

Elida Oliva Franceschi. SCIENCE OBJECTIVES OF SECONDARY SCHOOL TEACHERS OF PHYSICAL SCIENCE AND PHYSICS. (Under the direction of Robert L. Dough) Department of Science Education, March 1971.

A study of science objectives was made among forty-five high-school teachers of physical science and physics in eastern North Carolina, in order to determine (1) the objectives in science teaching which they hold most important, (2) differences between the objectives expressed by the physical science and physics teachers, and (3) differences between objectives held by the teachers and a panel of professors.

The information was gathered in two parts: (1) a statement of objectives from the teachers, and (2) evaluation of a list containing fifty-seven possible objectives. In addition, the panel of professors were asked to classify these fifty-seven items into categories. The first part (subjective part) yielded information concerning the objectives that the teachers held most important, some differences between physical science and physics teachers as well as the variety of objectives stated by them. In order to facilitate the study, the teachers' statements were categorized and tabulated into six categories and twelve sub-categories. The evaluation of the fifty-seven

items (objective part) also allowed for comparison of the teachers with the panel of professors (judges). Comparisons were made using "mean score" values for every person and mean values for each item. Analysis of variance was applied to determine differences in the ranking of all the items between teachers and judges as well as evaluation of items grouped in categories.

It has been concluded that the teachers' main concern is to teach the scientific methods primarily for the purpose of developing certain characteristics such as skills, abilities and critical thinking. To have the students learn about the world around them was placed second in importance followed by the appreciation of the importance of science. There were no outstanding differences between the responses of the physical science and the physics teachers. However, there were minor differences such as a tendency of the physics teachers to emphasize the preparation for a scientific career and content knowledge more than the physical science teachers. Finally, no significant difference was found between the teachers and the judges concerning the ranking of the fifty-seven items of the list. They showed a good agreement with respect to types of objectives which were most emphasized as well as to the items which should not be

considered as teaching goals. The humanistic aspects of science were not emphasized as much as the above mentioned ones.

SCIENCE OBJECTIVES
OF SECONDARY SCHOOL TEACHERS
OF PHYSICAL SCIENCE AND PHYSICS

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Elida Oliya Franceschi
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SCIENCE OBJECTIVES
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OF PHYSICAL SCIENCE AND PHYSICS

by
Elida Oliva Franceschi

APPROVED BY:

SUPERVISOR OF THESIS Robert L. Dough
Robert L. Dough

CHAIRMAN OF THE DEPARTMENT OF SCIENCE EDUCATION

Floyd E. Mattheis
Floyd E. Mattheis

DEAN OF THE GRADUATE SCHOOL

John M. Howell
John M. Howell

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Chapter 1

INTRODUCTION

There is no doubt of the relevance of science in all aspects of life at the present time. This makes it essential to pay constant attention to the scientific education of the youth. At East Carolina University, efforts are being made to improve the teaching of science at all levels.

To be able to take effective steps towards the promotion of good teaching in the secondary schools it is necessary to know as much as possible about the way in which science is presently being taught. Several different studies are being carried out in the Science Education Department and are leading to a better understanding of the situation in the eastern North Carolina area. The National Science Foundation (NSF) partially supports these efforts through an In-Service Institute in Physics for secondary school teachers of physical science and physics. This thesis reports the results of a study of objectives in science teaching of teachers of physical science and physics.

DEFINITION OF THE PROBLEM

This study can be summarized as an attempt to find out what science objectives are held by the physical science and physics teachers in eastern North Carolina at the secondary school level. More specifically, it is intended (1) to determine the objectives in science teaching which the teachers of the area hold most important, (2) to indicate, if any, differences between the statements given by physics teachers and physical science teachers and (3) to compare the objectives of the teachers with those of a panel of professors.

The importance of such a study is based on the assumption that the effectiveness of a teacher is related to the objectives in which he believes. As Hurd stated: "good teachers have reasons for the ways in which they work; these reasons are expressed in terms of educational objectives."¹

Justification of the Problem

In the past, science educators in the United States have conducted many studies concerning science objectives, some studies have extended to the whole country while

¹Paul De Hart Hurd, Biological Education in American Secondary Schools 1890-1960 (Washington: American Institute of Biological Sciences, 1961), p. 176.

others were confined to a region. With regards to eastern North Carolina, there has been a thorough study related to the structure and dynamics of science teaching at the junior and senior high school level.² However, this field of study has not been exhausted and there is a definite need for continuous research in this area. Furthermore, there is interest in having a more up-to-date survey so that plans to improve the science teaching of this area can best be prepared. In analyzing the objectives, ways may be determined to better understand and help with the problems of science teaching.

Delimitations

This study was subject to the following delimitations:

1. The research was based on information given by forty-five science teachers attending the NSF In-Service Institute.
2. These teachers teach the junior or senior high school level.
3. The teachers are presently teaching one or more of the following subjects: physical science, physics,

²Moses M. Sheppard, "The Relation of Various Teacher and Environmental Factors to Selected Learnings of Ninth-Grade Science Pupils" (Unpublished Doctor's dissertation, Ohio State University, 1966).

biology, chemistry, and mathematics, but all of them have at some time taught physical science or physics.

4. These teachers come from the eastern North Carolina area.

5. Their answers to the questionnaire are based on the teaching of physical science or physics.

6. There has been no attempt to correlate the objectives held by these teachers with their experience in science or science teaching or with any other factors.

DEFINITION AND DISCUSSION OF TERMS

In many studies which refer to objectives, words such as objective, goal, aim or outcome have been used interchangeably. In order to clarify these ideas, Good's Dictionary of Education has been used to search for similarities or differences among the above terms. The following meanings are given:

Objective: "aim, end in view, or purpose of a course of action or a belief; that which is anticipated as desirable in the early phases of an activity and serves to select, regulate, and direct later aspects of the act so that the total process is designed and integrated."

Aim: "a foreseen end that gives direction to an activity and motivates behavior. Syn.: goal."

Goal: "an aim or purpose; the objective or end to be attained in any behavior situation."

Outcome: "change in behavior resulting from learning (not to be confused with objective which is a desired result)."³

According to the Dictionary there seems to be no significant difference between objective, aim and goal. In addition, the Dictionary distinguishes five types of objectives: general, immediate, indirect, specific and ultimate.

Many authors have given their own definition of the terms defined above. For example, Brandwein, Watson and Blackwood have stated that ". . . when we try to have the student do as the scientist does, we have specific objectives, goals, aims, purposes, or whatever word you wish to use which signifies 'why you are doing what you are doing'" and further on: "objectives are personal, are based on knowledge of the special teaching situation, and should have the flavor of personal thought and statement."⁴

Hunter admitted that the words "objective, outcome,

³Carter V. Good (ed.), Dictionary of Education (New York: McGraw-Hill Book Co., 1959).

⁴Paul F. Brandwein, Fletcher Watson, and Paul Blackwood, Teaching High School Science: A Book of Methods (New York: Harcourt, Brace and Co., 1958), p. 86.

aim and goal seem to have been used by different authors rather promiscuously." For that reason, he gave the following terms in a descending order of generalization: ultimate goal, which would be the most general term, then ultimate aims, which would be attainable through objectives. He allowed two ways for expressing objectives: in terms of acquisition of specific knowledge or in broader terms of interests, ideals, attitudes, appreciations or abilities.⁵ Therefore, there are specific and generalized objectives. The objectives that have been studied in this thesis are mostly expressed in broad terms. However, as these come from different sources it is difficult to set a unique definition of terms and have general agreement.

More recently, Mager defined the term objective as "an intent communicated by a statement describing a proposed change in a learner. . . . It is a description of a pattern of behavior we want the learner to be able to demonstrate."⁶ This is the definition of what today is called behavioral objective or instructional objective. This term has been discussed considerably by science educators in recent publications. The definition of behavioral

⁵George W. Hunter, Science Teaching at Junior and Senior High School Level (New York: American Book Co., 1934), p. 58.

⁶Robert F. Mager, Preparing Instructional Objectives (Palo Alto: Fearon Publishers, 1962), p. 3.

objective according to the Encyclopedia of Educational Research is the following:

Behavioral Objective: "statement of purpose which describes desired student behavior and indicates the content through which the behavior is to be developed."⁷ This definition, as well as Mager's corresponds to what Good's dictionary defines as outcome. Those authors who consider an objective a "setter of direction" and not a terminal behavior disagree with the given definition. Behavioral objective, apparently, is a recently coined term since it is not found in Good's Dictionary of Education (1959). Behavioral objective seems to differ from the term "objective" in that a behavioral objective refers to a terminal behavior whereas a general objective appears to be an indicator of direction. However, this study deals with more general objectives than behavioral objectives.

When mentioning or listing science objectives, they are frequently expressed in terms of "knowledge of" or "understanding of." Sometimes these two expressions are used as if they were equivalent. Nedelsky explains the difference as follows:

Knowledge: to be able to recall the content, that

⁷Robert L. Ebel (ed.), Encyclopedia of Educational Research, American Educational Research Association (Toronto: The Macmillan Co.-Collier-Macmillan Canada Ltd., 1969), p. 911.

is, laws, theories and other assertions presented in the course.

Understanding: to be able to use the knowledge of a portion of subject matter in a new context or situation which requires more than a simple application of rules taught in the course.⁸

Therefore, these are clear differences between the two terms which must be carefully observed when formulating science objectives in order to really know on what base the class work must be organized and what is expected from the student. This difference has been kept in mind when categorizing the teachers' stated objectives and it was also kept in mind when formulating the list of objectives for the teachers to rate.

It was considered useful to give the range of grades that are implied in the terms junior, senior and high school, because the courses in physical science and physics are normally given in the ninth grade and twelfth grade respectively. Possible definitions of these terms are as follows:

Junior high school: Institution offering courses from seventh through ninth grade.

⁸Leo Nedelsky, Science Teaching and Testing (New York: Harcourt, Brace and World, 1965), p. 21.

Senior high school: Institution offering courses from tenth through twelfth grade.

High school (composite school): Institution offering courses from ninth through twelfth grade.

GENERAL PROCEDURE FOR COLLECTION OF DATA

In order to obtain information on the objectives of the physical science and physics teachers, a questionnaire was given in two parts. It was given to the teachers while they were attending meetings of the In-Service Institute.

In the first part, which is to be identified as the subjective part, the teachers were asked to state briefly their major science objectives when teaching a physical science or a physics course. The form used is given in Appendix A. Teachers who worked with both courses were told to answer for both courses if they wished or to state their objectives for physics only. They were given a time limit of ten minutes to answer, so that hopefully those ideas which were foremost in their minds were obtained.

In the second part, to be referred to as the objective part, the teachers were presented with a list of 57 possible objectives (see Appendix B), and they were to rank each objective on a 1, 2, 3, 4, 5 scale according to the degree of importance they rated for each one. An answer of 1 meant that the statement was considered a main objec-

tive while an answer of 5 meant that the statement was not an objective at all. A 2, 3 or 4 represented a choice between these two extreme cases. The choices were written on an IBM answer sheet to facilitate tabulations. The teachers were given twenty minutes in which to answer this section. The list was also submitted to a panel of professors (judges) who were instructed to rank the objectives according to their ideas concerning a high school physics course. They were also asked to classify these 57 items into seven categories that were presented to them in the form shown in Appendix C. The categories thus obtained were used to compare the rankings of the teachers and the judges for objectives within specific areas.

SOME CHARACTERISTICS OF THE SAMPLE STUDIED

The information for the present study was gathered during the fall quarter of 1970. The participating teachers were asked to state what courses they were teaching at the time of the survey. As it is shown below not all the teachers were teaching physics or physical science. However, they had taught physics previously so they stated their objectives as intended for a physics course. This increases the number of physics teachers from 11 to 15. It must be noted that the physical science and physics teachers were also teaching other courses. The distribu-

tion of the teachers according to the subject they were teaching is the following:

<u>Subject matter</u>	<u>Number of teachers</u>
Physics	11
Physical science and physics	21
Physical science	9
Chemistry and biology	2
Mathematics	1
Chemistry	1

Four different types of institutions and thirty-four different schools were represented by the forty-five teachers as is shown below:

<u>Institution</u>	<u>No. of teachers</u>	<u>No. of institutions</u>
High school	32	25
Junior high	8	4
Senior high	4	4
Private school	<u>1</u>	<u>1</u>
Total	45	34

Chapter 2

REVIEW OF THE LITERATURE

The review of literature concerning objectives in science teaching will be approached in two ways: (1) a chronological presentation of some of the objectives that have been formulated either by one person or by committees, and (2) some research work done in this field. The first section will present the sources that were used to prepare a list of 57 science objectives for science teachers to rank. It will also justify the classification of these objectives into categories. The second section will present research done in the field of objectives in science teaching in which the information was mostly obtained from the teachers' opinion rather than from the students. It will also justify the method employed in this research.

