to use,

some of the methods of study that have been used by creative
workers in the fields of science.\textsuperscript{79}

Relative to the attitude of science toward enriched living:

The attitudes of science are those of respect for tested
truth and the methods by which it is revealed. Enriched
living is the goal toward which science is striving, and it
is the hope of science that, through tested truth, it may
help to neutralize prejudice and animosity, and reduce the
friction between individuals who are the entities of our
human social order.\textsuperscript{80}

Regarding the program of general education:

In a program of general education which is for the most
part the program of the public schools, the work of instruc-
tion will be directed toward increasing the understanding of
those principles and generalizations of science that have
character of our society and of those which have within them
potentials for influence in the future. Attainments of
such understandings are important, if not in large measure
essential, for an understanding of our social life and for
effective participation in it.\textsuperscript{81}

The famous educator, Dewey, showed concern over the fact that
the mass of people did not have the scientific spirit and that those
responsible for its development must be concerned:

The field of education is immense and it has hardly been
touched by the application of science. There are, indeed,
courses in science installed in high schools and colleges.
... But the scientific attitude, the will to use scientific
method and the equipment necessary to put the will into effect,
is still, speaking for the mass of people, inchoate and
unformed. The obligations incumbent upon science cannot be
met until its representatives ... devote even more energy
than was spent in getting a place for science in the curriculum

\textsuperscript{79}S. Ralph Powers, "The Plan of the Public Schools and the Program
of Science Teaching," \textit{A Program for Teaching Science}, Thirty-First
Yearbook, Part I, National Society for the Study of Education

\textsuperscript{80}S. Ralph Powers, "What are Some of the Contributions of Science
to Liberal Education," \textit{ibid.}, p. 27.

\textsuperscript{81}\textit{Ibid.}, p. 33.
to seeing to it that the sciences which are taught are themselves more concerned about creating a certain mental attitude than they are about purveying a fixed body of information, or about preparing a small number of persons for the further specialized pursuit of some particular science. 82

Wood projects science into the future for the boys and girls who are going out into the work-a-day world:

What, then, shall be the science of tomorrow? Few boys and girls of our secondary schools will enter the fields of pure and applied science through the doors of the technical schools. Most of them will step straight out into the work-a-day world to fight the battle of existence. What kind of science should be taught these boys and girls? . . . Is it the kind that inspired Galileo, Lister, and Pasteur and sent them out as apostles of truth and right living? If this is not the science they are getting, they do not get what they ought to have—a science which should develop right thinking, a wholesome attitude to the problems, and a full appreciation of the eternal verities of life . . . These sciences should open the eyes of our boys and girls to the wonders and mysteries of nature, reveal to them the romance of the commonplace and set before them ideals of truth and discipline as guides throughout life. 83

Karl Compton gives justification for science in schools on the basis for the need to think and act rationally:

In these days of complex problems and of increasing tendency to emotional group or mob action, it is more than ever necessary that our youth be trained to think and act rationally. Science is the best possible training for developing this capacity. Therefore, I believe that it is highly significant that science is now not a secret cult, but a matter of universal interest and concern. I, therefore, add this argument to the more common arguments, based on cultural and practical value, as justification for increased emphasis on science in the programs of our schools and colleges. 84


In 1932 the Progressive Education Association established a Commission on the Secondary School Curriculum. The Commission established a series of committees in various areas of instruction in secondary schools. The Committee on the Function of Science in General Education prepared a report entitled *Science in General Education*. The purpose of the report was to orient science teaching to broad areas of living characterized as (1) personal living, (2) immediate personal-social relationships, (3) social-civic relationships, (4) economic relationships. The report identifies the personal characteristics essential to democratic living which the science teacher should help develop: social sensitivity, tolerance, cooperativeness, disposition and ability to use reflective thinking in the solution of problems, creativeness, self-direction, esthetic appreciation.\(^85\)

As the war clouds gathered, people became more and more inclined to conclude that science was a menace and a threat to the future of civilizations. All the ills of the world were laid at the feet of the scientists. Many writers upheld the rightful place of science. Moulton wrote of the scientific spirit:

> What we are really interested in is the scientific spirit which is an attitude of mind . . . The objective, openminded, scientific outlook need not, of course, be restricted to consideration of natural phenomena; it may and should pervade all other realms of investigation. Nor is there any single methodology or technique of scientific inquiry. There are as many different types of observation, experimentation, and analysis as there are divisions of science; . . . It should also be observed here that the conception of science as a body of exact

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knowledge . . . has in recent times undergone profound modification.

A state of flux in scientific thought is disturbing to some minds, to others it only serves to open anew, and more widely the avenues of intellectual adventure and to stimulate the quest for yet more knowledge, as well as for greater wisdom in its use. 86

Johnson spoke of the social effects of scientific discoveries and inventions:

Scientific discoveries and inventions have been so closely linked to the rise and decline of nations and events in history that one wonders why histories have not been written with all the generals left out and the important scientists and inventors put in their places. The far-flung social effects of these people have certainly been greater. 87

Bruce writes concerning the importance of a public understanding of science to deal with world conditions:

Attempts to deal with these (world) conditions in a democratic way can meet with but little success with a public that is untrained in the truth seeking method of science (the handmaiden of democracy). Likewise it can meet with little success in a public unaware of the basic interdependencies that actuate the world and a public that lacks an understanding of the forces that the method of science has revealed and rendered available to us.

Science education, seeks, therefore, to assist in producing a generation of lay conservationists or lay directors of the power which science has made available; a generation with at least a layman's insight into the meaning of the forces that are constantly transforming and disturbing our social and economic life so that democracy may cease to be frustrated through selfish and unwise use of that power. 88


Rosene recognized the values of science as a means of education:

We must recognize the value of science as a means of education . . . The growing child needs to develop increasingly greater understanding of fundamental scientific facts and principles concerning himself and his environment; he needs to develop scientific attitudes and the use of the scientific method to the end that it may motivate and determine his conduct and behavior in an intelligent manner. The mass of knowledge-consumers and users need enough insight into new knowledge that they may use and appreciate its significance; not only the material benefits from modern knowledge, but the scientist's ways of working need to be more fully understood and more widely used in everyday life.\(^9\)

Relative to the need of educating for the world of the future Rakestraw spoke thus:

We can only guess at the nature of the situations with which the students of today will be faced at the time when they must make use of their present training. We must therefore be careful to conserve the more enduring elements of scientific education in our present curriculums. This is not necessarily inconsistent with the movement toward integration and socialization of science education, but we must be careful to avoid centering our attention too much upon the world picture as it exists today.

As I understand the movement toward socialization and integration, its aim is, among others, to develop a thorough appreciation of the way in which science has contributed to make our modern everyday life what it is . . . But it is essential to be able to view science as incomplete and continually and inevitably changing. This is a viewpoint seldom appreciated by the layman, who often feels that the readiness of science to "change its mind" is a sign of weakness rather than of strength . . . Too much popular science literature often results in an unfortunate gullibility. Science education should engender critical thinking not only about the world in general, but about the method and content of science itself.\(^10\)


The reports of the Educational Policies Commission issued over a period of several years, dealt with general education, but had important implications for the teaching of science. The books call attention to the fact that education must change with changing social conditions. The underlying thought embodied in these reports is that American education should satisfy the needs of a democratic way of life. The purpose of education should be to help boys and girls develop themselves in four areas: Self-Realization, Human Relationship, Economic Efficiency, Civic Responsibility.

This type of thinking dominated the publications of the National Committee on Science Teaching of the American Council of Science Teachers. The title of one of four reports made by this group was *Science Teaching for Better Living*, published in 1942. Concerning its purpose the subcommittee on philosophy stated:

> Whatever contribution the reports of the National Committee on Science Teaching may make, its work will continue recent trends from the subject-centered science teaching of the past toward the person-centered social type of approach with a continuous program adequate to the needs of young people.  

The report dealt with the functional aspect of science teaching and set up the outcomes as follows:

> A vital function of science teaching is to provide people with sufficient understanding of science and its importance to enable those not actually engaged in scientific pursuits to cooperate rationally with those who are and to use intelligently the benefits of science in everyday living. A second

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purpose is to give people sufficient understanding of the scientific principles in solving problems of personal and social significance.92

A University Committee on the objectives of a General Education in a Free Society was appointed at Harvard University in 1943. The committee considered the problem of general education in both the school and the college. The report of the committee was made in 1945. Regarding science instruction in general education the committee reported:

Science instruction in general education should be characterized mainly by broad integrative elements—the comparison of scientific with other modes of thought, the comparison and contrast of the individual sciences with one another, the relations of science with its own past and with general human history, and of science with problems of human society. These are the areas in which science can make a lasting contribution to the general education of all students. Unfortunately, these areas are slighted most often in modern teaching.93

1946 to Present

Following World War II many articles appeared regarding the future of the world with atomic energy available. There was a feeling that education must keep pace and close up the social lag of civilization behind science. The Forty-sixth Yearbook of the National Society for the Study of Education entitled Science Education in American Schools envisioned a broader, more functional science program. The general purpose of the Yearbook was to present a challenging and workable philosophy which would assist and encourage science teachers to make a contribution to the welfare of society.

92American Council of Science Teachers, op. cit., p. 31.

The importance of the relationship of science to society was expressed by writers of the time among whom was Hovde:

In a scientific and democratic nation, the nature of the scientific education provided in the schools is of prime importance. I am not worried or concerned with training of professional scientists and engineers . . . More difficult, yet equally important is the nature and kind of scientific training we provide for all other citizens to enable them to understand the kind of society of which they are a part, to enable them to use rational methods in the conduct of their personal affairs.94

Concerning science teaching in the atomic age Novikoff wrote of general aims:

The average citizen has always wanted to learn and to understand . . . These men and women do not wish to become science specialists. Neither do most of our school children and the majority of college students. Our general aims in teaching them science are basically the same, whether they be 12 years old, 15, 19, or 49. These aims can be simply stated: to help the individual understand phenomena in the world about him, and to teach the social relations of science so that the individual understands the role of science in modern society and can act intelligently on scientific matters.

Genuine science teaching should emphasize neither rote learning of fact upon fact, nor the mastery of certain techniques; it should stress basic principles and social implications of the subject. It should help our students . . . to become human beings. We want them to be world citizens who understand the essential one-ness of all mankind, and we want them to act upon that understanding—to help eliminate from society all practices based upon prejudice.95

Powers was of the opinion that teachers should be aware of the major contributions science makes to general education:

The goal of science teaching in general education is to help young people to make science as much a part of their lives


as it is of the society in which they grow up, work, raise their families, and play their parts as citizens. In working toward this goal, teachers and curriculum workers will wish to know the major contributions that studies in science have made and are making to personal and social education. Some of the contributions may be summarized under the following major headings:

1. Understanding of the world and man and competence to use this understanding to correct the inconsistencies and naive notions that may become obvious in the thinking of young people as they mature . . .

2. Understanding of the processes and the potentialities of technology and competency to use this understanding in directing the utilization of resources.

3. Competence in using the elements of scientific method that have general application in dealing with personal and social problems.

