THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE INFLUENCE OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY ON AFFECTIVE PROCESS DEVELOPMENT AND CREATIVE THINKING

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

TALBERT W. BROWN

Norman, Oklahoma

1973

THE INFLUENCE OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY ON AFFECTIVE PROCESS DEVELOPMENT AND CREATIVE THINKING

APPROVED BY

_____

_____

_____

_____

_____

DISSERTATION COMMITTEE

ACKNOWLEDGMENTS

The writer expresses his sincere appreciation and gratitude to Dr. John W. Renner for the constant guidance and support he provided as Chairman of the Doctoral Committee and as the director of this investigation. The association with Dr. Renner has resulted in the writer's educational philosophy to be shaped and interest in science education to be developed.

Appreciation is extended to Dr. Mary C. Petty, Dr. Bernard O. Heston, Dr. Arthur J. Myers, and Dr. Donald G. Stafford for the valuable assistance which they have provided in the giving of their time and advice during the entire period of graduate study.

The writer also wishes to thank Dr. M. C. Weber and Dr. William J. Coffia for their valuable contributions. Their suggestions, constructive criticisms, and support were sincerely appreciated.

The assistance and cooperation received while the data were collected from the Putnam City Schools and Norman Schools are gratefully acknowledged. Special thanks are extended to Mr. Leonard Bates, Mr. Charles Cooly, Mr. Jerry Maynard, and Mrs. Jack Herron. Appreciation is extended to

the teachers and students in those two school systems.

Special appreciation and acknowledgment goes to Mr. George Atkins, Director of Computer Science at Southwestern State College for assistance in the use of the IBM 1130 computer. Thanks go to Mr. Sucnai Vadhanasiripong for developing the computer programs used in scoring the test instruments.

Special thanks go to Mrs. Sue Settles in the preparation and typing of the manuscript.

Above all, the writer is grateful to his family, his wife Carol and two sons, Scott and Russell, who provided constant support, understanding, encouragement, and patience, not only during the writing and completion of this research study but throughout the entire period of graduate study. Carol not only provided moral support, but assisted greatly in providing valuable advice and comments in developing the study. The time of graduate study and research would not have been possible if not for the writer's family's love and faith. This research is dedicated to them.

TABLE OF CONTENTS

LIST OF TABLES

THE INFLUENCE OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY ON AFFECTIVE PROCESS DEVELOPMENT AND CREATIVE THINKING

CHAPTER I

INTRODUCTION

Statement of the Problem

The stated long range goal for science education has been the development of scientific literacy in children, which has been said to result from a basic knowledge of scientific concepts, investigative experiences, and curiosity.[1] A positive attitude towards science and the development of a positive and lasting impression of the nature of the scientific enterprise is stated as a concomitant outcome of the science curriculum. To accomplish this objective, inquiry science curricula, such as the Science Curriculum Improvement Study (SCIS), were developed.

The principal problem of this study was to determine if there was a significant difference in the affective process

---

[1]Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science, (Chicago: Rand McNally and Company, 1967), p. 24.

development of learners who have studied the Science Curriculum Improvement Study for six years as compared to learners who have not had the same experience. For the purpose of this investigation, the affective processes were defined as scientific curiosity, creative thinking, and scientific attitudes. A sub-problem of the investigation involved whether or not correlations exist among the three variables of scientific curiosity, creative thinking, and scientific attitudes.

Definitions

Affective Process Development--For the purpose of this study affective process development was defined as the acquisition of those behaviors which lead to the development of curiosity, and the attitudes of willingness to suspend judgment, critical mindedness, open-mindedness, objectivity, rationality, cause and effect relationships, skepticism, and the desire to be creative. These affective behaviors are developed along a continuum that ranges from awareness through a complete conceptualization and internalization of the attitude.

Curiosity--A person is said to be curious to the extent that he exhibits the following qualities:[2]

---

[2]Rayman P. Richardson, "Development and Use of the SCI Inventory to Measure Upper Elementary School Children's Scientific Curiosity and Interest," (unpublished doctoral dissertation, the Ohio State University, 1971), p. 186.

(a) Scans his surroundings looking for new experiences.
(b) Moves toward new mysterious or incongruous elements in the environment either physically or psychologically.
(c) Examines, explores, and/or manipulates new, mysterious, incongruous elements in his environment either physically or psychologically.
(d) Persists in such examinations, explorations, and/or manipulations.

Scientific Curiosity--A person possesses scientific curiosity to the extent that he exhibits curiosity about the area of science. Scientific curiosity is considered to have the components of:[3]

(a) Empirical curiosity--an observational interest in elements in the environment.
(b) Rational curiosity--the examination, either physically or psychologically, of a new element in the environment.
(c) Authoritative curiosity--the examination, exploration, manipulation, and the persistence in these activities.
(d) General curiosity--refers to an over-all approach to new and incongruous elements in the environment.
(e) Interest--refers to what a person would like to do if placed either physically or psychologically in a given situation.

Attitude--Allport defines attitudes as a "mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's responses to all objects and situations with which it is related."[4] Krathewohl, et. al., define attitudes as existing along a continuum that describes the involvement of a student

---

[3] Ibid.

[4] Gordon W. Allport, "Attitudes," in Readings in Attitude Theory and Measurement, edited by Martin Fishbein, (New York: John Wiley and Sons, Inc., 1967), p. 8.

in such a way that he has a positive or negative feeling about something when he is asked.[5]

Scientific Attitude--A scientific attitude is defined as an opinion or position taken with respect to scientific objects, situations, and/or statements about science and/or scientists.

Creative Thinking--Torrance defines creativity as:

> A process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, etc., identifying the difficulty; searching for solutions, making guesses or formulating hypotheses about the deficiencies; listing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results.[6]

Fluency, flexibility, originality, and elaboration are defined as the factors in creative thinking. The definitions which follow are provided by Torrance.[7]

(a) Fluency refers to the "ability to produce a variety of ideas or hypotheses concerning possible solutions to problems."
(b) Flexibility is the "ability to adapt to changing instructions, to be free from the inertia of thought, to use a variety of approaches."
(c) Originality is the "ability to produce uncommon responses; remote, unusual, or unconventional association, cleverness."

---

[5]David R. Krathewohl, Benjamin S. Bloom, and Bertram B. Masia, Taxonomy of Educational Objectives: Affective Domain (New York: David McKay Company, Inc., 1964), p. 25.

[6]E. Paul Torrance, Torrance Tests of Creative Thinking, Norm-Technical Manual (Princeton, N.J.: Personnel Press, Inc., 1966), p. 6.

[7]E. Paul Torrance, Education and the Creative Potential (Minneapolis, Minn.: University of Minnesota Press, 1963), pp. 94-98.

(d) Elaboration would characterize persons who are inventive and take constructive action. This reflects the person's "ability to develop, carry out, or otherwise elaborate ideas." Elaboration is associated with keenness or sensitivity in observation.

Torrance[8] identifies two areas of creative thinking, figural and verbal, each being composed of the four factors defined above. Figural creative thinking describes thinking with figures, drawings, and non-verbal type tasks and verbal creative thinking describes tasks that require writing or telling about a given task or event.

Premises of the Study

The premises tested by this investigation were:

1. An inquiry science program has a positive influence on a child's development of scientific curiosity.

2. An inquiry science program has a positive influence on a child's development of a scientific attitude.

3. An inquiry science program has a positive influence on a child's development of creative thinking.

Background of the Study

Science education was significantly changed in the late 1950's and during the decade that followed. Public attention was focused on science due to the launching of Sputnik in 1957 and the federal government appropriated funds for the improvement of the science curriculum. The National

---

[8] Ibid.

Science Foundation was given the responsibility of administering those funds and in the process established a philosophical base for science curriculum projects. An outgrowth of this ferment of activity was a significant alternation of pedogogical theory, philosophy, and technique.

These changes are reflected in the yearbook of the National Society for the Study of Education (NSSE). That publication states the objectives for science education as including such learning outcomes as (1) functional information, concepts, and principles; (2) instrumentation and problem-solving skills; (3) attitudes; (4) appreciation; and (5) interests.[9] The committee introduced such terms as critical thinking, scientific process, and inquiry and a greater emphasis is placed upon those aspects of science which deal with these terms. The committee further states,

> The knowledge and methods of science are of little importance if there is no disposition to use them appropriately. Open-mindedness, a desire for accurate knowledge, confidence in the procedures for seeking knowledge and the expectation that the solution of problems will come through the use of verified knowledge, these are among the "scientific attitudes." To understand the scientist is also to understand some of his attitudes, such as the desire to know and to discover, a curiosity about the world, the excitement of discovery and the desire to be creative.[10]

---

[9] Paul D. Hurd, Vernon Anderson, J. W. Buchta, John H. Fisher, Eric M. Rogers, Guy Suits, and Ralph W. Tyler, "Science Education for Changing Times," in Rethinking Science Education, 59th Yearbook of the National Society for the Study of Education, Part I, (Chicago: University of Chicago Press, 1960), pp. 33-37.

[10] Ibid., p. 26.

The Educational Policies Commission stated in The Central Purpose of American Education that the paramount objective of the schools should be to develop the ability to think. The commission described this cognitive ability as the development of the ten rational powers which were defined as recalling and imaging, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring.[11]

In another document this same group states the values gained from science are of equal importance. The Educational Policies Commission describes their position as follows:[12]

> The school should help to realize the great opportunities which the development of science has made apparent in the world. They can do this by promoting understanding of the values on which science is everywhere based. Although no particular scientist may fully exemplify all these values, they characterize the enterprise of science as a whole. We believe that the following values underlie 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.

The Educational Policies Commission further states:

---

[11]Educational Policies Commission, The Central Purpose of American Education, (Washington, D.C.: National Education Association, 1961), p. 5.

[12]Educational Policies Commission, Education and the Spirit of Science (Washington, D.C.: National Education Association, 1966), p. 15.

> To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the principal goals of education in our own and every other country.[13]

The re-directed pedogogy brought about through curriculum improvement projects and statements by groups such as the NSSE altered the posture of science education. Some science educators were no longer content to view science as a fact oriented static discipline, but rather as a dynamic, process-oriented area of study. The objectives of science education shifted towards the student's development of cognitive abilities such as the ten rational powers and to have students approach science in the way in which a scientist approaches his work. Curriculum developments which incorporated this philosophy were referred to with a special descriptive term, inquiry. Inquiry denotes the philosophical difference between science curricula which emphasize cognitive development and the values of science, as compared to the more conventional textbook-oriented approaches in science. Elementary science curriculum projects were then developed that are based upon the inquiry philosophy.

