A STUDY OF THE DEVELOPMENT OF AN UNDERSTANDING OF SCIENCE IN TWO JUNIOR HIGH SCHOOL SCIENCE COURSES

By

KENNETH E. SHEPPARD JR.

Bachelor of Science
East Texas State University
Commerce, Texas
1962

Master of Science
East Texas State University
Commerce, Texas
1962

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SCIENCE COURSES

Thesis Approved:

Kenneth E. Wiggins
Thesis Adviser

L. Herbert Bruneau

Wm. D. Frazier

J. A. Blankenship

Alex R. Ross

D. D. Durham
Dean of the Graduate College

PREFACE

The work reported in this investigation was performed in four junior high schools in Oklahoma. The primary objective of this study was to investigate understandings of science as they are fostered by the new programs in science at the junior high school level. The resultant recommendations and the techniques used in the study should provide the basis for further investigations in this area.

I am especially grateful to Dr. Kenneth E. Wiggins, my supervisor and thesis adviser, for his advice and encouragement which made this study possible.

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CHAPTER I

INTRODUCTION

Background of the Study

In recent years there has been a dynamic shift occurring in the types of science courses taught at the junior high school level. The need for a new approach to science teaching at this level, however, was advocated in the K-12 program as early as 1947 (1). Perhaps the launching of the first Russian satellite did have some effect on the curriculum changes that we are witnessing today in all the science instructional areas, but the change, in part, was based on the actual need for curriculum revision in all areas of our present public school system (2, 3).

The explosion of knowledge along with the population explosion has placed an ever increasing demand on our public schools in their effort to give each student the best education possible.

Hurt (4) has made an interesting observation concerning the knowledge explosion:

> Since the time of Newton, the production of new knowledge in science has increased by a factor of 1,000,000. Those who teach in the secondary schools net about 150 hours each year to influence the life of every student in class. What ideas and facts have we chosen from the research in science that we judge to be of most worth to teach in these few hours?
>
> ...How has this problem of increasing knowldge been handled in many textbooks and classrooms? Mostly there has been a futile attempt at "coverage." Textbooks have become thicker,

> courses have become larger inventories of facts, and teaching a mad race from September to June, with the result that the surest way to develop a neurosis in a teacher is to create the fear that he will not be able to finish the course of study by the end of the school year.
>
> Sometimes new scientific achievements are added to courses but seldom is anything dropped. The accepted rationalization is that what we now teach is fundamental or basic, whereas it all too frequently is only traditional.

The new surge of knowledge in the sciences shook the very foundations of the traditional approach to science teaching. How does one transmit the accumulated knowledge in the sciences? This question has brought about a search for new approaches to science teaching. Drummond (5) expresses the following opinion about some of our current attempts.

> While these programs seem to represent significant advances in approach and organization, they cannot cope with the information explosion in science, with the need to integrate into classroom activities what is going on today in the world's laboratories.

A course in general science has been the traditional science course taught at the junior high school level, but in the last few years, educators in general and science educators in particular have taken a serious look at the curriculum in the various science courses at all levels of instruction as evidenced by the many new curricular revisions that have been implanted in the sciences of late (6, 7).

The Earth Science Curriculum Project, ESCP, was the result of a joint effort of scientists and educators working together to create, in part, a program of study designed for a segment of the junior high school science program (8, 9). The particular earth science course developed by the Earth Science Curriculum Project is most generally used at the ninth grade level. In the State of Oklahoma this program developed by the Earth Science Curriculum Project is taught at the ninth grade level, but across the river in the State of Texas, the earth science course is taught at the eighth grade level.

Stephenson (10) feels that recent experiences have shown that the ninth grade appears to be the ideal level to present the full year of earth science. His reasons are:

1. Modern science programs have caused much of the material formerly presented in general science to be taught in the lower grades. There is now a need for a more advanced science course at the ninth grade level.

2. Most ninth grade students have acquired the necessary reading ability to understand basic earth science subject matter and to master the required vocabulary.

3. Taught by competent teachers, earth science can be used to illustrate the interdependence of the various basic sciences in the study of scientific concepts and processes of the earth and space.

4. A challenging, well-presented earth science course can introduce the student to the basic methods of scientific inquiry and investigation. This should prove helpful when more advanced science courses are taken.

The program developed by the Earth Science Curriculum Project was one of the first of several programs that has been designed especially for the junior high school science sequence (11, 12). This program, as well as most of the other new curricular programs in science, has as one of its major objectives the development of a realistic understanding of science and of the scientist. This objective is necessary because of the mistaken identity and purpose that has many times been attached to the scientist. Drummond (13) expresses the opinion that is widely held today among science educators.

> The general public today has a completely erroneous picture of the typical scientist. The image is of a white-coated benevolent witch doctor puttering around in his isolated, mysterious, and bewildering laboratory, surrounded by a maze of glassware, wires, and assorted "black boxes." Out of this totally incomprehensibel scene, by equally obscure methods, come earth-shattering discoveries and conclusions.

> But is this really the case? In truth, the scientist is for the most part an ordinary person with ordinary desires and habits. True, some of his laboratory equipment may be complicated and mysterious, but is it more so than the radar trap of the highway police, or the control panel of a commercial airliner? Not to the non-scientist, at any rate.

An understanding of what a scientist does and how he does it is important to an overall understanding of the nature of the scientific enterprise (14, 15). If these understandings are to be considered important goals, there is a definite need in the evaluation process of the new curricular programs to determine the types of understandings fostered by these new programs.

Statement of the Problem

The primary purpose of this study was to determine understanding of science that is developed in one of the new science curriculum projects at the junior high school level. The new course involved the use of the Earth Science Curriculum Project program in earth science which places heavy emphasis on student participation and independent student investigation. This method attempts to place the student in the role of the scientist, and the student is encouraged to do things that a scientist does in the way that a scientist would do them. This is known as the inquiry method.

The second method or second type of junior high school science course in this study was a traditional general science course. The general science course places heavy emphasis on the lecture method of science teaching, and there is little or no student participation in the scientific process.

This study attempted to examine specific differences between the

Earth Science Curriculum Project course and the traditional general science course in relation to student understandings. The following questions were used in developing the study.

1. Do junior high school students understand the role of the scientist?
2. Do junior high school students understand the nature of the scientific enterprise?
3. Do junior high school students understand the methods and aims of science?

Hypotheses

The specific hypotheses tested in this study were:

1. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the _Test on Understanding Science_ designed to measure the students understanding of the scientist.
2. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the _Test on Understanding Science_ designed to measure the students understanding of the methods and aims of science.
3. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth

Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the *Test on Understanding Science* designed to measure the students understanding of the scientific enterprise.

4. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the *Test on Understanding Science* designed to measure the students understanding of science as a field of study as it relates to the scientist, the methods and aims of science, and the scientific enterprise.

Significance of the Study

There is a definite need in the evaluation process of the many new science programs to determine the understandings of science and of the scientist that a student develops during such a course. Although the Earth Science Curriculum Project has done as much in the way of evaluation of their program as any of the other new curriculum projects, there has been no formal allowance for the study of this aspect, understandings, of the program. If these understandings are worthwhile goals, as stated earlier in this study, then they need to be included in the total evaluation process.

> The development in pupils of scientific attitudes, appreciations, and other so-called noncognitive attributes should be goals of science instruction,...(16).

There is a need to have more empirical evidence of the effects of these programs before they can be accepted as better than our traditional science courses. More evidence is needed on the total effect of the new programs.

Watson and Cooley (17) have expressed the following viewpoint:

> Confident theory and practical action in education, as in science, must be based upon the results of research. However, now that the spotlight of public concern has been turned abruptly upon science-teaching in the schools, we find that proven research in this area is not sufficient to guide us in determining what changes would be profitable for improving the teaching of science. Some advances have been made, but only on a narrow front.

This study is significant in that it does attempt to contribute empirical evidence to this limited pool of knowledge. This study attempts to determine if understandings of the scientist, the methods and aims of science, the scientific enterprise, and science, as it is composed of the three former elements, are influenced by the type of science course that a student completed at the junior high school level. To the degree that it will give evidence to this basic question about the teaching of science, this study will be significant. If differences appear in this study, then a whole new line of research may be suggested that has had far too little attention in the past.

Limitations of the Study

This study was limited by factors that may have influenced the conclusions reached. The following factors should be included:

1. This study included ninth grade students from four junior high schools in Oklahoma. Only students present the day that the test was given were considered, and only those students who had been enrolled in their particular course

for the complete academic year were included.

2. There are factors outside the classroom situation that will influence understandings of science.

3. The teachers involved in this study were different in their personality, I.Q., knowledge of the subject being taught, knowledge of science teaching methods, philosophy of teaching, and in other characteristics that are inherent in each individual teacher.

Clarification of Terms

Attitudes Toward Science

Attitudes toward science refers to how an individual feels about science; an emotional feeling for or against science as exhibited through the behavior of the individual.