4. Comprehension of the effects of infiltration of ideas and concepts, scientific in their origins, upon man's conceptions of good and bad.  

In reply to the question, "What should a student gain from science that will make him a happier, better-informed citizen of his community?" Garrett's answers run as follows:

1. A student should have a knowledge of the evolutionary processes that have altered the organic and inorganic world over the eras of time . . .

2. A student should have a knowledge of the organic and physical world around him. This is almost mandatory for its basic value as well as for its philosophical impact . . .

3. A student should have an awareness of the impact of the new scientific developments upon social, economic, political, and religious problems . . .

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4. The student should have an experience in the way that science solves problems.

5. A student should have training in the use of the scientific method; and essentially, this is training to think.

6. A student should have a perspective of what can be expected of science in the future.

7. The student should be acquainted with some of the world's great scientific ideas.

8. The student should have a conviction that science is power.

Palmer and Stidham wrote of the increasing necessity for people to know and understand certain fundamental scientific concepts in order to participate in a world society:

Continuous developments in science and their effect on social change confront the individual with more and more problems. Science teaching, therefore, should not be confined to pure science, but must include the vast social implications which result from scientific advancements. The individuals whom we teach must be conditioned to adjust themselves now to these forces and develop preparation for further adjustments during maturity.

The content of science instruction is undergoing a rather thorough reorganization in an effort to develop a more functional understanding of facts, principles, concepts, and growth in the use of scientific method and attitude. There is less emphasis on systematic science per se and greater emphasis upon practical applications and social implications for daily living.

Cohen gave the purpose of teaching science from the point of view of General Education:

From the point of view of General Education the purpose

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of teaching science is twofold: social and intellectual. This reflects the dual role played by science in our civilization. Science has come to occupy a foremost place among the factors affecting our health, wealth and security and producing social change; whether we like it or not, the promotion of science must be a primary concern for all active citizens in a free society. 99

In his guest editorial for *The Science Teacher*, Stollberg wrote of the relationship between science and people:

Science affects people. Science involves people. And in a very real sense, science is people. Science can be defined as a pattern of thinking—a manner of behaving. In this sense, science is not really a subject, but rather an activity. The so-called "content of science" then takes its place as a product of scientific activity. If we accept science as being basically a mode of behavior, then learning science becomes a process of adopting this behavior. This means meeting problem situations effectively, deriving true pleasure from the appreciation of natural and man-made scientific processes and products, being active in the science-related aspects of one's socio-civic responsibilities. From this point of view, the "subject-matter" of science becomes less of an end in itself, and more a means to other ends. 100

During the decade following World War II, American esteem for science and scientists diminished despite the rising realization of the importance of technology to the national economy and national military position. The attitude of the citizenry is reflected in the answers given by youth in the Purdue Opinion Pole No. 45, *Physical Science Aptitude and Attitude Toward Occupations*. The Purdue Physical Science Test and an attitude questionnaire were administered to a nationwide sample of school children. 101


sample of high school students in April of 1956. The questions phrased in stereotypes of scientists yield results which are hardly encouraging:

14% of the students think there is something evil about scientists.

30% believe that one can't raise a normal family and become a scientist.

45% think their school background is too poor to permit them to choose science as a career.

9% believe that one can't be a scientist and be honest.

25% think scientists as a group are more than a little bit "odd."

28% don't believe scientists have time to enjoy life.

35% believe that it is necessary to be a genius to become a good scientist.

27% think that scientists are willing to sacrifice the welfare of others to further their own interests. 101

The launching of the first Sputnik by the Russians brought to the American people an awareness of the crisis in science education. Our rapid stride into a new technological era emphasized the need for an ample supply of high calibre scientists, mathematicians, and engineers. The reaction to Sputnik was an indictment of the American high school system and an awareness of facts about the weaknesses in our science education program. Bolton wrote of the unpopularity of science:

Of course it is shocking that only about one-fourth of all our high school students study physics, only a third take chemistry or geometry ... Science is unpopular partly because of cultural pressures, because of our heritage of

anti-intellectualism, which makes young people suspect that a scientist is a queer duck, not quite human and probably not very happy. Science also fails to attract many students for the simple reason that they have had little opportunity to become interested in the subject.102

The importance of a degree of scientific knowledge adequate to meet the goal of good citizenship began to be recognized. Furnas said:

As I view it, the scientific segment of a proper liberal education which should be pursued in secondary schools should encompass knowledge of some essential, basic facts; a comprehension of the significance and impact of science; a real grasp of the relation between cause and effect; a respect for orderly thinking; and the acquisition of the habit of being logical, when at all possible. It would appear that some such base as this is essential for the preparation for living in the latter half of the twentieth century.103

Still stressed the importance of reforms in our educational system if we are to maintain a leading position in science and technology:

We know our educational system has not been emphasizing science. For several years before Sputnik, we had a spate of books and articles showing that our present educational system was failing to produce college students who could read and write as well as their parents did. In our present situation, we must not ignore that evidence. Our educational program needs to be overhauled so it will produce both scientists and humanists who are "broadly educated." No humanist can claim he is "broadly educated" if he does not know the fundamentals of physics, chemistry, and biology. There is no contradiction between being "broadly educated" and being scientifically educated. Science is not opposed to humanistic values. What is inhuman about studying nature? Science is a humanistic endeavor.104

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In 1959, several volumes were published for the purpose of giving the viewpoints of educators and critics regarding science education in our crucial times. Contributors to *Education in the Age of Science* had the following to say regarding aims of science education:

Blanshard:

Above all things in the world we in America need an educated citizenry. That means, I have suggested, a citizenry with a disciplined sense of values and a disciplined power to think . . . What they (students) need is introductions to science taught by dedicated men who will give them some conception of the achievements, the importance, and the attractions of the specific branches of inquiry, and at the same time awake in those of them who are born to the purple the excitement of a high calling. The thing is not impossible because it has been done.\(^{105}\)

Nagel:

Whatever be the urgencies of foreign or domestic policies, we must not institute a system of science education whose primary aim is to prepare students for careers in applied science. We must aim also to develop capacities which will contribute to the pursuit of the disinterested love of learning along the entire front. But above all, somewhere in their education we must equip the future laymen in science, as well as the future engineers and the future pure scientists, with mature conceptions concerning the nature of the scientific enterprise and the logic of scientific inquiry.\(^{106}\)

Writers for *The Scientific Revolution: Challenge and Promise* express views concerning science education:

Rabinowitch:

What we badly need, however—and in my belief can achieve—is not only to satisfy the limited requirement of holding our own in the technological race, but also the more ambitious—and in the long run decisive—aim: to educate a generation of Americans who will have, in addition to adequate training in military science, a general understanding of what science

\(^{105}\) Brand Blanchard, *op. cit.*, p. xviii.

\(^{106}\) Nagel, *op. cit.*, p. 203.
is about, how it operates, and what it implies for the nations of the world, now and in the foreseeable future. These generations will have to assimilate not only some of the subject matter of science, but also some of its spirit. They will have to learn how to approach, in this spirit, the various grave problems with which the scientific age will confront them. They will have to be more open-minded, more objective, more ready to revise traditional attitudes and inherited laws, in the light of new experience than their ancestors. They will have to resist prejudice and acquire a deep-ingrained respect for facts. They must know how to live in a changing, dynamic world. Without losing roots in the past and contact with the present, they will have to learn to look with open eyes into the future.\footnote{Zacharias, \textit{op. cit.}, p. 137.}

Zacharias:

We have to create a system of scientific education that will make physics as exciting to a large part of the public as a Yankee-Braves series and far more exciting. This calls for revision of our teaching methods in the secondary schools. \ldots Until the public has been educated to understand at least what science is trying to do--and in the process succumbs to some of the fascinations of science--the scientist will not be able to count on the public support he needs.\footnote{Eugene Rabinowitch, "Decision Making in the Scientific Age," \textit{The Scientific Revolution: Challenge and Promise}, ed. Gerald W. Elbers and Paul Duncan (Washington: Public Affairs Press, 1959), pp. 27-28.}

The Fifty-ninth yearbook of the National Society for Study of Education entitled \textit{Rethinking Science Education}, regarded science as an interwoven part of the fabric of our culture. The aim of science education should now be directed toward a change in behavior in the individual so that the results will become a part of him and make him one who understands and speaks for science and cherishes scientific attitude. The nature of science should be away from facts toward more meaning in real life.
Writing of science in our lives Calder said:

Science is not something which is just taught in school to those who choose to study it. It is something which alters the nature of education itself because it is the factor which is changing the world and the conditions of society for which students are being trained . . . All students ought to be taught what science means, what its thought processes are, and what its effects are likely to be.  

Baum states four objectives we could set for ourselves in science education for the citizen:

First of all, it behooves every educated citizen who will live in the scientific culture to know a modest amount of science.

Second, it is of the utmost importance for the citizen to understand clearly the distinction between science and technology, if for no other reason that it is technology which is much more a part of our daily lives and, therefore, tends to play a dominant role in our thinking.

Third, the study of science should serve to equip our students with an understanding of the scientific method as an approach to problem solving. One thing about the scientific method is indisputable: namely, it works.

Fourth. . . . the study of science should make our students aware of some of its limitations, lest they fall into the trap of believing that it has all the answers mankind is searching for. Perhaps the most important limitation lies in the fact that science makes no value judgements.

Summary

From the founding of Benjamin Franklin's Academy in 1751, science has had a part in the public school curriculum. The first hundred years of science teaching in the public high school saw such

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courses as natural philosophy, astronomy, chemistry, geology, and botany introduced into the curriculum. As the number of high schools began to rise rapidly toward the close of the nineteenth century, there was pressure toward standardization and many short separate science courses became the vogue of the time.

The Report of the Committee of Ten stabilized science offerings and knocked out shorter courses. The Science Committee of the Commission on the Reorganization of Secondary Education proposed that a continuous science program be inaugurated. It gave encouragement for science instruction toward the achievement of larger social goals. The aim of the Thirty-first Yearbook of the National Society for the Study of Education, A Program for Teaching Science, had considerable influence upon science instruction at all levels. It had as its aim life enrichment and stressed the part science could play in a liberal education.

The Forty-sixth Yearbook of the National Society for the Study of Education, Science Education in America, recognized science as a pillar of general education and stressed the importance of science taught for its functional value. The ideas and aims of these various reports were reflected in the writings of the times.

Since Sputnik, the writings of science educators have stressed the need for a citizenry literate in science if we are to have democratic ideas continue to prevail in the United States. Teachers and educators have been asked to fulfill an urgent national need--that of supplying technical manpower for these ages. This has led to new curriculums for education in science with emphasis on modern concepts and theories. Writers of the times generally are in agreement that our
quality and quantity of science instruction must be improved if we are to meet the challenges of today's world.
CHAPTER III

DESIGN OF THE STUDY

The general purpose of the investigation was to make a comparative study of the scientific literacy of high school seniors in urban, suburban, and rural schools in Kentucky. The following hypotheses were tested:

1. Scientific literacy depends upon mental ability.

2. Students from rural areas are as scientifically literate as those from urban or suburban areas.

3. There is a relationship between the number of science courses completed in high school and scientific literacy.

4. The environment contributes to scientific literacy.

5. High School senior boys are more scientifically literate than high school senior girls.

6. The size of the graduating class is a contributing factor to scientific literacy.

Selection of the Sample

The population selected for the study was limited to public high schools in Kentucky, chosen so as to be representative of the entire state with respect to urban, suburban, and rural schools. Only seniors expected to graduate in the spring of 1964 were included in the sample.

