Philip Ray Dail. SCIENCE ATTITUDE TRAINING IN SECONDARY EDUCATION. (Under the direction of Dr. Moses M. Sheppard). Department of Science Education, July 1976.

The emphasis of this project was directed at answering three major questions:

1. Can science attitudes be taught as part of the instruction in science classes?
2. Does exposure to science as affected by the number of previous courses affect the learning of science attitudes by students?
3. Do students of differing ability levels learn attitudes in relation to their level?

To fairly evaluate the change in attitude of students enrolled in science at the secondary level, an attitude survey designed by Richard Moore was employed to measure the results of attempted teaching of attitudes.

Students were selected as randomly as possible in grades ten, eleven, and twelve to be used in the project. No student was prevented from participating in the project for any reason. Some students' scores are not included in the project findings because they were absent when either the pre-test or post-test was administered. A total of 167 students were involved in the project either as control groups or experimental groups at South Edgecombe High School, Pinetops, N. C.

The data that has been collected was analyzed and comparisons were made between control groups and experimental groups as to the change in

their ratings on the attitude survey as a result of the attempted teaching of attitudes.

The study gave significant results that attitudes can be taught as part of the instruction rather than the science teacher assuming attitude development because the student is enrolled in science. The study also indicates that for this sample, the ability to learn science attitudes was not significantly affected by previous exposure to science courses or general ability differences as indicated by the Otis IQ score.

# SCIENCE ATTITUDE
# TRAINING IN
# SECONDARY EDUCATION

A Thesis

Presented to

the Faculty of the Department of Science Education

East Carolina University

In Partial Fulfillment

of the Requirements for the Degree

Master of Education in Science Education

by

Philip Ray Dail

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SCIENCE ATTITUDE

TRAINING IN

SECONDARY EDUCATION

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# CHAPTER I

## INTRODUCTION

In secondary science education, most science educators are concerned about scientific attitudes. Richard W. Moore implies the unfortunate truth that many high school science teachers are not developing scientific attitudes in their students. Moore notes that teaching to develop "scientific attitudes is at least as important as teaching the facts and principles of science".[1] Moore also believes that too much high school science leads students to an unreal concept that science is an absolute world where anyone can deduce a positively correct answer when provided with enough accumulation of facts.[2]

Many writers and researchers are clear in their statements concerning the necessity to incorporate attitude development in the course of study. Fisher states that the surge in public education toward the "accountability" of the educational process is stringently pressing science educators to develop new evaluation techniques which will record usable, measurable, reliable data. He further states that the more important factor to be measured is the attitude of the student toward science. The real acceptance of science as a viable structure will produce an awareness of the importance of learning the facts and principles of science.[3]

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[1]Richard W. Moore, The Development, Field Test and Validation of the Scientific Attitude Inventory (Michigan: University Microfilms, Inc., 1970), p. 1.

[2]Ibid., pp. 3-4.

[3]Thomas H. Fisher, "The Development of an Attitude Survey for Junior High Science," School Science and Mathematics 73 (October 1973):647.

H. Bentley Glass states that the most important goal in science teaching is the attitude development of the student.

> It is indispensable to young scientists and nonscientists alike--to everyone who hopes to participate intelligently in the life of a scientific age which so constantly demands difficult decisions and real wisdom. ...to know what science really is--to recognize its spirit and to appreciate its methods.[4]

## The Problem

To fairly evaluate the attitudes of students enrolled in science at the secondary level, an attitude survey was employed to measure the effects of concerted attitude training as a unit in the course of study. The emphasis of the project was directed at answering three questions.

1. Can science attitudes be taught as part of the instruction in science classes?
2. Do students of differing ability levels learn attitudes in relation to their level?
3. Does the amount of exposure to science which is determined to some extent by previous courses affect the development of a scientific attitude?

Students were selected as randomly as possible in grades ten, eleven, and twelve to be used in the project. No one in any of the six classes tested was prevented from participating for any reason. Some students' scores were not included in the final results because they were absent when either the pre-test or post-test was administered. A total of 167 students were involved in the project as either control

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[4]H. Bentley Glass, "The Most Critical Aspect of Science Teaching," The Science Teacher 34 (May 1967):19.

groups or experimental research groups at South Edgecombe High School, Pinetops, North Carolina.

The results were compared to control groups that were tested but did not receive any attitude training lessons. Even with all efforts that were employed, it is recognized that this study is only a beginning in the area of accessing the concrete differences between classes where attitude training is taught and those where no effort to teach attitude is employed.

## Hypotheses Tested

The null hypotheses are as follows: (1) there is no significant difference between measured changes in science attitudes where instruction was directed specifically at altering attitudes and where no attempt was made at teaching such attitudes; (2) there is no significant difference between groups as affected by the number of science courses taken in high school; and (3) there is no difference between groups as affected by the ability level of the student based on norms for the school. The scores on the attitude inventory were analyzed statistically to test these hypotheses.

## The Sample Studied

One hundred sixty-seven students in grades ten, eleven, and twelve who were enrolled in a science course at South Edgecombe High School were included in this study during the school year of 1975-1976. The sample included mostly rural and small town pupils in what is an obviously agricultural region with small industry located in the towns. The students were from biology, chemistry, and advanced biology classes and were chosen by units of entire classes being taught in these areas. The classes were very well balanced by race and sex. Class size ranged from 15 to 37 pupils. These classes were then randomly divided into control or experimental groups for purposes of the study.

Experimental and Control Groups

1. Chemistry I Class--Level I (Control Group)
   Lesson Plans Used--Type R
   Composition of Class-16 Girls and 10 Boys

2. Advanced Biology--Level I (Experimental Group)
   Lesson Plans Used--Type P
   Composition of Class-7 Girls and 8 Boys

3. Advanced Biology--Level I (Experimental Group)
   Lesson Plans Used--Type P-N
   Composition of Class-13 Girls and 6 Boys

4. Sophomore Biology--Level II (Control Group)
   Lesson Plans Used--Type R
   Composition of Class-18 Girls and 17 Boys

5. Sophomore Biology--Level I (Experimental Group)
   Lesson Plans Used--Type P-N
   Composition of Class-18 Girls and 17 Boys

6. Sophomore Biology--Level II (Experimental Group)
   Lesson Plans Used--Type P
   Composition of Class-18 Boys and 19 Girls

Explanation of Levels:

Students at South Edgecombe have the opportunity to be placed in one of three levels in academic courses. Student's choice is a prime criteria for placement in levels. It is expected that student choice is based upon sound advice, with test scores, past performance, interest, and teacher recommendation playing roles in the counseling. It is further expected that parents have the opportunity to understand fully which level of work the student has chosen to enter and to endorse this decision. The opportunity for mobility, upward or downward, is provided within a desirable framework in each department. Some sectioning occasionally takes place within the levels, but care is exercised to assure desirable heterogeneity within the sections.

Description of Levels:

Level I. Students are expected to do research and to work independently. Challenging assignments beyond the normal high school level are required. Courses in this level are designed especially for those students who are willing to assume some responsibility for their own learning. Students at this level have exceptional ability and motivation.

Level II. Students receive more teacher direction but are expected to do a reasonable amount of outside work, research, and independent study. Work at this level is generally geared to the student with average to above average ability and motivation based on norms for that school.

Level III. Students receive most of their instruction in class and do very little assigned work outside the classroom. Work at this level is geared to the below average who needs special help and additional motivation beyond average expectations based on norms for that school.

## Definition of Terms

In this study, the term scientific attitude is of major importance. According to Noll, a scientific attitude can be described as certain habits of thought. According to Brandberry, a scientific attitude is a feeling or sentiment that is related to a psychological object. Moore defines a scientific attitude as "...an opinion or position taken with respect to a psychological object in the field of science."[5]

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[5]Moore, Scientific Attitude Inventory, p. 1.

For purposes of this study, the term <u>scientific attitude</u> is defined as an opinion about acceptable (positive) and unacceptable (negative) factors in the field of science. The scientific attitudes in this study were measured in terms of change that were calculated by administering an attitude inventory designed by Richard W. Moore in his doctoral dissertation published in 1970. This inventory known as the <u>Scientific Attitude Inventory</u> (SAI) was made available for use by any person interested in science education in secondary school particularly. He stated that one of his major objectives was the development of a valid and reliable instrument to be used for the purpose of taking inventory of high school students' scientific attitudes.[6]

The term <u>positive attitude</u> is defined by Moore as acceptance of a position that is positive with respect to science or the rejection of a position which is judged as negative in respect to science. The term <u>negative attitude</u> is defined as acceptance of a position judged as negative in respect to science or the rejection of a stated position that is judged positive in respect to science. Positive attitudes are also deemed as "acceptable" positions in relation to the world of science. An example from the SAI is: "The laws and/or theories of science are approximations of truth and are subject to change." Negative attitudes are also further defined as "unacceptable" position in relation to science. An example of these attitudes from the SAI is: "The laws and/or theories of science represent unchangeable truths discovered through science." Moore's choice of positive and negative attitudes was based on decisions

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[6]Ibid., pp. 162-163.

of a panel of judges who indicated their opinions when asked whether certain statements were acceptable or unacceptable in relation to science.[7]

For purposes of this study, the investigator will refer to the above definitions when indicated in the work.

SUMMARY--CHAPTER ONE

In a very scientific world, educators in the science discipline obviously have recognized the need to evaluate the more intangible aspect of instruction--attitude training or development. From available research, trends are indicated that reflect little real effort in the actual teaching of a desired set of stated objectives in attitude teaching. Numerous studies at all levels in the field of education are involved in developing instruments to test for attitudes, but the usefulness of such instruments is thwarted unless more science educators teach to develop a specific set of stated attitudes.