Earth Science Curriculum Project

The Earth Science Curriculum Project refers to a course of study developed by scientists and educators which emphasises an experience centered approach to science through use of the science laboratory and through a study of the sciences of the earth.

General Science Course

The general science course refers to the traditional lecture and teacher demonstration type science course that is taught at the ninth grade level in the junior high school.

Junior High School

The junior high school as used in this study is used to include the ninth grade.

Understanding of the Scientist

In this study the understanding of the scientist refers to how a student interprets the role that a scientist plays in our society, and what a scientist does when he is at his work. This will constitute the actual image of the scientist as the student perceives it.

Understanding of the Methods and Aims of Science

The understanding of the methods and aims of science in this study refers to how the student views the process by which science seeks answers to unsolved problems and the ultimate ends that are sought by scientific endeavors.

Understanding of the Scientific Enterprise

The understanding of the scientific enterprise in this study refers to how the student views such elements as money, instruments, communication, international character, and interaction with society as these elements relate to science.

Laboratory

The laboratory as used in this study refers to the place where observations are made and experiments are conducted by the students.

Assumptions of the Study

There are several assumptions that are basic to this study. It was assumed that:

1. The instrument used in this study was valid in measuring understandings of the methods and aims of science, understandings of the scientist, and understandings of the scientific enterprise.
2. The subjects used in this study were representative of the population from which they were drawn.
3. The factors outside the classroom that influence the students understanding of science were randomized.

CHAPTER II

REVIEW OF SELECTED LITERATURE

As stated earlier in this study, the satellite age has given impetus to the development of many new and revolutionary science programs that are unfolding today, but the fact remains that a revolution in science teaching had begun long before the satellite program got off the ground. Perhaps the event of the satellite launching did do more than any other single event to point out the weakness in research as pointed out by Watson and Cooley (18).

The results of the many revisions and the subsequent number of courses developed is often staggering. Haney (19) describes several new science programs. The Biological Science Curriculum Study, Chemical Bond Approach, Chemical Education Materials, Physical Science Study Committee, Secondary School Science Project, Harvard Project Physics, Engineering Concepts Curriculum Project, Portland Project, and a variety of other science programs which have appeared in the secondary school curriculum are included. The Elementary Science Study, Science Curriculum Improvement Study, American Association for the Advancement of Science Commission on Science Education, Elementary School Science Project, University of California Elementary School Science Project, University of Illinois Elementary School Science Project, Elementary Science Project, Study of a Quantitative Approach in Elementary Science, and the Conceptually Oriented Program for Elementary Science are the major projects that have been developed in the area of elementary school science programs.

With the development of these new programs both above and below the junior high school level, it became necessary to examine the science courses offered in the junior high school. Haney (20) gives a full description of at least three major programs that were developed to fill this void in the science curriculum at the junior high school level. The School Science Curriculum Project, Introductory Physical Science, and the Earth Science Curriculum Project are now being used in many K-12 programs.

The role of the junior high school has been historically rather uncertain. This has been especially true of the science curriculum of the junior high school. According to Rutledge (21):

> Presently the greatest amount of curricular change is seen at the high-school level, with considerably less activity observable in the junior high school. Charges have frequently been made that the usual Junior-high school science course has been repetitive, superficial, unstimulating, and almost devoid of laboratory work. Worse yet, these courses are particularly inadequate in systems where elementary-school science programs have been developed to include many topics formerly considered to be the responsibility of the junior high school.

The Earth Science Curricular Project was designed for the junior high school science course that was caught in the middle of these expanding programs.

> There is great concern about the methods and techniques used in teaching science and in the facilities and equipment needed to bring about efficient, effective teaching. Traditional methods, in general, do not always contribute to the realization of accepted objectives of science teaching, such as: development of an understanding of the process and product of science, problem-solving abilities, scientific attitudes and an appreciation of the importance of science in our society. A careful study of science programs in today's schools will reveal that science instruction is changing and that many trends are in evidence (22).

The Earth science Curriculum Project program was designed as an experimental science course and in many cases replaced the general science course typically taught at the ninth grade level. In the 1940's New York State introduced a course in earth science at the ninth grade level to bridge the gap that had developed between elementary grade science courses and the high school biology, chemistry, and physics courses. This experiment proved to be extremely successful in New York and led to greater interest in experimental programs for the junior high school.

Roy (23) warns:

> If an earth science course is to replace a year of general science, it will be an improvement only to the extent that it develops favorable attitudes toward science and aptitude for continued education in this field.

The Earth Science Curriculum Project was an outgrowth of the American Geological Institute Study which was devoted to developing interdisciplinary earth science course. In 1963 the Earth Science Curriculum Project came into existence. The general objectives of this project were to develop up-to-date teaching resource materials and aids to teaching. Among the philosophical tenets that guided the program were:

> 3. The materials produced by ESCP must be written with full understanding of the intellectual capacities and subject-matter background of the secondary school student for whom they are intended.
>
> 4. The course materials should make no pretense of covering the entire body of knowledge concerning the planet Earth; rather emphasis should be placed on developing a system of basic concepts and principles in earth science, which serve as a system of perspectives through which phenomena may be viewed in other sciences.
>
> 5. Materials developed by ESCP should place strong emphasis on laboratory and field study in which the student actively participates in the genuine process of scientific inquiry, rather than mechanically repeating "cookbook" exercises...

9. A thorough testing program for all materials developed for use in secondary school classes is essential to the success of the project.

10. Finally, the goal of the Earth Science Curriculum Project is to produce a "package" of course materials that will provide the basis for a solid, integrated earth science course which will be taught for the most part at the ninth grade level. The educated citizenry of tomorrow will be faced with the need to understand the scientific phenomena of their shrinking earth and its environs in space. It is hoped that ESCP will contribute a measurable progress toward this goal. In the process, the general public would gain new insight into the works of earth scientists and their unique role in human progress (24).

Statements of philosophy such as five and ten in the preceding quotation are typical of the emphasis that the Earth Science Curriculum places on the laboratory approach to science teaching. The basic rationale behind this philosophy is that when one does the work that a scientist does he will better understand the role that a scientist plays in our present society and that the scientist is usually an ordinary or average man solving problems that surround us.

Haney (25), in his description of the new programs in science, says of the laboratory:

> Teaching methods are related to the nature of science and the nature of the learner. The new programs place a great deal of emphasis on the inquiry aspect of science, hence, the laboratory has received considerable attention in these programs. The implied rationale for this is that if pupils learn, understand and appreciate the intellectual and psychomotor skills of scientists and the way in which knowledge is acquired they themselves must engage in the processes.

The student should therefore understand the methods and aims of science if he uses the methods of science in solving problems for himself and also the aim of science as he sees it from his experiences.

Hurd (26) says of science methods:

> This means that a considerable part of class time must be spent in the analyzing, organizing, and relating of

> learnings until the student is able to form concepts and to recognize something of the nature of the subject. That is, until he has acquired an understanding of the process by which knowledge has been produced in the particular discipline. Only then can the student be said to truly possess any part of the subject.
>
> Grasping the structure of a subject means understanding it in a way that permits other ideas and new knowledge to be related to it in a meaningful way. When ideas have been grouped and related, the student is in an intellectual position to use what he has learned in attacking new problems or new variations. He is also in a more favorable position to harbor the latest conclusions of science as they are generated.

The National Science Teachers Association has taken several definite positions on the adequate school science program. The following relates appropriately to this study.

> 4. Must result in understanding the nature of the scientific enterprise through direct student involvement in the processes of scientific inquiry; ... (27).

A basic position of The National Science Teachers Association on curriculum development in science:

> A basic premise of each of these groups (new curriculum) is that science instruction in most schools is out-of-date and fails to present an understanding of the objectives and methods of scientific inquiry. Programs in the elementary schools and junior high schools manifest the same obsolescence (28).

Armed with an understanding of the scientist and the methods that the scientist employs and the aims that he seeks, the student will develop an understanding of the complete scientific community or enterprise.

Carter (29) says of the Earth Science Curriculum Project laboratory:

> Inquiry involves teaching science as a way of thinking as a method of seeking answers. Students are involved in the methods of the scientist in a laboratory situation and come to know science as an active process. Emphasis is placed on the ability to observe, establish hypotheses, and arrive at sound conclusions based on observed data.

Sampler (30), in his views of the laboratory and inquiry, stated:

> One of the fundamental goals of the Earth Science Curriculum Project is to provide text materials and some manipulable laboratory materials that will guide young people toward recognizing the means and ends of the working scientist.

The Earth Science Curriculum Project program has not gone without evaluation of the majority of its goals. There are indirect indications that the students may be developing attitudes that are favorable to science or at least to their earth science course. A survey conducted by the Earth Science Curriculum Project asked several specific questions and requested comments that the students would like to make in general about the program which they were taking.

The comments that follow are typical of the ESCP report (31):

> "The lab was great; the text supplemented it, instead of the other way around."