A letter of invitation was prepared in February 1964 and sent to twenty-four superintendents in the state. Fifteen school systems
agreed to participate, giving a sample of at least thirty seniors from each of five urban, five suburban, and five rural schools. The total population tested was 471.

The Data-Gathering Instruments

In view of the purposes of the study and the hypotheses to be tested, the instruments for gathering data consisted of:

I. Personal Data Sheet


III. Sequential Tests of Educational Progress, Science Form 2A, Educational Testing Service.


VI. Personal Inventory on Science, Adapted from a Mathematics Inventory for Measuring Attitudes, Robert Neill, Teachers College, Columbia University.

VII. A Revised Occupational Scale for Rating Socio-Economic Class, by Martin Hamburger, Teachers College, Columbia University.

A brief description of each of the sources of data is presented in the sections that follow.

The personal data section

Copies of the personal data sheet and the Personal Inventory on Science are presented in Appendix A. Personal data provided a comprehensive view of the sample. These data were procured for determining
the environment of the students and their background of science in high school.

The standardized tests

The Iowa Tests of Educational Development, Test 6, Interpretation—Natural Sciences, is a test of the student's ability to interpret and evaluate representative reading selections from textbooks and references used in the natural sciences, from scientific articles in newspapers and periodicals, and from relatively non-technical scientific literature in general. The selections used are taken as examples of materials commonly read by high school pupils rather than as representative of the best literary efforts in the field. Specific abilities measured in the test are:

1. Ability to understand what is stated in a paragraph.
2. Ability to understand what is implied in a selection.
3. Ability to evaluate a selection critically.

Percentile norms for student scores were based on the April 1957 national standardization of the Iowa Tests of Educational Development. Percentile norms for school average scores were based on the averages for 254 school systems which participated in the national standardization program.

Sequential Tests of Educational Progress, Science Form 2A is for the "typical" students in grades ten through twelve. The STEP series is a special kind of achievement test growing out of the demands of educators for instruments measuring the broad outcomes of general education. The test in science measures ability to identify and define
scientific problems, suggest or eliminate hypotheses, select procedures for testing hypotheses, interpret data and draw conclusions. Questions are included in biology, chemistry, physics, meteorology, astronomy, and geology. The tests include items which cut across the conventional dividing lines between the sciences and emphasize practical applications of science.

Ways in which results from groups can be used include:

1. Comparing abilities of students in one group with those of other or larger groups.

2. Conducting educational research, where as an independent measure of scientific abilities present in a group is a necessary experimental "control."

Individual score norms were based upon the scores of 767 seniors from 41 different schools.

Test on Understanding Science, Form W, is an instrument to measure high school students' understandings of science and scientists. The authors maintain that an understanding of the scientific enterprise and scientists can be described in terms of definite components—which have been drawn from analyses of scientists at work, from the history and philosophy of science, from biographies of scientists, from the writings of scientists and commentators—and that the sum of these components provides a reasonably valid picture of the nature of science and scientists. In the analysis of the nature of science and scientists, several components were designated as "themes" and these themes were grouped into three major areas:

Area I - Understandings about the scientific enterprise.

Area II - Understandings about scientists.
Area III - Understandings about the methods and aims of science.

Although this test is still an experimental test, extensive standardization operations have been conducted. Reliability was determined by applying the Kuder-Richardson Formula 20 to Form X test data from 2,535 students. The reliability for the total score yielded a standard error of measurement of 3.49. Several consultants were used to provide a check upon the content validity of TOUS and the validity of the themes upon which TOUS is based. Percentile ranks for high school students in grade 12 were based on a nationwide sample of 742 students.

The Otis Quick-Scoring Mental Ability Test was used to obtain a measure of the students' mental ability. The norms for Forms Em were based on a comparison of scores on Gamma Em and Fm with Am, by means of an experiment in which 1,176 pupils in Grades 10-12 took part. The reliability coefficient for Form Em corrected by the Spearman-Brown Formula for the twelfth grade is 0.92. Norms are available.

The attitude scale

Hypothesizing that attitudes toward science have an effect on achievement in this field, it was necessary to have an instrument for measuring attitudes. An instrument was developed based on an instrument for measuring mathematical attitudes from the Horace Mann-Lincoln Institute. Items were rewritten and additional statements pertinent to science were added. Fifty-eight statements were developed to which
students might show a favorable, unfavorable, or neutral feeling. The following criteria were used by the investigator in editing the statements:

1. Statements that were short.
2. Statements that were simple, clear, and direct.
3. Avoidance of words that might not be understood by those who were responding to the completed scale.
4. Statements referring to the present.
5. Statements with only one complete thought.
6. Statements with only one interpretation.
7. Statements relevant to the attitudes under consideration.

A sample group of 203 seniors from Southern High School who were not directly connected with the study was used to develop an item analysis. Items which bore indices of discrimination of 0.2 or higher were used in the final instrument. Item analysis reduced the original fifty-eight statements to forty-six statements with the following number of items in each category:

- **Category I** Impact of Science on Society 8 items
- **Category II** Characteristics of a Scientist 6 items
- **Category III** Science as a career 8 items
- **Category IV** Nature of Science 8 items
- **Category V** Self Appraisal of Scientific Ability and Interest 16 items

The instrument was so designed that half the statements in each category appeared in the first or second half of the test. The coefficient of reliability was then computed using the Spearman-Brown
Formula (split-half coefficient of reliability). The split half coefficient of correlation was first computed according to the formula:

\[ r = \frac{N \sum XY - \sum X \sum Y}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}} \]

The reliability coefficient was computed by the formula:

\[ R = \frac{2r_{xy}}{1 + r_{xy}} \]

The index of discrimination and a summary of data are to be found in Appendix B.

The occupational scale

The Revised Occupational Scale for Rating Socio-Economic Class by Martin Hamburger makes use of the dimensions of income, responsibility and prestige. It attempts to use up-to-date census and income data and precise occupational definitions. The scale may be termed a class-status scale, that is, economic position and rewards as well as social prestige are considered the chief links between occupational and socioeconomic class.

Handling the Data

Collecting the data

Once the data-gathering instruments were assembled, arrangements were made with the participating schools for the testing. The investigator administered the tests to a random sample of students
selected by the principal in each school. The testing program required approximately four hours.

Processing the data

To facilitate processing, the personal information for each respondent was coded. This information, along with all tests scores was then recorded on data sheets. IBM cards were punched in accordance with the information on the data sheets.

The data on the IBM cards were processed by the IBM electronic computer, Model 7094 in the Statistics Laboratory at The Ohio State University. The results were entered upon record sheets for purposes of making analyses.
CHAPTER IV

ANALYSIS OF DATA

Analysis of Variance

In order to determine the significance of the difference between the three groups involved in the study, an analysis of variance on the four dependent variables was computed. Table 2 shows the distribution of Test on Understanding Science, Form W, scores of the sample from urban, suburban, and rural areas.

TABLE 2

DISTRIBUTION OF SCORES FROM TESTS ON UNDERSTANDING SCIENCE, FORM W, OF URBAN, SUBURBAN, AND RURAL AREAS

<table>
<thead>
<tr>
<th>Range and Scores</th>
<th>TYPE OF SCHOOL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
</tr>
<tr>
<td>51-49</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>48-46</td>
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<td>45-43</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>42-40</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>39-37</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>36-34</td>
<td>27</td>
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<td>33-31</td>
<td>34</td>
<td>23</td>
</tr>
<tr>
<td>30-28</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>27-25</td>
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<td>31</td>
</tr>
<tr>
<td>24-22</td>
<td>10</td>
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<td>21-19</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>18-16</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>15-13</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>12-10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
</tr>
</tbody>
</table>
Table 3 is the analysis of variance for the data from Table 2.

**TABLE 3**

**ANALYSIS OF VARIANCE OF TEST ON UNDERSTANDING SCIENCE SCORES OF URBAN, SUBURBAN, AND RURAL AREAS**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Estimated Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas</td>
<td>2</td>
<td>4,121</td>
<td>2,060.50</td>
<td>--</td>
</tr>
<tr>
<td>Within</td>
<td>467</td>
<td>29,966</td>
<td>64.03</td>
<td>32.18**</td>
</tr>
<tr>
<td>Total</td>
<td>470</td>
<td>34,087</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Significant at the 1% level.**

The F value of 32.18 is significant with 2 and 468 degrees of freedom.

Table 4 shows the distribution of Iowa Tests of Educational Development, Test, scores of the sample. Table 5 is the analysis of variance for the data from Table 4. The F value of 74.86 is significant with 2 and 468 degrees of freedom.

Table 6 shows the distribution of Science Inventory scores of the sample. Table 7 is the analysis of variance for the data from Table 6. The F value of 22.88 is significant with 2 and 468 degrees of freedom.

Table 8 is the distribution of Sequential Tests of Educational Progress, Science scores for the sample. Table 9 is the analysis of variance for the data from Table 8. The F value of 17.90 is significant with 2 and 468 degrees of freedom.