EVOLUTION OF THE OBJECTIVES IN SCIENCE TEACHING

Richardson divided the history of science teaching in the United States into three periods, each characterized by a predominant objective. They are as follows: from 1751 to 1872 it was practical and expository; from 1872 to 1900 it was aimed toward college preparation, and from 1900 to the present time it has been evolving toward being more

functional.¹ At the present time "science is included in the curriculum because of its contribution to the general education of future citizens as contributing members of a democratic society."²

An important contribution to the definition of science objectives was made in the Thirty-first Yearbook of the National Society for the Study of Education. Here, development of scientific attitudes and the principles and generalizations of science are considered as objectives of science teaching. The Committee makes a point of disagreeing with the emphasis on the environment as recommended by the Fifth Yearbook of the Department of Superintendence in 1927.³ Sheppard points out that the emphasis with the environment could easily have appeared under the influence of the accepted textbooks of the period, such as the Wood and Carpenter series.⁴ In 1938 the Committee on the Function of Science in General Education recommended that the objectives of science teaching should be adapted to the

¹John S. Richardson, Science Teaching in Secondary Schools (Englewood Cliffs, N. J.: Prentice-Hall, 1957), p. 7.

²Sheppard, op. cit., p. 14.

³The Thirty-first Yearbook of the National Society for the Study of Education, A Program for Teaching Science (Chicago: University of Chicago Press, 1932), p. 43.

⁴Sheppard, op. cit., p. 17.

needs of the youth in personal living, personal-social, social-civic and economic relationships.⁵

Another document containing recommendations for science objectives was issued by the Educational Policies Commission of the National Education Association in 1944. They emphasized teaching the methods of science, scientific inquiry and the cultural aims of science.⁶ An important contribution to the clarification of ideas concerning science objectives was given in the Forty-sixth Yearbook of the National Society for the Study of Education in 1947. The general objectives of science teaching proposed were:

- (1) functional information of facts; (2) functional concepts; (3) functional understanding of principles; (4) instrumental skills; (5) problem-solving skills; (6) attitudes; (7) appreciation; (8) interests.⁷

A report from the Scientific Research Board of the Presidency issued in 1947 also contained a set of four objectives in science teaching. They considered that the

⁵Committee on the Function of Science in General Education of the Commission on Secondary School Curriculum, Progressive Education Association, Science in General Education (New York: Appleton-Century Company, 1938), pp. 46-47.

⁶Educational Policies Commission, Education for all American Youth (Washington: National Education Association, 1944), p. 130.

⁷National Society for the Study of Education, The Forty-six Yearbook, Part I, Science Education in American Schools, ed. Nelson B. Henry (Chicago: The University of Chicago Press, 1947), pp. 28-29.

students should acquire an understanding of: (1) the methods of science; (2) the influence of science upon human life and thought; (3) the factual knowledge necessary to understand themselves and their environment and (4) appreciation of science.⁸ Each of these four statements stands for a different type of objective. They are general and can represent a category of objectives. Most of the specific objectives belong to one of these general types.

A very important publication in the field of secondary education is the Fifty-ninth Yearbook of the National Society for the Study of Education which appeared in 1960. In chapter 2, Hurd recognizes the following main objectives for science teaching: "(1) understanding science; (2) problem-solving; (3) the social aspects of science; (4) appreciations; (5) attitudes; (6) careers; (7) abilities."⁹ In this case the objectives are given in very broad terms. This document was also considered to formulate the set of categories on which the analysis of the teachers' objectives was based in this study.

⁸Paul De Hart Hurd, Biological Education in American Secondary Schools 1890-1960 citing the Scientific Research Board Report (Boulder: Biological Science Curriculum Study, 1961), p. 91.

⁹Paul De Hart Hurd, "Science Education for Changing Times," Rethinking Science Education, The Fifty-ninth Yearbook of the National Society of the Study of Education, Part I (Chicago: The University of Chicago Press, 1960), pp. 34-37.

In 1960 the National Association of Secondary School Principals listed eleven items of major objectives for the junior high school science courses. They are as follows:

1. To acquire those scientific facts, concepts, and generalizations which lead to a better understanding and appreciation of the universe.
2. To develop skill in using many resources for solving problems.
3. To understand the variety of methods employed by the scientists.
4. To appreciate the tentative nature of scientific data and conclusions.
5. To facilitate effective communication of scientific ideas.
6. To nurture the natural scientific interests of each individual.
7. To develop an awareness that man's ability to modify his environment is limited by his understanding of its nature.
8. To appreciate the contributions of scientists.
9. To develop an understanding of the inter-relatedness of the various sciences.
10. To develop an awareness that science is but one factor which contributes to man's well-being.
11. To make the pupil aware of his social and moral responsibility to mankind.¹⁰

Most of these statements were included in the list of objectives of this research.

In 1961 the National Association of State Directors of Teacher Education and Certification published a set of six major objectives for science and mathematics courses.

¹⁰Helen Hale, "Quality Science for the Junior High School," Quality Science for Secondary Schools, Prepared by The National Association of Secondary School Principals (Washington: National Science Teachers Association, 1960), pp. 42-43.

They emphasized the understanding of basic concepts and interrelationship within science, and the development of a scientific mind to approach different kinds of problems or situations.¹¹

Due to the special interest in the area, it is considered important to show the objectives for the physical science course in the North Carolina public schools. The following list of objectives was published by the State Department of Public Instruction in 1964:

1. A better understanding of our physical world.
2. A better understanding of the aims and methods of science.
3. An interest in current happenings in the changing world of science.
4. A better understanding of the role of a scientist.
5. An understanding of scientific endeavor and its relationship to society.
6. An ability to approach and solve problems effectively.
7. A background in scientific experimentation.
8. A favorable attitude toward science, which in some cases might lead to the pursuance of a scientific career.¹²

All of these eight objectives have been used to prepare the list of 57 objectives for evaluation.

¹¹National Association of State Directors of Teacher Education and Certification, Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics. A report prepared by the Teacher Preparation-Certification Study (Washington: National Association of State Directors, 1961), p. 4.

¹²State Department of Public Instruction, Science-Grades 7-9, No. 372 (Raleigh: State Department of Public Instruction, 1964), p. 144.

According to Sheppard:

. . . there seems to be general agreement that as a result of secondary school science education the pupil should:

1. Acquire and be capable of demonstrating increased knowledge and understanding of the facts, concepts, and principles of science.

2. Show improvement in his ability to use his increased understanding of the facts, concepts, and principles of science by applying the methods of scientists in the solution of problems.

3. Be capable of demonstrating an increase in his ability to think critically.

4. Demonstrate improvement in his understanding of the scientific enterprise, the scientists, and the methods and the aims of science.¹³

More recent statements of opinions concerning the goals of science teaching with respect to physical science and physics are found in the specialized periodicals. In all cases it is advisable to keep in mind that "the objectives that govern thought and action find their origin in the philosophy that men hold and in the values they hope to realize."¹⁴ This is a very important remark that partially explains the subjectivity underlying any statement of objectives. Disagreements might also arise due to differences in semantics, in addition to differences because of philosophy.

¹³Sheppard, op. cit., pp. 23-24.

¹⁴Richardson, op. cit., p. 6.

Objectives of Recent Programs in Physical Science and Physics

A discussion of the recently developed programs in physical science and physics will now follow. The first large project to create a physics program which was adapted to the needs of the times was that of the Physical Science Study Committee (PSSC) which started in 1956. As stated in the preface of the textbook, "physics is presented not as a mere body of facts but basically as a continuing process by which men seek to understand the nature of the physical world,"¹⁵ and this is done while the student is introduced to the different aspects of what is called scientific methods.

The physical science course has received attention too, for example a new course, Introductory Physical Science (IPS) was created, again with the collaboration of many educators. The objectives of this course are: (1) to give a feeling for the kind of human effort that is involved in the development of science, (2) to put across the point that the root of all science is phenomena and that the names come later, (3) to allow the student to get information from the original source, from nature

¹⁵Physical Science Study Committee, Physics, (Boston: D. C. Heath and Co., 1960), p. v.

itself.¹⁶ More recently, as a sequel of the IPS program a Physical Science II (PSII) program has been developed with the same general objectives.

Another important effort toward the improvement of physics teaching was Harvard Project Physics, developed recently at Harvard University. The objectives are given in the following statements:

From the beginning Harvard Project Physics had three major goals in mind. These were to design a humanistically oriented course, to attract more students to the study of introductory physics, and to find out more about the factors that influence the learning of science in schools. . . . In practice, this meant designing a course that would have the following effect:

1. To help the students increase their knowledge of the physical world by concentrating on ideas that characterize physics as a science at its best, rather than concentrating on isolated bits of information.

2. To help students see physics as the wonderfully many-sided human activity that it really is. This meant presenting the subject in historical and cultural perspective, and showing that the ideas of physics have a tradition as well as ways of evolutionary adaptation and change.

3. To increase the opportunity for each student to have immediately rewarding experiences in science even while gaining the knowledge and the skill that will be useful in the long run.

4. To make it possible for teachers to adapt the course to the wide range of interests and abilities of their students.

5. To take into account the importance of the

¹⁶Uri Haber-Schaim, "Objectives and content of the Course," Introductory Physical Science, Physical Science II--A Progress Report (Newton, Mass.: IPS Group, 1969), p. 2.

teacher in the educational process, and the vast spectrum of teaching situations that prevail.¹⁷

Some Recent Ideas on Objectives in Science Teaching

Although in many respects the aims of science teaching have not changed, a different approach to their formulation is noticeable in many authors. A very interesting article by Wolfe comments on the change in objectives experienced through the years. To show explicitly the evolution of science teaching through the years, she quotes Philip G. Johnson of Cornell University who summarized his ideas in fourteen statements, some of which are shown below:

From one problem-solving method to many relatively unstructured instructional methods.

From emphasis on accumulating knowledge to an emphasis on how to find and create knowledge.

From facts and factual concepts to skill in inquiry as teaching goals.

Wolfe considers that the reasons for studying science are "the mental stimulation and satisfaction of exploring our environment, learning about its past, gaining into the future, acquiring a sense of order in our universe, examining man's role in the scheme of things and discovering one's own talents and interests."¹⁸ Conceptually, these

¹⁷Project Physics, The Project Physics Course--Text and Handbook, Unit I Concepts of Motion (New York: Holt, Rinehart and Winston, 1970), Preface.

¹⁸Deborah P. Wolfe, "Trends in Science Education," Science Education, LIV, 1 (1970), 75.

reasons are closely related to statements of objectives that have been reviewed, such as those given by the Scientific Research Board of the Presidency given earlier.

In 1942 a new term called behavioral objective appeared in the field of education. From that moment on many educators have supported behavioral objectives as a new approach to achieve effective teaching. During the last ten years the interest in this new tendency has increased and many authors such as Mager,¹⁹ Nedelsky,²⁰ Gagne,²¹ Atkin,²² Gideonse,²³ and Ryder²⁴ have published papers referring to behavioral objectives or instructional objectives. The NSTA has also issued some papers on this much-discussed topic in science education.²⁵

¹⁹Robert F. Mager, op. cit.

²⁰Nedelsky, op. cit.

²¹R. M. Gagne, "Elementary Science: A New Scheme of Instruction," Science, CLI (1966), 49.

²²J. Myron Atkin, "Behavioral Objectives in Curriculum Design," The Science Teacher, XXXV (May, 1968), 27.

²³Hendrik D. Gideonse, "Behavioral Objectives: Continuing the Dialogue," The Science Teacher, XXXVI (January, 1969), 51.