Obviously, the investigator could have chosen other instruments to use independently or in conjunction with the SAI. The decision to use only this instrument resulted from the very emphasis placed on teaching to develop a specific set of objectives. The objectives in the SAI are not by any means the only set of valid objectives, but the investigator chose to teach to develop these objectives.

Pre-test and post-test scores on the SAI contained in this study will be analyzed to determine if the investigator was therefore successful or unsuccessful in his attempt to teach the set of stated

[7]Ibid., pp. 8-10.

objectives. A set of lessons included in this study was designed to be coordinated with the set of objectives in Moore's SAI. Analysis of the data should provide further information as to the feasibility of teaching attitude development in secondary education.

# CHAPTER II

## REVIEW OF THE RELATED LITERATURE

Numerous studies have been made related to attitudes in all disciplines in education. Further studies have been designed to develop instruments to measure the attitudes in all disciplines. Science is no exception to this massive endeavor. However, insufficient research and work in the area of how to teach to change attitudes in science is noted by the investigator. Field tests of the instruments designed have been made by the persons who developed the instruments, but more people in science education need to assert their interest in this area by testing and teaching to develop specific objectives in attitude development.

A review of selected, pertinent, and related literature is contained in this chapter. The chapter is intended to support from literature the importance of attitude teaching in science.

Man exists in a scientific civilization without a choice on his part. Every educated person realizes that his intellectual outlook is influenced by science.[8] Unfortunately, the attitude assumed by some toward science is unfair. If science as a discipline is not shown to be completely objective and rational beyond all other disciplines, then it is no better than any other discipline or activity. Therefore, if science is not completely objective, then it is faulty with a subjective characteristic.

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

In actuality, science is unique in its methods and styles of inquiry. Granted, science is not free of impeding subjective elements. However, these very elements may be among the greatest strengths found in science.[9] The investigator feels here is partial defense for the importance of attitude training in science which is subjective in nature compared to the learning of facts and principles.

Throughout the literature, science teaching was stated as having two major aims. The first of these aims is to acquaint students with the concepts and theories or principles of science. The second and according to Glass, the most important aim, is to develop a realization in the student of the proper attitude concerning what the real nature of science is.[10]

In direct contrast to this second aim, science teaching has developed among most nonscientists mistaken concepts, dislikes, and the very familiar statement of "I never did understand science."[11] Even those students inclined toward science arrive at institutions of higher learning with the misconception that science is a type of game where the players are in pursuit of finding enough facts to support a right answer.

The first attitude exhibited in nonscientists seems to result from science being presented in the classroom as "a sort of smorgasbord course of snippets of information."[12] Schulz indicates that due to the rapid

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[9] I. I. Mitroff, "Disinterested Scientist: Fact or Fiction?", Social Education 37 (December 1973):764.

[10] Glass, "Critical Aspects," p. 19.

[11] Rogers, "Research Scientist Looks at Science Teaching," p. 19

[12] Ibid., p. 19.

expansion in science and the discoveries associated with science, too many high school courses have been developed that are aimed at teaching all there is to know about science. The result is an effort by the teacher to cover the entire text for the course. The teacher presents factual material on a variety of topics and then tests for the student's ability to recall facts. Unfortunately, this practice has resulted in serious misconceptions by high school students. "Science cannot be taught in a vacuum of facts."[13]

The second attitude which exists among science inclined students is as equally serious in its error as the first. The idea of pursuing facts as a game to result in a final absolute answer is not consistent with the aims of science as a total viable organism. In 1958-59, the Bureau of Examinations and Testing of New York State Education Department decided to develop a Regents Biology Examination that would satisfy the demands of more progressive science teachers to test more than the student's ability to simply recall facts. The problem of designing such a test was centered around the lack of background research for such testing. The Bureau solicited test items from over 50 experienced teachers, and of the several thousand items submitted, most were discarded immediately because they were purely factual recall. Of the select few items that remained in the final examination, many were judged too difficult because teachers had not yet realized how to prepare their students to handle tests that measure skills and attitudes. The general conclusion

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[13]National Science Teachers Association, ed., Quality Science for Secondary Schools (Washington, DC: National Science Teachers Assoication, 1960), p. 82.

as a result of the attempt left educators in New York keenly aware that teachers must pay more attention to how they teach their science students to learn rather than what they teach them.[14]

Paul Hurd further supports the necessity of teaching more than the facts of science. He states that facts and concepts are essential for the understanding of science, but the only avenue of usefulness in this role is for the student to first be capable of handling the meaning of science. He expresses concern that the teaching of findings of science is illusive of the real body of scientific knowledge.

> To be sure one must have an interest in facts since it leads to their discovery, but facts alone are sterile of meaning, unwieldy and uneconomical for teaching purposes. Our responsibility as science teachers is to help young people learn how facts are known and, knowing them, how they can be built from fragments of information into structures having more meaning. It is not our function to educate young people as factual illiterates.[15]

Hurd further states that the facts and observations of science are only useful when they are incorporated into the process of problem solving. This process of problem solving is where the teacher should teach information organization and understanding of how science operates. If future science students are to be able to comprehend the "cumulative nature of science", it must be through this understanding.[16]

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[14]Walter A. Thurber and Alfred T. Collette, Teaching Science in Today's Secondary Schools (Boston: Allyn and Bacon, Inc., 1968), pp. 389-390.

[15]Paul DeHart Hurd, New Directions in Teaching Secondary School Science (Chicago: Rand McNally and Company, 1970), p. 59.

[16]Ibid., p. 59.

The ultimate paradox of the emphasis on right answers and facts is the failure of the teacher to place the deserved emphasis where it duly belongs. The emphasis belongs on spotlighting science as the powerful means of finding understanding that science is in itself.[17] Coupled with this misdirected emphasis on right answers is the traditional pressure to achieve the top grade academically. Actually, this pressure to receive "all A's" is forcing the student to substitute a factual retention for the reality of an introspection of himself as a person and the ultimate decision as to his own capabilities to understand the nature of science. Evaluation methods need to undergo a dramatic examination to place the emphasis on attitudes rather than factual recall.[18] Perhaps this shift in evaluation would reduce the pressures of good grades to the extent that more of the concepts and principles that are taught factually would be more meaningful to a more enlightened student who understands the nature of science.[19]

Link refers to the method of factual recall evaluation as an "outdated dehumanizing system of marks and credits." Usually the student faces only one test which will prove or disprove his knowledge and understanding of the topic or course. Failure to prove that he is capable of a mastery of factual recall leaves a student with a hate for the subject,

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[17]Ralph W. Tyler, "The Behavioral 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: The University of Chicago Press, 1960) p. 31.

[18]Frances R. Link, "An Approach to a More Adequate System of Evaluation in Science," The Science Teacher 34 (February 1967):21.

[19]Tyler, "The Behavioral Scientist," p. 31.

a fear for tests, and a lack of confidence in his own self-image as a learner. Again the apparent paradox surfaces in the description of testing. The very scientific method itself does not support such an outdated technique. The bulk of the knowledge existing in science resulted not from a "once-only-testing" of facts but from repeated verification attempts that lead to acceptance or rejection of the stated principles.

The scientific method while not supporting present methods of evaluation is demanding that students be taught how to think and how to operate in a world of science. The very cooperation between the complex natures of the physical and natural worlds is the basis for the search for such abilities. Science teaching desperately needs to place values on questions of evaluation that are verifiable. The sweeping changes in the curricula of science are pointing clearly to the obvious stagnation in the process of evaluation of students in science. The urgent need now is to evaluate the student in such a manner as to create in science teaching the realization of the importance of preparing the student to face the reality of his own strengths and weaknesses.[20]

What should evaluation of a student lead him into as far as the understanding of science is concerned? The Educational Policies Commission (EPC) stated in 1969 that schools have the responsibility to assist students in the development of an awareness of the great advancements science has made possible in the world. To fully understand these advancements, the EPC proceeded to emphasize the need to understand the values on which

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[20] Link, "An Approach to a More Adequate System," p. 22.

science is universally based in order that the advancements may be more adequately appreciated. The EPC proposed a list of seven values which were felt to underlie science. The following seven items were included in an article entitled "Education and the Spirit of Science."

1. Longing to know and to understand.
2. Questioning of all things.
3. Search for data and their meaning.
4. Demand for verification.
5. Respect for logic.
6. Consideration of premises.
7. Consideration of consequences.[21]

While these values are not listed in the usual traditional manner utilizing such words as love, honesty, and beauty, these values are not in contradiction with the basic meanings conveyed by such words. For example, demanding verification is an emphatic quest for honesty. Rather more important, this list of values is part of any true education. Not only are these values an intrinsic part of science, but they are also vital in every area of life. The stress contained in teaching such a list of values is not merely to develop only scientists with more clearly defined attitudes, but rather the development of people with the ability to approach life with rational thinking.[22] Thus, the report by the EPC concludes with a resounding challenge to science educators. "To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the principle goals of education in our...country."[23]

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[21]Educational Policies Commission, Education and the Spirit of Science (Washington, D.C.: National Education Association, 1966), pp. 51-57.

[22]Ibid., p. 15.

[23]Ibid., p. 21.

The development of an appreciation for such a goal revolves around the ability of science teaching to provide the necessary education to instill in nonscience and science oriented students alike "a sense of understanding what science is and how scientists work."[24] Tyler has stated this in emphatic terms.