> "The biggest thing I got from the course was to realize how much there is to learn that I didn't know."

> "I found the text hard, but the lab investigations nearly always cleared it up."

> "This course was fun because we were able to learn by ourselves instead of listening to the teacher all the time."

> "I always thought scientists knew everything - now I know they're as confused as the next guy."

> "The book doesn't teach you - you teach yourself."

Hook (32) suggested that the Earth Science course, at least in one major respect, has a certain desirable advantage over the presently used general science courses:

> ...In other words it would seem that through Earth Science it is easier to show the scientific method in action.

The scientific method or the science method for solving problems is one of the most important tools of the scientist and is equally important to the nonscientist. In a recent issue of the ESCP Newsletter

(33) the following comment was made:

> The laboratory approach, if properly implemented, is a powerful means of conveying the essence of the so-called scientific method.

Mahan (34) has said of the lab:

> Critical and careful observation is stressed at all times; it is hoped that each student will gain insight into the scientific method.

In their guidelines for the development of a coordinated science curriculum through a local action program. The National Science Teachers Association (35) had several comments on the laboratory, the scientific process, and other aspects of the science program.

> The laboratory, as the term is used in science teaching, is the place where observations are made and experiments are conducted. This may be in the school building, outdoors, or in the home. Both scientists and educators have insisted for many years that scientific inquiry and laboratory-centered instruction are essential components of every desirable science program.
>
> ...The curriculum should be organized around broad principles in science and should provide opportunity for all students to gain some understanding of the scientific process.
>
> ...The goal of developing scientific literacy and understanding of science on the part of all students is an extremely important part of curriculum development. It will require considerable attention to the needs of the slower student as well as planning for students who will become scientists, professional persons, or leaders in other areas of society. Ample provision for study of educational research on teaching and learning techniques for various ability and interest levels should be included in the plans for the local action program.

It was noted earlier in this study that the ESCP is undergoing constant evaluation and revision. There have been additions to teaching aids in the form of certain audio visual materials. These materials included films, resource booklets, and various other items for both teacher and student to use. The evaluation program as a whole has been good.

Shea (36) has commented on the evaluation results by saying:

> It is too early to arrive at any definite conclusions regarding the evaluation program; however, students are reacting to the new course with real enthusiasm. With time they are adjusting to the new approach to laboratory investigations. Once students learn that they are expected to proceed with the laboratory investigations, they are more than willing to do so. In fact, most students prefer this method to being guided every step of the way.

Roy (37) has said:

> Few students in these courses [new science program courses] find them boring, and their sterotypes of science and scientists are possibly more favorable.

The development of the many new science courses has not been without new problems, and the new courses will perhaps generate several more problems before they are rooted into our philosophy of teaching and learning. Roy (38) has brought to light the following information.

> It is understandable that the recent developments in high school mathematics and the sciences have put a real strain on the adaptive capacities of local schools. This led to a statement of policy by the Curriculum Committee of the National Science Teachers Association (NSTA). ... to be fully adequate the school science program...(3) must encompass a full range of the contemporary knowledge and ideas which scientists employ; (4) must result in understanding the nature of the scientific enterprise through direct student involvement in processes of scientific inquiry.

There seems to be a direct relationship between attitudes and understandings in respect to science and the scientist. It could hardly be expected that one would have a favorable attitude toward an object without an understanding of that object.

> ...the term "attitude" is merely a convenient way of referring to the preparedness that exists within the organism for some future activity (39).

> An attitude...is a predisposition to think, feel, perceive, and behave toward a cognitive object (40).

Dressel (41) has made an interesting observation on scientific attitudes:

> The principles of learning which are to be observed in teaching directly for the attitudes and methods of science are the same as those applicable for any other educational objective. The experiences should be psychologically sound, with due cognizance given to student aims and needs. There should be student activity - such as would be in agreement with the types of learning involved in the student's objective. There is also need for wise direction for the student's endeavors. The teacher's own attitudes and methods are certain to be influential in such learning situations.
>
> With reference to the acquisition of scientific methods and attitudes, it seems obvious that if students are to develop these abilities they must have practice in them. That is, situations should be designed to allow students to select worth-while problems and attempt to solve them. They should have experiences in collecting data, making guesses, devising experiments, and checking for accuracy while cultivating methods and attitudes conducive to effective learning in the field of science.

Empirical studies related to scientific attitudes became important with the studies of Davis (42), Noll (43), and Hoff (44) in 1935-36. Curtis (45) as early as 1924 had made an analysis of scientific attitudes. Extensive lists of scientific attitudes have been accumulated through the studies of Crowell (46), Ebel (47), and Lampkin (48).

The study by Mead and Metraux (49) was concerned with the image of the scientist held by high school students. They found that science was seen as a good thing, but few of the students felt that they would like to be personally involved in science. The scientist was seen as a man who wears a white coat and works in a lab. He is a brilliant man. The study indicated that the majority of the students did not understand the role of science or of the scientist. There were several recommendations made as a result of this study which have implications to the teaching of science.

1. Encourage more participation and less passive watching in the classroom. ....a decrease in the passive type of experience found in many general science courses seems particularly necessary...

4. Emphasize group projects; let the student have an opportunity to see science as team work, where minds and skills of different sorts complement one another...

7. Deemphasize individual representatives of science... Instead, emphasize the sciences as fields, and the history of science as a great adventure of mankind as a whole.

8. Avoid talking about "the scientist," "science," and "the scientific method." Use instead the names of the sciences...and speak of what a biologist or a physicist does and what the many different methods of science are - observing, measurement, hypotheses-generating, hypotheses-testing, experiment (50).

Perrodin (51) used a projective type instrument to test the attitudes of elementary and junior high school students toward science. In general, he found that the fourth and sixth grade children had a favorable attitude toward science. This favorable attitude declined somewhat in the eighth grade group. In his recommendations Perrodin (52) asked several questions relative to junior high school science attitudes.

> Should it be expected that eighth graders' attitudes toward science will be less favorable than sixth or fourth graders? Is it possible that improvements in elementary science instruction in the lower grades have not been recognized by science teachers at the seventh and eighth grades?

Charen (53) concluded from a study of laboratory methods and their influence on science attitudes that laboratory activity builds more positive attitudes toward science.

A study by Powell (54) indicated that high school students had a favorable attitude toward science. This study considered several variables including I.Q.

> The results of this study seem to point out again that the subjects a student find interesting and in which he meets with success are the subjects he prefers. The students in the lower group (I. Q.) were indifferent toward science... The upper intelligence group regarded science more favorably (55).

Bernatowicz and Kay (55) point out from their research the need to experience science rather than being told. They also indicated that if the student is able to experience and find out things on his own he will have a more accurate knowledge of what occurs and thus perhaps a better attitude toward the scientific process.

Blackwood (57) says that one of the major challenges which science teachers face today is:

> ...to work continually for a clarified understanding of what science is.

Since the ultimate product of any science course depends primarily upon the teacher, the Earth Science Curriculum Project included teacher training as one of its prime objectives for existing. Developing an understanding of what a scientist is and what a scientist does, as well as how he does it, is directly influenced by the teacher. The teacher must have the proper attitude toward science in order to reflect a positive attitude. These attitudes can be detected in each of the following objectives of ESCP as listed by Stephenson (56) in relation to institutions training teachers:

1. Dedicate themselves to the training of teachers of high quality who can export enthusiasm and sound science to the secondary schools.

2. Provide accurate, modern subject-matter training in astronomy, geology, meteorology, oceanography, and physical geography for prospective teachers, by using the resources of their own department or through interdepartmental cooperation.

3. Revamp courses to emphasize concepts, principles, and the challenge of unsolved problems, and curtain the traditional

emphasis on descriptive and taxonomic aspects of the geosciences. Stress the manner of scientific inquiry and problem solving.

4. Foster cooperation on teacher training between the liberal arts and education faculties to provide the most effective balance between subject matter and essential professional education courses.

5. Provide the incentive for postgraduate improvement of subject matter competency among secondary school teachers by granting graduate credit for undergraduate courses to those working toward advanced degrees in science education.

6. Develop the departmental and institutional philosophy that the training of secondary school science teachers is a highly important departmental function, worthy of high caliber, enthusiastic instructional talent.

7. Recognize that effort invested in sound scientific preparation of secondary school science teachers will pay dividends in future years, in the form of capable, top-ranking, science-oreinted students entering college to train for careers in the earth sciences.

If earth science departments across the country are observing these objectives, one could assume that the teachers who come through the preparation program possess those qualities that would be conducive to the understanding of science for their students. Item three above is the essence of what the teacher must possess.