²⁴M. Briant Ryder, "Behavioral Objectives--An Introduction for Physics Teachers," The Physics Teacher, VIII (October, 1970), 361.

²⁵i.e. John J. Koran, Jr., Earl J. Montague, and Gene E. Hall, "How to Use Behavioral Objectives in Science Instruction," How to . . . series, Washington: NSTA, 1969, Stock No. 471-14596; see also Albert F. Eiss and Mary B. Harbeck, Behavioral Objectives in the Affective Domain (Washington: NSTA, 1969).

There have always been people concerned with the humanistic aspect of science and it is not difficult to find books or articles discussing this topic almost in any period of American history of education. Recently, the concern has increased and one proof is that Harvard Project Physics is oriented toward a more humanistic approach.

Alfred Garrett states in an article on "Science Education Toward the World We Want" his hypothesis that "what we need is to develop a science of humanity." He considers that "our curricula will be mission- or problem-oriented. This becomes almost essential from the viewpoint of motivating students--as well as bringing about a scientifically literate civilization which is cognizant of the problems that science must solve in the future."²⁶

Another very interesting paper was written by Harmin, Kirschenbaum and Simon and refers to "Teaching Science with a Focus on Values." They state that science teaching has also to become involved in the big problems that surround everyone. "Under the guise of objectivity, too many of us have simply avoided dealing with the hot and always controversial issues surrounding the science we teach." They consider that "we simply cannot afford to

²⁶ Alfred B. Garrett, "Science Education Toward the World we Want," The Science Teacher, XXXVII, 5 (1970), 18.

train a generation of students who know the how and why of scientific phenomena but do not have a process for inquiring into the values issues raised by the topics they study."²⁷ To accomplish their objective they suggest that any topic should be developed in three levels, where the third one makes the information relevant to the students' lives. This article evidently stands for a very new approach to science teaching and makes the social-humanistic objectives the central point. Even if many others have stated this position, as far as the literature that was reviewed this article contains one of the most explicit examples of what to do in order to achieve these objectives.

In July 1970, the National Science Teachers Association (NSTA) approved a series of statements concerning, among others, the social implication of science teaching; they are:

1. Understanding of the principles, processes, content, and social implications of the sciences.
2. Recognition of the contributory role of rational thought to the making of value judgements and to the solution of social problems.
3. Recognition of the necessity for translating judgements regarding the solutions to critical problems into rational and effective actions.

²⁷ Merrill Harmin, Howard Kirschenbaum, and Sidney B. Simon, "Teaching Science with a Focus on Values," The Science Teacher, XXXVII (January, 1970), 16.

Concerning the environment they urge "that significant components of environmental education be included in the science learning activities of all students."²⁸

As has been shown, there seems to be an agreement with regards to the fact that science must become involved in the problems that are affecting society today and there is a conviction that proper handling of these objectives will lead to effective learning and an increased interest and appreciation of the scientific enterprise.

Conclusions

The objectives that have been mentioned thus far constitute the pool from which the preliminary list of objectives was prepared. Other objectives were added later from books or suggested by members of the panel of professors in order to prepare the final list.

An overall review of the objectives above shows that most of them can be classified into a few categories. Many authors have divided science objectives into categories, and there are many ways or criteria for doing this.²⁹ Here, an attempt has been made to present a

²⁸NSTA Committee on Issues, "NSTA Positions on Critical Issues Confronting the Science Teaching Profession," The Science Teacher, XXXVII (October, 1970), 55.

²⁹i.e. Nathan S. Washton, Teaching Science Creatively in the Secondary Schools (Philadelphia: W. B. Saunders Company, 1967), p. 35.

classification of the most frequently mentioned objectives shown in the reviewed literature. Science objectives can be grouped into five categories as follows: (1) transmission of knowledge, (2) use of the scientific methods, (3) humanistic aspects of science, (4) science as a background, and (5) interest in science and appreciation of science. These categories have been used in the analysis of the subjective part of the questionnaire which is analyzed in Chapter 3. In order to present a well defined content of each of the categories they have been re-stated in an expanded form in the following chapter.

RESEARCH ON SCIENCE OBJECTIVES

Before discussing some research done in this field it is interesting to mention Richardson's remark:

Several studies of the objectives of science teaching have been made. These and other studies reveal a wide variety of goals, some stated very specifically, others quite generally. However justifiable they may be from the standpoint of the classroom teacher such lists may suffer from their lack of conciseness.³⁰

Anyone going through the numerous statements of objectives will have the opportunity to verify the above comment.

A significant study of science teaching objectives was done by George W. Hunter of Claremont Colleges, California starting in 1930. He conducted a series of

³⁰ Richardson, op. cit., p. 8.

inquiries among science teachers, in some cases nationwide, in others confined to a smaller region. The purpose was to determine which objectives were held by the high school science teachers of the nation. The collection of data was mainly done by means of questionnaires. The third of the series of questionnaires was reported in a paper by Hunter and Knapp in 1932. The four main objectives of science teaching were found to be: (1) the understanding of the environment, (2) the preparation for college, (3) the acquisition of information, and (4) the mastering of the scientific method of problem-solving. It must be noted that the scientific method appeared fourth in the list.³¹ The stress in the environment is consistent with the textbooks used at the time and with the recommendations appearing in the Fifth Yearbook of the Department of Superintendence in 1927, as discussed earlier.

In 1943 Hunter and Spore published another paper on science objectives. They used a list of objectives obtained from previous works and presented it to teachers asking them to rank each item according to a scale with five possible grades. The objective that was ranked highest was "to develop a better understanding of the environment."

³¹George W. Hunter and Roy Knapp, "Science Objectives at the Junior-and-Senior-High-School Level," Science Education, XVI (October, 1932), 407.

Differences in ranking were shown between junior and senior high-school teachers. While for the junior high-school teachers the three objectives heading their list related to the same type of objective--knowledge, appreciation and understanding of the environment--for senior high-school teachers the three items heading the list referred to the environment, the health and the scientific methods. Among their conclusions those concerning the geographical distribution of the ranking showed that in the southern States health needs, conservation, and preparation for vocation were rated highest.³²

One of the last surveys conducted by Hunter was published in 1947 and referred to a comparative study of the situation of science teaching in California in 1940 and 1947. Among his conclusions he was able to show how the emphasis of teachers shifted from the factual knowledge and college preparation to the teaching of scientific methods.³³

A study of objectives was done in 1930 at the University of Wisconsin by Bergen and others. The informa-

³²George W. Hunter and Leroy Spore, "The Objectives of Science in the Secondary Schools of the United States," School Science and Mathematics, XLIII (October, 1943), 633.

³³George W. Hunter and H. J. Edward Ahrens, "The Present Status of Science Objectives in the Secondary Schools of California," Science Education, XXXI, 5 (1947), 287.

tion was provided by 25 teachers attending a summer course on science education. During this research a list of objectives was prepared, classified and then evaluated according to estimated importance. Here again, the habit of scientific thinking and a scientific attitude were placed first in the list followed by specific knowledge.³⁴

In 1954 Burmester and Noll developed a technique for synthesizing and evaluating objectives for a biology course at college level which can be also applied to high school physics and physical science. The technique resembles that used by Hunter: a rating sheet with 32 objectives was presented to the subjects. To analyze the data, the items were classified in seven categories in order to present tables and graphs.³⁵

In 1959 Lee conducted an evaluation of a list of 314 specific items of content and skills generally considered as objectives of high-school physics. This included very specific topics of physics and also behavioral objectives. He submitted it to four different groups of persons representing the scientific and the non-scientific.

³⁴L. M. Bergen and others, "Objectives of Science Teaching," School Science and Mathematics, XXXI (May, 1931), 550.

³⁵Mary A. Burmester and Victor Noll, "A Synthesis and Evaluation of Objectives for a Course in College Biology," Science Education, XXXVIII (March, 1954), 143.

tific point of view. As a result of this research "no items were found to be considered unanimously either important or unimportant by any jury" and "the skills of a behavioral nature were generally rated of far greater importance than most of the items of content." Finally, it was statistically shown that the specific objectives of high-school physics seem to be the same for training of future physics majors as for the general education of all students.³⁶ The latter statement agrees with Rogers who considers that the objectives of science are intended for the future scientist as much as for the non-scientist. "The same thing, then, is wanted for all: an understanding of science; but the level of knowledge and the speed of teaching need not be the same for all."³⁷

In 1966 Pella, O'Hearn and Stiles published a study on scientific literacy. The information was gathered from bibliographical material and interviews with different

³⁶Donald E. Lee, "An Evaluation of Certain Objectives of High School Physics with Reference to the Training of Future College Physics Majors and the General Education of all Students," Science Education, XLVI (October, 1962), 385.

³⁷Eric M. Rogers, "The Research Scientist Looks at the Purposes of Science-Teaching," Rethinking Science Education, The Fifty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago, University of Chicago Press, 1960), p. 19.

people. An extensive set of conclusions was obtained which can be summarized in the following statement:

Evidence from analysis of the literature concerned with scientific literacy reveals that knowledge of the (1) interrelationships of science and society, (2) ethics of science, and (3) nature of science are more important than (4) conceptual knowledge, (5) differences between science and technology and (6) the interrelationships of science and the humanities."³⁸

In 1966, Sheppard made a study of ninth grade science teachers in North Carolina secondary schools. The teachers were asked why science should be taught in high school. From the answers to that question, and assuming that the reasons for having science taught in high school were closely related to their own objectives, Sheppard stated his results in terms of objectives. The three objectives that were stated most frequently by the teachers were:

1. Science is such an important area and affects our lives so much that pupils need to learn more about science.

2. There is such a shortage of scientists that we need to introduce the students to the area and possibly persuade more of them to become scientists.

3. A study of science should aid the student in learning how to think and to solve problems.³⁹

Summarizing, this review of research in science objectives shows that one of the methods for gathering the

³⁸ Milton O. Pella, George O'Hearn, and Lindley Stiles, Scientific Literacy, Technical Report No. 1, The Scientific Literacy Research Center (Madison: University of Wisconsin, January, 1966), p. 21.

³⁹ Sheppard, op. cit., p. 100.

information from the teachers is to present a list of possible objectives and have them ranked. Different techniques for the analysis of the results were employed. A second method is to ask the teachers to write their own objectives. Both ways have been used here in the assumption that they complement each other.

Chapter 3

THE SUBJECTIVE PART OF THE RESEARCH STUDY

This chapter will refer to the statement of science objectives as given by the teachers. For this part, the answers of the teachers were written on a special form which is shown in Appendix A.

PROCEDURE

In most cases the statements of the teachers were expressed in brief sentences, each sentence stating one objective. This made it relatively easy to categorize the statements. There was no attempt to have the objectives listed in order of importance, therefore, they were all given the same weight regardless of their position in the list.

Some difficulties were experienced with a few of the teachers' statements due to the construction of the sentences, vagueness or ambiguity. This involves a certain amount of subjectivity which limits further conclusions. However, this is a problem which is expected to arise when dealing with statements expressed without any suggestion whatsoever. Another distorting psychological factor which might influence the answers is the desire to give a good impression.

For the purpose of analyzing the teachers' stated objectives, they were divided into specific categories. In order to facilitate classification and further analysis these categories were broken down into sub-categories. The statements of the teachers were categorized twice, at different times, to reduce errors in classification.

The list of categories presented here is a synthesis of the most frequently mentioned objectives in the reviewed literature which has been adapted to the statements given by the teachers. The six general categories are as follows:

1. To provide the student with the basic knowledge about the physical laws and theories in order to understand his environment.
2. To teach the student the use of scientific methods and to enable him to develop skills, abilities and scientific attitudes.
3. To show the relationship of science and society in the cultural and technological fields.
4. To provide all students with a background in science.
5. To arouse interest in science and develop appreciation of the importance of science.
6. Others.

Category number 6 was intended to include miscellaneous

objectives which were expressed by only one person and do not bear any weight as far as a group concerns.

The categories have been sub-divided in the following sub-categories:

1a. To learn about the physical laws and theories.

1b. To understand and appreciate the physical world and the environment.

1c. To acquire information on specific topics.

2a. To understand and apply scientific methods.

2b. To develop scientific attitudes, skills and abilities.