The significant F values on all the tests which comprise the dependent variable of the investigation indicate that individual
TABLE 4

DISTRIBUTION OF SCORES FROM IOWA TESTS OF EDUCATIONAL DEVELOPMENT, TEST 6, INTERPRETATION—NATURAL SCIENCES

<table>
<thead>
<tr>
<th>Range and Scores</th>
<th>TYPE OF SCHOOL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
</tr>
<tr>
<td>51-49</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>48-46</td>
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<td>45-43</td>
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<td>39-37</td>
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<td>33-31</td>
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<td>30-28</td>
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<td>18-16</td>
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<td>15-13</td>
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<td>11</td>
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<td>12-10</td>
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<td>9-7</td>
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<tr>
<td>3-1</td>
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<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
</tr>
</tbody>
</table>

TABLE 5

ANALYSIS OF VARIANCE OF IOWA TESTS OF EDUCATIONAL DEVELOPMENT, TEST 6 SCORES OF URBAN, SUBURBAN, AND RURAL AREAS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Estimated Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas</td>
<td>2</td>
<td>9,234</td>
<td>4,617</td>
<td>--</td>
</tr>
<tr>
<td>Within</td>
<td>468</td>
<td>28,863</td>
<td>61.67</td>
<td>74.86**</td>
</tr>
<tr>
<td>Total</td>
<td>470</td>
<td>38,097</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Significant at the 1% level.
### TABLE 6

DISTRIBUTION OF SCORES FROM SCIENCE INVENTORY OF URBAN, SUBURBAN, AND RURAL AREAS

<table>
<thead>
<tr>
<th>Range and Scores</th>
<th>TYPE OF SCHOOL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
</tr>
<tr>
<td>43-41</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>40-38</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>37-35</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>34-32</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>31-29</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>28-26</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>25-23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>22-20</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>19-17</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>16-14</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>13-11</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>10-8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7-5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
</tr>
</tbody>
</table>

### TABLE 7

ANALYSIS OF VARIANCE OF SCIENCE INVENTORY SCORES OF URBAN, SUBURBAN, AND RURAL AREAS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Estimated Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas</td>
<td>2</td>
<td>2,408</td>
<td>1,204</td>
<td>--</td>
</tr>
<tr>
<td>Within</td>
<td>468</td>
<td>24,633</td>
<td>52.63</td>
<td>22.88**</td>
</tr>
<tr>
<td>Total</td>
<td>470</td>
<td>27,041</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Significant at the 1% level.
### TABLE 8
DISTRIBUTION OF SCORES FROM SEQUENTIAL TESTS OF EDUCATIONAL PROGRESS, SCIENCE, FORM 2A

<table>
<thead>
<tr>
<th>Range and Scores</th>
<th>Type of School</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
</tr>
<tr>
<td>53-51</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>50-48</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>47-45</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>44-42</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>41-39</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>38-36</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>35-33</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>32-30</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>29-27</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>26-24</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>23-21</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>20-18</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>17-15</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>14-12</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>11-9</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>158</td>
<td>154</td>
</tr>
</tbody>
</table>

### TABLE 9
ANALYSIS OF VARIANCE OF SEQUENTIAL TEST OF EDUCATIONAL PROGRESS, SCIENCE, FORM 2A SCORES OF URBAN, SUBURBAN, AND RURAL AREAS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Estimated Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas</td>
<td>2</td>
<td>2,284</td>
<td>1,142.0</td>
<td>--</td>
</tr>
<tr>
<td>Within</td>
<td>468</td>
<td>29,850</td>
<td>63.78</td>
<td>17.90**</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>470</td>
<td>32,134</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Significant at the 1% level.
differences among the members within the groups influenced the criterion. Some of the characteristics hypothesized to affect test scores were: sex, number of science courses, socioeconomic status of parents, intelligence, size of graduating class, and type of school. The sex distribution of students participating in the study is shown in Table 10.

**TABLE 10**

SEX DISTRIBUTION OF STUDENTS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th>Sex</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>75</td>
<td>81</td>
<td>92</td>
<td>248</td>
</tr>
<tr>
<td>Girls</td>
<td>83</td>
<td>73</td>
<td>67</td>
<td>223</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
</tr>
</tbody>
</table>

Table 11 is a tabulation of the number of science courses completed by the participants.

**TABLE 11**

NUMBER OF SCIENCE COURSES COMPLETED IN GRADES 9-12 BY STUDENTS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th>Number of Science Courses</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>66</td>
<td>22</td>
<td>30</td>
<td>118</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>43</td>
<td>36</td>
<td>114</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>72</td>
<td>77</td>
<td>195</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>8</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
</tr>
</tbody>
</table>
Table 12 gives the socioeconomic status of parents as determined by *A Revised Occupational Scale for Rating Socio-Economic Class* by Martin Hamburger.

**TABLE 12**

SOCIOECONOMIC STATUS OF PARENTS

<table>
<thead>
<tr>
<th>Level</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>7</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>13</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>37</td>
<td>36</td>
<td>14</td>
<td>87</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
<td>54</td>
<td>73</td>
<td>164</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
<td>39</td>
<td>39</td>
<td>106</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>2</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td><strong>158</strong></td>
<td>154</td>
<td>159</td>
<td><strong>471</strong></td>
</tr>
</tbody>
</table>

*Levels determined by *A Revised Occupational Scale for Rating Socio-Economic Class*, May, 1957, Martin Hamburger, Teachers College, Columbia University.*

Table 13 shows the distribution of the graduating classes by size.

**TABLE 13**

SIZE OF GRADUATING CLASS OF STUDENTS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th>Rank</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>30</td>
<td>0</td>
<td>128</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>124</td>
<td>31</td>
<td>185</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>0</td>
<td>128</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td><strong>158</strong></td>
<td><strong>154</strong></td>
<td><strong>159</strong></td>
<td><strong>471</strong></td>
</tr>
</tbody>
</table>

*Rank 1--size of graduating class 261 and above; rank 2--size of graduating class 131-260; rank 3--size of graduating class 130 and below.*
The intelligence range as determined by the Otis Test of Mental Maturity, Gamma, Form Em is given in Table 14.

**TABLE 14**

RANGE OF I.Q. AS DETERMINED BY OTIS TEST OF MENTAL MATURITY, GAMMA; FORM EM

<table>
<thead>
<tr>
<th>Interval (I.Q.)</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>140-136</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>135-131</td>
<td>19</td>
<td>1</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>130-126</td>
<td>24</td>
<td>6</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>125-121</td>
<td>29</td>
<td>13</td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td>120-116</td>
<td>24</td>
<td>19</td>
<td>5</td>
<td>48</td>
</tr>
<tr>
<td>115-111</td>
<td>21</td>
<td>24</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>110-106</td>
<td>15</td>
<td>31</td>
<td>18</td>
<td>64</td>
</tr>
<tr>
<td>105-101</td>
<td>11</td>
<td>20</td>
<td>27</td>
<td>58</td>
</tr>
<tr>
<td>100- 96</td>
<td>5</td>
<td>11</td>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>95- 91</td>
<td>6</td>
<td>13</td>
<td>27</td>
<td>46</td>
</tr>
<tr>
<td>90- 86</td>
<td>2</td>
<td>9</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>85- 81</td>
<td>1</td>
<td>5</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>80- 76</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>75- 71</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Totals</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
</tr>
</tbody>
</table>

The urban, suburban, and rural groups comprising this study were to be compared on their responses to a specific criterion. The individual difference among the members within the groups are suspected to influence the criterion; therefore, an attempt must be made to control these individual differences. To provide the investigator with a means of attaining a measure of control of individual differences, analysis of covariance was now used in treatment of the data from the criterion.
Analysis of Covariance

Scientific literacy as measured by Test on Understanding Science, Form W; Iowa Tests of Educational Development, Test 6; Sequential Tests of Educational Progress, Science Form 2A; and the Science Inventory was considered as a dependent variable in an analysis of covariance model against the independent variables:

1) Sex
2) Type of School--Urban, Suburban, Rural
3) Socioeconomic Position--Classes 1 or 2, 3, 4, 5, 6 or 7
4) Number of science courses
5) I.Q.
6) Size of high school class

For each of the four tests the following hypotheses were tested:

1) No difference due to sex
2) No difference due to type of school
3) No difference due to socioeconomic class
4) Number science courses not important
5) I.Q. not important
6) Size of high school class not important

The F's testing the above hypotheses appear in the accompanying analysis of variance tables. In these tables "Regression" takes into account the three variables, 4) number of science courses, 5) I.Q., and 6) size of senior class. The analysis of covariance for the Test on Understanding Science scores is shown in Table 15. The F values obtained indicate that regression is significant beyone the 1 per cent level on all parts of the test and the total test score. In Part 2, sex and socioeconomic status are significant at the 5 per cent level. Table 16 is the Analysis of Regression for TOUS. For this particular test, the number of science courses, intelligence and large senior class are significant.
TABLE 15

ANALYSIS OF COVARIANCE OF TEST ON UNDERSTANDING SCIENCE SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part 1a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1.912</td>
<td>1.912</td>
<td>0.35</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>4.827</td>
<td>2.413</td>
<td>0.43</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>15.882</td>
<td>3.970</td>
<td>0.72</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>763.473</td>
<td>254.491</td>
<td>46.16**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>2,537.935</td>
<td>5.517</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Part 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>28.292</td>
<td>28.292</td>
<td>4.78*</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>5.952</td>
<td>2.976</td>
<td>0.50</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>61.300</td>
<td>15.325</td>
<td>2.59*</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>605.805</td>
<td>201.935</td>
<td>34.12**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>2,722.236</td>
<td>5.917</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Part 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>15.480</td>
<td>15.480</td>
<td>2.33</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>27.154</td>
<td>13.577</td>
<td>2.04</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>15.301</td>
<td>3.825</td>
<td>0.57</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>949.512</td>
<td>316.504</td>
<td>47.65**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>3,055.023</td>
<td>6.641</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>TOTAL TEST SCORE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>5.450</td>
<td>5.450</td>
<td>0.20</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>24.164</td>
<td>12.082</td>
<td>0.44</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>126.976</td>
<td>31.744</td>
<td>1.15</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>6,725.801</td>
<td>2,241.933</td>
<td>81.78**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>12,610.440</td>
<td>27.414</td>
<td>--</td>
</tr>
</tbody>
</table>

*Significant at the 5 per cent level.

**Significant at the 1 per cent level.

aPart 1--The Scientific Enterprise, Part 2--The Scientist, Part 3--Methods and Aims of Science.
### TABLE 16

**ANALYSIS OF REGRESSION ON TEST ON UNDERSTANDING SCIENCE SCORES**

<table>
<thead>
<tr>
<th>Test</th>
<th>NUMBER OF SCIENCE COURSES</th>
<th>I. Q.</th>
<th>SIZE OF CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b_8$</td>
<td>$t$</td>
<td>$b_9$</td>
</tr>
<tr>
<td>TOUS 1</td>
<td>0.236</td>
<td>1.96*</td>
<td>0.099</td>
</tr>
<tr>
<td>TOUS 2</td>
<td>0.432</td>
<td>3.453**</td>
<td>0.077</td>
</tr>
<tr>
<td>TOUS 3</td>
<td>0.507</td>
<td>3.830**</td>
<td>0.093</td>
</tr>
<tr>
<td>TOUS TOTAL</td>
<td>1.155</td>
<td>4.292**</td>
<td>0.269</td>
</tr>
</tbody>
</table>

*Significant at the 5 per cent level.

**Significant at the 1 per cent level.

The analysis of covariance for the *Iowa Tests of Educational Development*, Test 6, Interpretation--Natural Sciences is found in Table 17.

### TABLE 17

**ANALYSIS OF COVARIANCE OF IOWA TESTS OF EDUCATIONAL DEVELOPMENT, TEST 6**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>558.704</td>
<td>558.704</td>
<td>15.22**</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>47.450</td>
<td>23.725</td>
<td>0.64</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>702.162</td>
<td>175.540</td>
<td>4.78**</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>14,688.150</td>
<td>4,896.050</td>
<td>133.42**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>16,880.46</td>
<td>36.697</td>
<td>--</td>
</tr>
</tbody>
</table>

$F$ scores indicate sex, socioeconomic status and regression are significant. Table 18 is the Analysis of Regression for *I.T.E.D.*, Test 6.
TABLE 18

ANALYSIS OF REGRESSION ON IOWA TESTS OF EDUCATIONAL DEVELOPMENT, TEST 6

<table>
<thead>
<tr>
<th>NUMBER OF SCIENCE COURSES</th>
<th>I. Q.</th>
<th>SIZE OF CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>b8</td>
<td>t</td>
<td>b9</td>
</tr>
<tr>
<td>1.22</td>
<td>3.922**</td>
<td>0.432</td>
</tr>
</tbody>
</table>

**Significant at the 1 per cent level.

In addition to sex and socioeconomic status, the number of science courses and intelligence are significant.