The American Association for the Advancement of Science (AAAS) developed the program Science--A Process Approach which is totally process oriented. The AAAS group identified thirteen processes which were considered to be

---

[13] Ibid., p. 27.

representative of scientific activity. These processes arranged in a hierarchy were used as the basis for the development of a K-6 elementary science program. The inquiry philosophy of Science--A Process Approach is seen in the statement:[14]

> The procedures of scientific inquiry, learned not as a canon of rules but as ways of finding answers, can be applied without limit. The well-taught child will approach human behavior and social structure and the claims of authority with the same spirit of alert skepticism that he adopts toward scientific theories. It is here that the future citizen who will not become a scientist will learn that science is not memory or magic but rather a disciplined form of human curiosity.

The AAAS program is also concerned with the fostering of the scientific attitude in elementary school children. The description of the attitude of science is:

> The willingness to wait for a conclusive answer--the skepticism that requires intellectual restraint and the maintenance of doubt--is often times difficult for adult and child alike. The discipline of scientific inquiry demands respect for the work of the past together with a willingness to question the claims of authority. The attitude of intelligent caution, the restraint of commitment, the belief that difficult problems are always susceptible to scientific analysis, and the courage to maintain doubt will be learned best by the child who is given an honest opportunity to try his hand at scientific inquiry. With his successes will come an optimistic appreciation of the strength of inquiry; with his failures will come an understanding of the variety and challenge of our ignorance. For the scientists, child and adult, novelty is permanent; scientific inquiry continually builds novelty into a coherent design,

---

[14] American Association for the Advancement of Science, Science--A Process Approach, Commentary for Teachers (Washington, D.C.: American Association for the Advancement of Science, 1965), p. 1.

> full of promise, always tentative, that tames our terror and satisfies for a while the human desire for simplicity.[15]

The Elementary Science Study (ESS), developed in 61 separate and distinct units, is also concerned with the inquiry process but is a somewhat different approach. The program is developed in such a way that there is no grade by grade curricular design. Some of the 61 separate units may be used at various grade levels. For example, one particular unit may be recommended for grades K-3, while another for K-8. The units are unstructured and may be used with a wide variety of applications. The ESS is an overt attempt to develop a program based upon "open inquiry." The ESS has made an effort to "incorporate both the spirit and the substance of science" into a program to increase every child's understanding rather than to develop or prepare scientific personnel.[16]

The Science Curriculum Improvement Study (SCIS) has been developed with the concept of interaction as a central theme and four major concepts are utilized to expand this viewpoint--matter, energy, organism, and ecosystem. In addition, the "process-oriented" concepts of property, reference frame, system, and model together with observing, describing,

---

[15] Ibid., p. 2.

[16] Educational Services Incorporated, Introduction to the Elementary Science Study (St. Louis: Webster Division, McGraw-Hill Book Company, 1966), pp. 1-2.

comparing, classifying, measuring, interpreting evidence, and experimenting form the heart of the specific units. The SCIS states "children advance their thinking processes from the concrete to the abstract and develop a disciplined curiosity as they accumulate experiences and ideas."[17]

The SCIS program provides for three stages in the child's learning cycle which are termed exploration, invention, and discovery. The exploration phase is based upon children learning through spontaneous behavior. Minimal guidance is given in the form of instruction or questions. This type of learning is limited by the child's preconceptions, therefore, a new concept is invented. This provides the child the opportunity to use the new ideas and discussion by teacher and child provide a wide range of experiences in testing the validity of the concept. The third phase, discovery, is designed to reinforce the original concept and enlarge and refine its meaning. Teachers are encouraged to ask questions of both the convergent and divergent type as the inquiry and discussion proceed.[18]

By design, the SCIS program combines the factors of content, process, and attitude as children investigate diverse physical and biological materials. The SCIS program states "the program helps children form positive attitudes

---

[17]Science Curriculum Improvement Study, Sample Guide (Chicago: Rand McNally and Company, 1970), pp. 6-7.

[18]Ibid., pp. 16-18.

towards science as they explore phenomena according to their own preconceptions. They learn to cope confidently with new and unexpected findings by sifting evidence and forming conclusions."[19] This study was designed to evaluate the premise stated in that quotation.

The success as to the accomplishment of cognitive objectives is reflected in the research that has been carried out to measure that attainment. Stafford and Renner[20] studied the effect of the SCIS on the entry of preoperational children into the stage of concrete operations. The study found that children who had the SCIS Material Objects unit used conservation reasoning more readily than children who had not had such an experience. Weber and Renner[21] studied the influence of the SCIS upon the child's utilization of the processes of observing, measuring, classifying, experimenting, interpreting data, and predicting. A test instrument was constructed to measure the attainment of these processes. Significant differences were found in comparing the scores of children who had taken four and one-half years of the SCIS program as compared to children in a traditional

---

[19] Ibid., p. 6.

[20] Don G. Stafford and John W. Renner, "SCIS Helps the First Grader to Use Logic in Problem Solving," School Science and Mathematics, February, 1971, pp. 159-164.

[21] Marvin C. Weber and John W. Renner, "How Effective is the SCIS Program?" School Science and Mathematics, November, 1972, pp. 229-234.

course. With respect to achievement, Coffia[22] compared fifth grade children in the SCIS program with children in a traditional course. The Stanford Achievement Test was used to compare scores of the subjects in social studies, mathematics, and language arts. Significant differences were found in favor of the SCIS group with respect to mathematical applications, social studies skills, and paragraph meaning. Porterfield[23] studied the effect of the SCIS curriculum upon the questioning strategy of elementary teachers in the teaching of reading. It was found that teachers who had had experience with the SCIS philosophy asked fewer questions based upon recognition and recall abilities and more questions of the translational, analytical, and snythesis type.

The data from the aforementioned researches indicated that the SCIS program does positively affect the cognitive development of the learner. This would lead to the conclusion that the program is accomplishing cognitive objectives. The statement has been made that, "the development of the ability to think represents the unifying purpose (the common thread) which ties all learning experiences provided our

---

[22]Dr. Coffia's research has been reported in Research Studies of SCIS Success in the Classroom, contributors include John W. Renner, Donald G. Stafford, M. C. Weber, W. J. Coffia, and Donald H. Kellogg, published by Rand McNally and Company, 1972, pp. 9-12.

[23]Ibid., pp. 16-18.

educational establishment together."[24] This investigator believes that the affective and cognitive domain are integral factors in a learner's mind and if there is a favorable cognitive position then a positive affective position will ensue.

Support for this position is found in the developmental theory of Jean Piaget. Basically, the Piagetian model consists of the factors of assimilation, accommodation, and equilibration. Piaget focuses his research on the logical, critical use of intelligence and proposes that "development is the essential process and each element of learning occurs as a function of total development rather than being an element which explains development."[25] Development becomes the essential factor in explaining what a person can learn, rather than the learning explaining and accounting for the development.

The individual is placed in a state of disequilibrium from experience in the environment. He must, according to Piagetian theory, assimilate and accommodate the experiences into his cognitive structure and equilibrate. In other words, he must return to a state of balance psychologically

---

[24] John W. Renner, Don G. Stafford, and William B. Ragan, Teaching Science in the Elementary School (New York: Harper and Row Publishers, 1973), p. 50.

[25] Jean Piaget, "Development and Learning," Journal of Research in Science Teaching, Vol. 2, Issue 3, (New York: John Wiley and Sons, 1964), pp. 176-186.

through this internal organization which leads directly to the development of adult intelligence.[26]

In the Piagetian model, knowledge is the structural aspect of psychological life and affectivity is the dynamic aspect. Piaget views intelligence from an evolutionary standpoint and development "proceeds in a manner of an organizing totality, not in the sense of an outside influence or purpose that pulls from ahead."[27] In other words, the influences upon motivation, interest, and values are an intrinsic, "self regulating factor of equilibration"[28] that leads to individual development.

The affective domain deals with behaviors that are usually classified as a "feeling tone, an emotion, or a degree of acceptance or rejection."[29] This domain would include such behaviors as interests, attitudes, values, appreciation, and emotional sets or biases.

An effort has been made by various groups and individuals to isolate the components of the scientific attitude. From these efforts the suggestion has been made that

---

[26]John W. Renner and Don G. Stafford, Teaching Science in the Secondary School (New York: Harper and Row Publishers, 1972), pp. 64-77.

[27]Hans G. Furth, Piaget and Knowledge (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1969), p. 206.

[28]Ibid., p. 206.

[29]Krathewohl, et al., op. cit., p. 7.

there are factors that describe a positive position in relation to the scientific enterprise.

Vitrogan[30] surveyed the writings of many of the philosophers of science, and from the writings of these individuals stated that a positive generalized attitude towards science seems to be characterized by:

(1) differences rather than similarities will be stressed; a tendency to emphasize differences; a predisposition to discern the degree to which one person or thing differs from another.

(2) controlled observation will be given more importance than authoritative suggestion; a tendency to challenge authority, to test traditional beliefs and customs with actual observation and experience.

(3) multiple and flexible solutions to problems will be preferred to single rigid solutions; a readiness to change as conditions require.

(4) controlled observation will be distinguished from casual observation.

(5) constant change will be stressed over non-change; a basic notion that reality is to be regarded as a process implying continuous change; no two things are exactly alike, no one thing stays the same.

(6) structure in the form of relations and equations will be stressed over function; structure, the nature of the phenomenon, the broad unifying principle is stressed rather than the application (detail) or function.

(7) the form of the question will be considered more important than the answer.

---

[30]David Vitrogan, "A Method for Determining a Generalized Attitude of High School Students Toward Science," Science Education, Vol. 51, No. 2, March, 1967, p. 170.

(8) probability will be stressed over absolute orientation; an emphasis on probability type explanations rather than absolute solutions.

Diederich[31] lists components of the scientific attitude which he argues can be taught. Those components are:

(1) Skepticism. Not taking things for granted. Asking the prior question.
(2) Faith in the possibility of solving problems.
(3) Desire for experimental verification.
(4) Precision.
(5) A liking of new things.
(6) Willingness to change opinions.
(7) Humility.
(8) Loyalty to truth.
(9) An objective attitude.
(10) Aversion to superstition.
(11) Liking for scientific explanations.
(12) Desire for completeness of knowledge.
(13) Suspended judgment.
(14) Distinguishing between hypotheses and solutions.
(15) Awareness of assumptions.
(16) Judgment of what is of fundamental and general significance.
(17) Respect for theoretical structures.
(18) Respect for quantification.
(19) Acceptance of probabilities.
(20) Acceptance of warranted generalization.

Haney[32] in an article aimed at the redirection of science teaching towards the scientific attitude discusses attitudes which directly govern intellectual behavior of scientists and science students. He delineates curiosity, rationality, suspended judgment, open-mindedness, critical mindedness, objectivity, honesty, and humility as being attitudes of science.

---

[31]Paul B. Diederich, "Components of the Scientific Attitude," The Science Teacher, February, 1967, pp. 23-24.

[32]Richard E. Haney, "The Development of Scientific Attitudes," The Science Teacher, Vol. 31, No. 8, December, 1964, pp. 33-35.