3a. To learn about the relationship of science with other disciplines and other aspects of life.

3b. To learn about the historical development of physical science and the work of scientists.

3c. To learn about the relationships between science and technology.

4a. To acquire a general background in physical science and physics.

4b. To be adequately prepared for a scientific career.

5a. To develop interest in science matters.

5b. To develop an appreciation of the importance of science.

In many cases, if two distinct objectives were expressed in a compound sentence, they were separated; in others, several objectives belonged to the same category and even to the same sub-category. Here are two examples of the criteria followed when categorizing the objectives from the answer sheets:

a) a statement like: "Relate science to everyday work" was considered in two sub-categories, 3a and 3c.

b) specific statements such as: "Development of training in experimental science," or about "Some elementary mathematics involvements in science" have been included in 2a, that is, understanding and application of the scientific method.

Once the teachers' statements were categorized, the results were easily tabulated.

RESULTS AND ANALYSIS

With regards to the teachers answering in the physics or physical science areas the distribution is as follows:

(1) 21 teachers stated objectives for a physical science course.

(2) 15 teachers stated objectives for a physics course.

(3) 9 teachers stated objectives for both courses.

This makes thirty sets of statements for physical science courses and twenty-four sets of statements for physics courses. The fact that the discussion is based on physical science and physics course objectives automatically divides the group into junior and senior high-school level, although several teachers work at both levels in composite schools.

Table 1 shows the distribution of the answers (raw data) according to categories and sub-categories. The answers have been divided into two main groups according to physical science and physics courses. Each of these has been sub-divided into three columns: physics, physical science and physics, and total for the two sub-groups in the case of physics. In the case of physical science the subdivisions are: physical science, physical science and physics, and total for both subgroups. In this way the teachers who expressed one set of objectives have been differentiated from those who answered for both courses. The same grouping will be used in Tables 2 and 3.

Table 1. Distribution of the Teachers' Statements of Objectives

Category	Sub-category	PHYSICAL SCIENCE			PHYSICS			Overall total
		Physical science	Phys. sci. & physics	Total	Physics	Phys. sci. & physics	Total	
1	1a	8	4	12	7	3	10	22
	1b	6 17	4 9	10 26	4 17	1 4	5 21	15 47
	1c	3	1	4	6	0	6	10
2	2a	6	3	9	5	4	9	18
	2b	12 18	5 8	17 26	5 10	6 10	11 20	28 46
3	3a	6	3	9	3	4	7	16
	3b	4 16	1 7	5 23	2 8	0 10	2 18	7 41
	3c	6	3	9	3	6	9	18
4	4a	2	0	2	2	0	2	4
	4b	1 3	0 0	1 3	4 6	0 0	4 6	5 9
5	5a	9	4	13	5	4	9	22
	5b	8 17	2 6	10 23	2 7	2 6	4 13	15 37
6		1	1	2	1	0	1	3
Number of teachers		21	9	30	15	9	24	54

Since there is a different number of teachers in each group (21, 9, and 15), the results of Table 1 have been re-expressed in percentages so as to make the comparisons among them easier. This is shown in Table 2 which shows the distribution of the objectives only within sub-categories. The percentage was found by dividing the number of teachers in each group into the number of objectives for a given sub-category. Thus, 7 objectives expressed by the physics group for sub-category 1a yielded a percentage of 47, since the number of teachers in that group was 15.

Table 2 makes it possible to determine which aspects received more emphasis within each category. For example, the acquisition of skills, abilities and scientific attitudes (2b) seems to be more important than the mere learning and application of the scientific methods (2a). This is stressed in the case of physical science teachers by 57 and 28 percent respectively. The overall percentages are 33 for sub-category 2a and 52 for sub-category 2b. Therefore, at the high-school level, the teaching of the methods of science would be valuable in that it offers the possibility to develop certain traits in the students' personality such as those mentioned above.

Table 2. Percentage Distribution of the Statements of Objectives by Sub-categories

Sub-category	PHYSICAL SCIENCE			PHYSICS			Over-all total
	Phys. sci.	Phys. sci. & physics	Total	Physics	Phys. sci. & physics	Total	
1a	38	44	40	47	33	42	41
1b	28	44	33	27	11	21	28
1c	14	7	13	40	0	25	18
2a	28	33	30	33	44	37	33
2b	57	55	57	33	67	46	52
3a	28	33	30	20	44	29	30
3b	19	11	17	13	0	8	13
3c	28	33	30	20	40	37	33
4a	10	0	7	13	0	8	7
4b	5	0	3	27	0	17	9
5a	43	44	43	33	44	37	41
5b	38	22	33	13	22	17	28
6	5	11	7	7	0	4	5
No. of teachers	21	9	30	15	9	24	54

In looking at the totals for category 1, the understanding of physical laws and theories (1a) prevails on the learning of scientific topics (1c) as objectives for the physics teacher, or on the understanding of the environment (1b) for the physical science teacher. Category 1 shows a difference between the physics and physical science teachers which appear logical because the physics course follows the physical science course, and the physics teacher might feel that an objective such as (1b) has been accomplished at the junior level.

The totals in category 3 (see Table 2), with three sub-categories, show that major emphasis has been given to the relationship between science and technology (3c). It can be observed that very few teachers considered the historical aspect of science and the work of scientists (3b) in their objectives, especially among the answers for physics. This is an area that the Harvard Project Physics program is attempting to bring up to an important place. As evidenced in category 4, science teaching aimed at preparing students for future studies or to give them a reasonable background does not seem to be a prime objective for most teachers. To develop interest in science (5a) was considered important by about 40 percent of all the teachers, while appreciation of the importance of science (5b) seems to be more of an objective among physical

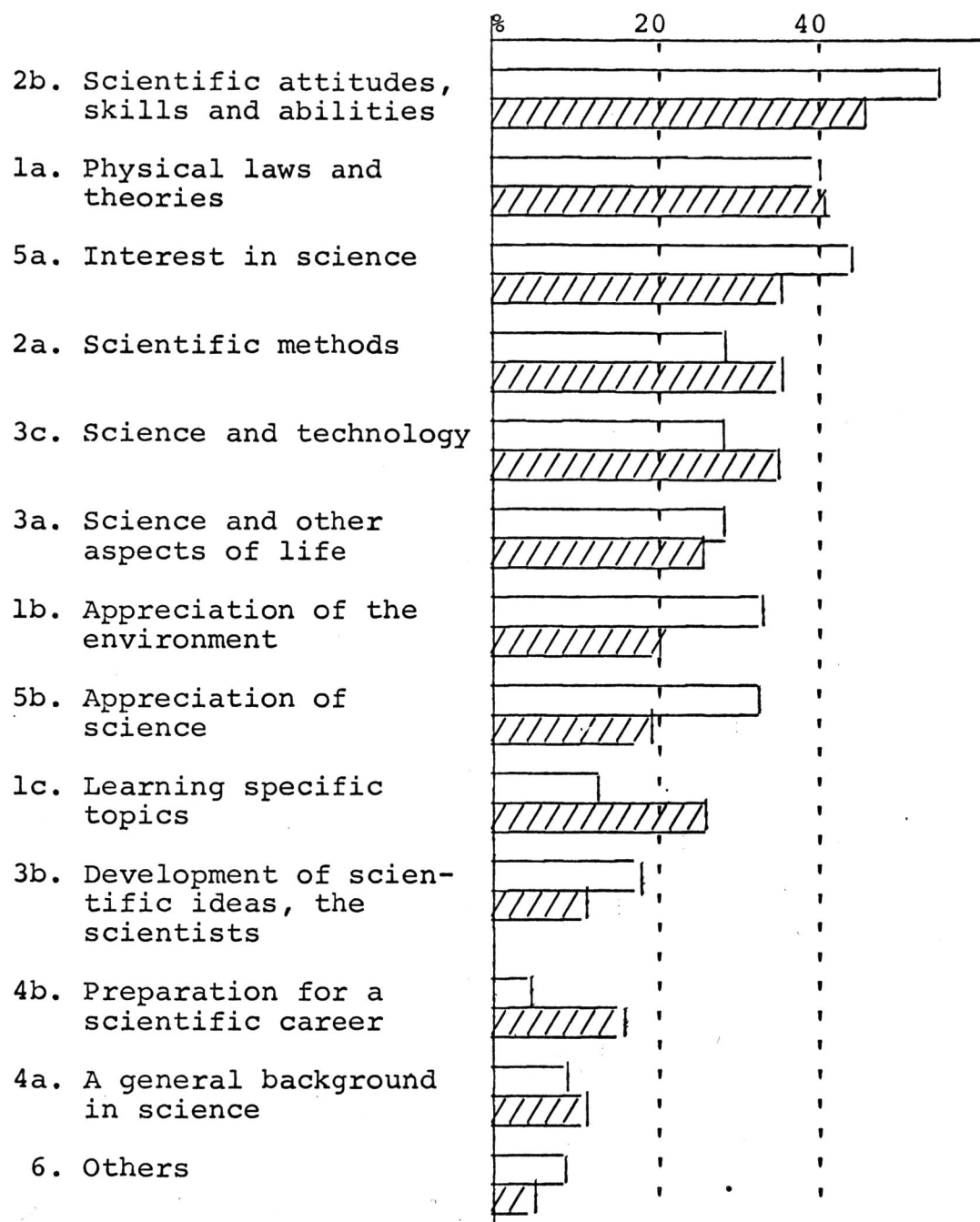
science teachers than among physics teachers, although the figures reveal a tendency more than a very sharp difference. The nature of both courses might justify this difference, since physical science is more general than physics. Category 6--others--is not significant since the interest in the results does not involve individual responses.

Table 2 also allows one to compare the statements given for physical science and physics courses by the same group of nine teachers who have taught both courses. Looking at the figures under the two columns "physical science and physics," it seems that these same teachers stress different objectives for each of the courses. Their answers for physics and for physical science courses differ clearly in subcategories 1a, 1b, 2a and 2b. In the physical science course these teachers emphasize the learning of laws and the understanding of the environment (1a, 1b) and de-emphasize the scientific methods (2a, 2b) in comparison with the physics course. In particular, the difference of emphasis in the understanding of the environment was considerable (44 percent to 11 percent). However, they agree in emphasizing the development of scientific attitudes, skills and abilities (2b) as well as they show the same response with respect to categories 4 and 5 (4a,

4b, 5a, 5b). The low number of persons, nine, prevents one from drawing more conclusions.

The two columns corresponding to "total" in Table 2 allows a comparison between the two groups of answers: science objectives for a physical science course and science objectives for a physics course. This division is comparable to junior high-school science teachers and senior high-school science teachers. In order to compare the answers given by the two groups the histogram in Figure 1 illustrates the sub-categories in descending order of frequency mentioned according to the overall total percentages. Significant differences between the two groups are indicated for sub-categories 1b, 1c, 2b, 3b, 4b and 5b. From this analysis it is apparent that physics teachers place a greater emphasis on the learning of specific topics and the preparation for college science, whereas these physical science teachers emphasize the appreciation of the environment and the importance of science. This result is not surprising and is in agreement with what was shown in Hunter's surveys.¹

¹George W. Hunter, Science Teaching at Junior and Senior High School Levels (New York: American Book Co., 1934), p. 105.



White bars: physical science; single-hatched bars: physics

Figure 1. Comparison between Physical Science and Physics Answers Given by the Teachers According to Sub-categories.

Table 3 shows the distribution of science objectives in six categories by percentages where the percentages were calculated depending on the number of possible answers available in each category. This procedure was followed since categories 1 and 3 have three sub-categories and the number of possible answers available is three times the number of teachers in each group, while for categories 2 and 4 it is two times. For example; since the group of 15 physics teachers answered 17 objectives dealing with category 1 (see Table 1), the corresponding percentage will be $17 \times 100 / (3 \times 15) = 38$. This explains the fact that while in Table 1 the overall totals for category 1 and 2 are 47 and 46 respectively, the corresponding percentages in Table 3 reverse the order giving 29 percent and 43 percent respectively.