> A major objective, then, in science-teaching is to help students develop the ability to carry on the whole process of scientific inquiry. ...which involves restating the explanations and the new questions and problems that result from this cycle of inquiry.[25]

What then are the major objectives to emphasize in the stress on attitude development in science education? It is an obvious truth that specific attributes of attitude training will vary from one instructor to the next. However, there exists a need for a general direction for the entire discipline of science education to pursue.

Help in establishing a direction came from the National Assessment of Educational Progress (NAEP) which was financed by the United States Office of Education. NAEP was a direct response to public demand nationally for evaluation of the effectiveness of the increased expenditures in public education.

Science was one of ten areas selected for examination by NAEP. Four major objectives were formulated to be examined by the program in science. These four objectives were subdivided and then analyzed. The objective of concern to this investigator for this study was Objective IV which dealt specifically with a set of objectives in attitude teaching.

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[24]Rogers, "The Research Scientist," p. 19.

[25]Tyler, "The Behavioral Scientist," p. 32.

The following is a statement of Objective IV.

IV. Have attitudes about and appreciation of scientists, science, and the consequences of science that stem from adequate understandings.

A. Recognize the distinction between science and its applications.
B. Have accurate attitudes about scientists.
C. Understand the relationship between science misconceptions or superstitions.
D. Be ready and willing knowingly to apply and utilize basic scientific principles and approaches, where appropriate, in everyday living.
E. Be independently curious about and participate in scientific activities.[26]

As any educator realizes, the statement of any set of attitude objectives faces the expected questioning as to what attitudes are desirable and what attitudes are not desirable. Even this set of objectives received constructive criticism but were decidedly "valid, well-stated, and deserving of careful attention by school people and interested citizens." [27]

While this set of objectives is obviously a general set to utilize, it is interesting to note that it includes some of the specific objectives that educators feel need immediate attention. Champlin notes in his dissertation in 1970 that there are apparently negative feelings about future careers and negative feelings concerning the social stereotyping of the lifestyle of scientists as two examples of misconceived attitudes students possess about science.[28] It is imperative that science teaching

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[26]Education Commission of the States, National Assessment of Educational Progress: Summary of Report 1, Science: National Results, (Denver: Education Commission of the States, 1970), pp. 22-23.

[27]Ibid., p. 24.

[28]Robert Francis Champlin, "The Development and Field Testing of an Instrument to Assess Student Beliefs About and Attitudes Toward Science and Scientists" (Ph.d. dissertation, The Ohio State University, 1970), p. 2.

revamp its emphasis to include correction of such attitudes in the early years of education.

According to Jerry Ayers, it is imperative that students acquire at an early age realistic attitudes toward science. He also emphasizes the necessity to examine the approach to science at all levels in order to change attitudes in high school.[29] Moore's interest in changing attitudes in high school culminated in his developing the Scientific Attitude Inventory (SAI) for purposes of measuring scientific attitudes at the secondary level. Moore's survey of a group of ninth grade students at two schools in Pennsylvania resulted in some general conclusions including the lack of strong acceptance or rejection of certain scientific attitudes and a most important idea that "if this group is typical, it appears that the development of scientific attitudes is in need of greater attention.[30]

Academic Ability in Attitude Attainment

Kemper and Dubé conducted a study to test for significant differences in the interest level and attitude development of students enrolled in general chemistry. The data collected strongly favored the idea that attitude development is positively affected by students with higher academic capabilities.[31] Moore also completed a field test of the SAI which involved three intact groups of low-ability sophomore biology students. He found that

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[29]Jerry B. Ayers, "Children's Attitudes Toward Science," School Science and Mathematics 75 (April 1975):311.

[30]Richard W. Moore, "Profile of the Scientific Attitudes of 672 Ninth-Grade Students: Scientific Attitudes," School Science and Mathematics 71 (March 1971):232.

[31]R. F. Kemper and G. E. Dubé, "Science Interest and Attitude Traits in Students Subsequent to the Study of Chemistry at the Ordinary Level of the General Certificate of Education," Journal of Research in Science Teaching 77 (Issue 4, 1974):368.

students failed to develop the anticipated changes in attitudes at any level of significance.[32]

This investigator noted that much of the research in teaching attitudes compares total groups while not pursuing the possible effects of variations within the groups caused by general academic ability differences.

A further study completed by Novick and Duvdvani at the Hebrew University in Jerusalem, Israel, also indicates a lack of rejection or acceptance in certain areas of attitude as measured by Moore's SAI. This study also concluded by stating that if their study group were typical, it was obvious that much more emphasis needed to be placed on attitude instruction.[33]

## SUMMARY--CHAPTER II

The concurrent themes which appear to reverberate in the literature are that science teaching should include scientific attitude instruction as well as concept and principle instruction, but the unfortunate discovery is that many science teachers while probably aware of the importance of attitude teaching are doing too little to foster the development of attitudes in students.

Many works at all levels of education deal with the stating of goals and objectives of science teaching. Some of these goals are long-range while others attempt to simply reinstate values that underlie science to the level of importance they deserve.

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[32]Richard W. Moore, "The Development, Field Test, and Validation of an Inventory of Scientific Attitudes," Journal of Research in Science Teaching 7 (1970):87.

[33]Shimshon Novick and Dina Duvdvani, "The Scientific Attitudes of Tenth-Grade Students in Israel, as Measured by the Scientific Attitude Inventory," School Science and Mathematics 76 (January 1976):13-14.

Curricula in science have forged ahead to create the urgent need for students with attitudes that allow for a contextual grasp of the whole nature of science. The serious question the investigator poses is when will science teaching begin to stress the same attitudes? It is feared that tests of purely factual recall used to conclude artificially imposed "unit" structures in science are crippling the student's ability to grasp the totality of the nature of science as it relates to society and to him.

The purpose of this study is to further delve into the new area of instruction specifically aimed at scientific attitude improvement. While this is the stated purpose, it is an obvious fact that an area so desperately in need of attention merits the research and dedicated efforts of all involved in science teaching. "It is indispensable to young scientists and nonscientists alike...to know what science really is--to recognize its spirit and to appreciate its methods."[34]

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[34]Glass, "Critical Aspects," p. 19.

CHAPTER III

# THE STUDY DESIGN AND PROCEDURE

The purpose of this study was to determine if change in certain desirable attitudes of high school students toward science could be taught in classroom instruction.

## Research Design

Before any attempt to teach attitudes could be feasible, an acceptable measuring instrument designed specifically for scientific attitudes had to be chosen. This instrument had to be designed to test specific objectives and the attainment of certain attitude objectives by those involved in the study. The statement of objectives and the determination of the successful or unsuccessful attainment of these objectives is of major concern in science education. Many teachers acknowledge the vital part attitude training occupies in the classroom, yet they continue to test facts and principles predominantly.[35]

For the purposes of measuring changes in attitudes, this study employs Richard Moore's instrument for testing attitudes--The Scientific Attitude Inventory--which was developed to partially meet the pressing need for such instruments in science education. This inventory may be located in Moore's dissertation for examination by educators.

The study design is based on the assumption that the 167 students chosen would be diverse enough to allow for separation of this group into three categories for purposes of testing and attitude training.

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[35]Moore, Scientific Attitude Inventory, pp. 4-5.

Analysis of the experimental groups is based on the test scores of the control groups used as the standard. Any favorable significant changes the experimental groups showed in comparison to the control groups on the attitude inventory were used to support the assumption that specific attitude changes can be taught. Chapter IV presents the analyzed data from the testing.

Delimitation of the study

This study was delimited to the following:

1. The high school science students at South Edgecombe High School, Pinetops, North Carolina.

2. The 1975-76 school year.

3. The success of attitude training as determined by positive changes in the class-mean scores of the pre-test and post-test of the attitude inventory.

4. The groups were taught either "regular lessons" with factual presentation, lessons designed to enforce and develop positive attitudes, or lessons constructed to enforce and develop positive attitudes while including instruction to eliminate negative misconceived attitudes.

Basic Assumptions

The investigator assumed that attitudes can be changed and developed by teaching for the development of stated specific objectives. Further, it is assumed that the Scientific Attitude Inventory will measure the changes that are results of teaching to the stated objectives covered in this inventory. The inventory is a useful guide as it was developed to decide what attitudes to attempt to develop or eliminate and also to measure the success of an attempt to do so. This inventory is designed to test a set of stated objectives which have been validated by a panel of judges on the basis of their responses to a set of position statements.

The inventory was made available to be used by science educators to pursue development of additional such instruments or to ascertain the feasibility of teaching to develop specific attitudes.[36]

The Procedure of Research

The choice of Moore's instrument was the basic decision made before this project was begun. Moore states that few such instruments as his inventory have been designed and tested to satisfactory limits. The inventory therefore was of major consequence to the success of this project. At the time of this experimentation, Moore's instrument is valid in testing the specific objectives it was designed to test according to the results of his field testing as reported in "The Development, Field Test, and Validation of an Inventory of Scientific Attitudes" published in the Journal of Research in Science Teaching in 1970.

Moore's Scientific Attitude Inventory was basically designed for use at the secondary level. To insure its usefulness on this level, the reading level was designed to be below that of an average eighth-grade student. The scope of this inventory is both intellectual and emotional in its measure of scientific attitudes. According to Moore, his inventory is the only current instrument available which meets both these criteria effectively.