The listing of scientific behaviors have many common items. From these listings it is possible to gather items which can be considered as components of a scientific attitude. For the purpose of this study, the behaviors of (1) curiosity, (2) open-mindedness, (3) willingness to suspend judgment, (4) liking of new things, (5) objectivity, (6) skepticism, (7) critical mindedness, (8) tentative nature of scientific explanations, (9) rationality, and (10) an appreciation of the limitations of science will be considered as components of the scientific attitude.

Creativity is not usually considered as part of the affective domain. When considering attitudes like those which have just been listed, however, creative thinking would involve many such aspects.

Torrance refers to creative abilities and tendencies as a "constellation of general abilities, personality variables, and problem-solving traits,"[33] rather than as a particularized and substantive capacity. Generally, creative thinking is one kind of problem solving and is present when one or more of the following conditions are satisfied:[34]

(1) The product of thinking has novelty and value (either for the thinker or for his culture).

(2) The thinking is unconventional, in a sense, that it requires modification or rejection of previously accepted ideas.

---

[33]Torrance, Torrance Tests, op. cit., p. 7.

[34]Ibid., pp. 8-9.

(3) The thinking requires high motivation and persistence, taking place over a considerable span of time (continuously or intermittenly) or at high intensity.

(4) The problem, as initially posed, was vague and undefined so that part of the task was to formulate the problem itself.

The structure-of-intellect theory proposed by J. P. Guilford affords a basis for creative development.[35] The Guilford model consists of three parameters, content, operation, and product which are in turn broken down into sub-categories. One of these sub-categories is that of divergent thinking which is composed of the factors of adaptive flexibility, fluency, originality, and elaboration. These four factors are considered to be directly involved in creative thinking.

The prior discussion of the inquiry philosophy and curriculum models reveals that inquiry science programs are concerned with the achievement of both cognitive and affective behaviors. Furthermore, from the description of scientific curiosity, scientific attitudes, and creative thinking common elements such as liking of new things, open-mindedness, unconventional thinking, motivation, persistence, and rationality are evident. Classroom procedures and materials which are based upon the inquiry philosophy should

---

[35] John Curtis Gowan, "What Makes a Gifted Child Creative--Four Theories," in Creativity: It's Educational Implications, edited by J. C. Gowan, G. D. Demos, and E. P. Torrance, (New York: John Wiley and Sons, Inc., 1967), pp. 9-10.

lead children to develop these characteristics of affective behaviors. A logical procedure, then, would be to evaluate an inquiry science program with respect to the characteristics of scientific curiosity, scientific attitude, and creative thinking.

The focus of this study was to evaluate the SCIS, an inquiry science program, with respect to the three factors of scientific curiosity, scientific attitude, and creative thinking. The SCIS served as the independent variable and scientific curiosity, scientific attitude, and creative thinking served as the dependent variables.

Need for the Study

The literature yields little in research undertaken to determine whether or not childrens' affective behaviors develop and/or change as a result of a particular curriculum model. There has been a significant amount of research done in science education at both the elementary and secondary level with respect to the cognitive domain. Curriculum projects have been credited with contributing to pupil success in the realm of academic achievement and the development of cognitive processes.[36, 37, 38]

---

[36] Stafford and Renner, op. cit.

[37] Weber and Renner, op. cit.

[38] Renner, et al., op. cit.

The curriculum reform movement has stated on many occasions that one of the long range goals of science education should be to foster in students affective behaviors, attitudes, and the approach of the scientist. Primarily, due to the difficulty in developing test instruments, there has not been a great deal of research activity in the affective domain.

The present thinking relative to the acquisition of scientific attitudes by children is that if the children acquire an understanding of the content of science they will automatically acquire and demonstrate a positive attitude towards science and scientific activity. Deady[39] in a study of student attitudes and achievement of fourth grade students found changes in attitudes toward science in both directions (positive and negative) and an increase in achievement.

Glass[40] assumes the position that due to a rapidly changing educational environment there is a great need for "evaluative" type research in science education. Evaluative research is defined as "the determination of the worth of a thing. This involves the worth of a program, product, or

---

[39]Deady, Gene M., "The Effects of an Increased Time Allotment of Student Attitudes and Achievements in Science," paper presented at Annual Meeting of the National Association for Research in Science Teaching (Minneapolis, Minn., March 5-8, 1970), ERIC ED039126.

[40]Gene V. Glass, "The Wisdom of Scientific Inquiry on Education," Journal of Research in Science Teaching, Vol. 9, Issue 1, 1972, pp. 3-17.

procedure."[41] Research that stresses the evaluation of a program, he states, is necessary to further educational development and in the decision making process. This study was of the evaluative type.

There is a need in science education, then, for research to determine the contribution science makes to the affective domain. Research done by determining whether or not children are accomplishing affective objectives will test and evaluate methodologies of science instruction which can be used to lead children to achievement in the affective domain. Further consideration must be given to the fact that all children are not going to be scientists, but each will be a citizen in a complex scientific and technological society. If these children, as they reach adulthood, do not have a positive affective position towards science, then science education will not have accomplished its mission.

Limitations

The limitations discussed here govern the degree to which the results of this study can be generalized to the interactions between other populations of children and other curriculum models.

I. The procedures of this study are representative of ex post facto research. Kerlinger defines ex post facto research as:

---

[41]Fred N. Kerlinger, Foundation of Behavioral Research (New York: Holt, Rinehart, and Winston, 1964), p. 360.

> Research in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables. He then studies the independent variables in retrospect for the possible relations to and effects on, the dependent variable or variables.[42]

The independent variable, the learning of science through the SCIS curriculum, occurred during the six years prior to this study. Ex post facto research has major weaknesses which are (1) the inability to manipulate independent variables; (2) the lack of power to randomize; and (3) the risk of improper interpretation.[43] Campbell and Stanley list eight different classes of extraneous variables which, if not controlled, might produce effects confounded with the effect of the experimental variable.[44] With respect to ex post facto research design, these are: (1) maturation; (2) selection; (3) mortality; (4) interaction of selection and maturation; and (5) interaction of selection and the independent variable. Kerlinger further states that despite its weakness, much ex post facto research must be done in psychology, sociology, and education because many research problems in the social sciences and education do not lend themselves to experimental inquiry.[45] Many field studies are of such a

---

[42]Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart, and Winston, 1964), p. 360.

[43]Ibid., p. 371.

[44]Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago: Rand McNally and Company, 1963), p. 56.

[45]Kerlinger, op. cit., p. 372.

nature that due to limitations of the schools in which the investigation is to take place and the time involved, the ex post facto research may give a better insight into actual cases than an experimental study. This may be the instance when considering large scale curriculum studies. This investigation was of such a curriculum study.

II. This study also contained the limitation of subject selection. The population of the experimental group is limited because of the small number of schools which had had the SCIS curriculum for six years. In this study, forty-six students were identified as having studied the SCIS program for six years. This population represented the total number of students who had studied the SCIS curriculum for the most consecutive years in the state of Oklahoma. The students selected for both the experimental and control groups[46] were essentially from the middle strata of the socio-economic levels in their respective communities. Indicative of this limitation also is the fact that the group's mean intelligence level is above that considered to be average. The experimental group's mean IQ was 114 and the control group was 116.

III. This study is based on the measurement of the learner's position relative to affective behavior. There has been no instrument developed that has national norms. The populations where these instruments have been used are

---

[46]The control group had six years of non-laboratory science which focused upon a single textbook series.

narrow in scope. Thus, the results of this research must be viewed in terms of the instrument's reliability and validity.

Hypotheses of the Study

Four major null hypotheses were tested against four alternate hypotheses and fourteen subsidiary null hypotheses with alternates were also tested. The following are the major null hypotheses and subsidiary hypotheses with the respective alternate hypothesis.

Scientific Curiosity

Major Null Hypothesis and Alternate Hypothesis:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's curiosity as measured by the Scientific Curiosity Inventory.

H_1 The learner in the SCIS curriculum will develop a significantly greater degree of scientific curiosity than the learner in a conventional textbook program as measured by the Scientific Curiosity Inventory.

Subsidiary Null Hypothesis and Alternates:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's empirical curiosity.

H_2 The learner in the SCIS curriculum will develop a significantly greater degree of empirical curiosity than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's rational curiosity.

H_2 The learner in the SCIS curriculum will develop a significantly greater degree of rational curiosity than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's authoritative curiosity.

H_3 The learner in the SCIS curriculum will develop a significantly greater degree of authoritative curiosity than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's general curiosity.

H_4 The learner in the SCIS curriculum will develop a significantly greater degree of general curiosity than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's interest in science.

H_5 The learner in the SCIS curriculum will develop a significantly greater degree of interest in science than the learner in a conventional textbook program.

Scientific Attitude

Major Null Hypothesis and Alternates:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's scientific attitude as measured by Scale of Attitudes Towards Science and Scientists.

H_1 The learner in the SCIS curriculum will develop a significantly more positive attitude towards science and scientists than the learner in the conventional textbook curriculum as measured by the Scale of Attitudes Towards Science and Scientists.

Subsidiary Null Hypotheses and Alternates:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's attitude towards science.

H_1 The learner in the SCIS curriculum will develop a significantly more positive attitude towards science than the learner in a conventional textbook curriculum.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's attitude towards scientists.

H_2 The learner in the SCIS curriculum will develop a significantly more positive attitude towards scientists than the learner in a conventional textbook curriculum.

Creative Thinking

Major Null Hypotheses and Major Alternate Hypotheses:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's figural creative thinking as measured by the Torrance Tests of Creative Thinking.

H_1 The learner in the SCIS curriculum will develop a significantly greater degree of figural creativity than the learner in the conventional textbook program as measured by the Torrance Tests of Creative Thinking.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's verbal creative thinking as measured by the Torrance Tests of Creative Thinking.

H_1 The learner in the SCIS curriculum will develop a significantly greater degree of verbal creative thinking than the learner in a conventional textbook program as measured by the Torrance Tests of Creative Thinking.

Subsidiary Null Hypotheses and Alternates:

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's figural fluency.

H_1 The learner in the SCIS curriculum will develop a significantly greater degree of figural fluency than the learner in the conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's figural flexibility.

H_2 The learner in the SCIS curriculum will develop a significantly greater degree of figural flexibility than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's figural originality.

H_3 The learner in the SCIS curriculum will develop a significantly greater degree of figural originality than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's figural elaboration.

H_4 The learner in the SCIS curriculum will develop a significantly greater degree of figural elaboration than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's verbal fluency.

H_5 The learner in the SCIS curriculum will develop a significantly greater degree of verbal fluency than the learner in the conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's verbal flexibility.

H_6 The learner in the SCIS curriculum will develop a significantly greater degree of verbal flexibility than the learner in a conventional textbook program.

H_o No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a child's verbal originality.

H_7 The learner in the SCIS curriculum will develop a significantly greater degree of verbal originality than the learner in a conventional textbook program.