Looking at the column corresponding to overall totals there is noticeable emphasis in the objectives related to the scientific method and its incidence on acquisition of skills, abilities and scientific attitudes. To develop interest in science and appreciation on the importance of science is ranked second in importance. Objectives concerning factual knowledge including one's environment comes third with 29 percent. The humanistic aspects of science had a 25 percent response. This result does not agree with the new tendencies among science educa-

tors stressing the social, historical and philosophical implications of science. This should be taken into account if efforts are directed toward emphasizing this type of objective.

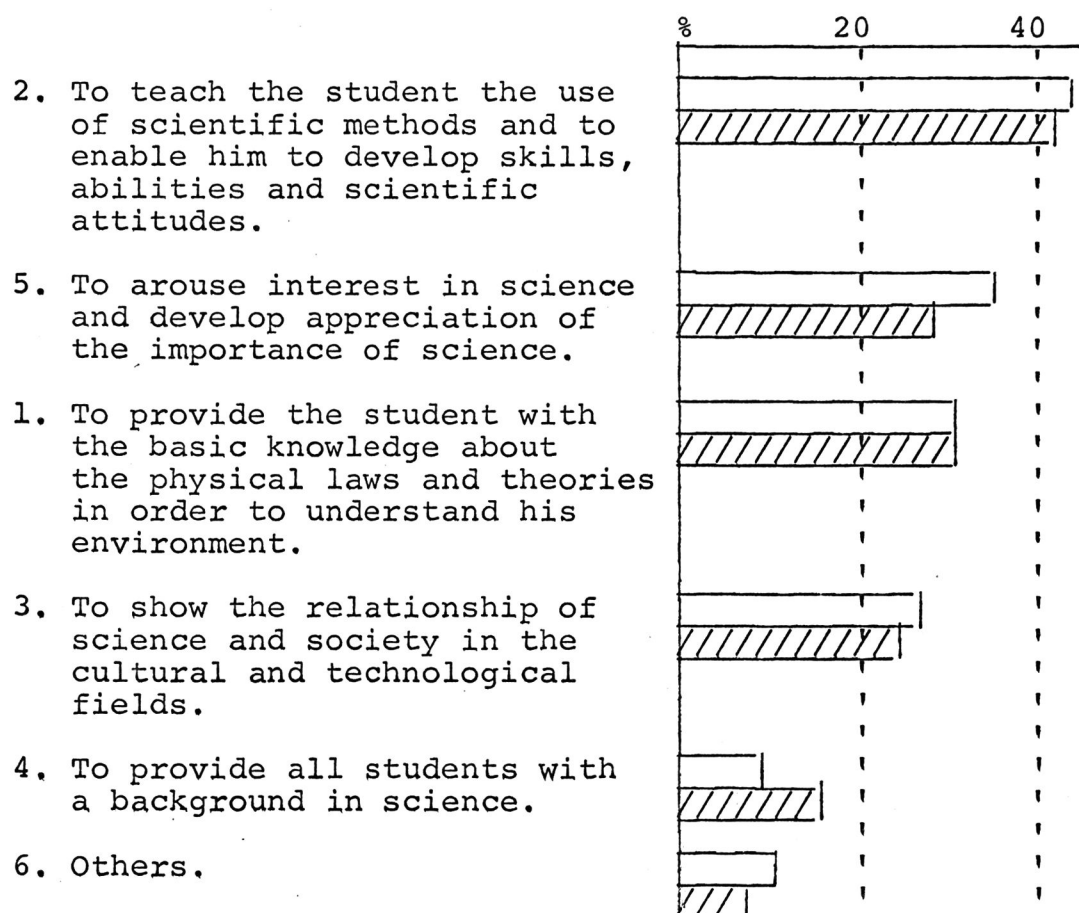
The objectives expressed by teachers as desirable in a physics course compared with those desired for a physical science course (under "total") show that category 2, that is related to scientific methods, is first with 42 and 43 percent respectively. In second ranking there is some difference in that the physics teachers prefer category 1 and the physical science teachers category 5. There is a slight preference in the physical science course for category 5 since its content is more general. Here again, it is possible to compare the emphasis in different types of objectives according to physics and physical science as given by the same group of teachers. Differences are noticeable in Table 3 for category 1 with 15 and 33 percent respectively.

Table 3. Percentage Distribution of the Statements of Objectives by Categories*

Cat.	No. of sub-cat.	PHYSICAL SCIENCE			PHYSICS			Over-all total
		Phys. sci.	Phys. sci. & physics	Total	Physics	Phys. sci. & physics	Total	
1	3	27	33	29	38	15	29	29
2	2	43	44	43	33	55	42	43
3	3	25	26	25	18	37	25	25
4	2	24	0	5	20	0	13	8
5	2	40	33	38	23	33	27	34
6	1	5	11	7	7	0	4	6
Number of teachers		21	9	30	15	9	24	54

*The percentages were calculated taking into account the number of sub-categories.

The histogram in figure 2 shows a comparative distribution of the answers given by physical science and physics teachers based on results shown in Table 3.



White bars: physical science; single-hatched bars: physics.

Figure 2. Comparison Between Physical Science and Physics Answers Given by the Teachers According to Categories.

The values given in the preceding tables are rather low. This suggests that the answers of the teachers did not cover all the categories, but in some cases only responded to one sub-category.

Variety of Objectives Listed
by the Teachers

Some teachers stated as many as five different objectives, thus covering different categories or, at least, different sub-categories. Meanwhile, others expressed but one or two different types of objective. Tables 4 and 5 account for the variety of answers given by the teachers according to the number of sub-categories and categories respectively. Two statements were considered different if they belonged to different sub-categories. The tables show the values corresponding to physics courses, physical science courses and both of them together.

Analyzing Tables 4 and 5, it can be concluded that:

1. For both physics and physical science the tendency is to give three different types of objectives. It is shown that they cover three categories as well. Most of the teachers stated between two and four different objectives.

2. The rest is distributed in the extreme values. 9 percent of the whole stated only one type of objective. To this group others were added which covered more than one sub-category but only one category.

3. As for those covering five different sub-categories there is a difference between physics and physical science answers: 8 percent and 27 percent respectively.

Looking at the results in the distribution according to categories it is easy to realize that the above 27 percent for physical science was distributed into 2, 3 or 4 categories.

4. The highest display of objectives obtained here was from the physics group with 8 percent of the answers presenting 6 to 7 different objectives. As for the categories, the highest value also corresponds to 4 percent of the physics group covering 5 categories. In order to avoid an overestimation of these results it is advisable to refer to the raw data which calls the attention to the low numbers obtained and prevents one from coming to risky conclusions.

The fact that some teachers' objectives only cover one or two areas while others cover four or five can be meaningful if it affects their teaching. The approach to the different topics that teachers take in their everyday work in the classroom may be influenced by the quality and amount of expectations they possess.² If this is true, these will be directly related to their objectives.

²Sheppard, op. cit., p. 5.

Table 4. Distribution of the Teachers According to the Number of Sub-categories Stated

Number of different sub-categories	Physical science		Physics		Total	
	No. of teachers	%	No. of teachers	%	No. of teachers	%
1	2	7	3	13	5	9
2	7	23	4	17	11	20
3	7	23	7	29	14	26
4	6	20	6	25	12	22
5	8	27	2	8	10	19
6			1	4	1	2
7			1	4	1	2
No. of teachers		30	24		54	

Table 5. Distribution of the Teachers According to the Number of Categories Stated

Number of different categories	Physical science		Physics		Total	
	No. of teachers	%	No. of teachers	%	No. of teachers	%
1	3	10	3	12.5	6	11
2	7	23	6	25	13	24
3	12	40	11	46	23	43
4	8	27	3	12.5	11	20
5			1	4	1	2
No. of teachers		30	24		54	

Conclusions

On the basis of this study the majority of the teachers seem to possess a set of objectives in agreement with the traditional standards published by educational committees. Their statements seem to be oriented toward the development of scientific attitudes in the student by introducing him to the scientific methods. A knowledge of physical laws especially concerned with the individual's environment and the application of science to improve such environment were highly considered. These were the most frequently mentioned objectives. Secondly, the desire to get the students interested in science and to show them its importance was emphasized more by the physical science group. Inasmuch as the teachers were not required to list a definite number of objectives, the fact that 43 percent of the teachers listed statements in three different categories is significant.

Chapter 4

THE OBJECTIVE PART OF THE RESEARCH STUDY

This chapter will refer to the evaluation of science objectives in secondary school physics courses by the teachers and by a panel of professors. The list of objectives and the corresponding directions are given in Appendix B.

PROCEDURE

As it was explained in Chapter 1 the teachers had to rank 57 possible science objectives. The items were taken from many sources such as reports issued by educational committees that were discussed in the reviewed literature review, books on science teaching,¹ and suggestions from the judges. Initially 64 items were listed. A proper selection of objectives was made with the most varied and representative ones chosen. The original list was submitted to a panel of professors at East Carolina University, five from the Science Education Department and

¹i.e. Elwood D. Heiss, Ellsworth S. Obourn, and Charles W. Hoffman, Modern Science Teaching (New York: The Macmillan Co., 1950), pp. 25-30; Nathan S. Washton, Teaching Science Creatively in the Secondary Schools (Philadelphia: W. B. Saunders Company, 1967), pp. 33-45.

seven from the Physics Department. These professors were asked (1) to rank each one of the items and (2) to classify them into seven different categories that were presented to them (see Appendix C). Many of them suggested changes, such as to eliminate, to re-word or to add items. The list of objectives as finally prepared to be submitted to the teachers consisted of 57 items and was formulated so that among the objectives held high by science educators, there were also some objectives which were less important or negative. The validity is supported by the authority of the sources from which they were taken and the conformation of the panel of professors at East Carolina University. No attempt was made to calculate the reliability of the list of objectives.

The answers given by the judges and the teachers were tabulated on a computer in order to obtain a frequency distribution for each item as well as a distribution of the ranking given to each. The categorization of the statements done by the judges was also analyzed and submitted to a validity test.

From the tabulated data the following calculations were made:

1. An average score for each judge and each teacher, obtained by adding all the numbers representing the rank for each item (scale 1 through 5) and dividing it

by the number of items that were ranked. For example: one of the teachers answered in the following way:

Scale	1	2	3	4	5
No. of items in the rank	28	11	7	4	7
Score for each	28	22	21	16	35

This gives a total score of 122 and an average score of $122/57 = 2.14$. The latter value will be referred to as the mean score.

2. The mean value for the ranking of each item obtained separately for the judges and the teachers. For example: item 23 had the following distribution of ranks given by the judges:

Scale	1	2	3	4	5
Frequency	5	5	1	1	0

A total score is obtained as follows: $5 \times 1 + 5 \times 2 + 1 \times 3 + 1 \times 4 + 0 \times 5 = 22$ so, the mean value is $22/12 = 1.83$.

This will be referred to as an item mean value.

The two sets of values were further used for comparisons between judges and teachers or among subgroups of teachers. The item mean values for judges and teachers were compared after items were grouped in categories.

RESULTS AND ANALYSIS

The results of this part of the survey are now presented.

Analysis Based on the Mean Scores

The mean score obtained for each person in the two groups (judges and teachers) is a measure of the trend in ranking the statements of the list. Although this list deliberately contained minor and non-objectives, which could affect the score by increasing the average value of each person toward a 5 rank, all would be affected the same way. The score obtained does not only depend on the nature of the items presented to the group but also on the tendency of the individuals to rank higher or lower.

The range of the mean scores is from 1 to 5. A mean score near 1 indicates that most of the items of the list were ranked as major objectives. The average mean score for the judges was 2.37 and for the teachers was 2.29. Thus, the group of teachers appear to rank these objectives slightly higher than the judges. The standard deviation for the judges was 0.41 and for the teachers 0.42 which indicates that the judges varied about as much as the teachers overall. The two sets of values have been compared by means of a one-way analysis of variance. As it

is shown in Table 6 there is no significant difference between the mean scores for judges and teachers.

Table 6. Comparison Between the Mean Scores of Judges and Teachers--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean square	F ratio
Between	.0614	1	.0614	.34
Within	9.6452	54	.1786	(not significant at .05 level)
Total	9.7065	55		

To give a general idea of the distribution of the mean scores, a histogram showing its frequency distribution for both groups is presented in Figure 3. The diagram for the teachers approaches the normal distribution. The judges show a relatively more spread configuration than the teachers which is not unexpected from such a small sample.