The inventory is further designed to employ certain techniques which are accepted as widely used in instruments of the nature of the Scientific Attitude Inventory. The inventory is based on a set of stated particular attitudes that are to be assessed. The text of the inventory is a set of

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[36] Ibid., pp. 162-163.

several items pertaining to the stated attitudes which are answered by the respondent on a range of four replies which include strongly agree, mildly agree, mildly disagree, and strongly disagree.[37]

Moore based the development of the specific attitudes to be assessed upon three criteria.

1. The attitudes to be assessed should reflect the concerns of science educators for the objectives of science teaching. Others who have prepared instruments for the measurements of scientific attitudes have based their work on these concerns.

2. Both intellectual attitudes toward science and emotional attitudes about science should be assessed....

3. Both positive and negative attitudes should be assessed.[38]

Moore's inventory was thus based on a set of attitudes to be tested that he felt met these criteria. He developed six major objective attitudes each with a positive and a negative approach to consider. These are listed below. The numbers that are followed by the letter A are the positive attitude statements while those followed by the letter B are the negative attitude statements corresponding to the positive statement with the same number.

1-A The laws and/or theories of science are approximations of truth and are subject to change.

1-B The laws and/or theories of science represent unchangeable truths discovered through science.

2-A Observation of natural phenomena is the basis of scientific explanation. Science is limited in that it can only answer questions about natural phenomena and sometimes it is notable to do that.

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[37]Ibid., pp. 45-47.

[38]Ibid., pp. 48-49.

2-B The basis of scientific explanation is in authority. Science deals with all problems and it can provide answers to all questions.

3-A To operate in a scientific manner, one must display such traits as intellectual honesty, dependence upon objective observation of natural events, and willingness to alter one's position on the basis of sufficient evidence.

3-B To operate in a scientific manner one needs to know what other scientists think; one needs to know all the scientific truths and to be able to take the side of other scientists.

4-A Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. Its value lies in its theoretical aspects.

4-B Science is a technology-developing activity. It is devoted to serving mankind. Its value lies in its practical uses.

5-A Progress in science requires public support in this age of science, therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.

5-B Public understanding of science would contribute nothing to the advancement of science or to human welfare, therefore, the public has no need to understand the nature of science. They cannot understand it and it does not affect them.

6-A Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.

6-B Being a scientist or working in a job requiring scientific knowledge and thinking would be dull and uninteresting; it is only for highly intelligent people who are willing to spend most of their time at work. I would not like to do scientific work.[39]

The preceeding twelve attitude statements are the ones around which the investigator designed his study to direct his instruction at the

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[39] Ibid., pp. 52-54.

developing of the positive attitudes and the elimination of the negative attitudes.

Included in the appendix is the set of lesson plans the investigator prepared including any materials or techniques he employed to attempt to teach attitude development. The control groups were deliberately given the usual presentations of facts and concepts. These plans are designated with the letter R. The students in these classes were not informed of the different lessons their experimental counterparts were receiving and never acknowledged knowing to the investigator's awareness.

The experimental groups which received the lessons identified with the letter P received only instruction aimed at increasing their acceptance of the attitudes judged positive in this study. The investigator desired to ascertain if instruction to develop positive acceptable attitudes without the corresponding emphasis to eliminate negative unacceptable attitudes would indeed foster improving positive attitudes and to determine if this emphasis would affect the elimination of negative attitudes by reason of the stress on positive attitudes alone.

Those classes presented lesson identified by the letters P-N were given instruction designed for the dual purpose of strengthening positive attitudes and eliminating negative attitudes. The lessons used were based on the same format as those for the lesson type P, but in addition to the stress on positive attitude development the investigator included additional instruction to eliminate negative concepts. The lesson plans will elucidate the differences.

The SAI developed by Moore based on the twelve attitude statements contained 60 statements in final form. These items were responded to in one of four ways by the students--strongly agree, mildly agree, mildly disagree, or strongly disagree. Scoring of the SAI will be discussed later in the next chapter.

The investigator chose to administer the Otis Quick--Scoring Mental Ability Test since research suggests that attitude attainment is affected by academic ability. This test while not a perfect instrument to measure scholastic ability is useful to indicate an acceptable range of ability on the part of the students in relation to the mean score obtained for this study. The Gamma Test designed for high school and college use was administered.

Organization of the Study and Selection of the Sample

The first phase of the research involved the selection of the classes to involve in the study. The choice made included all sophomores instructed by the investigator and the two classes of advanced biology which included juniors and seniors as well as a chemistry class also composed of juniors and seniors. It was the decision of the investigator at the time of the study to only include senior high students in this study.

The next choice was to decide which classes would serve as controls or experimental groups. This arrival at the final decision was by random chance. Numbers were simply drawn from a beaker as a means of making the choice random. The groups as they were assigned by drawing are indicated in Chapter I in the section on the sample (see page 4).

After this was completed, the investigator proceeded to execute the experimental instruction and collect the data.

Collection of the Data

The SAI was administered as a pre-test to all students during the week of March 1, 1976. The students were not given information as to the reason for the test other than the investigator told them that a man wanted to use their responses and that the investigator would never know how individuals chose to answer. They were urged to answer exactly as they felt and were assured that the investigator would not use their responses in any way grade-wise. The students were satisfied with this explanation.

The post-tests were administered to all students during the week of April 12, 1976 after completion of the designated lesson plan series for each group. The actual instruction toward attitude training did not take place immediately following the pre-test. It was the decision of the investigator to allow a lapse of about seven days so that the students would not necessarily formulate opinions because they associated inventory items with the content of the instruction. It was unavoidable and intended that the association would be made between the content of instruction and their attitudes about the nature of science--not just the particular 60 items on the SAI.

In addition to administering the SAI, the investigator in cooperation with the guidance department administered the Otis Quick-Scoring Mental Ability Test the week of May 3, 1976 well after the attitude training. These are the IQ scores which appear in the study.

The data from the SAI pre-test and post-test were collected by taking the Standard Answer Sheets and preparing computer cards by processing these answer sheets through an optical scanner which made the conversion. These data cards were then scored by the East Carolina University Computer by using a modified Fortran program similar to the one Moore used to score his field test. Moore also made this available to researchers for their use if they desired and had the facilities.[40] The investigator then proceeded to decide which comparisons to make among the data to determine the effectiveness of the instruction.

Description of the Data

Each pupil has a pre-test score and the corresponding post-test scores on the Scientific Attitude Inventory, a score on the Otis Quick-Scoring Mental Ability Test and also the number of science and mathematics courses taken by the end of the school year of 1975-76. These data are to be used to analyze the effectiveness of instruction on attitudes and the effects of some pertinent factors on attitude development as well.

The students were provided with identification numbers so that they would be aware that no names would accompany the scoring and use of the SAI to eliminate their tendency to respond as they felt the investigator would have them to respond. Each computer data card contained this six digit identification number which was coded to indicate sex, type of lesson received, group, and pre-test or post-test.

A composite data sheet was then prepared for each group that contained the following information for each student.

1. Student Identification Number
2. Score on Otis Quick-Scoring Mental Ability Test

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[40]Moore, Scientific Attitude Inventory, p. 91.

3. Number of science and mathematics courses

4. A composite score on the SAI for pre-test and post-test

## SUMMARY--CHAPTER III

This study design was formulated around pre-test and post-test scores on Moore's SAI. This instrument was chosen because it was specific for a set of objectives that the investigator wished to attempt to use as a guide for directing his instruction in attitude training. The students' SAI scores were compared with the variables of general academic ability as indicated by their scores on the Otis Quick-Scoring Ability Test and their exposure to science gaged by the number of courses they had taken previously. Further comparisons are indicated in Chapter IV on analysis of data. The implications of the findings are given in Chapter V.

CHAPTER IV

# ANALYSIS OF THE RESEARCH DATA

The data and their analyses are contained in this chapter. The chapter may be divided into two sections, as follows:

1. The individual student data including composite pre-test and post-test scores on the SAI.

2. The analysis of the student data to determine any relationships between the change in the pre-test and post-test means and the other variables the investigator was interested in working with.

## The Individual Student Data

The student data presented does not include students who did not take both the pre-test and post-test SAI. There were 152 students who completed both tests; of these 42.8 percent were males and 57.2 percent were females. The Otis Quick-Scoring Mental Ability Test, Gamma was administered to provide an overall reflection of the general academic ability level of participating students. The mean Otis IQ for the entire group tested was 98.98, 105.10 for the junior-senior group, and 95.95 for the sophomores. The following table illustrates the distribution of the students' scores on the Otis Quick-Scoring Mental Ability Test, Gamma:

TABLE 1

OTIS IQ DISTRIBUTION OF THE PARTICIPATING STUDENTS

| | $-3\sigma$ | $-2\sigma$ | $-1\sigma$ | Mean | $+1\sigma$ | $+2\sigma$ | $+3\sigma$ |
|---|---|---|---|---|---|---|---|
| Expected Frequencies | 2.3% | 13.0% | 34.1% | 34.1% | 13.0% | 2.3% | |
| Total Sample | 3.3% | 15.7% | 31.6% | 28.3% | 17.8% | 3.3% | |
| Jr.-Sr. Group | 0.0% | 16.0% | 36.0% | 30.0% | 16.0% | 2.0% | |
| Sophomore Group | 0.0% | 11.8% | 39.2% | 33.4% | 14.7% | 0.9% | |

On the basis of Table 1, the sample appears to be acceptably normally distributed. The 0.0% encountered is due to the statistical calculations involved in the separate distributions of each group.