Goodlad (59) has also emphasized the importance of teacher education in the current curriculum reform projects:

> Broad-scale implementation of current curriculum projects depends upon both the usefulness of materials produced and the in-service education of the teachers who use them. Most projects have distinguished themselves on both accounts. Continuing self-renewal of the current curriculum reform of movement, however, depends upon the pre-service preparation of teachers in the new content, and the education of teachers who understand and are sympathetic to the place of organized subject matter in the education of the young. Current projects havd not distinguished themselves on this account

A study by the National Association of Science Writers (60) found that, in general, their sample leaned toward a favorable view of the scientist. Our problem is to determine if these feelings are generated by a different approach to science teaching.

CHAPTER III

PERSONNEL AND EXPERIMENTAL PROCEDURES

Sample Included in the Study

The sample for the Earth Science Curriculum Project course consisted of students from the ninth grade in three separate junior high schools in a large metropolitan school system in the State of Oklahoma. At the present time, the Earth Science Curriculum Project course is not taught extensively in the junior high schools in Oklahoma. This is partly due to the fact that the Earth Science Curriculum Project program is an experimental program and has not undergone a complete evaluation.

The Earth Science Curriculum Project staff conducted a survey of schools in the United States to discover the extent of course offerings in each state. The primary purpose was to discover the position of earth science in the secondary schools (61). The survey indicated that Oklahoma fell into the category of offering earth science in only a few schools, but the survey also stated that a tentative future interest did exist in Oklahoma. This fact, in part, has been realized with the new course offering in the Oklahoma City Public School System.

The relative lack of Earth Science Curriculum Project courses in Oklahoma caused the investigator to use the three previously mentioned junior high schools in this study. All three of these junior high schools were located in the same city, and the three were scattered around the city and served several socio-economic areas.

The Earth Science Curriculum Project sample included both male and female students. The average age for both sex groups was fifteen years. Each student included in this sample had completed the full academic year of study under the Earth Science Curriculum Project program. Only those students present the day that the test was administered were included in the study.

All of the students in the Earth Science Curriculum Project sample were taught by a teacher who had special training in the materials and the basic philosophy of the Earth Science Curriculum Project. There were three individual teachers involved in this sample.

The sample for the general science group was also drawn from a large metropolitan school system. This sample was also from an Oklahoma school. Each student in the general science sample was enrolled in the general science course for the entire academic year. Only those students present on the day that the test was administered were considered part of the sample. The general science sample contained both boys and girls and the average age for this group was fifteen years.

The investigator was unable to find any single school system that offered both the Earth Science Curriculum Project course and the general science course at the ninth grade level that was large enough to supply both samples. The second large system was similar to the system from which the Earth Science Curriculum Project sample was drawn in many respects. The general science sample was drawn from one junior high school, but this particular junior high school drew students from several socio-economic areas.

The samples could be considered random to the extent that the investigator had no control over any student being in one group or the other. Compbell and Stanley (62) refer to this situation as a natural setting. Each student in the study had an equal chance to be in either group.

Instruments Used in the Study

The basic instrument used in the study was the _Test on Understanding Science_ (63). This test is a new research instrument designed by Cooley and Klopfer.

The need and rationale for this particular test is adequately expressed by Cooley and Klopfer (64).

> For many years, science educators have acknowledged the importance of teaching and learnign certain so-called "intangible" aspects of science. These intangibles include an understanding of the nature of scientific inquiry, of science as an institution, and of scientists as people. Such understandings are particularly important today, as our nation and the world are increasingly affected by the results of scientific activity, and as we seek to attract young people into scientific career fields. However, while a large variety of tests has been prepared to measure student achievement in the facts and principles of science, no adequate instrument has yet been constructed to assess the extent to which the important instructional outcome of understanding science and scientists has been achieved. Numerous studies of science curriculum methods assert that a particular technique or procedure has contributed to these understandings in the students, but, in the absence of a valid instrument, such judgements cannot be made objectively to any extent. Thus, there exists a definite need for an instrument that adequately measures these understandings. It is the purpose of TOUS to meet this need.
>
> ...We maintain that an understanding of the scientific enterprise and scientists can be described, completely enough for our purpose, in terms of definite components--which have been drawn from analyses of scientists at work, from history and philosophy of science, from biographies of scientists, from writings of scientists and commentators--and that the sum of these components, then, provides a reasonably valid picture of the nature of science and scientists. To the extent that a student apprehends these components, he also understands science and scientists.

The *Test on Understanding Science* is not a revolutionary testing technique. It uses a familiar, four-alternative, multiple-choice item.

The *Test on Understanding Science* is designed around three basic areas. Area one is concerned with the scientific enterprise. The themes included in this area are the human element in science, communication among scientists, scientific societies, instruments, money, international character of science, and interaction of science and society.

Area two is concerned with the scientist. The themes for this area include generalizations about scientists as people, institutional pressures on scientists, and abilities needed by scientists.

The third area of the test is concerned with the methods and aims of science. The themes for this area include generalities about scientific methods, tactics and strategy of sciencing, theories and models, aims of science, accumulation and falsification, controversies in science, science and technology, and unity and interdependence of the sciences.

The authors see several possible uses for the *Test on Understanding Science*. Cooley and Klopfer (65) state:

> Turning to the possible applications of TOUS in curriculum development, the most obvious use of this instrument is in the direct testing of high school students to determine to what extent a realistic understanding of science and scientists has been attained as a result of taking science courses. Such testing would provide teachers and curriculum workers with comparative objective evidence on the extent to which these important objectives of instruction are being achieved.

The *Test on Understanding Science* (Form W) has been tested and revised several times. The reliability of the test is shown in Table I. The reliability was determined by applying the Kuder-Richardson Formula 20 to Form X test data from 2535 students. The reliability for the total score yielded a standard error of measurement of 3.49.

TABLE I

RELIABILITY OF TEST ON UNDERSTANDING SCIENCE KUDER-RICHARDSON FORMULA 20 FROM COOLEY AND KLOPFER (66)

Scale	Reliability
Area I	.58
Area II	.52
Area III	.58
Total	.76

Standard error of measurement ± 3.49

Collection of Data

The Earth Science Curriculum Project sample and the general science sample were drawn from similar school systems, and, as stated earlier in this chapter, to the extent that the investigator had no control over the sample in which a student might be included, the samples could be considered random in a natural setting.

In both samples, each student was administered the *Test on Understanding Science*. The test was administered by the investigator in all cases, and all tests were administered two weeks before the end of the school year in order that the student would complete the entire course of study.

The same pretest instruction was given to each tested group. These instructions are included in the Test on Understanding Science Manual, Form W (67). In addition, each group was advised that the results of this test would not be included in their particular course grade. The time limit of forty minutes was observed in all cases.

Analytical Procedures

The data derived from the application of the Test on Understanding Science was interval data in all three areas. The total score was also interval in nature. In order to determine the correct model of the *t* test to be used in calculations, it was necessary to make a variance check of each group. A summary of the significance of group variances was placed in Table II. The value of F at the .05 level of confidence in each case was 1.26. Since the ration of the variance between groups of each test was less than the F-value at the .05 level of significance, the assumption that the variance within subgroups of each test was homogeneous was justifiable.

The basic design used in this study is a "Post-test-Only Control Group Design." Campbell and Stanley (68) make this observation concerning this particular design:

> While the pre-test is a concept deeply embedded in the thinking of research workers in education and phychology, it is not actually essential to true experimentation designs. For psychological reasons it is difficult to give up "knowing for sure" that the experimental and control groups were "equal" before the differential experimental treatment. Nonetheless, the adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence, randomization can suffice without the pre-test.

A *t* test was used to test for significance of the difference between means of the experimental and control groups on each part of the

TABLE II

SIGNIFICANCE OF DIFFERENCES BETWEEN TEST SCORE VARIANCES OF SAMPLE GROUPS

Area	Group	N	Mean	Variance	F	F .05 level
I	E	282	9.38	8.14	1.05	1.26
	C	294	7.69	7.69		
II	E	282	10.21	9.01	1.12	1.26
	C	294	8.36	8.02		
III	E	282	10.53	10.64	1.07	1.26
	C	294	8.35	9.90		
Total	E	828	30.06	56.52	1.09	1.26
	C	294	24.24	51.55		

Test on Understanding Science. The *t* test is a powerful parametric statistic designed for use with interval data from two independent sample groups (69).

Popham (70) says of the function of the *t* test statistic:

> In educational situations one encounters numerous problems wherein it is important to determine whether the mean performances of two groups are significantly different. For example, educators often examine a new method of instruction by trying it with an experimental group of students and employing a conventional method with a comparable control group. If the mean performance of the experimental group on a criterion test is considerably better than that of the control group, one might conclude that the new method of teaching is so effective that it should be employed in other classes of a similar nature.
>
> ...The *t* test is used to determine just how great the difference between two means must be in order for it to be judged significant, that is, a significant departure from differences which might be expected by chance alone.

CHAPTER IV

TREATMENT OF DATA

As indicated in the former chapters, the primary purpose of this study was to compare two approaches to science teaching at the junior high school level. Specifically the study deals with the Earth Science Curriculum Project course and the traditional general science course.