CHAPTER II

REVIEW OF THE LITERATURE

The subject of this investigation was the Science Curriculum Improvement Study (SCIS) and its affect upon curiosity, attitudes, and creative thinking. The population of interest in this study was the elementary grades, specifically, children who have studied the curriculum for six years. Much of the research dealing with the affective characteristics of curiosity, attitudes, and creative thinking has been relative to secondary school science and in developing instruments to measure behaviors in the affective domain. There is also some significant research on the SCIS program. The literature will be divided into three sections. The first part will review researches that directly involve the SCIS. The second part will be concerned with curiosity and attitudes and the last section will review the domain of creative thinking.

Science Curriculum Improvement Study

The number of research studies relating to the Science Curriculum Improvement Study is limited, especially those concerned with SCIS evaluation. Several investigations

reported in the literature deal with the influence of the SCIS program on certain cognitive processes, and several others relate to teaching strategies.

Siegelman and Karplus[1] evaluated the trial edition of Relativity, an SCIS unit designed for third grade students. The evaluation was made relative to the student's performances on tasks designed to measure the attainment of five objectives of the unit. Those five objectives were:

1. To describe and identify the position of objects relative to reference objects in the children's immediate environment.
2. To describe the position of objects relative to Mr. O.[2]
3. To understand and use one, two, or three major directions in a description of relative position.
4. To observe and identify motion relative to Mr. O.
5. To observe and identify motion relative to objects or systems other than Mr. O.

All tests consisted of a pictorial group test on the relative position concept and an individual interview on the relative motions concept. Twenty-eight children were given

---

[1]Robert Karplus, ed., What is Curriculum Evaluation--Six Answers (Berkeley: Science Curriculum Improvement Study, 1968), pp. 3-8.

[2]Mr. O is a paper, stick-man used in the Relativity unit of the SCIS. Mr. O is an artificial observer used to lead the child to think of the relative position of objects from viewing the positions other than the child's.

the test before and after they were taught the Relativity unit. Results indicated the unit definitely aided the children in developing strong spatial relationships. Also, objectives two and three were successfully attained while the partial attainment of objectives one, four, and five was accomplished.

Stafford and Renner[3] studied the influence of inquiry-centered teaching on the intellectual development of children. Their study focused on the Material Objects unit as the content vehicle of the study. They found the unit to significantly accelerate the development of conservation reasoning in children. According to Piaget,[4] conservation reasoning is basic to the stage of concrete operational thinking--a stage of intellectual growth through which every individual progresses. Thus, the SCIS curriculum definitely leads to accelerated intellectual development of children.

Neuman[5] explored the effect of instruction in selected experiences taken from the Science Curriculum Improvement Study Material Objects unit on first grade pupils' attainment

---

[3]Don G. Stafford and John W. Renner, "SCIS Helps the First Grader to Use Logic in Problem Solving," School Science and Mathematics, Feb., 1971, pp. 159-64.

[4]Jean Piaget, Psychology of Intelligence (Patterson, N.J.: Littlefield, Adams, and Company, 1963), p. 123.

[5]Donald B. Neuman, "The Influence of Selected Science Experiences on the Attainment of Concrete Operations by First Grade Children," address given at the annual meeting of the National Association for Research in Science Teaching, Pasadena, Calif., February, 1969.

of conservation of weight and quantity. Pupils were pretested, given 18 weeks of instruction based on Material Objects then posttested and given instruction based on a textbook. No differences were observed between the experimental group and the control group on the pretest and on the posttest. However, on the pretest, boys scored higher than girls.

Allen[6] studied the effects of the SCIS Interaction unit upon cognitive, affective, and motivational behavior. The results were not clear cut, however, differences were found that seem to favor the SCIS group with respect to (1) cognitive performance in terms of tasks performed by the subjects; (2) affective categories when the subjects were questioned about their opinion on school science lessons; and (3) the program objectives of SCIS. Only in terms of the cognitive scores and the SCIS objectives were there strong statistical meanings. Affective and motivational performance of the SCIS group appear no better than the behavior displayed by the control.

Almy[7] studied logical thinking of second grade pupils who had received instruction based on Science--A Process

---

[6]Leslie R. Allen, "An Evaluation of Children's Performance on Certain Cognitive, Affective, and Motivational Aspects of the Interaction Unit of the Science Curriculum Improvement Study Elementary Science Program," Journal of Research in Science Teaching, Vol. 9, No. 2, 1972, pp. 167-173.

[7]Millie Almy, Logical Thinking in Second Grade (New York: Teachers College Press, Columbia University, 1970).

Approach, Science Curriculum Improvement Study, and The Greater Cleveland Mathematics Program during kindergarten and first grade. A control group that did not receive instruction based upon any of these programs was also included. Assessment of logical thinking was achieved through individual, clinical interviews on conservation, class inclusion, seriation, transitivity of length and multiple classification. Some classroom observations were made to determine if the instructional materials were used in ways intended by the developers. In all, more than 1,000 children were studied in six suburban school districts in metropolitan areas near New York and San Francisco.

Some of the specific questions the study was designed to answer were:

(1) Do children who have participated in any of the "new" programs reveal more advanced thinking at the second grade level than children who have not been involved in such instruction?

(2) Do children who have participated in any of the new programs in kindergarten, as well as in first grade, reveal more advanced thinking at the second grade level than children who have participated in such programs only in first grade?

(3) Do children who have participated in programs stressing the actual manipulation, as well as the labeling, of objects reveal more advanced

thinking at the second grade level than children who were in classes where the experience was predominantly of a paper-and-pencil character?

(4) Do children participating in any one program tend to be more advanced in their thinking at the second grade level than children participating in any other program?

(5) What evidence is there to suggest that variation in the level of thinking attained by the second grade may be associated with variation in the skills of the teachers of the "new" program?

Since the number of teachers involved in teaching any one program was small, and many other factors might also contribute to the variation in the children's performance, the intent of the study was to look for clues for further research rather than anticipating definite answers.

The results of the study are not clear-cut. Second grade children from the control group scored as well as second grade children who had had prescribed lessons in kindergarten and first grade. However, children in these two groups scored better than children who had received only one year of instruction, beginning in the first grade. In spite of the equivocal nature of the findings, this study does provide evidence of the nature of young children's thinking and complexities involved in instructing children in this age group.

Coffia[8] investigated the influence of the SCIS curriculum on achievement in other subject areas. The research was concerned with the degree to which extended SCIS experience contributes to the achievement of fifth grade students in reading, mathematics, and social studies. Scores on the Stanford Achievement Test for students who had had the SCIS for five years were compared to students scores who had experienced a textbook centered science curriculum for the same length of time. The SCIS group attained significantly higher scores in mathematical application, social studies skills, and paragraph meaning. This supports the notion that inquiry enhances the student's ability to manipulate data, interpret graphs, tables, and in reading maps.

Weber and Renner[9] constructed an instrument to assess the attainment of the processes of observing, measuring, classifying, experimenting, predicting, and interpreting data. The instrument was used to compare a group of students who had studied SCIS for five years to a group that had studied a conventional textbook for the same length of time. Significant differences were found in favor of the SCIS group. The observation was made in this research that the SCIS

---

[8]William Coffia, Report in Research Studies of SCIS Success in the Classroom (Chicago: Rand McNally and Company, 1972), pp. 10-12.

[9]Marvin C. Weber and John W. Renner, "How Effective is the SCIS Program?" School Science and Mathematics, November, 1972, pp. 729-734.

children virtually "attacked" the materials of the clinical type test. The willingness of the SCIS subjects to manipulate the materials of the science process tasks, ask questions, and to generally show an interest in the materials lead this investigator to consider the study being reported here.

Chalmer[10] studied the effects of Selected Frostig Visual Perception Units on educationally disadvantaged first graders' achievement in the Science Curriculum Improvement Study Material Objects unit. Criterion measures included Frostig Developmental Test of Visual Perception and ten Material Objects Student Activity Pages. It was found that the Frostig program enhanced pupil achievement in the Material Objects unit in some classes but not in others.

Allen[11] determined there was no significant difference in the development of classification skills by students who had had SCIS science for two years and those who had not. His study was based on the performance of students in grades two, three, and four.

---

[10]Freda Chalmer, "The Effect of Selected Frostig Visual Perception Units on First Grade Children's Achievement on the Science Curriculum Improvement Study Unit Material Objects" (unpublished doctoral dissertation, State University of New York at Buffalo, 1969).

[11]Leslie Robert Allen, "An Examination of the Classifactory Ability of Children Who Have Been Exposed to One of the "New" Elementary Science Programs" (unpublished doctoral dissertation, University of California, 1967).

Kellogg[12] determined that the SCIS unit, Material Objects, served as a valid reading readiness experience for students entering the first year of school. In his study he compared a group of first graders who studied SCIS science as their only reading readiness program with a second group who participated in a leading, conventional reading readiness program. On a test, retest comparison, the SCIS group made significantly greater gains on five of the six subtests of the Metropolitan Reading Readiness Test than the conventional curriculum group.

Several studies were available which indicated teachers, who had been educated in the basic SCIS philosophy, required their students to operate at significantly higher intellectual levels than did teachers not so educated. This was determined through the kinds of classroom experiences those teachers provided and the kinds of questions which were asked in the classroom.

Wilson and Renner[13] compiled observational data from thirty classrooms in the first through the sixth grades. Fifteen science classes were taught by teachers who had had educational orientation to the SCIS philosophy and were using

---

[12]Renner, John W., et al., Research Studies of SCIS Success in the Classroom (Chicago, Ill.: Rand McNally and Company, 1972), pp. 9-10.

[13]John H. Wilson and John W. Renner, "The New Science and the Rational Powers: A Research Study," Journal of Research Science Teaching, VI (1969), pp. 303-307.

the curriculum in their science classes. The other fifteen teachers had had no prior SCIS orientation and were using the conventional textbook approach in their science classes. In comparing the two groups as to the kinds of science experiences and the kinds of questions which were asked, they found the following:

1. The SCIS educated teachers provided more of the essential experiences[14] of science in their classes than did the conventional group.
2. Recognition and recall types of questions were asked to a greater extent by the conventional group.
3. Analysis and synthesis types of questions were asked to a greater extent by the SCIS group.
4. Comprehension types of questions were asked in greater numbers by the conventional group whereas demonstration of skill questions were asked in greater numbers by the SCIS teacher-oriented group.

Schmidt[15] made observations of sixteen teachers before and after they participated in a workshop which provided

---

[14]John W. Renner and William B. Ragan, Teaching Science in the Elementary School (New York: Harper and Row Publishing, 1968), pp. 112-197.

[15]Fred Schmidt, "The Influence of a Summer Institute in Inquiry-Centered Science Education Upon the Teaching Strategies of Elementary Teachers in Two Disciplines" (unpublished doctoral dissertation, University of Oklahoma, 1969).

experiences in the SCIS program. A comparison was made of the kinds of social studies and science experiences which they provided in the classroom and the kinds of questions asked before and after the teachers attended the workshop. He found the workshop experience caused a change in certain behaviors. The SCIS educated teachers asked fewer recall and convergent questions, asked more questions which required the pupils to operate at higher rational levels, and provided the pupils with a greater number of essential learning experiences in science.[16] Of special significance was Schmidt's finding that those teacher behavior changes influenced the way the teachers involved taught their social studies classes after the workshop experience even though traditional social studies materials were used.