Students' scores on the SAI

Moore's SAI was designed to contain five items for each of the twelve attitudes listed in the objectives in Chapter 3 thus giving the total of 60 items. The scores on the SAI range from 0 to 15 for each attitude on the A scale and B scale. To arrive at the composite score, point values are assigned to each of the four responses as well as no answer and errors. Strongly agree, mildly agree, mildly disagree, and strongly disagree receive 3, 2, 1, and 0 points respectively on A scale items. For B scale items, the point values are reversed. No answers and errors received 1.5 points for computation. A maximum of 15 on any A scale attitude represents total acceptance while a maximum of 15 on a B scale attitude represents total rejection. The converse of this is that a score of 0 on any A scale attitude represents total rejection of a positive attitude while a 0 on a B scale attitude represents total acceptance of a negative attitude. If a score of 7.5 is obtained, this represents neither acceptance or rejection of the attitude. This Likert-type of rating scale lends itself most readily to statistical analysis.[41]

If a student completely accepts those attitudes judged positive and completely rejected those judged negative, he could score a total of 180 on the SAI. The data analysis will make use of composite total scores composed of individual scores on the negative and positive attitude items.

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[41]Moore, "Profile of the Scientific Attitudes," p. 230.

The following tables will present the student data for each group in the study.

TABLE 2

JUNIOR-SENIOR LEVEL CONTROL GROUP

| I.D. No. | OTIS IQ | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 136 | 103 | 3 | 3 | 97 | 100 |
| 001 | 117 | 3 | 3 | 117 | 114 |
| 002 | 104 | 3 | 3 | 113 | 112 |
| 003 | 110 | 4 | 3 | 130 | 123 |
| 004 | 101 | 3 | 3 | 101 | 102 |
| 005 | 117 | 4 | 3 | 136 | 136 |
| 006 | 102 | 4 | 3 | 111 | 101 |
| 007 | 109 | 4 | 3 | 117 | 117 |
| 008 | 107 | 4 | 3 | 122 | 130 |
| 009 | 103 | 3 | 3 | 116 | 110 |
| 010 | 101 | 3 | 3 | 96 | 90 |
| 011 | 111 | 4 | 3 | 106 | 108 |
| 012 | 116 | 4 | 3 | 139 | 125 |
| 013 | 92 | 3 | 3 | 103 | 105 |
| 014 | 102 | 4 | 3 | 111 | 106 |
| 015 | 104 | 4 | 3 | 103 | 94 |
| 016 | 120 | 3 | 3 | 110 | 113 |
| 017 | 92 | 4 | 3 | 106.5 | 101.5 |
| 018 | 97 | 3 | 3 | 115 | 114 |
| 019 | 124 | 4 | 3 | 106 | 112 |
| 020 | 112 | 4 | 3 | 116 | 118 |
| 021 | 93 | 3 | 3 | 91 | 111.5 |
| 022 | 91 | 4 | 3 | 122 | 112 |
| 023 | 90 | 3 | 3 | 104 | 115 |
| MEANS | 104.91 | - | - | 112.02 | 111.25 |
| S.D. | 9.67 | - | - | 11.97 | 10.72 |

TABLE 3

JUNIOR-SENIOR LEVEL GROUP P LESSONS

| I.D. No. | OTIS IQ | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 111 | 103 | 4 | 4 | 122 | 123.5 |
| 112 | 100 | 4 | 4 | 120 | 130 |
| 113 | 119 | 4 | 4 | 94 | 121 |
| 114 | 98 | 4 | 3 | 104 | 120 |
| 115 | 108 | 4 | 4 | 113 | 135 |
| 116 | 102 | 4 | 4 | 124 | 133 |
| 143 | 113 | 4 | 3 | 113 | 122 |
| 144 | 100 | 4 | 3 | 119 | 125 |
| 145 | 102 | 4 | 4 | 123 | 129 |
| 146 | 92 | 4 | 3 | 123 | 130 |
| 147 | 101 | 4 | 4 | 126 | 122 |
| MEANS | 103.54 | - | - | 116.45 | 126.41 |
| S.D. | 7.39 | - | - | 9.83 | 5.19 |

TABLE 4

JUNIOR-SENIOR LEVEL GROUP P-N LESSONS

| I.D. No. | OTIS IQ | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 117 | 120 | 4 | 4 | 104 | 128 |
| 118 | 106 | 4 | 4 | 117.5 | 127.5 |
| 119 | 120 | 4 | 4 | 106 | 112 |
| 120 | 98 | 4 | 4 | 107 | 113 |
| 121 | 100 | 4 | 4 | 103.5 | 104 |
| 122 | 90 | 3 | 3 | 103 | 94 |
| 123 | 114 | 4 | 4 | 117 | 120 |
| 124 | 116 | 4 | 4 | 130 | 135 |
| 125 | 100 | 4 | 4 | 116 | 100 |
| 126 | 103 | 4 | 2 | 138 | 139 |
| 127 | 91 | 4 | 4 | 128 | 134.5 |
| 128 | 102 | 4 | 4 | 102 | 106 |
| 129 | 114 | 4 | 4 | 107 | 111 |
| 130 | 110 | 4 | 4 | 117 | 117 |
| 131 | 113 | 4 | 2 | 116 | 122 |
| MEANS | 106.53 | - | - | 114.13 | 117.53 |
| S.D. | 9.78 | - | - | 11.03 | 13.52 |

TABLE 5

SOPHOMORE LEVEL CONTROL GROUP

| I.D. No. | OTIS IQ | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 024 | 95 | 2 | 2 | 91 | 91 |
| 025 | 107 | 2 | 2 | 97.5 | 98 |
| 026 | 85 | 2 | 2 | 106 | 94 |
| 027 | 104 | 2 | 2 | 123 | 101 |
| 028 | 89 | 2 | 2 | 115 | 119 |
| 029 | 87 | 2 | 2 | 103 | 97 |
| 030 | 89 | 2 | 2 | 113 | 100 |
| 031 | 95 | 2 | 2 | 118 | 101 |
| 032 | 92 | 2 | 2 | 113 | 118 |
| 033 | 115 | 2 | 2 | 120 | 128 |
| 034 | 105 | 2 | 2 | 110 | 108 |
| 035 | 94 | 2 | 2 | 104 | 97 |
| 036 | 91 | 2 | 2 | 117 | 98.5 |
| 037 | 90 | 2 | 2 | 96 | 96 |
| 038 | 115 | 2 | 2 | 119.5 | 115 |
| 039 | 90 | 2 | 2 | 96 | 100.5 |
| 040 | 85 | 2 | 2 | 97 | 100 |
| 041 | 103 | 2 | 2 | 86.5 | 84.5 |
| 042 | 88 | 2 | 2 | 102.5 | 91 |
| 043 | 104 | 2 | 2 | 97 | 110 |
| 044 | 113 | 2 | 2 | 124 | 121 |
| 045 | 98 | 2 | 2 | 109 | 110 |
| 046 | 117 | 2 | 2 | 107 | 104 |
| 047 | 85 | 2 | 2 | 115 | 112 |
| 048 | 87 | 2 | 2 | 101 | 100 |
| 049 | 89 | 2 | 2 | 97 | 87 |
| 050 | 100 | 2 | 2 | 117 | 118 |
| 051 | 100 | 2 | 2 | 100 | 103 |
| 153 | 94 | 2 | 2 | 89 | 109 |
| 149 | 95 | 2 | 2 | 91 | 94 |
| 150 | 86 | 2 | 2 | 97.5 | 97 |
| 148 | 99 | 2 | 2 | 97 | 96 |
| 151 | 89 | 2 | 2 | 96 | 96 |
| MEANS | 96.21 | - | - | 105.02 | 102.86 |
| S.D. | 9.49 | - | - | 10.61 | 10.35 |

TABLE 6

SOPHOMORE LEVEL P GROUP

| I.D. | OTIS | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 083 | 95 | 2 | 2 | 105 | 103 |
| 084 | 89 | 2 | 2 | 101 | 119 |
| 085 | 90 | 2 | 2 | 105 | 107 |
| 086 | 79 | 2 | 2 | 95 | 118 |
| 087 | 98 | 2 | 2 | 112 | 118 |
| 088 | 92 | 2 | 2 | 109 | 128 |
| 089 | 82 | 2 | 2 | 97 | 93 |
| 090 | 82 | 2 | 2 | 123 | 129 |
| 091 | 81 | 2 | 2 | 105 | 97 |
| 092 | 95 | 2 | 2 | 102 | 104 |
| 093 | 82 | 2 | 2 | 108 | 102.5 |
| 094 | 88 | 2 | 2 | 101 | 121 |
| 095 | 77 | 2 | 2 | 101.5 | 96 |
| 096 | 76 | 2 | 2 | 110 | 126 |
| 097 | 95 | 2 | 2 | 111 | 116 |
| 098 | 92 | 2 | 2 | 116 | 102.5 |
| 099 | 87 | 2 | 2 | 108 | 97 |
| 100 | 89 | 2 | 2 | 97 | 98 |
| 101 | 76 | 2 | 2 | 111 | 113.5 |
| 102 | 77 | 2 | 2 | 80 | 101.5 |
| 103 | 99 | 2 | 2 | 106 | 109 |
| 104 | 93 | 2 | 2 | 82.5 | 90 |
| 105 | 91 | 2 | 2 | 114 | 131 |
| 106 | 86 | 2 | 2 | 98 | 109 |
| 107 | 80 | 2 | 2 | 104 | 108 |
| 108 | 93 | 2 | 2 | 103 | 105 |
| 109 | 88 | 2 | 2 | 121 | 115.5 |
| 110 | 82 | 2 | 2 | 113 | 115 |
| 132 | 86 | 2 | 2 | 101 | 123 |
| 133 | 98 | 2 | 2 | 89 | 114 |
| 135 | 91 | 2 | 2 | 109 | 127 |
| 137 | 104 | 2 | 2 | 116 | 123 |
| 138 | 84 | 2 | 2 | 97 | 113 |
| MEANS | 87.79 | - | - | 104.58 | 111.29 |
| S.D. | 7.33 | - | - | 9.62 | 11.30 |