Table 19 is the Analysis of Covariance for the Science, 2 A part of Sequential Tests of Educational Progress.

TABLE 19

ANALYSIS OF COVARIANCE OF SEQUENTIAL TESTS OF EDUCATIONAL PROGRESS, SCIENCE SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1</td>
<td>1,930.412</td>
<td>1,930.412</td>
<td>61.55**</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>150.640</td>
<td>75.320</td>
<td>2.40</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>443.660</td>
<td>110.912</td>
<td>3.53**</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>10,527.450</td>
<td>3,509.150</td>
<td>111.90**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>14,425.35</td>
<td>31.359</td>
<td>--</td>
</tr>
</tbody>
</table>

F scores indicate sex, socioeconomic status of parents and regression to be significant on this particular test.

The Analysis of Regression for S.T.E.P. is given in Table 20.
**TABLE 20**

ANALYSIS OF REGRESSION ON SEQUENTIAL TESTS OF EDUCATIONAL DEVELOPMENT, SCIENCE SCORES

<table>
<thead>
<tr>
<th>NUMBER OF SCIENCE COURSES</th>
<th>I. Q.</th>
<th>SIZE OF CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_8$</td>
<td>$t$</td>
<td>$b_9$</td>
</tr>
<tr>
<td>1.732</td>
<td>6.017**</td>
<td>0.338</td>
</tr>
</tbody>
</table>

**Significant at the 1 per cent level.**

In addition to sex and socioeconomic status of parents, the number of courses and intelligence are significant.

The analysis of covariance for the five separate categories and the total scores of the Personal Inventory on Science is shown in Table 21. F values show regression to be significant for all categories and the total score of this test. Sex is significant at the 5 per cent level for Category 1. Sex and type of school are significant for Category 3 at the 1 per cent level. Sex is significant at the 1 per cent level and type of school at the 5 per cent level for Category 5. Analysis of regression on Personal Inventory of Science scores is given in Table 22. T values indicate a large number of science courses to be significant for scores on Categories 1, 3, 4, 5 and the Total. Intelligence is significant for Categories 1, 2, 5 and the Total. Small senior class size is significant for Category 3 only.
TABLE 21
ANALYSIS OF COVARIANCE OF PERSONAL INVENTORY ON SCIENCE SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Category 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>9.611</td>
<td>9.611</td>
<td>3.97*</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>4.271</td>
<td>2.135</td>
<td>0.88</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>4.145</td>
<td>1.036</td>
<td>0.43</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>153.230</td>
<td>51.076</td>
<td>21.122**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>1,112.514</td>
<td>2.418</td>
<td></td>
</tr>
<tr>
<td><strong>Category 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>3.100</td>
<td>3.100</td>
<td>1.55</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>6.272</td>
<td>3.136</td>
<td>1.57</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>6.853</td>
<td>1.713</td>
<td>0.86</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>54.640</td>
<td>18.213</td>
<td>9.15**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>915.630</td>
<td>1.990</td>
<td></td>
</tr>
<tr>
<td><strong>Category 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>25.036</td>
<td>25.036</td>
<td>9.20**</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>26.020</td>
<td>13.010</td>
<td>4.78**</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>8.906</td>
<td>2.226</td>
<td>0.82</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>149.717</td>
<td>49.905</td>
<td>18.35**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>1,250.752</td>
<td>2.719</td>
<td></td>
</tr>
<tr>
<td><strong>Category 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.676</td>
<td>4.676</td>
<td>1.55</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>0.834</td>
<td>0.417</td>
<td>0.14</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>3.014</td>
<td>0.753</td>
<td>0.25</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>268.316</td>
<td>89.438</td>
<td>29.67**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>1,386.186</td>
<td>3.013</td>
<td></td>
</tr>
<tr>
<td>Source of Variation</td>
<td>Degrees of Freedom</td>
<td>Sum of Squares</td>
<td>Mean Square</td>
<td>F</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Category 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>219.573</td>
<td>219.573</td>
<td>19.14**</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>61.550</td>
<td>30.775</td>
<td>2.68*</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>11.044</td>
<td>2.761</td>
<td>0.24</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>1,058.352</td>
<td>352.784</td>
<td>30.75**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>5,276.700</td>
<td>11.471</td>
<td>--</td>
</tr>
<tr>
<td><strong>TOTAL SCORES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>4.131</td>
<td>4.131</td>
<td>0.08</td>
</tr>
<tr>
<td>Type of School</td>
<td>2</td>
<td>221.820</td>
<td>110.910</td>
<td>2.37</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>4</td>
<td>29.735</td>
<td>7.433</td>
<td>0.16</td>
</tr>
<tr>
<td>Regression</td>
<td>3</td>
<td>6,147.308</td>
<td>2,049.102</td>
<td>43.91**</td>
</tr>
<tr>
<td>Error</td>
<td>460</td>
<td>21,463.01</td>
<td>46.658</td>
<td>--</td>
</tr>
</tbody>
</table>

*Category 1—Impact of Science on Society, Category 2—Characteristics of a Scientist, Category 3—Science as a Career, Category 4—Nature of Science, Category 5—Self-appraisal of Scientific Ability and Interest.

*Significant at the 5 per cent level.

**Significant at the 1 per cent level.
TABLE 22
ANALYSIS OF REGRESSION ON PERSONAL INVENTORY ON SCIENCE SCORES

<table>
<thead>
<tr>
<th>Category</th>
<th>NUMBER OF SCIENCE COURSES</th>
<th>I. Q.</th>
<th>SIZE OF CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b8</td>
<td>t</td>
<td>b9</td>
</tr>
<tr>
<td>1</td>
<td>0.276</td>
<td>3.451**</td>
<td>0.036</td>
</tr>
<tr>
<td>2</td>
<td>0.135</td>
<td>1.861</td>
<td>0.023</td>
</tr>
<tr>
<td>3</td>
<td>0.512</td>
<td>6.042**</td>
<td>0.012</td>
</tr>
<tr>
<td>4</td>
<td>0.580</td>
<td>6.495**</td>
<td>0.032</td>
</tr>
<tr>
<td>5</td>
<td>1.323</td>
<td>7.595**</td>
<td>0.043</td>
</tr>
<tr>
<td>Total</td>
<td>2.851</td>
<td>8.117**</td>
<td>0.142</td>
</tr>
</tbody>
</table>

*Significant at the 5 per cent level.

**Significant at the 1 per cent level.

Summary of Results

On all four test scores used as dependent variables in determining scientific literacy, regression was found to be significant. Table 23 is a summary of the regression variables significantly associated with high scores.

Regarding the variables: sex, socioeconomic status of parents and type of school, F values showed the data given in Table 24 to be significant. Table 25 is a summary of means due to the grouping under these variables. The Table of Means (Table 25) was not adjusted for covariance. This can be done by use of a regression equation such as the following:

\[ \text{Adjustment of } Y = (X_1 - \bar{X}_1)\alpha_1 + (X_2 - \bar{X}_2)\alpha_2 + (X_3 - \bar{X}_3)\alpha_3 \]

---

<table>
<thead>
<tr>
<th>Test</th>
<th>Significant Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOUS 1</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>TOUS 2</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>TOUS 3</td>
<td>large number of courses in science, high I.Q., large senior class</td>
</tr>
<tr>
<td>TOUS TOTAL</td>
<td>large number of courses in science, high I.Q., large senior class</td>
</tr>
<tr>
<td>IOWA, Part 6</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>STEP, Science</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>Science Inventory</td>
<td></td>
</tr>
<tr>
<td>Part 1</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>Part 2</td>
<td>high I.Q.</td>
</tr>
<tr>
<td>Part 3</td>
<td>large number of courses in science, small senior class</td>
</tr>
<tr>
<td>Part 4</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>Part 5</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
<tr>
<td>Total</td>
<td>large number of courses in science, high I.Q.</td>
</tr>
</tbody>
</table>
TABLE 24

SUMMARY OF SEX, SOCIOECONOMIC STATUS, TYPE OF SCHOOL
SIGNIFICANT VARIABLES

<table>
<thead>
<tr>
<th>Test</th>
<th>Significant Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOUS 1</td>
<td>None</td>
</tr>
<tr>
<td>TOUS 2</td>
<td>Sex, Socioeconomic status of parents</td>
</tr>
<tr>
<td>TOUS 3</td>
<td>None</td>
</tr>
<tr>
<td>TOTAL</td>
<td>None</td>
</tr>
<tr>
<td>IOWA, Part 6</td>
<td>Sex, Socioeconomic status of parents</td>
</tr>
<tr>
<td>STEP, Science</td>
<td>Sex, Socioeconomic status of parents</td>
</tr>
<tr>
<td>Science Inventory Part 1</td>
<td>Sex</td>
</tr>
<tr>
<td>Science Inventory Part 2</td>
<td>None</td>
</tr>
<tr>
<td>Science Inventory Part 3</td>
<td>Sex, type of school</td>
</tr>
<tr>
<td>Science Inventory Part 4</td>
<td>None</td>
</tr>
<tr>
<td>Science Inventory Part 5</td>
<td>Sex</td>
</tr>
<tr>
<td>Science Inventory Total</td>
<td>None</td>
</tr>
<tr>
<td>Group</td>
<td>TOUS 1</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
</tr>
<tr>
<td>Male</td>
<td>9.07</td>
</tr>
<tr>
<td>Female</td>
<td>8.83</td>
</tr>
<tr>
<td>Urban</td>
<td>10.16</td>
</tr>
<tr>
<td>Suburban</td>
<td>8.76</td>
</tr>
<tr>
<td>Rural</td>
<td>7.92</td>
</tr>
<tr>
<td>Socioecon. 1</td>
<td>10.56</td>
</tr>
<tr>
<td>Socioecon. 2</td>
<td>9.47</td>
</tr>
<tr>
<td>Socioecon. 3</td>
<td>9.29</td>
</tr>
<tr>
<td>Socioecon. 4</td>
<td>8.59</td>
</tr>
<tr>
<td>Socioecon. 5</td>
<td>8.58</td>
</tr>
<tr>
<td>Group</td>
<td>Part 1</td>
</tr>
<tr>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Male</td>
<td>5.08</td>
</tr>
<tr>
<td>Female</td>
<td>4.83</td>
</tr>
<tr>
<td>Urban</td>
<td>5.34</td>
</tr>
<tr>
<td>Suburban</td>
<td>4.89</td>
</tr>
<tr>
<td>Rural</td>
<td>4.61</td>
</tr>
<tr>
<td>Socioecon. 1 or 2</td>
<td>5.25</td>
</tr>
<tr>
<td>Socioecon. 3</td>
<td>5.24</td>
</tr>
<tr>
<td>Socioecon. 4</td>
<td>5.01</td>
</tr>
<tr>
<td>Socioecon. 5</td>
<td>4.95</td>
</tr>
<tr>
<td>Socioecon. 6</td>
<td>4.73</td>
</tr>
</tbody>
</table>
Interpretation of Results

The preceding section gives the statistical results of the scores obtained from the criteria used in testing the hypotheses. The interpretation of these results is applied to the hypotheses as follows:

Hypothesis I

Scientific literacy depends upon mental ability.
Calculations on the unadjusted means indicated that in the sample tested, high mental ability was a significant variable in relation to all the test scores except Part 3 of the Science Inventory. This section of the test related to science as a career. It is reasonable to conclude that within the limitations noted above scientific literacy seems to depend upon mental ability.