Porterfield[17] studied how the SCIS curriculum and philosophical orientation influenced the questioning strategy of elementary teachers in the teaching of reading. He found teachers who had had experience with the SCIS philosophy definitely altered their questioning techniques. His conclusions are summarized as follows:

1. Teachers not having had SCIS exposure asked more questions which were based on recognition and

---

[16]Renner and Ragan, op. cit., pp. 112-197.

[17]Denzil R. Porterfield, "Influence of Preparation in Science Curriculum Improvement Study on Questioning Behavior of Selected Second and Fourth Grade Reading Teacher" (unpublished doctoral dissertation, University of Oklahoma, 1969).

recall abilities than teachers experienced in teaching the SCIS.

2. The SCIS oriented teachers asked more questions of the translation, analytical, and synthesis types.

3. The SCIS teachers asked fewer recall questions.

Bruce[18] investigated if there was any change in the SCIS teacher's attitude toward the teacher-pupil relationship. The Minnesota Teacher Attitude Inventory (MTAI) was used to measure the teacher's attitude and the relationship between the attitude score and the level of question-asking was analyzed. No significant change in teacher attitudes was found which is inconsistent with the question-asking findings. Overall the SCIS teachers did change their question asking behavior and Bruce observed, not quantitatively, what he considered to be a change in the degree of freedom and involvement permitted the students by the SCIS teacher. Bruce states further that the lack in change of the teachers attitude as measured by the MTAI may be due to the lack of sensitivity of the test instrument. The findings in the Bruce study relative to the level of question-asking are consistent with the results of the Porterfield and Willson and Renner studies.

---

[18]Larry R. Bruce, "A Study of the Relationship Between the SCIS Teacher's Attitude Toward the Teacher-Student Relationship and Question Types," Journal of Research in Science Teaching, Vol. 8, No. 2, 1971, pp. 157-164.

Based upon the data from the research just reviewed, it is evident that the SCIS program influences learner achievement of cognitive objectives, achievement in areas other than science, and in the manner in which teachers view their responsibilities. This investigator believed that the next question that needed to be asked was the one to which this study was directed.

Scientific Curiosity and Attitudes

Although limited in number, studies have been carried out to assess the affect of inquiry curriculum programs on affective behaviors. The studies cited represented mostly Science--A Process Approach. There has been a limited number of studies to date that involve SCIS and affective behavior. A great deal of activity has been in the area of developing instruments to measure curiosity and attitude.

Partin[19] compared achievement and interest in science between fourth graders taught Science--A Process Approach and a control group of fourth graders who used a textbook. Criterion measures were the California Achievement Test, the Sequential Tests of Educational Progress, Science Competency Measures, and an investigator developed informal interest inventory. No differences were found between experimental

---

[19]Melba S. Partin, "An Investigation of the Effectiveness of the AAAS Process Method Upon the Achievement and Interest in Science for Selected Fourth Grade Students" (unpublished doctoral dissertation, University of Southern Mississippi, 1967).

and control groups on the first two tests. However, boys scored higher than girls in these two tests and on the Informal Interest Inventory. The experimental group scored higher on the Competency Measures and the Informal Interest Inventory. Performance on the Competency Measures was unrelated to I.Q. scores.

Raun and Butts[20] studied the relationship between strategies of inquiry and pupils' cognitive and affective behavioral change. Pupils from grades four through six who had no other inquiry-centered instruction were exposed to five months of experience in Science--A Process Approach. After instruction, pupils were tested on achievement, attitudes, recall, and divergent thinking. Findings showed that performance in observing, classifying, using numbers, and using space/time relations is correlated with those behavior factors associated with intelligence, divergent thinking, science recall, reading, and perception of the potency of science.

An apparent contradiction occurred between the results of Butts and Raun and those of Partin. Butts and Raun found differences in achievement after instruction related to I.Q., whereas, Partin did not observe this. This discrepancy raises a question. Can the difference in results

---

[20]Chester E. Raun and David P. Butts, "The Relationship Between the Strategies of Inquiry in Science and Student Cognitive and Affective Behavioral Change," Journal of Research in Science Teaching, Vol. 5, 1968, pp. 261-268.

be attributed to treatment differences arising from the teachers whose classes were studied, or do they arise from teaching methodological differences? The research proposed here is addressed to the problem of teaching method and materials. In the SCIS program the teacher becomes an intergal part of the program. Through the use of exploration, invention, and discovery lessons,[21] the teacher is basic to the method employed by the SCIS program. This study was similar to Raun and Butts in that a strategy of inquiry was under consideration.

Klopfer[22] studied the effectiveness and the effects of the Elementary School Science Project astronomy materials on 90 fifth grade pupils in the University of Chicago Laboratory School. Children were tested before and after a 10 week instructional unit based on Charting the Universe. Effectiveness of instruction was measured by the Charting the Universe Test Forms 207 and 208, which assessed pupil's knowledge of astronomy and specific content included in the instructional sequence. Statistically significant differences

---

[21]Exploration, Invention, and Discovery are three interrelated phases in the inquiry method of teaching. Exploration refers to the learner probing a new area; Invention is when a label or concept is agreed upon or provided; Discovery refers to the expansion of the investigated concept or the finding of new ideas or concepts.

[22]Leopold E. Klopfer, "Effectiveness and Effects of ESSP Astronomy Units--An Illustrative Study of Evaluation in a Curriculum Development Project," Journal of Research in Science Teaching, Vol. 6, 1969, pp. 64-75.

were found between the pre- and post tests on both general knowledge and specific content. Effects of instruction were assessed by the Test on Understanding Science and an eight concept semantic differential test. Statistically significant improvement was shown in pupils' understanding of the scientific enterprise as measured by the Test on Understanding Science. Three attitudinal factors related to the instructional program and its content were identified: importance, enjoyment, and dynamism. Although pupils' attitudinal responses after instruction were still favorable, a significant decline in some areas between the time of pretest and posttest was noted.

Deady[23] investigated the effects of increased time allotments, and of the teacher's preference for a particular time allotment, in fourth grade student's achievements and attitudes towards science. The curriculum studied was Concepts of Science 4. Achievement was measured by Cooperative Sequential Test of Educational Progress, Science, Form 4A, and attitudes by Lowry's Projective Test of Attitudes. During the school year, all groups gained in science achievement. Changes in attitudes toward science occurred in both directions, positive and negative. No differences significant at

---

[23]Gene M. Deady, "The Effects of an Increased Time Allotment of Student Attitudes and Achievements in Science," (paper presented at the annual meeting of the National Association for Research in Science Teaching, Minneapolis, Minn., March 5-8, 1970), ERIC ED039126.

the 0.01 level were found attributal to either time allotment or teachers preference for time allotment. No significant interactions were found between students reading level or I.Q. and time allotment.

The literature yields some research in the area of instrument construction. Much of the work reported is relative to secondary school science and will not be reviewed here. What follows is a review of that type of research done at the elementary school level.

Motz[24] developed a valid and reliable science and scientists attitude instrument and used it to determine the attitudes of sixth and ninth grade students toward science and scientists. The groups compared were sixth grade urban, sixth grade suburban, sixth grade rural and ninth grade urban, suburban, and rural. The findings show significantly higher scores as to attitudes of sixth grade suburban, ninth grade rural, and ninth grade suburban students in relation to sixth grade rural and urban, and ninth grade urban students. Overall, ninth grade students showed a more positive attitude towards science and scientists than sixth graders. There was a significant difference reported with regard to socio-economic background. Students from higher socio-economic backgrounds showed a more positive response than students

---

[24]LaMoine L. Motz, "The Development of an Instrument to Evaluate Sixth and Ninth Grade Students' Attitudes toward Science and Scientists" (unpublished doctoral dissertation, University of Michigan, 1970).

from low socio-economic backgrounds. No significant differences were found between males and females. A statistically significant relationship was found between I.Q. and attitudes. The higher I.Q. students displayed a more positive response to science than the lower I.Q. students. There was no decline in attitude between the sixth and ninth grade students.

Richardson[25] developed a research study to construct an instrument to measure student's scientific curiosity and interest. The instrument developed was used with upper elementary-grade children and the only variable investigated that appeared to limit the development of curiosity was sex. Boys exhibited a higher degree of curiosity than girls. The students' scientific curiosity and interests were found to be multidimensional. The instrument did discriminate between classrooms in their preference for certain types of science activities.

Creative Thinking

The number of research studies done on this topic is overwhelming. The majority of the studies has been concerned with determining the effect of certain personality and psychological variables upon creativity. As a matter of fact,

---

[25]Rayman P. Richardson, "Development and Use of the SCI Inventory to Measure Upper Elementary School Children's Scientific Curiosity and Interests" (unpublished doctoral dissertation, The Ohio State University, 1971).

several publications[26] have been written discussing one or more of these variables. With all the research carried out, one is struck with a glaring deficiency. There has been little research done with regard to (1) teaching method, and (2) curriculum programs that enhance or destroy creative thinking. A most prolific researcher in these two areas, has been E. Paul Torrance. The review which follows is a summary of some of his studies of elementary school children. These studies have been selected since they are applicable to this study.

Torrance[27] designed a group of studies to clarify the problem of selecting appropriate test tasks for the two sexes. The study revealed that highly creative children are frequently skillful in restructuring tasks which they consider inappropriate to their sex in order to deal with them creatively. Second and third grade boys were found to be superior to girls on problems such as toy improvement tasks.

---

[26]Books and publications in this area are too numerous to mention, however any list would probably include: A. H. Compton, Nature of Creative Thinking (New York: Industrial Relations Institute Inc., 1953); C. W. Taylor, The 1955 University of Utah Research Conference on the Identification of Creative Scientific Talent (Salt Lake City: University of Utah Press, 1956; E. P. Torrance, Creativity: Proceedings of the Second Minnesota Conference on Gifted Children (Minneapolis: Center for Continuation Study, University of Minnesota, 1960); J. P. Guilford, Personality (New York: McGraw-Hill, 1959); J. P. Guilford, Structure of the Human Intellect (McGraw-Hill, 1963).

[27]E. Paul Torrance, Education and the Creative Potential (Minneapolis, Minn.: The University of Minnesota Press, 1963), pp. 103-136.

The second study confirms the importance of manipulation in generating inventive ideas. The third study used heterogeneous groups to study peer sanctions against highly creative children. Rather clear evidence of pressure against the most creative member was found in each of the twenty-five groups studied. Sixty-eight (68) percent of the most creative children initiated more ideas than any other member of the group, however, these creative members were not given credit for making the most valuable contributions to the group's performance. Other findings indicate that at the fifth grade, girls initiated slightly more ideas than boys and by the sixth grade a decreasing tendency for group members to work alone was found. These groups did not receive special instruction in creative tasks.