TABLE 7

SOPHOMORE LEVEL P-N GROUP

| I.D. | OTIS | No. of Science Courses | No. of Math Courses | SAI Pre-Test | SAI Post-Test |
|---|---|---|---|---|---|
| 052 | 94 | 2 | 2 | 121 | 117 |
| 053 | 110 | 2 | 2 | 115 | 118 |
| 054 | 103 | 2 | 2 | 125.5 | 104 |
| 055 | 109 | 2 | 2 | 116.5 | 129 |
| 056 | 88 | 2 | 2 | 100 | 118 |
| 057 | 117 | 3 | 2 | 130 | 135 |
| 058 | 115 | 3 | 2 | 145 | 139 |
| 059 | 116 | 3 | 2 | 128.5 | 117 |
| 060 | 90 | 2 | 2 | 112.5 | 126.5 |
| 061 | 107 | 3 | 2 | 125 | 122 |
| 062 | 100 | 3 | 2 | 133 | 131 |
| 063 | 100 | 2 | 2 | 125 | 117 |
| 064 | 126 | 3 | 2 | 129 | 131 |
| 065 | 97 | 2 | 2 | 106 | 117 |
| 066 | 112 | 2 | 2 | 128 | 134 |
| 067 | 117 | 1 | 2 | 117 | 121 |
| 068 | 107 | 3 | 2 | 121 | 134 |
| 069 | 83 | 2 | 2 | 117 | 121 |
| 070 | 95 | 2 | 2 | 100 | 121 |
| 071 | 94 | 2 | 2 | 105 | 124 |
| 072 | 98 | 2 | 2 | 97 | 117 |
| 073 | 115 | 2 | 2 | 111.5 | 137 |
| 074 | 88 | 2 | 2 | 110.5 | 118 |
| 075 | 112 | 2 | 2 | 119 | 125 |
| 076 | 88 | 2 | 2 | 117 | 120 |
| 077 | 87 | 2 | 2 | 108 | 121 |
| 078 | 107 | 2 | 2 | 103 | 125 |
| 079 | 107 | 2 | 2 | 116 | 116 |
| 080 | 98 | 2 | 2 | 93 | 105 |
| 081 | 94 | 2 | 2 | 111 | 102.5 |
| 082 | 97 | 2 | 2 | 107 | 118 |
| 140 | 115 | 3 | 2 | 116 | 120.5 |
| 141 | 102 | 2 | 2 | 116 | 121 |
| 142 | 115 | 3 | 2 | 123 | 138 |
| MEANS | 103.03 | - | - | 116.11 | 122.37 |
| S.D. | 10.91 | - | - | 11.26 | 9.05 |

The information for the student data was provided by the guidance department. The Otis IQ scores were collected in the spring of 1976 under the supervision of the guidance department. No data was released to any person.

No lists with names and scores of any kind are used in the study. All student data were handled by identification numbers.

## Analysis of Student Data

The following tables are the tests for significance of the indicated lesson plans for each group. An analysis of covariance using the pre-test as the covariant has been followed upon the recommendation of N. L. Gage in his Handbook of Research on Teaching. Gage recognizes the Pre-test--Post-test Control Group Design employed in this study as the most widely used of the three current true experimental designs. According to Gage, this type of design controls all rival factors that normally affect the results of an experiment without controls or pre-test and post-test. He further recommends not withdrawing a student who missed part of the experimental treatment but did take both the pre-test and post-test. This creates unjustifiable bias in the sample.[42] The investigator complied with this recommendation.

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[42]Nathaniel L. Gage (ed.), Handbook of Research on Teaching (Chicago: Rand McNally and Company, 1963), pp. 183-194.

TABLE 8

ANALYSIS OF COVARIANCE FOR THE POST-TEST TOTAL SCORES FOR SOPHOMORE CONTROL GROUP AND GROUP P-N ON THE SAI

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Between | 1 | 2555.28 | 2555.28 | *39.62 |
| Within | 64 | 4127.90 | 64.50 | |
| Total | 65 | 6683.18 | | |

$*F_{.01}(1,64)=7.05$

TABLE 9

ANALYSIS OF COVARIANCE FOR THE POST-TEST TOTAL SCORES FOR SOPHOMORE CONTROL GROUP AND GROUP P ON THE SAI

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Between | 1 | 1247.81 | 1247.81 | *15.51 |
| Within | 63 | 5067.15 | 80.43 | |
| Total | 64 | 6314.96 | | |

$*F_{.01}(1,63)=7.06$

TABLE 10

ANALYSIS OF COVARIANCE FOR THE POST-TEST TOTAL SCORES FOR JUNIOR-SENIOR CONTROL GROUP AND GROUP P-N ON THE SAI

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Between | 1 | 188.10 | 188.10 | *3.15 |
| Within | 36 | 2149.90 | 59.72 | |
| Total | 37 | 2338.00 | | |

*$F_{.01}(1,36)=7.39$ $F_{.95}(1,36)=4.10$

TABLE 11

ANALYSIS OF COVARIANCE FOR THE POST-TEST TOTAL SCORES FOR JUNIOR-SENIOR CONTROL GROUP AND GROUP P ON THE SAI

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Between | 1 | 1154.87 | 1154.87 | *26.60 |
| Within | 32 | 1389.06 | 43.41 | |
| Total | 33 | 2543.93 | | |

*$F_{.01}(1,32)=7.50$

From the analysis of the data, the overall null hypothesis that there is no significant difference between changes in scientific attitudes where instruction was directed specifically at altering attitudes and where no such instruction was employed must be rejected in three of the four experimental groups. The junior-senior level group which received lesson plan type P-N failed to show a F value of significance. All the other three groups showed high F values to attain significance at the .01 level.

The one group that failed to show a significant change in the SAI scores as shown in Table 10 was composed of juniors and seniors. During the experimental lessons, several of these seniors were absent due to school activities, and this fact may account in part for the lack of significance in the F values.

Of further interest to the investigator was the effect of the number of science courses taken by the experimental groups on the changes in scientific attitudes. With the sophomores having completed two sciences in most cases and the juniors and seniors having completed four in most cases or three in some cases, the investigator proceeded to compute an analysis of covariance between these two groups again using the pre-test as the covariant. The results are in Table 12.

From the analysis of the data, the subsidiary null hypothesis that there is no significant difference between attitude scores of students with two years of science and students with three or four years of science must be accepted for all the experimental groups combined. Only the analysis of the P Groups showed any significant difference and this was acceptable at the .05 level.

TABLE 12

ANALYSIS OF COVARIANCE FOR THE POST-TEST SCORES FOR THE JUNIOR-SENIOR LEVEL AS COMPARED TO THE SOPHOMORE LEVEL TO DETERMINE EFFECT OF THE NUMBER OF PREVIOUS SCIENCE COURSES ON THE SAI SCORES OF EXPERIMENTAL GROUPS

| Comparison To Be Analyzed | Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F |
|---|---|---|---|---|---|
| All Experimental Sophomores | Between | 1 | 53.01 | 53.01 | [1] .61 |
| vs All Experimental | Within | 90 | 7715.64 | 85.73 | |
| Juniors-Seniors | Total | 91 | 7768.65 | | |
| Sophomores P Group | Between | 1 | 514.57 | 514.57 | [2]6.20 |
| vs Juniors-Seniors | Within | 41 | 3419.85 | 83.41 | |
| P Group | Total | 42 | 3934.42 | | |
| Sophomores P-N Group | Between | 1 | 123.20 | 123.2 | [3]1.6 |
| vs Juniors-Seniors | Wtihin | 46 | 3533.62 | 76.82 | |
| P-N Group | Total | 47 | 3656.82 | | |

[1] .61, $F_{.05}(1,90) = 3.95$ -- Not significant at .05 Level.

[2]6.20, $F_{.05}(1,41) = 4.08$ -- Significant at .05 Level.
$F_{.01}(1,41) = 7.29$ -- Not significant at .01 Level.

[3]1.6, $F_{.05}(1,46) = 4.04$ -- Not significant at .05 Level.

Another subsidiary point of interest revolved around the effect of the general ability level of the student in the change on the SAI scores. The investigator chose to make comparisons within the experimental groups. The groups were each divided by the Otis IQ scores into thirds for purposes of analysis. The investigator then proceeded to compare the thirds to determine if general ability affected the change in scores on the SAI. To accomplish this, the investigator compared the thirds of each experimental group as shown in the following tables.