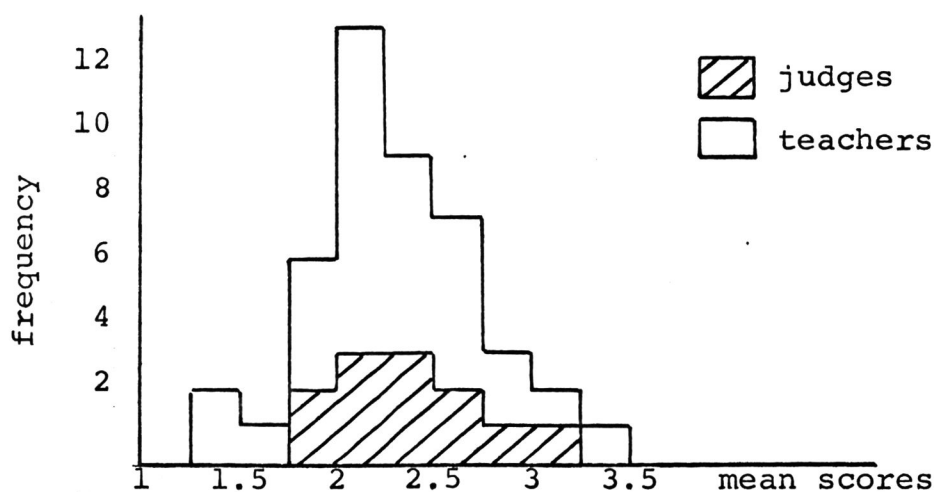


Figure 3. Frequency Distribution of the Mean Scores for Judges and Teachers

The whole group of teachers was divided into three sub-groups as it was done earlier for the first part: (1) physics teachers, (2) physical science and physics teachers, (3) physical science teachers. Their mean scores, obtained by adding up their ranking and averaging, were compared by computer program using a one-way analysis of variance (ANOVA). The results are given in Tables 7 and 8. The headings for the different columns of Table 7 have the same meaning as in Tables 1, 2 and 3, as stated above.

Table 7 shows that the groups do not differ from each other very much. However, the physical science teachers showed a tendency to score lower than the other two groups. It is noted that the value from one of the teachers of physical science had to be discarded due to incomplete ranking of the list.

Table 7. Mean Scores for the Three Groups of Teachers

	Physical science	Physics	Physical science and physics
Sample size	20	15	9
Mean	2.39	2.24	2.18
Standard deviation	0.46	0.43	0.33

Table 8 displays the ANOVA results for the comparison of the three groups of teachers. The low value for the F ratio shows that there is no significant difference

among the groups as far as their ranking mean scores concerns. Thus, the apparent differences are not real.

Table 8. Comparison Among the Mean Scores of Physics Teachers, Physical Science Teachers and Teachers of Both Physical Science and Physics--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean square	F ratio
Among	.3396	2	.1698	.94
Within	7.4371	41	.1814	(not significant at .05 level)
Total	7.7767	43		

Inasmuch as there were no differences between physical science and physics teachers as far as their mean scores were concerned, comparisons have been made between the judges and all the teachers.

Analysis Based on the Item Mean Values

The distribution of the ranking tabulated by the computer for each item allowed for several ways of analysis. The average ranking for each item was used to compare the teachers with the judges by means of the analysis of variance. This was done in two ways: first by comparing the two groups taking the mean for all the items and second, by comparing judges and teachers averages for categorized groups of items.

The comparison between mean values for each item

as given by judges and teachers is shown in Table 9. There is no significant difference between the rankings of the judges and teachers. The average values were 2.35 for judges and 2.33 for teachers with standard deviations of 0.83 and 0.71 respectively.

Table 9. Comparison Between Item Mean Values of Judges and Teachers--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean square	F ratio
Between	.0121	1	.0121	.0200
Within	67.5816	112	.6034	(not significant at .05 level)
Total	67.5936	113	.5982	

Categorization of the objectives by the judges.

Eleven judges categorized each of the 57 possible objectives into seven categories. The categories were prepared taking into consideration the items themselves, the categories already discussed in Chapter 3 and the suggestions of some of the judges. Category number 7 was intended to include the items that each of the judges considered could not fit into any of the other categories. The list of categories as presented to the judges is given in Appendix C. After the judges had classified the 57 items the results were arranged in a matrix as shown in Appendix D.

The content validity of this item pool was calculated using a two-way analysis of variance for factorial

design program. The method employed was based on a similar determination by Champlin.² He gave a measure of the content validity of an item pool by using the intra-class correlation (r_{cc}) which is presented by Guilford.³

The intra-class correlation is given by

$$r_{cc} = \frac{M_1^2 - M_r^2}{M_1^2}$$

where: M_1^2 is the mean square for variable 1 (items), and M_r^2 is the mean square for residual error. The mean square values are given in Table 10 as they were calculated by the computer. The intra-class correlation is, in this case,

$$r_{cc} = \frac{20.60 - 1.97}{20.60} = 0.90$$

This result implies that if the categorization were made by a similar set of judges one could expect a correlation of 0.90 for the two sets of averages. The value obtained for content validity is deemed acceptable by this researcher.

²Robert F. Champlin, "The Development and Field Testing of an Instrument to Assess Student Beliefs About and Attitudes Toward Science and Scientists" (unpublished Doctor's dissertation, The Ohio State University, 1970), p. 41.

³J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Co., 1956), pp. 280-281.

Table 10. Two-way Analysis of Variance for Factorial Design for the Categorization of the Items by the Judges

Source of variation	Sum of squares	Degrees of freedom	Mean squares
Items	1153.47	56	20.60
Judges	56.36	10	5.64
Residual error	1101.78	560	1.97
Total	2311.61	626	

Using the categorization of the objectives by the judges, those items with an agreement higher than 65 per cent were placed into categories. A number of items were discarded for this purpose because they showed a distribution spread throughout the categories, meaning that there was no agreement among the judges. Two reasons can account for this lack of agreement: misinterpretation of the content of a category by the judges, or items whose content belongs to two or more categories. As a result of this procedure only 34 items out of the 57 were categorized into the six categories.

The mean values per item within each category as given by the judges and the teachers are given below. Analysis of variance was used to determine if there was any significant difference between the teachers and the judges.

Analysis of the objectives grouped according to categories. For category number 1, the content and the objectives listed are as follows:

1. NATURE OF SCIENCE, THE SCIENTIFIC ENTERPRISE
AND THE SCIENTIST

1. To help the student obtain an appreciation of the general aspects of science.

8. To let the student know about the men and women who made important contributions to science.

15. To develop an appreciation of the work and contributions of scientists.

21. To help students learn how modern scientific ideas have developed.

48. To provide an understanding of the relations within and among the various sciences.

The item mean values for these statements are shown in Table 11. Item 1 was considered a main objective by both groups with mean values close to 1. This objective is much more than the rest of the group. Objectives 8, 15 and 21 are related to the historical and humanistic aspects of science. They are considered important objectives but not major objectives. It is interesting to relate this result to sub-category 3b in the first part of this survey as given in Table 2. There seems to be agreement in the emphasis given to this type of objective.

Table 11. Mean Values for the Objectives Classified in Category 1 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
1	1.54	1.45
8	2.54	2.73
15	2.17	2.45
21	2.25	2.29
48	2.50	2.12
Average:	2.20	2.21

The following table shows the calculated F ratio indicating that there is no significant difference between the averages obtained from judges and teachers with regards to objectives related to the nature of science, the scientific enterprise and the scientist.

Table 12. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 1--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.0002	1	.0002	.001
Within	1.5647	8	.1956	(not significant at .05 level)
Total	1.5649	9	.1739	

For category number 2, the content and the objectives listed are as follows:

2. UNDERSTANDING AND APPRECIATION OF THE METHODS OF SCIENCE

3. To provide a background in scientific experimentation.

4. To train the student in the application of the processes of critical thinking for the solution of problems and the discovery of new information.

30. To help the student master the scientific method of problem solving.

32. To show the student how mathematics is applied to physical problems.

34. To help the student acquire a better understanding of the aims and methods of science.

36. To help the student acquire an ability to approach and solve problems effectively.

46. To develop powers of observation and reasoning together with the habit of study.

The item mean values for these statements appear in Table 13. Analyzing the results given by Table 13 there seems to be low consistency in the answers given by both groups to relatively similar objectives as numbers 4, 30 and 36. The three of them relate to the application of the scientific methods to problem solving but this is expressed in different ways. Objective 4 is broader than the others, and that might be the reason why it was ranked

higher. Comparing again with what was found in the first part of the survey, for some objectives such as 30 and 34 the rank was lower than expected. Although the item mean values are almost the same for judges and teachers it is possible to find differences in several items. A very low average for both groups indicates a high ranking for these items. This average is the lowest of the six categories, which agrees with the emphasis given to methods of science found in the subjective part.

Table 13. Mean Values for the Objectives Classified in Category 2 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
3	1.75	2.14
4	1.50	1.34
30	2.50	2.00
32	2.27	2.34
34	1.36	2.04
36	1.73	1.44
46	1.92	1.69
Average:	1.86	1.85

The analysis of variance for these sets of values indicates that there is no significant difference between the groups as it is shown in Table 14.

Table 14. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 2--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.0001	1	.0001	.0009
Within	1.8263	12	.1522	(not significant at .05 level)
Total	1.8264	13	.1405	

For category number 3, the content and the objectives listed are as follows:

3. DEVELOPMENT OF SCIENTIFIC ATTITUDES AND INTEREST IN SCIENCE

2. To arouse enthusiasm by means of increased understanding of scientific truths.

9. To satisfy the student's natural curiosity about the physical world in which he finds himself.

14. To persuade more students to become scientists.

25. To develop an interest in current happenings in the changing world of science.

29. To help the student acquire the ability to make more objective judgements, avoiding personal bias.

49. To stimulate the student into wanting to learn more about the physical world around him

The item mean values for these statements appear in Table 15. The idea of teaching science for the purpose of training future scientists is not an important objective

as both groups agreed. Objective number 49 is considered very important among teachers, as it was expressed earlier in their own statements, although the judges did not rank this item as high as the teachers. As for the rest, there are different emphases between both groups but not significant ones.

Table 15. Mean Values for the Objectives Classified in Category 3 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
2	1.83	1.61
9	1.58	1.73
14	3.33	3.59
25	1.83	2.04
29	2.08	1.79
49	1.91	1.53
Average:	2.09	2.05

The results of the analysis of variance applied to this category are shown in Table 16. Here again it is shown that there is no significant difference between the groups.

Table 16. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 3--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.0061	1	.0061	.0123
Within	4.9710	10	.4971	(not significant at .05 level)
Total	4.9771	11	.4525	

For category number 4, the content and the objectives listed are as follows:

4. THE RELATIONSHIPS OF SCIENCE, TECHNOLOGY AND SOCIETY

5. To help the student understand the influence of science upon human life and thought.

6. To translate the complex and technological world in which we live into a form which is comprehensible to the student.

12. To develop an understanding of the scientific endeavor and its relationship to society.

24. To develop an appreciation of the benefits of science.

43. To provide a more penetrating understanding of the relationships of current science to the other activities of man and to his cultural patterns.

44. To provide knowledge and principles about appliances which are useful for comfort and convenience in home and community.

50. To enable the student to understand the role science plays in solving and creating problems in our society.

53. To make the student aware of an ethical obligation in the application of scientific knowledge.

55. To show the student the part which science has played in the development of the United States.

The item mean values for these statements appear in Table 17. Looking at the average values for the two groups, 2.43 for the judges and 2.33 for the teachers it may be concluded that this type of objective is not considered a major one. The same is shown in the individual values with the exception of objective number 5. Considering these results it seems that the major concern is to show how science interacts with human life and thought, and in second place how it interacts with society and technology. It is interesting to observe the ranking received by item 53, dealing with the moral implications of applied science. Judges ranked it 3 and teachers 2.58 which implies it is not an important objective at high school level.