The study was directly concerned with the types of student understanding fostered by the two courses. These understandings included understanding of the scientist, understanding of the scientific enterprise, understanding the methods and aims of science, and understanding science as it relates to the scientist, methods and aims of science, and scientific enterprise.

The following specific hypotheses were tested in this study:

1. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the _Test on Understanding Science_ designed to measure the students understanding of the scientist.

2. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the Test

on Understanding Science designed to measure the students understanding of the methods and aims of science.

3. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the Test on Understanding Science designed to measure the students understanding of the scientific enterprise.

4. There is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science course sample as measured by that portion of the Test on Understanding Science designed to measure the students understanding of science as a field of study as it relates to the scientist, the methods and aims of science, and the scientific enterprise.

These stated hypotheses were tested by the use of one instrument. The basic instrument used was the Test on Understanding Science, Form W. This particular test is made up of sixty items.

The first hypothesis was tested by using the score right on the questions included in the test designed to determine student understanding of the scientist. This group of questions is designated as area I. Area I contains eighteen items.

The second hypothesis was tested by using the score right on the questions included in the test designed to determine student understanding of the methods and aims of science. This group of questions is designated as area II. Area II contains eighteen items.

The third hypothesis was tested by using the score right on the questions included in the test designed to determine student understanding of the scientific enterprise. This group of questions is designed as area III. Area III contains twenty-four items.

The fourth hypothesis was tested by using the score right on the questions included in the test designed to determine student understanding of the comprehensive area of science made up of the scientist, the methods and aims of science, and the scientific enterprise. This is the total group of questions which is sixty.

The raw scores for the general science sample are contained in Appendix B for all areas of the Test on Understanding Science. Appendix A contains all raw scores from the Earth Science Curriculum Project group on the test.

The Scientific Enterprise

The scientific enterprise in this study was intended to cover those aspects of the scientific enterprise included in the Test on Understanding Science. Some questions dealt with scientific societies and their function. The role of government was also part of this area. The test contained questions on the instruments of science. The international character of science was also included. The interaction of science and society is an aspect of concern in the test. Scientific journals and other means of scientific communication are covered.

The eighteen questions which cover this area of student understanding are scattered throughout the testing instrument.

The data obtained from this area was tested for difference in the mean scores of the two groups. A *t* test was employed to test the significance of the difference between these group means. The t test is a strong parametric statistic designed for use with this type data and has a strong rejection level of the null hypothesis when such a rejection is justified. (71) The data necessary for computation of this test was obtained from Appendix A and Appendix B and summarized in Table III.

The value of t for area I was 7.008. The table value of t at the .001 level of significance with over 120 degrees of freedom, was 3.291.

Since the computed value of t was well above the table value necessary for significance at the .001 level of confidence, the null hypothesis for area I was rejected.

The mean scores for the two groups should be noted in order to express the difference. The mean score for the Earth Science Curriculum Project sample was 9.3297, and the mean score for the general science sample was 7.6904.

The Scientist

The scientist is included in the second area of this study. Questions in the Test on Understanding Science concern several areas about the scientist. Generalizations about scientists as people are made. The pressures that are placed on scientists, and the abilities that a scientist must have are covered. The basic questions give an impression of the image one has of a scientist.

There are eighteen questions dealing with student understanding of the scientist included in the test.

The data obtained from this area was also used to test for differences in the mean scores of the two groups. A t test was employed

TABLE III

SIGNIFICANCE OF DIFFERENCES BETWEEN TEST MEANS FOR EACH GROUP ON UNDERSTANDINGS ABOUT THE SCIENTIFIC ENTERPRISE

Group	N	EX	$\overline{X}$	EX^2	$(EX)^2$	t	.001 level t
ESCP	282	2631	9.3297	26846	6922161	7.008	3.291
GS	294	2261	7.6904	19621	5112121		

Symbols: N - Number of cases in sample.

X - Raw Scores.

$\overline{X}$ - Group mean score.

ESCP - Earth Science Curriculum Project.

GS - General Science.

t - Test of Significance (*t* test).

to test the significance of the differences between these group means in area two. The data was obtained from the raw scores in Appendix A and Appendix B for the computation of this test.

In this case the value of t for area II was 7.644. The table value of t at the .001 level of signfiicance with over 120 degrees of freedom, was 3.291.

The null hypothesis for area two was rejected in this case since the computed value of t was well above the table value necessary for significance at the .001 level of confidence. A summary of the data in this area is included in Table IV.

Again, it should be noted that the difference between the mean scores of the group was significant. The mean score for the Earth Science Curriculum Project group was 10.205 and the mean score for the general science group was 8.360. Both area one and area two contained eighteen questions. The mean scores for both groups are much higher for area two than for area one.

Methods and Aims of Science

The third area of this study was concerned with the methods and aims of science. This area contained more questions, twenty-four, than either of the other two areas covered previously. The methods and aims of science cover an important and broad area. The questions deal with the aims of science and the theories and models that are developed. Tactics and strategy of sciencing are also included. The controversies of science are covered in this area. The unity and interdependence of the sciences, and science and technology are found in this area. The methodology of science, of course, is given some attention.

TABLE IV

SIGNIFICANCE OF DIFFERENCES BETWEEN TEST MEANS FOR EACH GROUP ON UNDERSTANDINGS ABOUT SCIENTISTS

Group	N	EX	$\overline{X}$	EX^2	$(EX)^2$	t	.001 level t
ESCP	282	2878	10.205	31937	8282884	7.644	3.291
GS	294	2459	8.360	22906	6046681		

Symbols: N - Number of cases in sample.

X - Raw Scores.

$\overline{X}$ - Group mean score.

ESCP - Earth Science Curriculum Project.

GS - General Science.

t - Test of Significance (_t_ test).

As stated above, the Test on Understanding Science contains twenty-four questions relating to the methods and aims of science.

The data in this area was used to test for differences in the mean scores of the two groups. A t test was employed to test the significance of the differences between the group means. Appendix A and Appendix B were used to obtain the data necessary for computation of the t test.

The value for t in area three was found to be 9.603. At the .001 level of significance with over 120 degrees of freedom, the table value is found to be 3.291.

With this information the null hypothesis for area three must be rejected since the computed value of t was well above the table value necessary for significance at the .001 level of confidence. A summary of the data used in computing t for area three is found in Table V.

Although area three contained twenty-four items, the mean scores for both groups do not vary greatly from area two, the scientist, which contained only eighteen items. The mean score for the Earth Science Curriculum Project sample in area three was 10.53, and the mean score for the general science sample was 8.35.

Science

The total score on the Test on Understanding Science was used to evaluate science as a whole or comprehensive science. Understanding of the scientist, understanding of the methods and aims of science, and understanding of the scientific enterprise are the areas that make up the final area.

The Test on Understanding Science is made up of sixty items that

TABLE V

SIGNIFICANCE OF DIFFERENCES BETWEEN TEST MEANS FOR EACH GROUP ON UNDERSTANDINGS ABOUT THE METHODS AND AIMS OF SCIENCE

Group	N	Ex	$\bar{X}$	EX^2	$(EX)^2$	t	.001 level t
ESCP	282	2969	10.53	34273	8814961	9.603	3.291
GS	294	2455	8.35	22822	6027025		

Symbols: N - Number of cases in sample.

X - Raw Scores.

$\bar{X}$ - Group mean score.

ESCP - Earth Science Curriculum Project.

GS - General Science.

t - Test of Significance (t test).

cover the three previously mentioned areas.

The data from the total scores was used to test for differences in the mean scores of the two groups. A _t_ test was employed to test the significance of the differences between these group means. The data for this _t_ test was obtained from Appendix A and Appendix B.

The value of _t_ for the total score was found to be 9.910. The table value of _t_ at the .001 level of significance with more than 120 degrees of freedom was 3.291 as shown in Table VI.

Since the computed value of _t_ was above the table value necessary for significance at the .001 level of confidence, the null hypothesis for the total score on science.

Analysis of the mean total scores of the groups give some interesting information. The mean score for the Earth Science Curriculum Project sample was 30.06. The mean score for the general science group was 24.2346.

Cooley and Klopfer (72) have developed a tentative set of norms. The norms for the ninth grade were based on a small sample, but they do compare favorably with the norms developed for the tenth, eleventh, and twelfth grades. For a total score of 30 on the _Test on Understanding Science_ the rank is the 52nd percentile. For a total score of 24 on the test the rank is the 17th percentile. An interesting feature of the results shows that, while the mean score for the Earth Science Curriculum Project sample was 30.06, the mean score for the group from which the norms were established was 29.47.

Summary

This study was designed to test four specific hypotheses. Each

TABLE VI

SIGNIFICANCE OF DIFFERENCES BETWEEN TEST MEANS FOR EACH GROUP ON UNDERSTANDINGS ABOUT SCIENCE AS A WHOLE

Group	N	EX	$\overline{X}$	EX^2	$(EX)^2$	t	.001 level t
ESCP	282	8478	30.06	270755	71876484	9.910	3.291
GS	294	7175	24.2346	187905	51480625		

Symbols: N - Number of cases in sample.