TABLE 13

COMPARISON OF SAI SCORES AS AFFECTED BY OTIS IQ SCORES BY ANALYSIS OF COVARIANCE FOR JUNIOR-SENIOR GROUP P

| Source | Degrees of Freedom | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| | Top Third Compared to Bottom Third | | | |
| Test | 1 | 0.48 | 0.48 | .02[1] |
| Within | 5 | 145.39 | 29.08 | |
| Total | 6 | 145.87 | | |
| | Top Third Compared to Second Third | | | |
| Test | 1 | 0.28 | 0.28 | .03[2] |
| Within | 4 | 88.98 | 11.12 | |
| Total | 5 | 89.26 | | |
| | Second Third Compared to Bottom Third | | | |
| Test | 1 | 1.41 | 1.41 | .04[3] |
| Within | 5 | 181.77 | 36.35 | |
| Total | 6 | 183.18 | | |

[1,3] $F_{.05}(1,5) = 6.61$

[2] $F_{.05}(1,4) = 7.71$

TABLE 14

COMPARISON OF SAI SCORES AS AFFECTED BY OTIS IQ SCORES BY ANALYSIS OF COVARIANCE FOR JUNIOR-SENIOR GROUP P-N

| Source | Degrees of Freedom | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| | Top Third Compared to Bottom Third | | | |
| Test | 1 | 304.73 | 304.73 | [1]3.13 |
| Within | 7 | 682.45 | 97.49 | |
| Total | 8 | 987.18 | | |
| | Top Third Compared to Second Third | | | |
| Test | 1 | 105.80 | 105.80 | [2]1.66 |
| Within | 7 | 446.59 | 63.80 | |
| Total | 8 | 552.39 | | |
| | Second Third Compared to Bottom Third | | | |
| Test | 1 | 28.39 | 28.39 | [3]0.62 |
| Within | 7 | 321.08 | 45.87 | |
| Total | 8 | 349.47 | | |

[1,2,3] $F_{.05}(1,7) = 5.59$

As shown in tables 13 and 14, the F values for the effect of the general ability as measured by the Otis IQ scores were all calculated and determined to be insignificant at the .05 level for the junior-senior level groups.

TABLE 15

COMPARISON OF SAI SCORES AS AFFECTED BY OTIS IQ SCORES BY ANALYSIS OF COVARIANCE FOR SOPHOMORE GROUP P

| Source | Degrees of Freedom | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| | Top Third As Compared to Bottom Third | | | |
| Test | 1 | -7.48 | -7.48 | -0.08[1] |
| Within | 19 | 1834.83 | 96.57 | |
| Total | 20 | 1826.99 | | |
| | Top Third As Compared to Second Third | | | |
| Test | 1 | 200.51 | 200.51 | 1.78[2] |
| Within | 19 | 2143.96 | 112.84 | |
| Total | 20 | 2344.47 | | |
| | Second Third As Compared to Bottom Third | | | |
| Test | 1 | 112.96 | 112.96 | 1.10[3] |
| Within | 19 | 1950.49 | 102.66 | |
| Total | 20 | 2063.45 | | |

[1,2,3] $F_{.05}(1,19) = 4.38$

TABLE 16

COMPARISON OF SAI SCORES AS AFFECTED BY OTIS IQ SCORES BY ANALYSIS OF COVARIANCE FOR SOPHOMORE GROUP P-N

| Source | Degrees of Freedom | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| | Top Third As Compared to Bottom Third | | | |
| Test | 1 | 135.65 | 135.65 | 2.55[1] |
| Within | 19 | 1007.78 | 53.04 | |
| Total | 20 | 1143.43 | | |
| | Top Third As Compared to Second Third | | | |
| Test | 1 | 186.71 | 186.71 | 2.64[2] |
| Within | 20 | 1415.28 | 70.76 | |
| Total | 21 | 1601.99 | | |
| | Second Third As Compared to Bottom Third | | | |
| Test | 1 | 0.66 | 0.66 | .01[3] |
| Within | 20 | 1224.92 | 61.25 | |
| Total | 21 | 1225.58 | | |

[1] $F_{.05}(1,19) = 4.38$

[2,3] $F_{.05}(1,20) = 4.35$

As was the case with the junior-senior level courses, the calculated F values for the analysis of covariance to determine the effect of general ability as measured by the Otis IQ score was insignificant at the .05 level for sophomores also.

The general conclusion is that in this study, the learning of scientific attitudes is not significantly affected by general academic ability or the previous exposure to science as affected by the number of courses taken to date.

The statistical information used to calculate the significance levels in this study was obtained from Schefler's <u>Statistics for the</u>

*Biological Sciences* and Winer's *Statistical Principles in Experimental Design*.

SUMMARY--CHAPTER IV

The collected data analyzed by using the pre-test score as the co-variant has resulted in the following: (1) rejection of the null hypothesis that there is no significant difference in scores on the SAI between classes instructed in attitude development and those receiving no such instruction; (2) acceptance of the null hypothesis that there is no significant difference in scores on the SAI between students with exposure to two years of science as compared to students with three or four years of science; and (3) acceptance of the null hypothesis that there is no significant difference in scores on the SAI between different ability groups within the experimental classes.

# CHAPTER V

# CONCLUSIONS AND IMPLICATIONS

The analysis of the data in Chapter 4 includes specific conclusions pertaining to this study within the text. In this chapter, major conclusions and implications will be summarized.

## Major Conclusions

The results of the study indicate that science teaching designed for developing scientific attitudes can be successful if employed as illustrated by the significant changes between the experimental groups and the control groups. The changes were measured by the SAI administered.

In accordance with related literature, the emphasis of this study on scientific attitudes agrees with all the major objectives stated for progressive science teaching. The results indicate that evaluation of attitudes, as well as factual perception, can become and should become a realized part of an educator's methodology.

The results further indicate that attitude development can take place with no significant difference between scores of students of varying abilities and exposure to science courses. The results reduces suspicion that only the students' of higher general ability can be taught scientific attitudes. The results do not support the concept that students with more background will develop scientific attitudes more rapidly.

## Implications

The investigator anticipates that the results of this study hold implications for all levels of science teaching. Generally, the study implies that science attitudes can be taught as a part of the instruction in a science class. The study implies this to be a significant fact.

Specifically, the study implies the following:

1. It is feasible to teach to develop scientific attitudes.

2. Attitudes may be evaluated by instruments already available.

3. Attitude attainment is more likely with directed instruction than if it is left as an assumed result of a student's merely being enrolled in a science class.

4. In accordance with related literature, too much emphasis is placed on factual recall at the expense of attitude development.

5. All science teachers need to become keenly aware of the role they play in the development of scientific attitudes.

6. More research effort and instructional developments need to be desperately pursued in the area of teaching scientific attitudes.

The most lasting implication in the mind of the investigator is the development in his own thoughts of a new and hopefully more adequate and accurate philosophy toward the real goals of science teaching at the secondary level. Further, this study leaves the investigator keenly aware of the vital role the teacher-student relationship plays in not only attitude development, but also, all phases of education. The role of any true educator is to create the desire to learn in addition to instilling the facts.

# APPENDIX

## LESSON PLANS

Three types of lesson plans were used in this study: (1) Type P plans were used to stimulate the development of positive attitudes, (2) Type P-N lessons were used to stimulate positive attitude development and to eliminate misconceptions, (3) and Type R were regular topical lessons not aimed at attitude training in any manner which were used in the control groups.

These lesson plans were designed by the investigator to be coordinated with the twelve major objectives listed in this study on pages 24-25 that are tested by the SAI. The plans included are only brief summaries of the presentations which required from eight to twelve lecture days to complete in the various classes.

Each plan is identified by the name of the specific objective at the top of the plan. The same lesson plan was used for both sophomores and juniors-seniors of the same number and type, ex. 1-P, 1P-N, 2-P, etc., were used in both levels.

## LESSON #1 P

Objective: To develop the attitude that "Being a scientist or working in a science related occupation would be a prospective future for my life."

6-A

TEACHER AND STUDENT ACTIVITIES

1. Ask students to list as many science related jobs as they can.
2. Pass out pamphlets on science related careers in science areas for study by each student.
3. Ask each student to prepare about a one minute presentation on an occupation they studied in the pamphlets.
4. Discuss minorities in science areas.
5. Discuss women in science areas.
6. Class discussion on availability of jobs in science.
7. Class discussion on science jobs in local area.
8. Information presented on starting salaries for science related jobs.
9. Class discussion on educational requirements for certain types of jobs.
10. Show film related to jobs in the petroleum industry.

## LESSON #1 P-N

Objective: To develop the attitude that "Being a scientist or working in a science related occupation would be a prospective future for my life." Also, to eliminate the attitude that scientific work is boring, too difficult, and only for highly intelligent people.

6-A
6-B

TEACHER AND STUDENT ACTIVITIES

1. Ask students to list as many science related jobs as they can.

2. Pass out pamphlets on science related careers in multidiscipline areas for study by each student.

3. Ask each student to prepare about a one minute presentation on an occupation they studied in the pamphlets.

4. Discuss minorities in science areas.

5. Discuss women in science areas.

6. Class discussion on availability of jobs in science.

7. Discuss the misconception that scientists are strange people-- talk about practical aspects of science in areas that are related to the local people.

8. Discuss the rewarding satisfaction of scientific discoveries. Also stress the laboratory as an interesting place to work.

9. Discuss financial advantages of science-related jobs, starting salaries, etc.

10. Discuss science related jobs in the local area.

11. Discuss local people that are in science related jobs and their lifestyles to indicate the normalcy of such people in science related jobs.

12. Discuss post secondary educational requirements for various science related jobs.

13. Show film related to jobs in petroleum industry.

## LESSON #2 P

Objective: To develop the attitude that laws and/or theories of science are approximations of truth and are likely to be changed.
1-A

TEACHER AND STUDENT ACTIVITIES

1. Prepare a handout discussing the scientific process of inquiry and resulting change in existing laws and theories. Used Brandwein's A Book of Methods as a principle source. Allowed ten minutes time for reading.