Hypothesis II

Students from rural areas are as scientifically literate as those from urban or suburban areas.

An F value of significance was found only on Part 3 of the Science Inventory. A study of the unadjusted Table of Means shows the urban group to score higher than the suburban or rural groups and the suburban group to score higher than the rural group. On the foregoing bases no firm conclusions can be drawn relative to the second hypothesis.

Hypothesis III

There is a relationship between the number of science courses completed in high school and scientific literacy.
All test scores showed a positive relationship between high scores and a large number of science courses with the exception of Part 2, of the Science Inventory. On the basis of the test scores used as the dependent variable, there is adequate reason to assume a positive relationship between the number of science courses and scientific literacy.

Hypothesis IV

Environment contributes to scientific literacy.

Regarding this hypothesis, F values were found significant on Part 2 of the Test on Understanding Science which relates to the scientist. Significant F values for the Iowa Test of Educational Development, Test 6 and the Sequential Test of Educational Progress, Science were also obtained. The unadjusted Table of Means shows a decrease in test scores as the socioeconomic status of parents decreases in relation to these test scores. In so far as these particular test scores show, it seems reasonable to assume that the environment makes some contribution to scientific literacy.

Hypothesis V

High school senior boys are more scientifically literate than high school senior girls.

F values showed sex to be a significant variable on Part 2 of the Test On Understanding Science, the Iowa Test of Educational Development, Test 6, the Sequential Test of Educational Progress, Science, and Parts 1, 3, and 5 of the Science Inventory. The unadjusted Table of Means favors male over female on Part 2 of the Test on Understanding Science. This is indicative that boys might have a greater understanding of the
scientist than girls. Both the *Iowa Tests of Educational Development*, Test 6 and the *Sequential Tests of Educational Progress, Science* show means favoring female over male. These tests measure ability to read and interpret scientific material, and scientific achievement. Means for Parts 1 and 3 of the *Science Inventory* favor male over female, but Part 5 is decidedly in favor of the female. On the basis of these data, it is not conclusive to say that high school senior boys are more scientifically literate than high school senior girls.

Hypothesis VI

The size of the graduating class is a contributing factor to scientific literacy.

Only on Part 3 of the *Test on Understanding Science* and the total of this test was a large senior class a variable significantly associated with high scores. On Part 2 of the *Science Inventory* a small senior class was a significant variable. On the basis of these results, it can be concluded that the size of the graduating class does not appear to be an important contributing factor to scientific literacy.
The investigation of the hypotheses stated in Chapter III led to the formulation of some conclusions regarding the scientific literacy of the group involved in this study. These conclusions and supporting data were reported in Chapter IV. It is the purpose of this final chapter to make recommendations relative to the findings of the study with special reference to implications for science education and further studies in the area of scientific literacy.

Scientific Literacy and High Mental Ability

High mental ability was shown to be an independent variable significantly associated with high scores on the four tests used as a dependent variable. Free public education has as one of its fundamental ideas the equality of opportunity for all. This means recognition of individual differences in talent, motivation, and mental ability. Science education, as a democratic process, should meet the needs of individuals in such a way as to promote the fullest possible realization of personal potentialities. Science educators must be interested in the interpretation of science as a cultural subject to the nonscientist. At the same time, they must be cognizant of the fact that the academically talented student must be identified and developed to his full potential.
It is recommended that science courses, as a part of general education in Kentucky's high schools, be designed to:

1. Develop critical thinking.
2. Promote a friendly feeling toward science and scientists.
3. Teach appreciation and wise use of our natural resources.
4. Teach appreciation of the world in which students live.
5. Aid students in using science to improve their mental and physical health.
6. Develop scientific interests, skills and abilities.
7. Develop the attitude of the scientist--honesty, patience and an open mind.

Some measure of success toward accomplishment of these goals can be acquired by students no matter what their mental ability may be.

The educational opportunities for Kentucky's youth of superior intellectual ability should be evaluated. The future scientist can look after himself, but the high school can aid him by: (1) giving him a good foundation for advanced training, (2) exemplifying science work, and (3) developing the encouraging climate a young scientist needs. The academically talented student deserves the best teaching techniques available and we are challenged to see that he has them. The true responsibility of providing for these students is in the hands of the teacher who needs time and facilities for providing meaningful learning activities.
Science courses should be taught, not as a separate body of facts but in relation to other disciplines that mold the attitudes of growing generations. The science program should include all learners, but should be administered in such a way that each student progresses at his own rate.

One of the great dangers in a science program directed toward general education is that the general level of aspiration on the part of teachers, administrators, students, and parents is too low. What is expected of students is too uniform and does not recognize the great diversity of their talents. Our great task is to identify and make provision, in each field of learning, for the exceptional child. At the same time, all students need to be provided with educational experiences that will permit them to become of maximum worth to themselves, their community, and society. Opportunity consistent with ability should be the same for all students.

Scientific Literacy and Urban, Suburban, and Rural Schools

The type of school as a source of variation did not give F values of significance for any of the total test scores. However, the uncorrected Table of Means shows the urban group to have scored higher than the suburban or rural group on all four tests used as a dependent variable and the suburban group to have scored higher than the rural group. There would seem to be a tendency for a better and more diversified science program where there is a larger concentration of population.

It is recommended that high schools in rural areas take steps to evaluate the existing science program in consideration of the
students for whom the program is designed. The science program should be explained to and understood by the people of the community. Opportunities for teacher improvement should be made known to teachers. Wise use of funds available through the National Defense Education Act would give opportunity for improvement of existing science facilities and adequate supplies bringing about more effective science programs.

"Project Talent" findings show that the top four criteria for academic or vocational success are: Teachers' salaries, teacher experience, number of books in school libraries, and per-pupil expenditures by the schools. Considerations of these findings by state legislators and educators should improve the over-all educational program and hence have an impact on the science programs.

Scientific Literacy and the Number of Science Courses Completed

Results of the study show that there is a significant relation between the number of science courses a student has completed and scientific literacy as determined by the four tests used as a dependent variable. The Kentucky State Department of Education has realized the importance of science in the high school curriculum in changing the state requirement for graduation from one unit to two units of science. Of the 471 students involved in the study, 221 had completed no more than two units of science. This would indicate that general science and biology are the only sciences experienced by a large fraction of the high school population. There is evidence that science, in its broadest sense, is not being made attractive to the high school population.
In light of the results of this study, it is recommended that the State requirement be raised to three units of science or two units exclusive of general science. Diversified science programs should be offered in all schools for pupils of differing ability through such agents as honors classes, remedial programs and homogeneous groupings. In schools with limited facilities for science instruction, students should be encouraged to apply for summer institutes at various colleges throughout the state.

For any long-term influence upon the scientific literacy of future adults, programs of instruction must be consistent from the first day in kindergarten to the day of high school graduation. One cannot expect to produce men and women literate in science by a year or two of specialized science courses in the last few years of high school.

Science teachers create the atmosphere and viewpoint within which the teaching influences the development of children. We need teachers competent to provide differentiated instruction for various ability levels. Improvement and strengthening the science curriculum involves teamwork. Student-teacher, teacher-teacher, teacher-supervisor, teacher-administrator, and teacher-community relations need strengthening to in turn bring about individual student progress in scientific literacy.

Scientific Literacy and the Environment

In relation to the socioeconomic background of students and scientific literacy, F tests of significance were found on Part 2 of
the Test On Understanding Science, the Iowa Tests of Educational Development, Test 6, and the Sequential Tests of Educational Progress, Science. The uncorrected Table of Means indicates a decrease in test scores as the socioeconomic status decreases on all tests. Parts 2, 3, 4, and 5 of the Science Inventory show an increase in means of group 6 or 7 over group 5. Probably pupils whose parents are professional, semi-professional people, or highly skilled technicians would have received greater encouragement toward becoming scientifically literate than pupils whose parents are in lower socioeconomic brackets. It is recommended that science facilities and equipment and teaching be provided in deprived areas so that all high school students regardless of their home environment will have the opportunity to develop the inquiring spirit. Approaches and methods to reach and involve the home and the parents, as well as the schools and the children, are needed for a higher level of scientific literacy. Adult classes in recent advances in science or classes for parents who have never had formal science courses would upgrade the general level of scientific literacy in a community. A family's economic status is a crucial factor in determining whether or not a student will continue in school after he reaches the compulsory school age. Students showing an interest and aptitude in the sciences should be provided the financial assistance necessary to enable him to continue his education.

Scientific Literacy and Sex

The hypothesis that high school senior boys are more scientifically literate than high school senior girls was not proved by the
results of this study. Generally, it has been an accepted fact that boys were more interested in science, showed more ability in scientific fields and were more likely to choose science as a career than girls. Only thirty-six of the 223 girls participating in this study indicated a choice of a science-related vocation. Too few women today are tempted or encouraged to pursue careers in science. The longer span of education needed to prepare for the sciences and the trend toward earlier marriages limit women's participation in science careers. According to the National Science Foundation, the loss of women to science starts early—when science courses are passed up in high school. Interest and achievement in science among girls often is not encouraged at the high school level.

The primary career of women will continue to be that of wife and mother. To the extent that training in science can contribute to their primary careers, girls should be encouraged to seek it. As mothers who are scientifically literate they can exert an influence toward the development of more scientifically literate children. Girls who have the aptitude and desire to become scientists should have the opportunity and encouragement to consider careers in these fields. It is recommended that girls be encouraged to take more science courses. Guidance facilities should be available to help girls become acquainted with the many scientific vocations available to them and the means for obtaining scholarships at the present time. This is a precious natural resource which is not being fully developed.
Scientific Literacy and the Size of the Graduating Class

A large senior class was significant only on the Test On Understanding Science. Part 3 of the Science Inventory favored a small class. There is a trend in Kentucky toward consolidation with the elimination of the small high schools. It is recommended that consolidation be continued in order that pooling of resources offer children better educational opportunities. This is a means of enriching curriculum opportunities economically.

Further Studies Needed

The study reported here represents an attempt to investigate the scientific literacy of a sample of high school seniors in Kentucky. Three standardized tests and an attitudes inventory were used as the criterion for measuring scientific literacy in terms of understanding science, scientific achievement, reading and interpreting scientific literature of a general nature and attitude toward science. Further studies are now needed for determining when a person is scientifically literate.