Table 17. Mean Values for the Objectives Classified in Category 4 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
5	1.58	1.60
6	1.83	2.36
12	1.75	2.20
24	2.75	2.23
43	2.25	2.04
44	3.09	3.13
50	2.17	1.91
53	3.00	2.58
55	3.42	2.90
Average:	2.43	2.33

The corresponding analysis of variance for this category shows that there is no significant difference between the groups as far as the ranking of these objectives is concerned. The results are as follows:

Table 18. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 4--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.0440	1	.0440	.1320
Within	5.3364	16	.3335	(not significant at .05 level)
Total	5.3804	17	.3165	

For category number 5, the content and the objectives listed are as follows:

5. UNDERSTANDING OF SCIENCE AS A BODY OF KNOWLEDGE

26. To develop a conceptual understanding of the physical world.

38. To give information about the laws and principles of the physical world.

Only two items under this category had sufficient agreement of the judges to be included. The average values for each of the preceding statements appear in Table 19. These items are conceptually different and they were given different ranking as shown in Table 19. Both groups considered the understanding of the physical world to be more important than the learning of principles that relate to the physical phenomena. However, it is clear that the first objective implies a knowledge of the physical laws.

Table 19. Mean Values for the Objectives Classified in Category 5 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
26	1.25	1.68
38	2.17	2.45
Average:	1.71	2.06

The corresponding analysis of variance showed no significant difference. The results are shown in Table 20.

Table 20. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 5--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.1260	1	.1260	.3502
Within	.7196	2	.3598	(not significant at .05 level)
Total	.8457	3	.2819	

For category number 6, the content and the objectives listed are as follows:

6. SCIENCE AS A PRE-REQUISITE FOR FUTURE STUDIES

7. To provide specialized education in science for those who will constitute the creative scientific and engineering manpower for the future.

10. To give a preparatory instruction for future college courses.

19. To provide the background required of individuals entering technological occupations or professions.

20. To prepare scholars in the several disciplines of science.

35. To train the student in science matters in order to obtain high grades at the college entrance examination.

The corresponding item mean values are shown in Table 21. This type of objective was not considered important as it is clearly shown in the groups averages and even individually. However, in practice this objec-

tive has been given great importance in many classrooms in contrast to what is considered best by science educators.

Table 21. Mean Values for the Objectives Classified in Category 6 by Judges and Teachers

Item number	Item mean values	
	Judges	Teachers
7	3.00	2.68
10	2.92	2.23
19	3.08	2.77
20	3.17	3.34
35	3.75	3.98
Average	3.18	3.00

The analysis of variance between the two different groups shows no significant difference. The results are shown in Table 22.

Table 22. Comparison Between Item Mean Values of Judges and Teachers for Objectives in Category 6--Analysis of Variance

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F ratio
Between	.0847	1	.0847	.3001
Within	2.2791	8	.2824	(not significant at .05 level)
Total	2.3439	9	.2604	

In summary, the ranking given by the judges and the teachers to the different categories is presented in Table 23. For the teachers, the first place corresponds

to the understanding and appreciation of the methods of science (2) followed by development of scientific attitudes and interest in science (3) and understanding science as a body of knowledge (5). The judges ranked category 5 most important and category 2 in second place. The results obtained from the teachers correspond favorably with the stated objectives of the teachers discussed in Chapter 3.

Table 23. Average Ranking of Each of the Categories by the Judges and the Teachers

	<u>Judges</u>	<u>Teachers</u>
Understanding and application of the methods of science (2)	1.86	1.85
Understanding of science as a body of knowledge (5)	1.74	2.06
Development of scientific attitudes and interest in science (3)	2.09	2.05
Nature of science, the scientific enterprise and the scientist (1)	2.20	2.21
The relationships of science, technology, and society (4)	2.43	2.33
Science as a pre-requisite for future studies (6)	3.18	3.00

Statements Ranked Less Favorable
as Objectives

In contrast to the items that have been listed as favorable objectives it is of interest to examine the items that have been rejected as such by the judges and

the teachers. For this purpose, items ranked either 4 or 5 with an agreement over 50 percent among judges and among teachers are shown in figure 4.

There is a high degree of agreement between the two groups as to which statements must be rejected as possible objectives for science teaching at secondary school level. As for statement number 39 that was not mentioned by both groups, the teachers ranked it 2. This statement refers to help the student develop desirable study habits. There was a strong rejection of the statement number 56, "to have the student accept the teacher's point of view when discussing controversial topics." However, two teachers ranked it 3, one teacher ranked it 2 and one teacher ranked it 1! To provide for worthy use of leisure time (17) was ranked 5 by nine judges while it showed a spread distribution among teachers that shifts the mean value up to 3.41. However, 24 out of 45 teachers ranked it 4 or 5. This statement was included in Hunter's list of objectives and it was given major emphasis by about 28 percent of the Junior High School teachers and 15 percent of the senior High School teachers who participated in a country-wide survey in 1943.⁴ The rest of the items

⁴George W. Hunter and Leroy Spore, "The Objectives of Science in the Secondary Schools of the United States," School Science and Mathematics, XLIII (October, 1943) 636, 638.

relate to learning formulas in physics (28), writing reports for the experiments (41) and training in science to be able to pass the college entrance examination successfully (35).

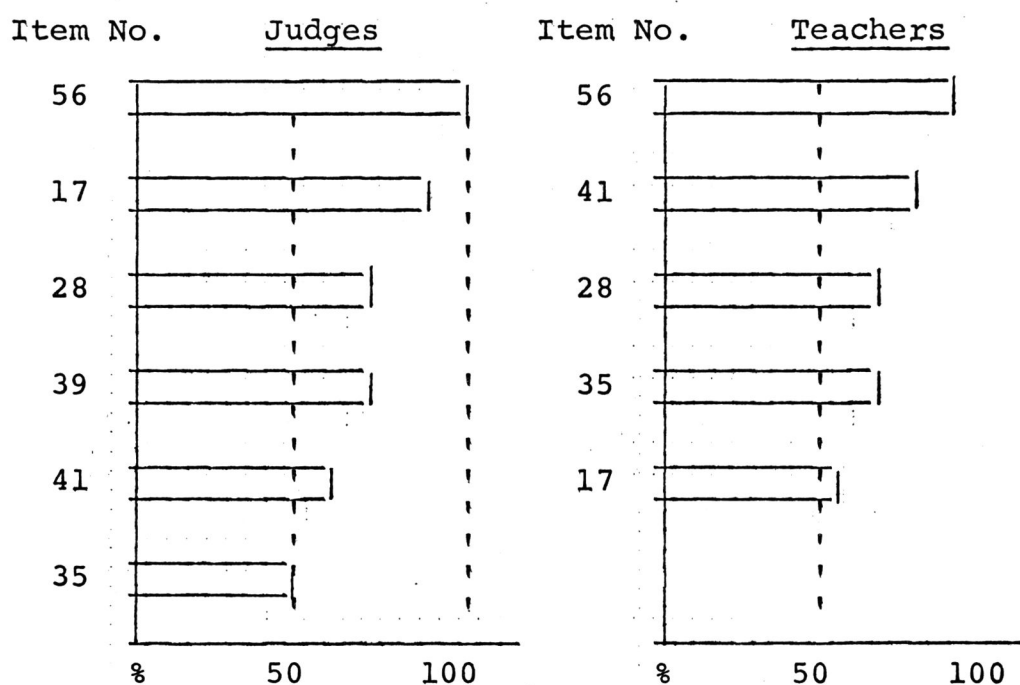


Figure 4. Statements that Have Been Classified 4 or 5 by Judges and Teachers.

Objectives that were Ranked 1 with a High Agreement in the Groups

There is a remarkable difference between an item showing a high percentage of agreement within the groups concerning its rank and an item showing a spread frequency distribution. The following lists present the objectives that were given major emphasis (rank 1) within an agreement greater than 66 percent.

Neither of the statements emphasized by the judges appear in the list for the teachers. There is no overlapping at all. However, the content of the above mentioned items is close. For instance, item 26 in the judges' list is related to items 49 and 57 of the teachers' list. In the same way there is some relation between items 54 and 4.

The statements that were ranked 1 by more than 66 percent of the group of judges are as follows:

- | | |
|--|-----|
| 26. To develop a conceptual understanding of the physical world. | 75% |
| 31. To provide a background in science as a part of the general education of the individual for effective citizenship. | 75% |
| 45. To develop knowledge which will give an insight into the nature and organization of the environment, making of it an organized whole instead of a lot of disjointed parts. | 67% |
| 54. To teach the student how to approach scientific information with an open-minded attitude and to base his conclusions on all available facts. | 67% |

The statements that were ranked 1 by more than 66 percent of the group of teachers are as follows:

- | | |
|---|-----|
| 57. To help the student better understand the physical phenomena in his everyday life. | 78% |
| 4. To train the student in the application of the processes of critical thinking for the solution of problems and the discovery of new information. | 77% |

- | | |
|--|-----|
| 36. To help the student acquire an ability to approach and solve problems effectively. | 73% |
| 1. To help the student obtain an appreciation of the general aspects of science. | 70% |
| 49. To stimulate the student into wanting to learn more about the physical world. | 69% |
| 54. To teach the student how to approach scientific information with an open-minded attitude and to base his conclusions on all available facts. | 67% |

Summary

The preceding analysis reveals, in the first place, that the judges and the teachers have ranked the list of objectives in a similar way since the analysis of variance showed that there is no significant difference between the way they ranked the objectives. Besides, the group averages, either when dealing with mean scores or item mean values were very close. However, in most cases the judges ranked slightly lower than the teachers (that is, closer to 5). Some differences in the item mean values for judges and teachers have been pointed out for a few items. Through the study of the item mean values given by the teachers it can be concluded that they emphasize the understanding and application of the scientific method, the development of scientific attitudes and interest in science, and the understanding of science as a body of knowledge. This is also corroborated by the three objectives that received ranking of 1 with highest average for

agreement, even though they are stated in a different way these are conceptually coincident (Items 57, 34, and 36). Secondly, no significant difference with respect to mean scores could be found between the three sub-groups of teachers that have been considered here: physical science, physics, and physical science and physics.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

The conclusions will be presented in the order in which the problem was defined. The limitations stated earlier will be taken into account.

CONCLUSIONS

The information gathered from the teachers' statements shows that the following objectives are held most important: (1) to develop in the student scientific attitudes, skills and abilities, (2) to have the student learn about the physical laws and theories, (3) to arouse interest in science, and (4) to have the student understand and apply the scientific methods. They have been mentioned in the order of importance given to them. There is an agreement with the results that have been discussed in the related literature. The evaluation of the 57 items yields four major objectives: (1) the understanding of physical phenomena in the student's everyday life, (2) development of critical thinking to solve problems and discover new information, (3) development of the ability to approach problems effectively, and (4) appreciation of the general aspects of science. These objectives are conceptually similar to those specified above, thus showing

that there is some consistency between the two parts of the survey. In summary, the teachers main concern is to teach the scientific methods, to have the student learn about the world around them and to show them the importance of science (that is, methods, facts and appreciation of science). The outstanding objective seems to be the development of characteristics that can be used in other fields of human endeavor such as critical thinking, skills, and abilities. In addition, the teachers seem to have a sufficient breadth of objectives in mind. However, it is to be noted that when they have a list of objectives before them, they will recognize many more.

It can be concluded that there are no general differences between the physical science and the physics teachers with regard to their objectives in science teaching. However, some minor differences can be mentioned as were shown in the analysis of the subjective part on page 44. For example, physical science teachers emphasized, the development of scientific attitudes, skills and abilities, the appreciation of the environment and the importance of science, and the historical aspects of science and scientists more than the physics teachers. Conversely, the latter emphasized the preparation for a scientific career and learning of specific topics more than the physical science teachers. This result is not new and has been

obtained in earlier research. There is a difference in emphasis of objectives for physical science and physics teachers with regards to those who teach both courses. However, the mean scores for the evaluation of the items did not differ significantly. In a sense, both courses should complement each other. Those persons who teach both courses are likely to have a broader prospective of the physical science-physics sequence and see that the courses are complementary.

There was agreement between the panel of professors and the teachers with regards to the main objectives in science teaching. There was also good agreement as to which statements must not be considered as objectives in a science course such as learning formulas, writing reports for experiments, training the student to pass the college entrance examination.