2. Ask students to write down at least three positive aspects about the selection.

3. Ask for the ideas of students and write ten or twelve on the board.

4. Ask students to condense these ten or twelve statements into two or three summary statements. List these on board.

5. Discuss the idea of changing scientific laws and hypotheses. Use examples from history of changes in theories, (ex.) The false conception about the surface of the earth being flat.

## LESSON #2 P-N

Objective: To develop the attitude that laws and/or theories of science are approximations of truth and are likely to be
1-A changed. And, to eliminate the attitude that laws and/or
1-B theories of science are unchangeable truths discovered by science.

TEACHER AND STUDENT ACTIVITIES

1. Give students prepared handout on process of inquiry with Brandwein as a source. Allow time for reading.

2. Ask students to write down at least three positive aspects about the reading selection.

3. Ask for the ideas of students and write ten or twelve on the board. Try to steer away from negative statements.

4. Ask students to condense these ten or twelve statements into two or three summary statements. List these on board.

5. Discuss the idea of changing scientific laws and hypotheses. Use examples from history of changes in theories.

6. Discuss the idea that science is a human endeavor and nothing is final or unquestionable.

7. Discuss known changes encountered in science already, and the fact that more good comes from questioning in science than harm.

8. Stress that changes in the natural world are ultimately leading to changes in laws derived by men concerning the world.

## LESSON #3 P

Objective: To develop the attitude that observation of natural phenomena is the basis of scientific explanation. Science is limited in that it is only capable of answering questions about such phenomena and sometimes cannot do that.

2-A

STUDENT AND TEACHER ACTIVITIES

1. Assign students section to read on expected ratios from specific crosses in genetics experiments in Mendel's work from Weinberg text.

2. Discuss his ratios and predictions.

3. Discuss idea that some questions cannot be answered due to a lack of knowledge and/or equipment. Point out that Mendel did not have available the knowledge of the existence of the gene, let alone DNA and RNA.

4. Stress that Mendel pointed out the "how to" in genetics' experiments, not the "Why some genes are dominant and others recessive."

5. Stress that science answers "how to" questions.

6. Use overhead transparencies to illustrate Mendel's ratios.

## LESSON #3 P-N

Ojbective: To develop the attitude that observation of natural phenomena is the basis of scientific explanation. Science is
2-A limited in that it is only capable of answering questions
2-B about such phenomena and sometimes cannot do that. And, to eliminate the attitude that science is authority and can give all correct answers to all problems.

TEACHER AND STUDENT ACTIVITIES

1. Assign students section to read on expected ratios from specific crosses in genetics experiments in Mendel's work from Weinberg text.

2. Discuss his ratios and predictions.

3. Discuss idea that some questions cannot be answered due to a lack of knowledge and/or equipment. Point out that Mendel did not have available the knowledge of the existence of the gene, let alone DNA and RNA.

4. Stress that Mendel pointed out the "how to" in genetic experiments, not the "Why some genes are dominant and others recessive."

5. Stress that science answers "how to" questions.

6. Discuss the idea of one having to be an expert in science to give scientific explanations. Mendel was trained to teach science but failed his teacher exams and was a monk.

7. Discuss "Can science provide correct answers to all questions?"

8. Discuss social questions science sometimes complicates rather than answers.

9. Discuss what natural phenomena are and how science answers questions by observation and data collection.

10. Discuss "human" element that can unintentionally result in incorrect answers in science.

11. Use overhead transparencies to illustrate Mendel's ratios.

## LESSON #4 P

Objective: 5-A — To develop the attitude that progress in science depends on public support and thus the public should be aware of what science is and attempts to do. The public needs to know what science is and how they benefit from science.

STUDENT AND TEACHER ACTIVITIES

1. Ask students to write a brief paragraph about public support in science and benefits of the public from science.

2. Discuss several paragraphs.

3. Discuss public understanding of science and the problem of misconceptions surrounding local uses of chemicals in agriculture.

4. Discuss the importance of public involvement in turn for more support for research endeavors. Stress the need of science awareness by citizens to safeguard public from psuedoscience information.

5. Discuss the pressure placed on science by the public to increase productivity of food by means which necessarily increase possible sources of pollution. Point out the close parallel between public understanding and scientific advancement.

6. Discuss the necessity of science aware voters when electing men to represent them on issues of all types.

7. Have local farmer discuss use of chemicals in agriculture.

## LESSON #4 P-N

Objective: To develop the attitude that progress in science depends on public support and thus the public should be aware of what science is and attempts to do. The public needs to know what science is and how they benefit from science. And to eliminate the attitude that the public does not need to understand science since they do not play any active role in research.

5-A
5-B

STUDENT AND TEACHER ACTIVITIES

1. Ask students to write a brief paragraph about public support in science and benefits of the public from science.

2. Discuss several paragraphs.

3. Discuss public understanding of science and the problem misconceptions surrounding local uses of chemicals in agriculture.

4. Discuss the importance of public involvement in turn for more support for research endeavors. Stress the need of science awareness by citizens to safeguard public from psuedoscience information.

5. Discuss the fact that it is <u>NOT</u> true that the public cannot understand the way science works and that they cannot understand science unless they are highly trained.

6. Stress the fact that research is expensive and requires public support which is more likely if the public understands the working of the science research.

7. Discuss the dependence of society and science upon each other and necessity of public understanding in matters such as food production which necessitates use of chemicals that can pose pollution problems as well as pest control which is accomplished by chemicals as well.

8. Stress the interdependence of an aware public and the need for research in areas of science such as disease control, etc.

9. Attempt to eliminate the over-dramatized "scare" personality science has acquired since pollution movement and since emphasis on carcinogenic agents has been discredited to some extent in areas where extreme measures were recommended.

10. Have local farmer discuss use of chemicals in agriculture.

# LESSON #5 P

Objective: To develop the attitude that scientists must operate in such a manner as to display traits such as intellectual honesty, dependency on objective observations of natural occurances, and willingness to change one's stand if provided with sufficient evidence.

3-A

STUDENT AND TEACHER ACTIVITIES

1. Discuss:

   a. Open-mindedness in science
   b. Objectivity in observation
   c. Intellectual honesty in recording and reporting results

2. Play word analogy--give students words such as record, data, experiment, results, interpretation, conclusions, honesty, variable, etc., and let them respond with their answer. Briefly discuss their ideas on the importance of each phase of inquiry being done with honesty and accuracy in each area.

3. Discuss the true nature of a scientist and his willingness to accept validated data that may cause him to change his stand.

# LESSON #5 P-N

Objective: To develop the attitude that scientists must operate in such a manner as to display traits such as intellectual honesty,
3-A dependency on objective observations of natural occurances,
3-B and willingness to change one's stand if provided with sufficient evidence. And to eliminate the idea that scientists must know what all other scientists think and agree with them.

## STUDENT AND TEACHER ACTIVITIES

1. Discuss:

   a. Open Mindedness in Science
   b. Objectivity in Observation
   c. Intellectual Honesty in Recording and Reporting Results
   d. Scientific Scrutiny and Criticism in Research

2. Play word analogy as in 5-P.

3. Discuss nature of scientist and his willingness to change position proved with necessary facts.

4. Stress lack of scientific grounds for agreement between all scientists on the same issue in question.

## LESSON #6 P

Objectives: To develop the attitude that science is an idea-generating experience devoted to explaining natural phenomena. The real value of science lies in its theoretical aspects.
4-A

STUDENT AND TEACHER ACTIVITIES

1. Ask students to define theoretical. Give them a definition from the dictionary.

2. Discuss applied science versus theoretical science.

3. Discuss the aspects of theoretical genetics in the development of the field of applied genetics. Substantiate with section in Weinberg on the development of superior varieties of livestock and crops for food production.

4. Stress that theory provides for application.

5. Show film entitled "Applied Genetics in Agriculture."

LESSON #6 P-N

Objectives: To develop the attitude that science is an idea-generating experience devoted to explaining natural phenomena. The real value of science lies in its theoretical aspects. And to eliminate the attitude that science is a technological developing process. Its value lies in practical application. Science is designed to serve man.

STUDENT AND TEACHER ACTIVITIES

1. Ask students to define theoretical. Give them a definition from the dictionary.

2. Discuss applied science versus theoretical science.

3. Discuss the aspects of theoretical genetics in the development of the field of applied genetics. Substantiate with section in Weinberg on the development of superior varieties of livestock and crops for food production. Discuss local farming operations designed to produce superior produce through selected breeding.

4. Discuss the idea that the basic purpose of science is to explain nature--not serve man.

5. Stress that man uses the product of science--not science.

6. Stress that before practical use is feasible, the real role of science is to provide theory that serves as the basis.

7. Stress that technology serves man, not theoretical science.

8. Show film entitled "Applied Genetics in Agriculture."

CONTROL GROUP--JUNIOR-SENIOR LEVEL
LESSON PLANS FOR REGULAR CLASS IN CHEMISTRY
*10 lecture periods*

1. Cover unit on gas laws--Boyles', Charles', Combined, Partial Pressures, and Ideal.

2. Work problems in class exhibiting each type.

3. Show by demonstration effect of increasing pressure on the volume. (Use IPS setup)

4. Work with graphing the gas laws.

5. Assign homework on laws.

6. Administer test on gas laws.

CONTROL GROUP--SOPHOMORE LEVEL
LESSON PLANS FOR REGULAR CLASS IN SOPHOMORE BIOLOGY
*12 lecture periods*

1. Cover unit consisting of class work in genetics problems.

2. Assign family "genetic trees" to be completed for homework.

3. Include class discussion of human genetics.

4. Use overhead transparencies to exhibit certain types of dominance in traits.

5. Administer test after unit is completed.

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