X - Raw scores.

$\overline{X}$ - Group mean score.

ESCP - Earth Science Curriculum Project.

GS - General Science.

t - Test of Significance (t test).

of these hypotheses was related to comparative effectiveness of two methods of teaching ninth grade science. The results indicated that the two approaches to science in the ninth grade produced significant changes in student understandings.

Specifically the four areas of the study were: student understanding of the scientific enterprise, student understanding of the scientist, and student understanding of the methods and aims of science, and understanding of the composite of science as it is made up of the previous three areas.

Students from three junior high schools made up the sample group of the Earth Science Curriculum Project. This group was designated as the experimental group. Students making up the control group were drawn from one junior high school. The control group was made up of students taking a course in ninth grade general science.

A _t_ test was used to test the hypothesis of no significant difference between mean scores of the experimental and control groups.

Each of the four hypotheses were rejected at the .001 level of confidence. Evidence indicated that the experimental group was superior in all areas tested.

The Earth Science Curriculum Project group developed higher understandings of the scientific enterprise, higher understandings of the scientist, and higher understandings of the scientific enterprise, than did the general science group. The average mean score of the Earth Science Curriculum Project was found to be 30.06. The mean score of the group from which the norms for the test were developed was 29.49. The general science group mean score ranked at the 17th percentile.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

General Summary and Overview

This study was designed to compare the effectiveness of two different approaches to science at the junior high school level. One approach was designated as the control group, and a second group was designated as the experimental group. The effectiveness of the two approaches was based upon student understanding of the scientist, student understanding of the scientific enterprise, student understanding of the methods and aims of science, and student understanding of science as it pertains to the scientist, the methods and aims of science, and the scientific enterprise. The first three areas were combined to make the fourth or total area.

The control group in the study was made up of students in ninth grade general science classes. The experimental group was made up of students in the Earth Science Curriculum Project ninth grade science class. The two approaches differ, perhaps as much as two types of presentation could differ, in their approach to student learning as well as in the basic content.

The Earth Science Curriculum Project course, experimental group, was based on direct student involvement in the scientific process. The basic idea is that the student must experience science in order to learn science. This approach could be labeled pragmatic in this respect. This idea of the student being directly involved in the scientific process would indicate that he would be working on his own.

The general science course, control group, was basically a lecture type presentation with heavy emphasis placed on the direct recall of facts about science. The student in the general science classes plays a passive role and does not enter into active participation in the scientific process. While the student is allowed to participate in the activities that a scientist follows and use the methods that a scientist employs in the Earth Science Curriculum Project course, he is afforded few of these opportunities in the general science course.

There were 294 students in the general science students in the control group from a large junior high school in a large Oklahoma school system. The Earth Science Curriculum Project students were drawn from three junior high schools also located in the large Oklahoma school system. There were 282 students in the experimental or Earth Science Curriculum Project group. There was no one large system from which both groups could be drawn.

In the study there was no effort made to compare the effectiveness of the five teachers involved in the study. The Earth Science Curriculum Project teachers had been trained in the methods and aims of the Earth Science Curriculum Project. These aims emphasized the experimental approach with direct student involvement. The student involvement theme is carried through the entire course designed by the Earth Science Curriculum Project. The two general science teachers were trained in traditional science in the respect that they had not been involved in any of the new training approaches to teaching science. Both these teachers had degrees in biology, and both teachers had taught general science for several years. Both expressed their philosophy as traditional.

The students in both the general science group and in the Earth Science Curriculum Project group were enrolled in their respective courses for the full academic year. The academic year in this case was from September, 1967, through May, 1968. Each school that was included in this study was visited on one occasion by the investigator prior to the day that the testing was actually performed in order that the students would be more familiar with the investigator. Basic instruction about the Test on Understanding Science was given to each group just prior to the actual testing period. The same instructions were given to each of the groups that were tested.

The Test on Understanding Science is designed to help evaluate student understanding of the three main areas of science with a total score for a comprehensive evaluation score. The first area that the test is designed to measure is the students understanding of the scientist. The scientist as a person and as an ordinary citizen is the view sought. What the scientist does and why he does it is also important.

The second area with which the Test on Understanding Science deals is the methods and aims of science. This important area has to do with how things are done in science. How process of science is carried on.

The third area of this test is designed to deal with the broad aspect of the scientific enterprise. This area deals with the international character of science. Money and instruments are also important to the scientific enterprise. Scientific societies are also included under the area of the scientific enterprise.

Summary of Results and Conclusions

The results of this study indicate that the two different courses involved produced significant differences in student understanding of science in several areas. A significant difference in student understanding of the scientist was found between the mean scores of students in Earth Science Curriculum Project course and the general science course. In the Earth Science Curriculum Project course the student is encouraged to play the role of a scientist at work. Making observations, recording data, making and testing hypotheses, and performing other acts that a scientist would perform in his day to day activity appear to give the student a better understanding of the scientist.

A significant difference was also found between the mean scores of students in the Earth Science Curriculum Project course and students in the general science course in the second area of the investigation. This second area is made up of understanding of the methods and aims of science. The students in the Earth Science Curriculum Project course deal directly with the methods of science as they work with these methods in their investigations. The basic aims of science are more easily understood if one works toward some goal himself.

The third area of the study dealt with student understanding of the scientific enterprise. A significant difference was also found between the mean scores of students in the Earth Science Curriculum Project course and students in the general science course on understandings of the scientific enterprise. The international character of science, money in science, instruments of science, and scientific publications are part of a complex structure that is usually understood by only those directly involved in science. The students in the Earth

Science Curriculum Project course actually had a chance to be involved and to be a real part of science. This involvement should have given these students a better understanding of the scientific enterprise.

The total scores for the three above areas make up a fourth or what could be called a comprehensive understanding of science. A significance difference was also found between the mean scores of students in the Earth Science Curriculum Project course and students in the general science course on understanding of the total or comprehensive aspect of science.

None of the above results were a surprise since anyone who has really worked with the student involvement methods of science teaching feels that the student is more able to develop lasting understandings about science if he experiences them first hand.

Certain specific conclusions seem to be indicated from this study:

1. Hypothesis 1, that there is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science sample as measured by that portion of the <u>Test on Understanding Science</u> designed to measure the students understanding of the scientist, is untenable in the light of the results of the analysis of the data.
2. Hypothesis 2, that there is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science sample as measured by that portion of the <u>Test on Understanding Science</u> designed to measure the students understanding of the methods and aims of science,

is untenable in the light of the results of the analysis of the data.

3. Hypothesis 3, that there is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science sample as measured by that portion of the Test on Understanding Science designed to measure the students understanding of the scientific enterprise, is untenable in the light of the results of the analysis of the data.
4. Hypothesis 4, that there is no significant difference, at the .05 level of confidence, between mean scores of students in the Earth Science Curriculum Project course sample and students in the general science sample as measured by that portion of the Test on Understanding Science designed to measure the students understanding of science as a field of study as it relates to the scientist, the methods and aims of science, and the scientific enterprise, is untenable in the light of the results of the analysis of the data.
5. Students seem to develop a stronger understanding of several areas of science as a result of being involved in science. Doing the work that a scientist does, doing things using the methods of science, doing things with scientific aims, and doing things using aspects of the scientific enterprise gives the student a better understanding of these elements.

Recommendations

As a result of this study, the following recommendations are presented for consideration for future study.

1. The first recommendation concerns the student centered approach to science instruction. Students should have the freedom to do the things that a scientist does in order to understand more about the scientist and the work he does. Each project or new course of study in science should be examined to determine the extent to which understandings about science, the scientist, the methods and aims of science, and the scientific enterprise are developed in each one.

2. Every effort should be made to inform prospective teachers of science that certain intangibles beyond specific facts exist and are an integral part of the science program. Specific science method courses should be developed to train these prospective teachers in the student center approaches to science teaching.

3. Immediate attention should be given to the development of various instruments that may be used in measuring such qualities as interest, attitude, and understandings. Such instruments should be related in such a way that a total picture may be developed.

4. The Earth Science Curriculum Project course of study should be examined in total. Further study should center on other forms of intangible aspects of science. These aspects should include attitudes and interests.

5. All of the new programs in science should be completely evaluated to determine the advantages, if any, over the present traditional science courses.

6. All of the curriculum projects should place heavy emphasis on the teacher training aspect of their program.

7. A follow up should be made on studies dealing with aspects such as understandings of science to determine the lasting effects of any particular program.