A second type of study would involve a state wide study of a very large sample for determining scientific literacy. It might compare students at the ninth, tenth, eleventh, and twelfth grade levels to determine how each grade level compares with the others. A group of selected ninth grade students might be tested each year throughout their high school program to determine what factors contribute most to a greater degree of scientific literacy. Comparative studies of the difference in scientific literacy in wider areas of the United States
could prove of great importance in determining the future science programs for the citizens of tomorrow.
APPENDIX A

INDIVIDUAL DATA SHEET

Name_________________________ Birthdate _______ Year _______ Month _______ Day _______

Last First Middle Age Class Sex

Address________________________________________________________________________ Age____ Class____ Sex____

School________________________________________________________________________ Date____________________

Please respond to every section to the best of your ability:

1. Father's Occupation: __________________________________________________________

On the lines below describe briefly what your father actually does. For example, if his occupation is "salesman," tell what he sells and where he works. If his occupation is "plant manager," describe the kind of plant he manages, its size, location, and what it produces. If his occupation is "teacher," tell at what grade level, which subjects, and where he teaches.

2. Mother's Occupation: ________________________________________________________

On the lines below describe briefly what your mother actually does, if her occupation is other than housewife. If she does not work outside the home, please indicate housewife.

3. Parent's Education: In the list below place an F in the space at the left of the place which describes the highest grade in school which your FATHER has completed, and an M at the left of the phrase which describes the highest grade in school which your MOTHER has completed.

   |   |   |   |
---|---|---|---|
   | a. Some elementary school | f. Graduated from a four-year college |
   | b. Graduated from elementary school | g. Some graduate work |
   | c. Some high school | h. Master's degree |
   | d. Graduated from high school | i. Holds a doctor's degree (MD, PhD, EdD, DDS, etc.) |
   | e. Some college |   |   |   |

111
4. Educational Plans: Check the one statement below which best describes what you are most likely to do after you graduate from high school.

   _____ a. Work full time, no further education
   _____ b. Attend full time junior college or technical school
   _____ c. Work during the day, go to school in the evenings
   _____ d. Go full time to a four year college
   _____ e. Don't know

5. Occupational Plans: On the line below list the occupation which you now think you will enter. Be as specific as you can. _______________________

6. Favorite Activities: Describe briefly in order of preference the three activities, other than school work (special lessons, watching T.V., hobbies, sports, out-of-school employment, etc.) which you enjoy most.

   a. _______________________
   b. _______________________
   c. _______________________

7. School Subjects:

   a. Which is your favorite school subject? _______________________
   b. Which school subject do you like least? _______________________

8. Science & Mathematics Background:

   A. List all the science courses you have taken during your high school program (9 - 12 grades). Include semester or yearly grades if you remember them.

      (1) ______________________ (2) ______________________ (3) ______________________
      (4) ______________________ (5) ______________________ (6) ______________________

   B. List all the mathematics courses you have taken during your high school program (9 - 12 grades). Include semester or yearly grades if you remember them.

      (1) ______________________ (2) ______________________ (3) ______________________
      (4) ______________________ (5) ______________________ (6) ______________________
PERSONAL INVENTORY ON SCIENCE

The purpose of this inventory is to obtain information about how students like you feel about the subject of science. This is not a test, but it is an opinionnaire in which you are asked for your frank opinions. In order for the inventory to be effective, you must give your true feelings in your answers. There is no such thing as a "right" or "wrong" answer, so please respond according to your own feelings and opinions. The results will be valuable in improving the teaching of the sciences in the future. Naturally, your answers to this inventory will have no bearing whatever on your school grades.

DIRECTIONS: Read each of the statements below regarding science, scientists, and scientific careers. Record your responses on the answer sheet.

Mark between the lines under 1 if you STRONGLY AGREE with the statement.
Mark between the lines under 2 if you are in MILD AGREEMENT.
Mark between the lines under 3 if you are NEUTRAL.
Mark between the lines under 4 if you are in MILD DISAGREEMENT.
Mark between the lines under 5 if you STRONGLY DISAGREE.

EXAMPLE: 100. I think ice skating is more fun than roller skating.

ANSWER SHEET

1 2 3 4 5

100.

Since a heavy line has been drawn between the lines under 1, the feeling recorded is STRONG AGREEMENT. If you had been in MILD AGREEMENT, then you would have recorded a heavy line under 2. If you had no feeling one way or the other about the statement, you would have recorded a heavy line under 3, the NEUTRAL position. If you had been in MILD DISAGREEMENT, then you would have recorded a heavy line under 4. If you had STRONGLY DISAGREED, you would have recorded a heavy line under 5.

BE CAREFUL TO RECORD ONLY ONE ANSWER FOR EACH QUESTION. If you make a mistake and need to correct an answer, erase the incorrect response completely and then mark the intended response. Work rapidly. Record the first response that comes to mind as you read each item.
IN MY OPINION:

1. Science is one of my best subjects.

2. To appreciate modern society fully, a person must understand the importance of scientific contributions.

3. Science is colder and less exciting than almost any other subject I have studied.

4. Scientists are too narrow in their views.

5. I frequently get so wrapped up in a scientific problem that I could spend hours working on it.

6. When I cannot solve a science problem fairly quickly, I wish that I could keep working at the problem until I solve it.

7. I frequently read about scientific subjects that are not necessarily related to our school work.

8. If I came across a tough science puzzle in a magazine, I would probably spend as much time as needed to solve it.

9. Scientists and mathematicians display more attachment to their work than other professional people.

10. If I wanted to, I could probably be a good science teacher some day.

11. Scientists are more concerned about the order of things than about the welfare of people.

12. I enjoy the study of science.

13. I believe that scientific work is boring.

14. Science receives too little serious attention in the mass media—newspapers, television, and radio.

15. A scientist's career is full of adventure.

16. It is possible to be a well-educated adult without going beyond junior high school science.

17. About all of the science worth knowing has been developed and can be found somewhere in books.

18. Success in scientific work requires great dedication and self-discipline.
19. High school science should be required only for those students who want to be scientists.

20. I would say that it is not worth much to get the right answer to a problem if you do not really understand the problem.

21. I think I have considerable talent for science.

22. The greatest value of elementary and high school mathematics is to enable people to handle their financial affairs competently.

23. In high school, boys should receive more encouragement to take science courses than girls.

24. At the present time, mankind has little need for creative scientists as more science is already known than is being used.

25. A scientist might be described as a nonconformist.

26. By translating ideas into mathematical symbols, their beauty and originality are lost.

27. Science is not a good field for creative people to enter.

28. Science will enable me to think more clearly in other subject areas.

29. Mathematics and science are so much more important to social progress than other fields that mathematicians and scientists should be exempt from military service.

30. There is much self-satisfaction to be received from work as a scientist.

31. I get enjoyment out of doing science problems.

32. When some of the students show that they understand the solution to a problem before I understand it, I feel discouraged and blame them for showing off.

33. For me, training for a career in mathematics or science is not worth the time and effort required.

34. The development of new ideas is the scientist's greatest source of satisfaction.

35. I am fairly sure that I will do well in all the science courses that I will take in the future.

36. Sometimes I see a good way of working a science problem which is different from the one we are expected to use.
37. Learning to solve scientific problems improves one's ability to solve other kinds of problems.

38. Outside of the fields of science and engineering man finds little in math that helps him to understand and solve his problems.

39. Science work is monotonous.

40. I do not have the intelligence for a successful scientific or mathematical career.

41. When my friends do not understand something in science, I am usually able to explain it to them.

42. The chief reward in scientific work is the thrill of discovery.

43. I enjoy solving science problems even when I cannot see any practical use for them.

44. Scientists are generally stiff and formal in their dealings with other people.

45. When I read an article that has graphs in it, I generally skip over them and continue with the text.

46. Important economic, political, and social processes are greatly influenced by scientists.
### APPENDIX B

#### INDEX OF DISCRIMINATION FOR PERSONAL INVENTORY ON SCIENCE

<table>
<thead>
<tr>
<th>D = Index of discrimination</th>
<th>U = Correct responses in upper 27%</th>
<th>L = Correct responses in lower 27%</th>
<th>N = Number in each 27%</th>
<th>N = 27% of 203 = 55</th>
<th>203 = Number in sample group</th>
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## TABLE 26
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\[
r_{xy} = \frac{N \sum xy - \sum x \sum y}{\sqrt{(N \sum x^2 - (\sum x)^2)(N \sum y^2 - (\sum y)^2)}}
\]

\( r_{xy} \) is split half coefficient of correlation.

\[
R_{xy} \text{ is reliability coefficient } = \frac{2r_{xy}}{1 + r_{xy}}
\]

- **Category I**: Impact of Science on Society
- **Category II**: Characteristics of a Scientist
- **Category III**: Science as a Career
- **Category IV**: Nature of Science
- **Category V**: Self Appraisal of Scientific Ability and Interest
APPENDIX C

REVISED OCCUPATIONAL SCALE FOR RATING SOCIO-ECONOMIC CLASS

Martin Hamburger
Teachers College, Columbia University

Level is used to denote socio-economic class level, from 1 to 7, in terms of the criteria as outlined at each level. The lettered categories, from A to G, are occupational groups, and are adapted from Edwards and Warner.

LEVEL 1

A. Professionals: high level; high responsibility; usually requiring post-graduate training, often at the doctoral level. All occupations which normally achieve this status level for their members. Examples: lawyers, physicians, dentists, engineers, judges, school superintendents, H. W. principals, airline captains, C.P.A.'s, Catholic priests, rabbis, Protestant clergy with Master's or Doctor's degree.

B. Semi-professionals: none

C. Proprietors, Managers, Business Officials: Ownership or Management of business valued at $150,000 or more. When enterprise is national in scale or has a number of plants or large offices, then regional or divisional managers are top-level executives with great deal of responsibility, and high pay, and (usually) large number of subordinates.

D. Clerical Sales: Clerical--none. Sales--sales managers would be in (c). Top not salesmen (very high individual income) in securities, real estate, or life insurance.

E. Manual: none. Contractors are really in C, but if a contractor actually engages in manual work, then business value is used, and he is then dropped one level.

F. Protective and Service Workers: Protective--Police Commissioner, colonel and above in armed services. Service--none, except proprietors (C) of large service establishment.

G. Farmers: Value-acreage above $150,000. Gentlemen farmers, landowners who do not supervise directly operations on their property.
LEVEL 2

A. Prof: Those occupations requiring bachelor's degree, or (in some cases) master's. Prof. nurses (coll. degree), teachers with degrees, F.B.I. agents, chiropodists, pharmacists, ministers with college degree, editors (except for large newspapers or magazines who are Level 1), optometrists, grad. librarians, prof. journalists, guidance counselors, accounts with bach. degree, social workers with M. A. (prof. training).

B. Semi-prof: undertakers, airline pilots

C. Prop. mgr., bus. off.--business values at $40 to $150,000. Sales managers, hotel managers, department managers of large businesses.

D. Clerical-Sales--Buyers or purchasing agents, life insurance salesmen, real estate sales.

E. Manual--none

F. Prot. and Serv.--Prot: capt. or major or equiv., high police official.

G. Farmers V. A. (value-acreage) $75 to $150,000 . . . Owner--manager and supervises his prop.; rarely actively works on it. Employed--professionals and others in technical, advisory or administrative capacities.