A study was designed by Torrance to train primary grade children to produce more and better ideas.[28] A variety of situations was developed and used to stimulate children to think of ideas for improving a toy. In a short period of time, the results indicated that primary grade children can be taught a set of principles that will elicit more and better ideas than those children who do not receive such training. The results further indicate that the production of the quantity of ideas should not be considered without attention to the quality.

---

[28] Ibid., pp. 137-144.

Another investigation was designed by Torrance to study the reactions of elementary grade girls to science tasks.[29] This study was done over a period of three years (1958, 1959, and 1960). During this time Torrance held regular meetings with the parents and teachers of the children in the study. In these meetings he stressed the misplaced emphasis and/or overemphasis on sex roles during the early school years. The groups were observed extensively over this period. The children were provided with a science toy and parts of a science toy and were asked to manipulate, explore, and experiment with the toy. The subjects were then asked how well they enjoyed the activity, what they thought was their contribution to the total group, what were other group members contributions to the group's ideas. The first year of the study the boys generated more ideas and their contributions were valued more highly. At the conclusion of the study (third year) the girls reported as much enjoyment as boys, but the boys' contributions remained more valued.

A study was performed by Torrance to investigate the relationship of I.Q. and creativity.[30] This investigation included 860 children in grades one through six. The I.Q. measures employed were the Wechler Intelligence Scale for

---

[29] Ibid., pp. 145-151.

[30] E. Paul Torrance, "Explorations in Creative Thinking in the Early School Years," in Scientific Creativity: Its Recognition and Development, edited by Calvin W. Taylor and Frank Barron (New York: John Wiley & Sons, 1963), pp. 173-183.

Children, the Otis Quick-Scoring Test of Intelligence, and the California Test of Mental Maturity. The findings in this study are revealing in that I.Q. and creativity seem to be independent of each other. The findings of the Torrance study is consistent with the results of a study by Getzels and Jackson[31] performed with high school students of which the Torrance study is a replication. Getzels and Jackson also found that teachers tend to favor the high I.Q. student and consider the low I.Q., highly creative students as discipline problems.

There has been little research activity in creativity in science education. One exception is Ransom[32] who studied the effect of Science--A Process Approach on creative thinking and performance in classifying and inferring among second grade children. Three groups were studied: eight classes using Science--A Process Approach whose teachers received in-service training and outside support; eight classes in which teachers were using Science--A Process Approach but who did not receive specialized training in the program; and eight classes whose teachers were using non-process oriented

---

[31]Jacob W. Getzels and Philip W. Jackson, "The Highly Intelligent and the Highly Creative Adolescent," in Scientific Creativity: Its Recognition and Development, edited by Calvin W. Taylor and Frank Barron (New York: John Wiley & Sons, 1963), pp. 161-172.

[32]Wayne E. Ransom, "Effect of Science--A Process Approach on Creative Thinking and Performance in Selected Processes of Science in the Second Grade" (unpublished doctoral dissertation, Syracuse University, 1968).

programs. Criterion instruments included the Science Process Instrument (Inferring and Classifying) and the Torrance Tests of Creative Thinking, Figural Form B. No differences were found among groups' performance on the criterion measures. Significant correlations were found in pupils' scores on the process measures and certain subscores on the Torrance Test.

Torrance[33] initiated research addressed to the problem of developing instruments to measure traits of creative thinking. An outgrowth of this research is the Torrance Tests for Creative Thinking which represents a battery of tests available for research with children. The tests were extensively analyzed using children in grades one through six, secondary school students, and college students. The tests were factor-analyzed and sub-scores derived for fluency, flexibility, originality, and elaboration. The tests were developed in two forms, figural and verbal, and validity and reliability were established. The Torrance Tests have been utilized in many research studies.

Landry[34] conducted a factor analytic study of the Torrance Tests, the Culture--Fair Intelligence Test, Stanford Achievement Test, and socio-economic status. The findings

---

[33]E. Paul Torrance, Torrance Tests of Creative Thinking (Princeton, J.J.: Personnel Press, Inc., 1966).

[34]Richard G. Landry, "The Factorial Orthogonality of the Torrance Tests of Creative Thinking and the Culture--Fair Intelligence Test," College of Education Record, University of North Dakota, Vol. 57, No. 2, November, 1971), pp. 20-25.

indicate the independence of divergent thinking abilities from achievement, intelligence, and socio-economic measures. Further findings were that the verbal and figural sections of the Torrance Tests were independent.

CHAPTER III

PROCEDURES OF THE STUDY

Overview

This investigation was designed with two major objectives (1) to assess the influence of the SCIS curriculum (defined as an inquiry approach) on the learner's scientific curiosity, scientific attitudes, and creative thinking; and (2) to study the independence and/or interdependence among the factors of scientific curiosity, scientific attitude, and creative thinking.

The affect of the SCIS was determined by comparing scores of two groups of students on four test instruments. One group studied science by using the SCIS curriculum while the second group studied science thrcugh the use of a textbook series. A further analysis was performed relative to the factorial independence and/or interdependence of the three test instruments.

Selection of the Subjects

Two groups of students were selected for comparison in this study, one group had studied only SCIS science while the second studied only textbook science. The SCIS group,

designated as the experimental group, consisted of forty-six sixth graders who participated in the SCIS curriculum in the same school for six years. The significance of this group is that it represents the total population available in the State of Oklahoma with respect to having been involved in the SCIS curriculum for a period of six years. After the SCIS group was identified, the following personal data were compiled for each student: sex, chronological age, I.Q., and socio-economic level according to Warner.[1]

The second group, the control group, consisted of sixty-three students. The group was selected to match the experimental group using the previously identified personal data as a basis. Also, each member had studied science from textbooks in the same school for six years.

Coffia established that the two groups to be used were comparable in their readiness to learn upon entering the first grade.[2] Both groups had scores recorded from the Metropolitan Learning Readiness Tests.[3] The chi square statistical test was used to test the hypothesis that no

---

[1]W. Lloyd Warner, Marchia Meeker, Kenneth Eells, Social Class in America: Manual of Procedure for the Measurement of Social Status (Harper Torchbook ed., New York: Harper and Brothers, Publishers, 1960), pp. 121-158.

[2]William Coffia, "The Effects of an Inquiry Oriented Curriculum in Science on a Child's Achievement in Selected Academic Areas" (unpublished doctoral dissertation, University of Oklahoma, 1971), pp. 35-40.

[3]Ibid.

significant difference existed between the two groups at the time they entered school with respect to their readiness for learning. The hypothesis was accepted.

Coffia[4] and Weber[5] further described the two groups with respect to school organization, curricular organization, and teacher variability. Based on data provided the present investigator by the principals in charge of each school no significant changes were found in the two school since Coffia's comparability study was done.[6]

The organizational structure of the two schools was similar in that they followed the self-contained classroom concept until grade five where both were then departmentalized. In the first four grades of the self-contained classroom structure, specialized teachers were used in certain fields such as music or art. The experimental group did experience one exception to the above structure in the fourth grade where the instructional approach of team teaching was introduced.

The curriculum, with the exception of the science program, was observed to be quite similar in the two schools. Descriptions of the curricular areas of mathematics, social

---

[4] Ibid.

[5] Renner, et al., op. cit.

[6] This information has been acquired through conversation and interviews with the principals of the schools involved.

studies, and language arts in the two schools are presented below.

Mathematics. The mathematics curriculum differed somewhat in grades one and two for the two schools. The control group was involved in a more traditional program which emphasized drill and mastery of facts along with a brief treatment of some modern concepts. The experimental group did use a more modern program in grades one and two but a different program was used later in grades three, four, and five.

Different commercial programs were implemented in both schools at the beginning of the third grade for each group. While the commercial materials were not the same, both were considered to be comparable in presenting the philosophies and concepts of modern mathematics.

Social Studies. The two schools follow Plan One as recommended by the Oklahoma Curriculum Improvement Commission on elementary school curricula for the social studies. In this plan, the study of the homes is begun in grade one with the scope expanded to include the local school, the local community, other communities, the local state, the United States, and consummating with the study of other countries in grade six.

Language Arts. The two schools follow a similar plan for the teaching of language arts. In grade one, the program is informal with no commercial textual materials used with

the exception of the reading program. Both schools initiate a basal reading program at the second grade level.

Teacher Variability. The teaching philosophy of the teachers who taught the students in the two groups follows. In the assessing of the affect of SCIS curriculum, with the textbook-centered curriculum serving as the control, one is essentially comparing an inquiry approach to a non-inquiry approach. Logically, then, the degree to which inquiry teaching methods are used with the two groups should be ascertained. Ideally, one would like to say that no inquiry was used with the textbook group, while all inquiry was used with the SCIS group. Realistically, however, one has to speak in terms of the degree to which inquiry was used by the teachers of the two groups. The control school had not introduced any inquiry-oriented programs in science or other discipline areas. Nor had there been any formal attempts to introduce the philosophy of inquiry to the teachers of this school. Stating, however, that absolutely no inquiry is used in this school is not possible; all teachers probably use some degree of inquiry at some time.

Every teacher of the SCIS group had had formal and planned learning experiences with the SCIS curricular materials prior to teaching the program. Those learning experiences included basic confrontations with inquiry in science teaching and learning.

The experimental school, therefore, used the philosophy of inquiry to a much greater degree in its science program than did the control school. That was to be expected. The Porterfield[7] study for example, shows that teachers of reading trained in and teaching the SCIS science program ask more questions of the translational, analytical, and synthesis type than non-SCIS teachers. In other words experiences with inquiry were probably not confined to the science class for the children in the SCIS group.

Instruments

The Richardson Scientific Curiosity Inventory[8] designed to measure curiosity and interest in science was administered to the experimental and control groups. The inventory consists of two parts. Part I, the "What-Would-You-Do?" section was designed to measure the student's level of curiosity. Part II, the "What-Would-You-Like-To-Do?" section was designed to measure the student's interest in science. The responses are of a Likert type scale.[9]

The Likert-type scale, or summated scale, is a response set to attitude items all of which are considered of approximately equal value. The subjects are asked to respond

---

[7] Denzil Porterfield, op. cit.

[8] Richardson, "The Development of the SCI Inventory," op. cit.

[9] Ibid., pp. 65-66.

with degrees of agreement or disagreement. The degree of agreement or disagreement is considered as the intensity of a response and these responses are summed to yield an individual's score.[10]

The "What-Would-You-Do?" section of the inventory resulted in subscores on four variables, empirical, rational, authoritative, and general curiosity. Empirical curiosity refers to the observational interest of a subject in elements in his environment. Rational curiosity would refer to the examination of a new element in the environment either physically or psychologically. Authoritative curiosity is the examination, exploration, manipulation, and particularly the persistence in these activities. General curiosity refers to an over-all approach to new and incongruous elements in the environment. The "What-Would-You-Do?" section consisted of twenty items; each item had four possible responses. The multiple-choice type responses indicate the score the subject would attain in each of the four categories. Only one response per item was required.