This study shows that the humanistic aspects of science have not been emphasized as objectives by this group of teachers, in comparison with the more traditional ones such as understanding of the environment, scientific methods, and appreciation of science. Thus, a possible plan to improve science teaching in the area would be to emphasize and develop topics concerning the relationship between science and the humanities. It is hoped that the

recent implementation of the Project Physics Course in this area will lead to a favorable change in the attitude of the teachers.

Teaching science to prepare students for a scientific career or to attract students towards scientific careers was not considered an important objective. This objective, which received considerable emphasis in the past few decades--especially after the launching of the first Sputnik--is now receiving less emphasis. One major reason for this change is probably due to the decrease in the demands for physicists. This problem has been frequently mentioned in periodicals such as Physics Today. The American Institute of Physics offered a report in one of its recent publications concerning the physicists and the job market.¹

RECOMMENDATIONS

The method of research discussed here can be used for further studies. Some changes and improvements for the gathering of information are now suggested. Instead of asking the teachers to state their objectives with no conditions at all, it might prove better to require them to list a fixed number of statements and then have them

¹American Institute of Physics, Educational Newsletter, XIV (February, 1971), special issue.

ranked. This would prevent a teacher from expressing only one or two objectives, and thus more information would be obtained from the ranking. However, this proposed procedure would introduce limitations to free expression.

Considering the difficulties experienced in the categorization of the list of items, a further use of this type of evaluation should require that each item used belonged to only one category. Instead of using the objectives exactly as they appear in several lists of the science education literature, it might be better to adapt them to the needs of the survey. In addition, the situation of a category with only two items in it should be avoided.

A further study using the two sources of information as it was done here, could be an analysis of the individual responses for the two parts of the questionnaire. A teacher might not have many objectives in mind but can recognize them when they are presented to him.

Since this study was limited to the forty-five teachers from eastern North Carolina who were participating in the In-Service Institute program, the conclusions are also subjected to the limits of application to this group. Therefore, it is suggested that a more comprehensive study of this nature include a larger sample of teachers.

Finally, it is clearly understood that the conclu-

sions obtained from this research relate to the objectives teachers have in mind, but this does not guarantee that they are actually applying their goals in the classroom. Some teachers might not know how to do this; others might not care to follow their objectives. For this reason, the only way to investigate the aims which are actually followed, and guide the science teaching is through the students. Appropriate tests are available to measure the accomplishments for some objectives, but not all. In this respect, a very important work is being done by the National Assessment of Educational Progress (NAEP) whose main task is to gather information about the knowledge, skills, attitudes and understanding of young people and to report the educational progress they make.² The assessment was based on a set of major objectives from which adequate sub-objectives (behavioral objectives) were stated. With these in mind exercises were produced with the purpose to measure the objectives.³ However, there are still certain "intangible" aspects of science teaching

²Education Commission of the States, "National Assessment of Educational Progress," Summary of Report 1, Science: National Results. July 1970.

³Richard J. Merrill, "National Assessment of Science Education--A Beginning," National Assessment of Educational Progress, Report 1--Science: National Results. Observations and Commentary of a Panel of Reviewers (July, 1970), p. 20.

which will require new instruments to be developed in order to be able to evaluate them through the students.

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APPENDIXES

APPENDIX A

STATEMENT OF SCIENCE OBJECTIVES

by _____ date _____

State briefly the main science objectives that you would like to realize in your physical science and/or physics classes.

PHYSICAL SCIENCE

PHYSICS

APPENDIX B

EVALUATION OF SCIENCE OBJECTIVES
IN SECONDARY SCHOOL PHYSICS COURSES

Name _____ Usual teaching area: (check)

School _____

☐ physical science
☐ biology
☐ chemistry
☐ mathematics
☐ physics

This is not a test. The purpose of this evaluation is to get information about the objectives that teachers have in mind and try to put into practice when they are teaching physics in their science classes.

There are no right or wrong answers. An answer is right if it is right for you.

DIRECTIONS:

Do not turn the page until you are told to do so.

This is a list of possible objectives for the teaching of physics in a physics or a physical science class. Some of them might seem to you more important than others, some might not be considered as objectives at all. You are expected to express your opinion by ranking each item according to its degree of importance.

You will find a statement like this:

"To teach the student the methods of science"

Place your ranking on the IBM score sheet according to a scale from 1 to 5, in a decreasing degree of importance, using a 1 for a main objective.

1	2	3	4	5
main objective				not an objective

NOTE: If you usually teach physics and physical science, answer the questions with reference to your physics class rather than your physical science class.

This test was developed in the course of research at the Department of Science Education, East Carolina University, Greenville, N. C. This test is not to be used, in whole or in part, without permission from the Department of Science Education, October 1970.

1. To help the student obtain an appreciation of the general aspects of science.
2. To arouse enthusiasm by means of increased understanding of scientific truths.
3. To provide a background in scientific experimentation.
4. To train the student in the application of the processes of critical thinking for the solution of problems and the discovery of new information.
5. To help the student understand the influence of science upon human life and thought.
6. To translate the complex and technological world in which we live into a form which is comprehensible to the student.
7. To provide specialized education in science for those who will constitute the creative scientific and engineering manpower for the future.
8. To let the student know about the men and women who made important contributions to science.
9. To satisfy the student's natural curiosity about the physical world in which he finds himself.
10. To give a preparatory instruction for future college courses.
11. To develop skills and abilities in science which will be useful in his future life.
12. To develop an understanding of the scientific endeavor and its relationship to society.

13. To show the student the accomplishments of applied science and technology.
14. To persuade more students to become scientists.
15. To develop an appreciation of the work and contributions of scientists.
16. To appreciate the tentative nature of scientific data and conclusions.
17. To provide for worthy use of leisure time.
18. To develop a scientific attitude toward any kind of problematic situation.
19. To provide the background required of individuals entering technological occupations or professions.
20. To prepare scholars in the several disciplines of science.
21. To help students learn how modern scientific ideas have developed.
22. To teach the students the how and why of scientific phenomena.
23. To develop an awareness that man's ability to modify his environment is limited by his understanding of its nature.
24. To develop an appreciation of the benefits of science.
25. To develop an interest in current happenings in the changing world of science.

26. To develop a conceptual understanding of the physical world.
27. To help the student to appreciate the value of scientific theories as explanation of facts and as predicting factors to force new experiments.
28. To assure that the student knows the major formulas in physics.
29. To help the student acquire the ability to make more objective judgements, avoiding personal bias.
30. To help the student master the scientific method of problem solving.
31. To provide a background in science as a part of the general education of the individual for effective citizenship.
32. To show the student how mathematics is applied to physical problems.
33. To teach students how to analyze critically the old and new concepts in science.
34. To help the student acquire a better understanding of the aims and methods of science.
35. To train the student in science matters in order to obtain high grades at the college entrance examination.
36. To help the student acquire an ability to approach and solve problems effectively.
37. To provide an education in science for all students that will ensure a level of scientific knowledge commensurate with the demands placed on society by science and technology.

38. To give information about the laws and principles of the physical world.
39. To help the student to develop desirable study habits.
40. To help the student acquire an appreciation of the universal operation of physical laws (cause and effect relationship).
41. To have the student write formal laboratory reports for every experiment.
42. To show the student that scientific theories are accepted on the bases of predictions and analytic success and not on the strength of traditions or personal interests.
43. To provide a more penetrating understanding of the relationships of current science to the other activities of man and to his cultural patterns.
44. To provide knowledge and principles about appliances which are useful for comfort and convenience in home and community.
45. To develop knowledge which will give an insight into the nature and organization of the environment, making of it an organized whole instead of a lot of disjointed parts.
46. To develop powers of observation and reasoning together with the habit of study.
47. To enable the student to understand the nature of physical quantities.
48. To provide an understanding of the relations within and among the various sciences.

49. To stimulate the student into wanting to learn more about the physical world around him.
50. To enable the student to understand the role science plays in solving and creating problems in our society.
51. To help the student learn to receive and express ideas effectively.
52. To provide an appreciation for the beauty, orderliness, and complexity of matter.
53. To make the student aware of an ethical obligation in the application of scientific knowledge.
54. To teach the student how to approach scientific information with an open-minded attitude and to base his conclusions on all available facts.
55. To show the student the part which science has played in the development of the United States.
56. To have the student accept the teacher's point of view when discussing controversial topics.
57. To help the student better understand the physical phenomena in his everyday life.

APPENDIX C
CATEGORIES OF OBJECTIVES

(I) Nature of science, the scientific enterprise and the scientist.

(II) Understanding and application of the methods of science.

(III) Development of scientific attitudes and interest in science.

(IV) The relationships of science, technology, and society.

(V) Understanding of science as a body of knowledge

(VI) Science as a pre-requisite for future studies.

(VII) None of the above.

APPENDIX D

Judges' Categorization of the 57 Items Listed

Item	1	2	3	4	5	6	7	8	9	10	11
1	1	7	3	1	1	1	1	1	4	1	1
2	3	3	1	3	5	3	2	7	3	3	3
3	2	1	2	2	2	2	5	6	2	2	2
4	2	3	2	2	2	2	6	2	5	2	2
5	4	4	4	4	4	4	4	4	1	4	4
6	4	4	4	5	4	4	3	4	4	4	5
7	6	6	6	6	6	6	6	6	6	6	6
8	1	1	1	1	1	1	1	1	1	1	4
9	3	3	4	3	3	3	3	3	2	5	5
10	6	6	6	6	6	6	6	6	6	6	6
11	2	3	4	2	6	6	4	7	2	6	6
12	4	4	4	4	4	4	4	4	4	4	4
13	5	4	4	5	4	2	4	4	4	5	5
14	3	3	6	3	3	3	7	1	7	3	3
15	1	7	1	1	1	3	1	1	1	1	4
16	3	1	1	2	2	1	1	2	2	2	3
17	7	7	7	3	3	3	7	7	7	7	7
18	3	3	2	3	3	6	7	2	3	2	3
19	6	6	6	6	6	6	6	6	6	6	6
20	6	6	6	6	6	5	6	6	7	6	6
21	5	1	1	1	1	1	3	1	1	2	5
22	5	5	5	1	1	5	2	2	2	5	5
23	5	4	3	1	2	4	2	2	4	2	1
24	4	4	1	4	1	4	4	5	4	4	3
25	3	3	3	3	3	3	1	7	4	3	3
26	5	7	5	5	2	5	1	7	5	5	5
27	1	1	2	2	1	1	2	2	5	2	5
28	5	6	5	7	7	5	7	6	6	5	7
29	3	3	3	2	2	3	7	3	3	3	2
30	2	2	2	2	2	2	2	7	3	3	2
31	5	7	4	4	4	1	4	7	3	5	4
32	2	1	2	2	2	5	5	2	6	2	2
33	3	3	2	2	1	2	5	2	5	3	3
34	2	2	2	2	2	2	2	7	3	3	2
35	6	6	6	7	6	6	6	7	6	6	5
36	2	3	2	2	2	6	2	3	2	2	2
37	4	7	4	4	4	4	5	7	4	6	5
38	5	5	5	5	5	5	4	2	5	5	5
39	7	7	7	7	7	6	7	7	7	3	7
40	1	2	3	5	3	2	7	2	5	1	1

APPENDIX D (continued)

Item	Judges										
	1	2	3	4	5	6	7	8	9	10	11
41	7	7	2	2	7	7	2	7	7	2	7
42	1	1	3	2	3	3	5	2	1	2	1
43	4	4	4	4	4	4	4	4	4	4	4
44	4	4	4	7	5	4	4	7	4	4	5
45	4	4	1	5	1	1	4	5	4	1	5
46	2	3	2	2	2	2	3	7	3	3	2
47	2	6	5	5	5	5	2	7	2	2	5
48	5	1	1	1	1	1	5	5	1	1	1
49	3	3	3	3	3	3	3	7	3	3	3
50	1	4	4	4	4	4	4	4	4	4	4
51	7	3	7	3	3	6	2	7	1	3	2
52	1	3	7	1	3	3	5	7	2	1	1
53	4	1	3	4	4	4	4	7	7	4	4
54	3	3	2	2	3	2	3	2	1	3	2
55	4	4	4	1	4	4	7	1	7	4	4
56	7	7	7	7	7	7	7	7	7	7	7
57	1	4	5	1	5	5	3	1	4	5	5