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APPENDIX A

TEST ON UNDERSTANDING SCIENCE SCORES FOR EARTH SCIENCE CURRICULUM PROJECT GROUP

TEST ON UNDERSTANDING SCIENCE SCORES FOR EARTH

SCIENCE CURRICULUM PROJECT GROUP

Student	Area I	Area II	Area III	Total
1M	8	9	8	25
2M	14	14	16	44
3M	8	14	10	32
4M	12	11	15	38
5M	9	10	7	26
6M	10	11	12	33
7M	9	12	14	35
8M	9	11	10	30
9M	12	13	12	37
10M	12	13	11	36
11M	6	14	16	36
12M	13	12	13	38
13M	6	3	6	15
14M	7	6	8	21
15M	7	11	14	32
16M	7	7	7	21
17M	8	13	12	33
18M	11	14	14	39
19M	8	11	11	30
20M	9	10	11	30
21M	11	15	9	35
22M	10	11	17	38
23M	12	14	16	42
24M	12	15	14	41
25M	14	9	15	38
26F	13	11	13	37
27F	9	7	10	26
28F	8	13	13	34
29F	5	8	7	20
30F	5	9	5	19
31F	12	10	6	28
32F	9	12	11	32
33F	9	8	9	26
34F	4	9	5	18
35F	8	12	8	28
36F	6	9	9	24
37F	9	10	7	26
38F	14	15	13	42
39F	13	11	10	34
40F	9	11	8	28
41F	13	12	13	38
42F	11	10	11	32
43F	7	7	10	24
44M	12	9	11	32
45F	12	10	11	33
46M	10	11	15	36

Student	Area I	Area II	Area III	Total
47F	8	13	14	35
48M	9	11	9	29
49M	10	11	9	30
50M	15	16	17	48
51M	11	10	14	35
52M	7	9	12	28
53M	14	13	15	42
54M	14	13	17	44
55M	13	10	9	32
56M	15	17	13	45
57M	10	7	12	29
58M	12	10	16	38
59M	12	14	16	42
60M	3	6	7	16
61M	7	8	9	24
62M	10	9	8	27
63M	12	13	16	41
64M	11	11	11	33
65M	10	10	15	35
66M	11	9	13	33
67F	10	8	10	29
68F	11	10	9	30
69F	11	14	12	37
70F	8	6	9	23
71F	9	15	13	37
72F	8	12	11	31
73F	12	15	14	41
74F	7	12	13	32
75F	10	13	10	33
76F	10	17	11	38
77F	9	15	10	34
78F	12	11	9	32
79F	12	12	12	36
80F	10	15	8	33
81F	14	16	16	46
82F	9	12	15	36
83F	15	6	9	30
84F	11	16	13	40
85F	12	9	10	31
86F	8	10	11	29
87F	14	7	17	38
88F	9	12	10	31
89F	9	8	13	30
90F	11	12	11	34
91F	12	10	15	37
92F	11	10	13	34
93F	12	12	6	30
94F	9	9	9	27
95F	11	11	8	30
96F	9	10	9	28

Student	Area I	Area II	Area III	Total
97F	8	5	7	20
98F	7	11	11	29
99F	13	13	14	40
100F	11	10	12	33
101M	12	10	13	35
102M	13	13	11	37
103M	10	13	7	30
104M	10	8	7	25
105M	5	7	10	22
106M	7	6	9	22
107M	8	9	6	23
108M	5	5	7	17
109M	10	8	11	29
110M	8	7	6	21
111M	8	11	7	26
112M	12	10	10	32
113M	7	6	6	19
114M	14	12	16	42
115M	13	11	20	44
116M	13	15	13	41
117M	16	13	15	44
118M	10	12	16	38
119M	13	12	12	37
120M	14	8	15	37
121M	14	14	12	40
122M	11	12	12	35
123M	12	8	8	28
124M	13	12	10	35
125M	13	12	7	32
126F	11	13	14	38
127F	11	11	7	29
128F	8	10	5	23
129F	9	8	8	25
130F	3	7	8	18
131F	10	12	11	33
132F	8	9	16	33
133F	6	8	11	25
134F	7	7	12	26
135F	7	10	8	25
136F	5	8	6	19
137F	8	13	12	33
138F	7	9	12	28
139F	8	10	11	29
140F	13	9	8	30
141F	8	10	17	35
142F	10	11	12	33
143F	13	13	14	40
144F	10	10	8	28
145F	7	16	11	34
146F	12	9	10	31

Student	Area I	Area II	Area III	Total
147F	8	10	13	31
148F	12	12	6	30
149F	5	9	8	22
150F	13	12	6	31
151M	13	15	19	47
152M	11	11	13	35
153M	8	7	11	26
154M	9	10	9	28
155M	13	11	10	34
156M	8	10	8	26
157M	9	12	14	35
158M	11	15	14	40
159M	13	13	13	39
160M	9	10	13	32
161M	11	13	7	31
162M	11	16	10	37
163M	10	8	13	31
164M	8	9	11	28
165M	11	9	11	31
166M	6	10	10	26
167M	11	12	16	39
168M	10	11	13	34
169M	3	7	5	15
170M	9	11	11	31
171M	5	9	3	17
172M	9	11	10	30
173M	6	9	5	20
174M	8	4	8	20
175M	9	13	12	34
176M	4	8	8	20
177M	4	8	6	18
178M	9	12	10	31
179M	10	10	7	27
180M	9	14	10	33
181M	6	11	9	26
182M	8	9	4	22
183M	8	6	10	24
184M	8	9	17	34
185M	6	7	5	18
186M	6	2	6	14
187M	8	9	9	26
188M	8	5	6	19
189M	8	9	6	23
190M	13	8	8	29
191M	7	7	12	26
192M	11	14	12	37
193M	11	12	13	36
194M	6	6	3	15
195M	2	3	8	13
196M	8	12	10	30

Student	Area I	Area II	Area III	Total
197M	9	9	12	30
198M	6	12	8	26
199M	8	11	13	32
200M	10	11	9	30
201M	8	13	13	34
202M	4	7	6	17
203M	7	4	9	20
204M	11	11	9	31
205M	13	14	14	41
206M	10	12	12	34
207M	10	10	13	33
208M	3	7	7	17
209M	5	4	7	16
210M	14	16	14	44
211M	15	15	16	46
212M	11	15	7	33
213M	13	14	16	43
214M	12	16	19	47
215M	9	10	12	31
216M	9	8	8	25
217M	13	10	10	33
218M	5	7	9	21
219M	12	12	16	40
220M	5	9	10	24
221M	10	13	11	34
222M	8	6	14	28
223M	11	9	11	31
224M	7	7	7	21
225M	5	3	10	18
226M	6	7	10	23
227M	7	7	7	21
228M	7	10	12	29
229M	7	7	8	22
230M	12	9	14	35
231M	10	12	13	35
232M	7	6	12	25
233M	7	5	8	20
234M	7	5	8	20
235M	10	12	13	35
236M	9	12	13	34
237M	7	7	8	22
238M	9	13	8	30
239M	7	4	8	19
240M	10	9	8	27
241M	7	7	9	23
242M	8	10	11	29
243M	7	7	14	28
244M	6	5	8	19
245M	14	12	17	43
246M	8	12	12	32

Student	Area I	Area II	Area III	Total
247M	9	10	10	29
248M	6	2	8	16
249M	4	6	3	13
250M	10	8	10	28
251F	5	10	8	23
252F	10	12	9	31
253F	8	8	7	23
254F	4	4	10	18
255F	7	10	6	23
256F	9	7	8	24
257F	7	8	10	25
258F	4	8	7	19
259F	11	14	15	40
260F	7	8	6	21
261F	6	6	7	19
262F	6	11	12	29
263F	12	10	9	31
264F	11	7	12	30
265F	5	10	6	21
266F	11	11	7	29
267F	11	8	13	32
268F	5	8	4	17
269F	12	12	6	30
270F	9	10	12	31
271F	9	11	8	28
272F	11	15	8	34
273F	12	11	9	32
274F	12	12	12	36
275F	8	15	10	33
276F	16	14	14	44
277M	4	10	9	23
278M	7	10	11	28
279M	15	13	13	41
280M	11	12	10	33
281M	5	11	8	24
282M	5	5	6	16

(M) Male

(F) Female

APPENDIX B

<u>TEST ON UNDERSTANDING SCIENCE</u> SCORES

FOR GENERAL SCIENCE GROUP

TEST ON UNDERSTANDING SCIENCE SCORES

FOR GENERAL SCIENCE GROUP

Student	Area I	Area II	Area III	Total
1F	4	8	9	21
2M	8	10	7	25
3M	6	6	6	18
4F	8	8	6	22
5F	4	9	7	20
6M	7	7	3	17
7M	7	7	11	25
8M	6	10	9	25
9M	7	6	4	17
10F	10	8	7	25
11M	6	6	6	18
12F	7	10	9	26
13M	9	10	5	24
14M	7	7	6	20
15F	5	10	7	22
16F	7	7	12	26
17M	6	7	3	16
18F	8	9	7	24
19M	7	10	5	22
20F	12	11	9	32
21F	10	9	7	26
22F	11	6	10	27
23F	9	12	8	29
24F	12	8	8	28
25F	5	10	8	23
26F	8	8	8	24
27F	10	8	14	32
28M	9	7	9	25
29M	10	11	7	28
30M	9	7	8	24
31M	10	6	9	25
32M	10	9	8	27
33M	13	15	10	38
34F	8	9	9	26
35M	13	14	12	39
36F	9	9	8	26
37M	10	10	8	28
38M	10	11	12	33
39M	12	13	17	42
40M	8	10	9	27
41F	10	12	14	36
42F	10	7	5	22
43M	12	11	9	32
44F	11	8	12	31
45M	4	5	5	14
46M	7	6	12	25