Part II, the "What-Would-You-Like-To-Do?" section was designed to measure scientific interests by inquiring into what the students would like to do. This part of the inventory consists of forty-eight items students record on a Likert scale ranging from "like to do very much" to "dislike to do very much."

---

[10]Kerlinger, Foundations of Behavioral Research, op. cit., p. 248.

Richardson used the following procedures in establishing the validity of the Scientific Curiosity Inventory. A sample of students was selected at random from a population of 1,601 students who were involved in the total study of scientific curiosity. Based upon the smaller sample, a prediction was made relative to the subject's interest and curiosity. Interviews were held and each interviewee was asked his preference of content areas among the physical, biological, and earth-space sciences. A correlation was computed between the subjects' scores on the inventory and the results of the interview. Richardson reports a high correlation between the interview scores which the investigator predicted from the Scientific Curiosity Inventory, and the results of the actual interview.[11]

An item analysis was executed using data collected on 1,601 subjects who had taken the Scientific Curiosity Inventory. An item analysis indicates the correlation of each item to the total score of the inventory. The correlation coefficient computed in this procedure can, in a very broad sense, be used as an index of validity. The index of validity will mean how well the item predicts some external criterion.[12] The correlation coefficients presented for the

---

[11]Richardson, op. cit. Richardson did not report the correlation coefficient nor the size of the sample.

[12]J. P. Guilford, Psychometric Methods (New York: McGraw-Hill Book Company, Inc., 1954), p. 417.

"What-Would-You-Do"" section (Part I) was 0.463 and for the "What-Would-You-Like-To-Do?" section (Part II) 0.915.[13] This intercorrelational data obtained by factor analysis indicates a high index for Part I and a high index for Part II. Indications are that the test is measuring variables that have a relationship.

Reliability concerns the precision of measurement regardless of what is measured. Test scores are not free from error and any score contains a true component and an error component. This may be represented by the formula $X_t = X\infty + Xe$, where X_t is the obtained score, $X\infty$ the true component, and Xe the error component which is random. Whenever a test or psychological measure is given, there are many factors which enter into the error component of a subject's score. The size of the error component or error score is related to the precision or reliability of the measuring instrument. A reliable instrument tends to be consistent and the measurements are relatively similar from time to time.[14]

A test score may be broken into parts and the variance may be treated as the variance with the true scores (s^2_∞) and the variance of the error scores (s^2_e). Therefore, $s^2_t = s^2_\infty + s^2_e$, where s^2_t is the variance in the obtained score.

---

[13] Richardson, op. cit., Appendix B.

[14] Jum Nunnally, Test and Measurements (New York: McGraw-Hill Book Company, Inc., 1959), pp. 95-112.

The assumption is made that the correlation between the true score and the error component is equal to zero. Rewriting the foregoing equation $\frac{s^2_{\infty}}{s^2_t} = 1 - \frac{s^2_e}{s^2_t}$,[15] $\frac{s^2_{\infty}}{s^2_t}$ can be thought of as that percent of the total variance (s^2_t) which represents the true or non-error variance.

In modern test theory, reliability is defined as that part of the variance which is true variance and is represented by the symbol, r_{tt}. Then, $r_{tt} = \frac{s^2_{\infty}}{s^2_t}$ and this may be stated as the reliability in the percent of the variance explained. Further, by substitution, $r_{tt} = 1 - \frac{s^2_e}{s^2_t}$ and the reliability becomes the percent of the non-error variance.[16] There is no hard and fast rule that says that any reliability has to be a certain size before any test or measuring instrument can be useful. Guilford states,

> For research purposes, one can tolerate much lower reliabilities than one can for practical purposes of diagnostic and prediction. We are frequently faced with the choice of making the best of what reliability we can get, even though it may be of the order of only .50, or of going without the use of the test at all. For some purposes, even a test of low reliability adds enough to prediction to justify its use.[17]

There are various methods for determining the reliability of an instrument. The reliability coefficients for the Scientific Curiosity Inventory were determined in three ways. These were (1) the use of the Kuder-Richardson

---

[15] Ibid., p. 97.

[16] Ibid., p. 98.

[17] Guilford, op. cit., p. 388.

formulas twenty and twenty-one, (2) test-retest reliability, and (3) the split half reliability using the Rulon formula.

The Kuder-Richardson formula twenty[18] (K-R#20) is a technique that yields a coefficient of internal consistency. An item analysis is performed on the test data and is reported in terms of item difficulty. Item difficulty is considered as part of the reliability coefficient that is computed by use of the K-R#20. The K-R#20 is usually considered to be an under estimation of the test reliability.

The Kuder-Richardson formula twenty-one[19] (K-R#21) is a modified version of K-R#20 and does not require a knowledge of item difficulty. The K-R#21 gives a lower estimate of reliability than the K-R#20. Reliability coefficients for the Scientific Curiosity Inventory reported were K-R#20 = 0.936 and K-R#21 = 0.929.

The test-retest method for determining the reliability coefficient consists of giving the same test on two different occasions. The correlation between the two sets of scores is the estimate of the reliability coefficient.[20] Test-retest reliability for the Scientific Curiosity Inventory was 0.712.[21]

---

[18] Ibid., pp. 380-381.

[19] Richardson, op. cit., p. 85.

[20] Nunnally, op. cit., p. 108.

[21] Richardson, op. cit., p. 87.

To establish the reliability of the instrument relative to the population selected for this study, a group of thirty children at a second school in the system of the control school was selected. This school was selected on the following basis. The socio-economic status of the school from which the sample was selected was the same as the experimental and control groups. The members of the group had been in attendance at the same school for six years. The sample was selected over a range of intellectual abilities from the various ability groups within the sixth grade. The mean I.Q. for this sample was computed to be 113.

The Scientific Curiosity Inventory was administered to this group and a split-half reliability using the Rulon formula[22] was computed. The reliability coefficients (r_{tt}) were: Part I, 0.67; Part II, 0.94; and total inventory, 0.95. (See Appendix A)

Based upon data from the K-R#20 and #21, the test-retest, the split-half, and the application of the Rulon formula to the populations to be evaluated, the Scientific Curiosity Inventory was judged as being a reliable instrument. The reliability coefficients may be interpreted to mean that for the total instrument 95 percent of the non-error variance is accounted for. In other words, the instrument is 90 percent reliable in the case of the Kuder-Richardson formula,

---

[22]David Magnusson, Test Theory (Reading, Mass.: Addison-Wesley Publishing Company, 1966), p. 111.

95 percent for the split-half, and 70 percent reliable in test-retest reliability.

The reading level of the instrument was determined by Richardson using the Chall method.[23] The reading level was judged to be fifth grade, sixth month.

Scientific Attitude

The Motz Scale of Attitudes Towards Science and Scientists[24] was used to determine the child's position relative to the nature of science and scientists. The scale consists of two parts. Part I deals with statements about science and the respondent is asked to check whether he agrees, disagrees, or is undecided with respect to the statement. Part II consists of statements about scientists and the subject again is asked to check agree, disagree, or undecided. To establish the validity of the instrument, ideas and statements about science and scientists were obtained by questioning 525 elementary, secondary, and college teachers, scientists, and science educators. The final form of the instrument resulted after trial administration for readability and understanding of the attitude statements. The instrument was validated by a jury panel of twenty professional scientists and science educators. The items were

---

[23]Richardson, op. cit.

[24]Motz, Instrument to Evaluate Attitudes Towards Science, op. cit.

tabulated and those items with two-thirds agreement or better were selected for the final instrument.

The reliability was determined by the split-halves correlation, with the use of the Spearman-Brown Prophecy formula. Reliability for Part I was .48 and Part II, .78. Reliability for the entire instrument was .78.

To establish reliability for this study, the Scale of Attitudes Towards Science and Scientists was administered to the same sample of sixth grade students used to establish the reliability of the Scientific Curiosity Inventory. (See Appendix B). A split-halves reliability using the Rulon formula was performed with the results as follows:

r_{tt} (Part I) = 0.84 r_{tt} (Part II) = 0.93 r_{tt} (total) = 0.89

The reliability of the attitude scale accounts for 89 percent of the variance. This is considered adequate for the purposes of this study since 8.9 cases out of 10 a "true" score is obtained. In other words, if the individual were to complete the attitude scale ten times, nine of those times he would probably make the same score.

The Flesch Reading Measurement scale was applied to the items included in the attitude scale. By use of this test, the readability of the statements was found to be 6.2 (sixth grade, second month).

Creative Thinking

The Torrance Tests of Creative Thinking,[25] Figural Form A and Verbal Form A were administered to both the experimental and control group. The Verbal form consists of five activities: Ask and Guess, Product Improvement, Unusual Uses, Unusual Questions, and Just Suppose. The Figural Form is composed of three activities: Picture Construction, Incomplete Figures, and Repeated Figures. The tests are timed and forty-five minutes were required for the verbal test and thirty minutes for the figural. The Figural test yields subscores on flexibility, fluency, originality, and elaboration and the verbal test resulted in scores on flexibility, fluency, and originality.

The following discussion was taken in part from the Torrance Tests of Creative Thinking, Norm-Technical Manual.[26] The data for reliability and validity were taken from studies summarized in that manual.

First, consideration must be given to reliability in scoring. Five teachers and two educational secretaries scored the tests using the scoring guides provided with the tests. The training procedure employed was to have the trainee read the scoring manual and then score 25 to 40 tests. Correlation coefficients were then computed between the scores of

---

[25] E. Paul Torrance, Torrance Tests of Creative Thinking, op. cit.

[26] Ibid.

the teachers and the secretaries as compared to experienced scorers. These computed coefficients are shown in Table 1.

TABLE 1[27]

CORRELATION OF SCORERS FOR TESTS OF CREATIVE THINKING

Scorer	Coefficients of Correlation-Figural Form			
	Fluency	Flexibility	Originality	Elaboration
First Grade Teachers	.95	.96	.94	.97
Second Grade Teachers	.89	.80	.88	.97
Third Grade Teachers	.98	.98	.66	.82
Fourth Grade Teachers	.99	.97	.89	.85
Sixth Grade Teachers	.97	.97	.94	.93
Educational Secretary (Fifth Grade)	.99	.98	.76	.87
MEANS	.96	.94	.85	.90

Scorer	Coefficients of Correlation-Verbal Forms		
	Fluency	Flexibility	Originality
Twelfth Grade Teacher	.99	.98	.91
Educational Secretary (Seventh Grade)	.99	.99	.86

Generally, there are almost no differences in the means, and the coefficients of reliability are generally in excess of .90, with the exception of .85 for Originality in the first group. The level of confidence for these correlations is 0.10. This would indicate 90 percent confidence

[27] Ibid., p. 19.

or 9 chances out of 10 that the score reliability indicates the true score on the test. The .90 correlation coefficient would be judged as high reliability in scoring. The data presented above would indicate that if a person reads and follows the directions manual that the score obtained would be highly reliable.