LEVEL 3

A. Prof.--social workers (B. A. or less, but no prof. training or equivalency), teachers without degrees, R.N., librarians (non-prof. training), ministers (non-college graduates), reporters on small or country newspapers, radio announcers (except networks, Level 2), county agricultural agents, laboratory technicians with B.A.

B. Semi-prof. clothes designers, commercial artist, architectural draftsmen, portrait or special (medical) photographers.

C. Prop. mgr. bus. off. Bus. value: $10 to $50,000. Minor officials of business such as office managers.

D. Clerical Sales--auto salesmen, administrative secretaries, accountants or auditors (non-degree).

E. Manual--none

F. Prot. and Serv.--Prot: detectives, Lt. in Regular Army. Serv: Sup't. of buildings and grounds.
G. Farmers--$50 to $75,000 V.A. Owners: actively operates own land with one or more "hired hands," and seasonal help. Tenants: operates leased property. Employed: managers and supervisors on large property; have general responsibility for operation.

LEVEL 4

A. Prof.--none

B. Semi-prof.--undertakers' assistants (trained), laboratory technician (2 years training typical), dental hygienist, draftsman, engineering aide, optician (perhaps manual), photographer, fingerprint technician.

C. Prop. Mgr. Bus. Off. Business value: $5 to $10,000. There are really no business officials at this level: they are either managers or clerical, sales.

D. Clerical Sales--Clerical: general bookkeeper, stenographer and secretary, bank teller, payroll agent, cashier, individual insurance collection agent, R.R. ticket agent. Sales: traveling salesman (soft goods), assistant buyer, furniture salesman (inside).

E. Manual--must be highly skilled, equivalent to formal apprenticeship and/or self-employment, or responsibility--radio and TV repairman, master plumbers and electricians, maintenance electrician for a large plant, watchmaker, machinist, tool and dye maker, printer, factory foreman, trained airplane mechanic (engine), carpentry contractor who also works on jobs.

F. Prot. and Serv.--Prot: Policemen and firemen. Serv.--R.R. conductors, fancy cake bakers, chef in large restaurant, custodial 'engineer' in public building, dressmaker (?), custom tailor, dry cleaning expert.

G. Farmers--V.A. $30-$50,000. Owners--operate own property with family and/or seasonal help. Tenants--operate rented property with one or more "hired hands," Employed--foreman on large prop.

LEVEL 5

A. Prof.--or--B. Semi-prof. or C. Prop. mgr. bus. of.--None

D. Clerical and Sales: Clerical--timekeepers, assistant bookkeepers, typists, telephone operators, postal clerks. Sales--store clerks, salespersons, usually soft goods or portable goods.
E. Manual—skilled at Journeyman's Level—carpenter or carpenter rough, construction electrical telephone or telegraph lineman, automobile mechanic (engines) Factory—certain assembly and inspection jobs requiring considerable responsibility and training.

F. Prot. and Serv: Prot. corporal or Sgt. in regular army. Serv.--barber, hair stylist, baker, cook, practical nurse, tailor, butcher, mail carrier, bus driver, waiter at fine restaurant.

G. Farmers: V.A. $15-$30,000. Owners--operate own property and (hire out) to supplement income, but only in farm work. Tenants: operate rented property without paid help other than seasonal. Employed: farm foreman.

LEVEL 6

A. or B or C—None

D. Clerical—dime-store clerks, shipping clerks, stock clerks, mail clerks, checkers at A & P, office boys (bonded messengers?). Sales (included in foregoing).

E. Manual—semi-skilled to low-skilled factory work—requiring relatively little training or experience—typical assembly line or operative work. In construction or other trades, helpers to skilled craftsmen. Heavy labor if regular and stable, including miners.

F. Prot: soldier, general duty; night policeman. Serv.--bartender, waiter, short-order cook or counterman, manicurist, chauffeur, truck driver, taxi driver, gas-station attendant, shoe repairman, janitor (not porter), butcher's helper, hospital attendant, longshoreman if regularly employed, elevator operator (?).

G. Farmers: V.A. $5 to $15,000--Owners--none. Tenants—who supplement income by "working out"—sharecroppers. Employed—established farm laborers.

LEVEL 7

A. or B or C or D—None

E. Manual—heavy labor not regular or stable; migratory labor (non farm); odd-job men.

F. Prot. and Serv.—night watchmen, porters, garbage collectors, charwomen, messengers or delivery boys.

G. Farmers—V.A. $5,000 and below--Owners--none. Tenants—"squatters" or "nesters" and other non-paying tenants. Employed—migrant and seasonal workers.
APPENDIX D

KENTUCKY SCHOOL SYSTEMS PARTICIPATING IN THE STUDY

URBAN
Bowling Green Public Schools
Hopkinsville Public Schools
Louisville Public Schools
Middlesboro Public Schools
Owensboro Public Schools

SUBURBAN
Boyd County Public Schools
Daviess County Public Schools
Jefferson County Public Schools
Kenton County Public Schools

RURAL
Adair County Board of Education
Bullitt County Board of Education
Harlan County Board of Education
Lincoln County Board of Education
Warren County Board of Education
March 3, 1964

Mr. T. S. Jeffries, Superintendent
Bullitt County School System
Shepherdsville, Kentucky

Dear Mr. Jeffries:

I am a candidate for the Ph.D. degree in the field of Science Education at the Ohio State University, Columbus, Ohio. My research is based on a comparative study of the scientific literacy of high school seniors in urban, suburban, and rural communities in Kentucky. I know you are aware of the need for a scientifically literate society in our complex technical world today. So many of our youth in Kentucky complete their formal education upon graduation from high school. These young citizens are called upon almost immediately to vote upon issues regarding air and water pollution, mineral rights, atomic waste disposal and conservation. My desire is to determine how well these graduates understand the work of scientists and the scientific enterprise; their attitude toward science and scientists and their ability to read and interpret scientific literature available to the general public.

Will you be so kind as to grant me permission to use thirty randomly picked seniors from Bullitt County High School to be a part of my sample? The testing will take approximately four hours. Should you be willing for me to come to your system, kindly send me the name of the principal I should contact for arrangements. A stamped self addressed envelope is enclosed for your convenience.

I earnestly hope you will be willing to aid me in this endeavor. The results of my findings will be made available to you. I hope this research will give educators an insight into the effectiveness of Kentucky's high school science program.

Very truly yours,

(Mrs.) Nancy Hamilton

Members of the Committee:

Dr. John S. Richardson, Professor of Science Education
Dr. A. B. Garrett, Professor of Chemistry; Vice-president in Charge of Research
Dr. F. W. Cyphert, Professor of Secondary Education
May 13, 1964

Mr. Willis Wells, Principal
Shepherdsville High School
Shepherdsville, Kentucky

Dear Mr. Willis:

My thanks to you, your staff and your seniors for your participation in my testing program. Without your help, I would not have been able to obtain the necessary data for my dissertation. I hope to complete my work next winter at which time the results of my study will be available to you.

I am enclosing the results of the test which were given to your students. I will be using raw scores only in computing my data. However, I am sending you the percentile rankings too. You may show these scores to the students if you so desire. In processing the data, the names of the students will not be used. In some instances, I was aware that the students were not serious about the tests. This may account for some low scores.

My visit to your school was an enjoyable experience. I do appreciate the courtesy shown me.

Very truly yours,

(Mrs.) Nancy Hamilton
NH/mw
Encl.


APPENDIX E

TABLE 27
EDUCATIONAL STATUS OF FATHERS OF STUDENTS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hold doctoral degree</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>8</td>
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<tr>
<td>Work toward or including Master's degree</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>College-level work</td>
<td>40</td>
<td>25</td>
<td>16</td>
<td>81</td>
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<tr>
<td>High school only</td>
<td>74</td>
<td>76</td>
<td>37</td>
<td>187</td>
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<tr>
<td>Elementary school only</td>
<td>24</td>
<td>46</td>
<td>104</td>
<td>174</td>
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<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
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</tbody>
</table>

TABLE 28
EDUCATIONAL STATUS OF MOTHERS OF STUDENTS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Suburban</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Hold doctoral degree</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Work toward or including Master's degree</td>
<td>15</td>
<td>0</td>
<td>4</td>
<td>19</td>
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<tr>
<td>College-level work</td>
<td>44</td>
<td>25</td>
<td>15</td>
<td>84</td>
</tr>
<tr>
<td>High school only</td>
<td>82</td>
<td>98</td>
<td>57</td>
<td>237</td>
</tr>
<tr>
<td>Elementary school only</td>
<td>16</td>
<td>31</td>
<td>83</td>
<td>130</td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
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</table>

128
### TABLE 29
FAVORITE SUBJECT OF SENIORS PARTICIPATING IN STUDY

<table>
<thead>
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<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Favorite subject--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>science related</td>
<td>35</td>
<td>31</td>
<td>23</td>
<td>89</td>
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<tr>
<td>Favorite subject--</td>
<td>123</td>
<td>123</td>
<td>136</td>
<td>382</td>
</tr>
<tr>
<td>non-science related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
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</tbody>
</table>

### TABLE 30
SUBJECT LIKED LEAST BY SENIORS PARTICIPATING IN STUDY

<table>
<thead>
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<th></th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least liked subject--</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>science related</td>
<td>22</td>
<td>20</td>
<td>29</td>
<td>71</td>
</tr>
<tr>
<td>Least liked subject--</td>
<td>136</td>
<td>134</td>
<td>130</td>
<td>400</td>
</tr>
<tr>
<td>non-science related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
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</tbody>
</table>
### TABLE 31
VOCATIONAL PLANS OF SENIORS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th>Plans</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science-related vocational plans</td>
<td>54</td>
<td>30</td>
<td>28</td>
<td>112</td>
</tr>
<tr>
<td>Non-science-related vocational plans</td>
<td>90</td>
<td>106</td>
<td>115</td>
<td>311</td>
</tr>
<tr>
<td>No vocational plans</td>
<td>14</td>
<td>18</td>
<td>16</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
</tr>
</tbody>
</table>

### TABLE 32
EDUCATIONAL PLANS OF SENIORS PARTICIPATING IN THE STUDY

<table>
<thead>
<tr>
<th>Educational Plans</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>College education and above</td>
<td>120</td>
<td>61</td>
<td>37</td>
<td>218</td>
</tr>
<tr>
<td>Junior college or technical school</td>
<td>11</td>
<td>14</td>
<td>29</td>
<td>54</td>
</tr>
<tr>
<td>Work days, attend night school</td>
<td>7</td>
<td>30</td>
<td>11</td>
<td>48</td>
</tr>
<tr>
<td>Work--no further schooling</td>
<td>10</td>
<td>34</td>
<td>49</td>
<td>93</td>
</tr>
<tr>
<td>Don't know</td>
<td>10</td>
<td>15</td>
<td>33</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>158</td>
<td>154</td>
<td>159</td>
<td>471</td>
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</tbody>
</table>
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