Student	Area I	Area II	Area III	Total
47F	10	9	5	24
48F	8	7	10	25
49M	8	6	14	28
50M	8	10	9	27
51M	3	5	9	17
52F	11	5	6	22
53F	11	4	9	24
54M	5	6	9	20
55F	10	6	9	25
56F	6	3	8	17
57F	8	9	10	27
58F	8	7	7	22
59M	2	6	6	14
60F	9	5	6	20
61F	6	6	9	21
62M	8	10	6	24
63M	6	0	9	15
64M	9	6	10	25
65F	7	10	9	26
66F	9	3	7	19
67M	8	9	8	25
68M	3	7	6	16
69F	8	11	5	24
70F	6	6	7	19
71F	6	8	10	24
72M	6	5	7	18
73M	7	14	4	25
74M	7	7	6	20
75M	6	8	7	21
76F	11	7	8	26
77F	5	8	8	21
78M	5	5	6	16
79F	7	10	5	22
80M	10	16	9	35
81M	12	11	12	35
82F	8	10	8	26
83F	9	7	10	26
84M	3	6	9	18
85F	8	9	10	27
86M	7	8	7	22
87M	9	7	10	26
88M	12	8	10	30
89M	4	9	7	20
90F	12	14	13	39
91M	12	12	12	36
92F	4	7	6	17
93M	7	12	6	25
94F	5	10	9	24
95F	10	9	7	26
96M	2	6	7	15

Student	Area I	Area II	Area III	Total
97F	3	8	4	15
98F	5	8	2	15
99M	8	10	7	25
100F	6	9	6	21
101M	6	8	8	22
102M	6	7	7	20
103F	6	6	8	20
104F	9	6	9	24
105F	4	1	4	9
106M	2	5	8	15
107F	3	8	11	22
108F	4	8	7	19
109F	4	6	6	16
110M	1	9	8	18
111M	3	8	12	23
112F	7	2	10	19
113M	7	6	9	22
114M	10	9	10	29
115M	4	6	8	18
116F	11	11	8	30
117M	5	3	7	15
118F	6	7	7	20
119M	11	12	8	31
120F	10	14	6	30
121M	8	11	10	29
122M	7	8	9	24
123M	7	5	6	18
124M	5	7	12	24
125F	2	5	7	14
126M	3	6	4	13
127F	9	5	5	19
128M	7	10	6	23
129M	7	8	10	25
130M	9	4	4	17
131M	9	11	12	32
132F	7	10	6	23
133F	10	7	8	25
134F	9	10	8	27
135M	9	10	14	33
136M	8	7	8	23
137F	5	9	5	19
138M	7	8	7	22
139M	6	6	7	19
140M	9	9	12	30
141M	5	7	9	21
142F	12	10	9	31
143F	11	11	6	28
144M	3	5	5	13
145M	7	10	9	26
146M	5	5	7	17

Student	Area I	Area II	Area III	Total
147M	8	11	10	29
148F	10	16	8	34
149M	9	9	7	25
150M	13	11	13	37
151M	9	11	9	29
152M	6	8	7	21
153M	9	10	9	28
154F	9	8	4	21
155M	10	12	10	32
156F	10	8	6	24
157F	8	4	6	18
158M	6	9	5	20
159M	12	12	6	30
160M	8	4	9	21
161F	9	12	9	30
162M	13	8	12	33
163M	6	8	9	23
164F	10	8	9	27
165M	9	11	8	28
166M	7	13	9	29
167M	7	8	4	19
168F	9	12	14	35
169F	10	10	10	30
170M	9	5	9	23
171M	5	12	12	29
172F	12	11	12	35
173M	5	8	8	21
174M	9	11	11	31
175M	9	13	11	33
176F	14	10	14	38
177M	6	6	6	18
178M	5	9	11	25
179M	6	7	8	21
180F	12	11	10	33
181F	7	4	5	16
182F	4	4	5	13
183F	6	3	3	12
184M	6	3	7	16
185F	7	10	9	26
186M	6	9	7	22
187M	4	4	2	10
188F	12	10	15	37
189F	7	7	11	25
190M	9	10	12	31
191F	4	5	7	16
192F	8	9	9	26
193M	7	7	5	19
194M	7	8	10	25
195F	6	5	6	17
196M	6	5	5	16

Student	Area I	Area II	Area III	Total
197F	8	9	13	30
198M	8	9	7	24
199F	6	8	5	19
200M	6	8	8	22
201F	5	13	11	29
202F	9	7	7	23
203F	7	8	6	21
204M	8	9	10	27
205F	7	4	9	20
206M	11	8	7	26
207F	9	9	9	27
208F	7	12	11	30
209F	7	5	2	14
210F	4	6	9	19
211M	4	6	7	17
212M	12	10	11	33
213F	7	10	6	23
214M	7	10	4	21
215F	4	4	5	13
216M	5	8	7	20
217F	6	10	10	26
218F	10	10	8	28
219M	11	9	10	30
220M	9	11	8	28
221F	10	8	7	25
222F	8	12	15	35
223M	13	15	11	39
224M	11	12	11	34
225F	9	10	5	24
226F	5	11	4	20
227F	7	7	5	19
228M	9	10	11	30
229M	7	4	4	15
230M	8	9	8	25
231M	15	11	11	37
232M	10	10	10	30
233F	8	11	17	36
234M	11	13	15	39
235M	9	6	10	25
236M	9	9	7	25
237F	12	9	11	32
238M	10	12	17	39
239F	11	9	9	29
240M	15	9	9	33
241F	9	7	6	22
242M	14	11	13	38
243M	10	11	18	39
244M	11	10	8	29
245M	9	9	8	26
246F	11	8	17	36

Student	Area I	Area II	Area III	Total
247M	9	10	9	28
248F	1	7	3	11
249F	12	7	13	32
250F	7	6	9	22
251F	8	12	7	27
252M	9	11	14	34
253M	8	7	9	24
254F	5	13	9	27
255M	11	11	12	34
256M	3	10	11	24
257M	6	4	4	14
258F	7	8	8	23
259F	5	6	7	18
260F	8	15	10	33
261M	6	9	9	24
262M	8	5	5	18
263M	2	5	4	11
264M	1	1	1	3
265F	9	10	8	27
266F	5	7	6	18
267M	7	16	10	33
268F	8	10	11	29
269F	12	13	9	34
270M	8	4	11	23
271M	4	5	9	18
272F	7	9	10	26
273F	0	1	8	9
274F	7	12	9	28
275F	5	5	7	17
276M	13	12	12	37
277M	9	8	6	23
278M	3	8	8	19
279M	10	12	8	30
280M	4	8	6	18
281M	3	9	9	21
282F	8	6	7	21
283F	10	4	10	24
284F	10	7	10	27
285M	5	9	7	21
286M	7	7	7	21
287M	4	7	5	16
288F	9	10	10	29
289M	6	9	7	22
290M	4	3	8	15
291M	9	12	8	29
292M	11	12	9	32
293M	8	6	10	24
294F	8	10	10	28

VITA

Kenneth Edgar Sheppard Jr.

Candidate for the Degree of

Doctor of Education

Thesis: A STUDY OF THE DEVELOPMENT ON AN UNDERSTANDING OF SCIENCE IN TWO JUNIOR HIGH SCHOOL SCIENCE COURSES

Major Field: Higher Education

Biographical:

Personal Data: Born in English, Texas, February 11, 1935, the son of Kenneth and Ella Sheppard.

Education: Received the Bachelor of Science degree from East Texas State University, with a major in biology and minors in earth science and education, in 1962; received the Master of Science degree from East Texas State University, with a major in biology and minors in education and earth science, in 1962; awarded Academic Year Institute grant, Ohio State University, in 1965; completed requirements for the Doctor of Education degree at Oklahoma State University in August, 1969.

Professional Experience: Appointed graduate teaching assistant, East Texas State University, in 1962, instructor in Department of Earth Science, East Texas State University, 1962-1965; 1966-1967; 1968-present; graduate assistant, Oklahoma State University, 1968; visiting professor, Sul Ross State College, summer, 1968.

Professional and Honorary Organizations: National Science Teachers Association; Phi Delta Kappa; Beta Beta Beta; East Texas State Archaeological Society.