A number of test-retest reliability studies was conducted with the Torrance Tests. Test-retest reliability is determined by giving the same test on two separate occasions. The correlation between the two sets of scores serves as an estimate of the reliability coefficient, r_{tt}. The coefficient estimated in this manner is called the coefficient of stability.[28]

Test-retest reliability studies were conducted with 118 intermediate grade children and 54 fifth grade children in schools in Wisconsin and Minnesota. A Pearson product-moment correlation coefficient was completed and the results are shown in Table 2.

---

[28]Nunnally, Tests and Measurements, op. cit., p. 110.

TABLE 2

PRODUCT-MOMENT COEFFICIENTS OF CORRELATION BETWEEN SCORES ON FORMS A AND FORMS B OF THE TORRANCE TESTS OF CREATIVE THINKING IN THREE SITUATIONS[29]

Measure	Coefficients of Correlation			
	Wisconsin Gr. 4-6	Minnesota Exper.	Sub. Gr. 5 Cont.	Mean for 3 Groups
Verbal Fluency	.93	.87	.79	.85
Verbal Flexibility	.84	.84	.61	.76
Verbal Originality	.88	.79	.73	.80
Figural Fluency	.71	.50	.80	.67
Figural Flexibility	.73	.63	.64	.67
Figural Originality	.85	.60	.60	.68
Figural Elaboration	.83	.71	.80	.71
Total Test Mean Correlation	.82	.70	.71	

Additional studies have been conducted and the reliabilities reported are in the same magnitude as those reported by Torrance. Goralski in administering the test battery to a group of suburban children obtained test-retest reliabilities of .82, .78, .59, and .83 for fluency, flexibility, originality, and battery total respectively. Macklen in a series of studies obtained reliabilities of (in the same order) .82, .61, .62, and .71.[30] The data from these studies would lead one to accept the test-retest reliability as being stable and relatively high.

---

[29] Torrance, Torrance Tests of Creative Thinking, op. cit., p. 21.

[30] Ibid., pp. 20-22.

The validity of tests for creative thinking is difficult to establish since a person can behave creatively in an almost infinite number of ways. Torrance believes that an overall validity coefficient for tests of creative thinking ability is grossly inappropriate.[31] Even so, the validity of the Torrance Tests has been approached in a variety of ways.

Torrance states that content validity has been pursued by a consistent and deliberate effort to base the test stimuli, the test tasks, instructions, and scoring procedures on the test theory and research available. Analyses of the lives of eminent creative people, the nature of performances regarded as creative, and research and theory concerning the functioning of the human mind were considered in the selection of the test tasks. Intercorrelational data obtained by factor analysis shows correlation coefficients varying from .51 for sixth graders to .82 for second graders. The relatively high positive correlation indicates the test is measuring variables that have a relationship.[32]

Construct validity may be established by correlating a test to other psychological variables or tests. In a study by Landry, results show that the Torrance Tests are measuring variables other than I.Q. and achievement. Wineberg and

---

[31] Ibid., p. 23.

[32] Ibid., pp. 23-24.

Springer conducted a personality study of 32 intellectually gifted children using the Torrance Tests and the Rorschack Ink Blots. The children considered to be creative as judged by the Creative Thinking Tests also rated high on self-image, ease of early recall, unconventional responses, unreal percepts, and imaginative treatment of the blots.[33]

Studies found outside the Torrance Tests of Creative Thinking, Norms-Technical Manual[34] show relationships to psychological variables such as withholding opinions, withstand uncertainty, resist premature closure, and persistence. The relationships indicated by these studies tend to lead to the judgment that the Torrance Tests do have a degree of construct validity. Since the test battery is the research edition, the extent of this validity is not reported quantitatively.

Treatment of Data

The Mann-Whitney U nonparametric test was used to analyze the raw data which consisted of the scores obtained from the four test instruments. Since the population variance was not known, the use of a nonparametric statistic was required. The Mann-Whitney requires that scaling be only ordinal and makes no assumptions about the means.

---

[33] Ibid., p. 25.

[34] Ibid.

The procedures of the computation of the U consists of first ranking scores of the two groups together in ascending order. Tied scores are assigned the average of the tied ranks and the sum of the ranks in the larger group is calculated.[35]

$$U' = \frac{N_1N_2 + N_2(N_2 + 1)}{2} - R_2$$

where N_1 = number of cases in smaller group

N_2 = number of cases in the larger group

R_2 = sum of ranks of the larger group

$U = N_1N_2 - U'$

if $U' > U$, set $U = U'$.

A correction factor for ties is obtained by using the following formula:

$$T = \sum \frac{t^3 - t}{12}$$

where t = number of observations tied for a given rank.

The standard deviation is computed for two cases:

(a) if $T = 0$

$$s = \frac{N_1N_2(N_1 + N_2 + 1)}{12}$$

(b) if $T > 0$

$$s = \frac{N_1N_2}{N(N-1)} \quad \frac{N^3-N}{12} - T$$

where N = total number of cases $(N_1 + N_2)$

---

[35] International Business Machines, 1130 Scientific Subroutine Package Application Description Manual, p. 52.

The significance of U is then tested:

$$Z = \frac{U-X}{s}$$

where X = mean = $\frac{N_1 N_2}{2}$

Z is the measure of significance of U in terms of the normal distribution.

The Mann-Whitney U is considered to be one of the strongest nonparametric tests. Compared to the normal t-test, the Mann-Whitney has a power-efficiency of approximately 95 percent.[36]

The null hypotheses were tested at the 0.10 significance level. This level was selected after considering the types of possible decision errors and their consequences. The results are shown in Table 3.

TABLE 3

TWO TYPES OF ERRORS[37]
(H_o = null hypotheses)

	Reject H_o	Accept H_o
H_o True	Type I Error	Correct
H_o False	Correct	Type II Error

[36]Sidney Siegel, Non-Parametric Statistics (New York: McGraw-Hill Book Company, Inc., 1956), pp. 116-127.

[37]J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, 1965), p. 206.

The possibility for committing Type I Errors will be lessened by using smaller significance levels because the possibility of rejecting the null hypothesis will be greatly reduced. In other words, there is less chance for rejecting the null hypothesis at a 0.01 level than at a 0.05 level. However, as the possibility for committing a Type I Error is reduced, the chances for making a Type II Error are increased.

Within the context of this study, the investigator believed the consequences for a Type II Error to be more serious of the two. A Type I Error would mean the null hypothesis would be rejected when in fact it would be true. As a result, educators would believe the curriculum approach did influence the learning processes in science and would possibly purchase the curriculum materials even though they were of no value. The learning of the children, however, progresses just as efficiently with the materials as without them, so no educational harm is done.

On the other hand, a Type II Error would mean the null hypothesis would be accepted when in fact it would not be true; the new materials and/or programs were producing educationally superior results. As a result, educators would be reluctant to attempt the new curriculum approach even though it would be educationally beneficial to the students. Succinctly, a Type II Error, at most, means wasted finances through the purchase of unnecessary curriculum materials. Conversely, a Type II Error means a beneficial pedological

approach might not be attempted. Evidently, a Type II Error will be more detrimental to the learner and is the consequence which should be avoided. A 0.10 level of significance would reduce the possibility for committing the Type II Error.

A chi-square statistic was performed to analyze the variables of I.Q. and sex with respect to high and low scores on scientific curiosity, scientific attitude, figural creative thinking, and verbal creative thinking. The chi-square is a distribution free statistic to be used with data that can be reduced to frequencies.[38] The data on the four test instruments were reduced to frequencies and 2 x 2 contingency tables were constructed in the sex and I.Q. categories. The null hypothesis of no difference was tested at the 0.10 level.

The chi-square was computed using the following formula:[39]

$$X^2 = \frac{N(|IAD-BCI-\frac{N}{2}|)^2}{(A+B)(C+D)(A+C)(B+D)}$$

where: N = total number in the group
A = frequency in upper left cell of contingency table.
B = frequency in the upper right cell of contingency table.
C = frequency in the lower left cell of contingency table.
D = frequency in the lower right cell of contingency table.

---

[38] Siegel, op. cit., pp. 104-111.

[39] Ibid.

The degrees of freedom (df) are determined by:

$$df = (r-1)(c-1)$$

where r = the number of rows in the contingency table
c = the number of columns in the contingency table

For a 2 x 2 contingency table:

$$df = (2-1)(2-1)$$
$$df = 1$$

A factor analysis was executed to determine the independence and/or interdependence of the four test instruments. Factor analysis is a multivariate statistical method which is used in the analysis of tables or matrices, or of correlation coefficients. Factor analysis reduces the original number of variables to a smaller number of variables, called factors which are amenable to interpretation. Factor analysis is usually applied to data where no distinction between dependent and independent variables is made.[40] Factor analysis involves analyzing the correlation matrix to account for or explain a small number of variables or factors. Each variable corresponds to loading upon a particular factor until all the variance has been accounted for. The independence and/or interdependence is then amenable to interpretation so that structures may be determined.

In this investigation, the scores of the combined experimental and control group on the fourteen subscores of

---

[40] Jum C. Nunnally, Psychological Tests and Multivariate Statistics (New York: McGraw-Hill Book Company, Inc., 1964), pp. 404-425.

the four test instruments were analyzed. Although in the other statistical analyses the independent and dependent variables are of concern during the testing of hypotheses, in the factor analysis the concern is with the study of structure among the test scores on variables.

The procedure involved the collection of measurements on fourteen variables from the Scientific Curiosity Inventory, the Scale of Attitudes Towards Science and Scientists, and the Torrance Tests of Creative Thinking. The variables were intercorrelated for all possible N(N-1)/2 pairings, producing a square symmetrical correlation matrix, R.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

This study was conducted to determine if there were significant differences in scientific curiosity, scientific attitude, and creative thinking between two groups of learners--one group studied the Science Curriculum Improvement Study (SCIS) six years and the other had studied mainly from a textbook for the same length of time. Forty-six sixth grade students made up the experimental group and sixty-three students comprised the control group.

Data were collected using the Scientific Curiosity Inventory, Scale of Attitudes Towards Science and Scientists, and the Torrance Tests of Creative Thinking. The data from the tests instruments were analyzed using the Mann-Whitney U statistic, a principal axis factor analysis (varimax), and the chi square technique. Confidence levels for the Mann-Whitney U were set at 0.10 level and all levels are reported. For significance at this level a value equal to or greater than $Z = \pm 1.28$ was required.

The data relative to sex and I.Q. were analyzed using the chi square statistic. The confidence level was set at the 0.10 level. For significance at the 0.10 level a chi

square equal to or greater than 2.71 with one degree of freedom was required for significance.

A factor analysis was performed to examine the nature of the test instruments used in the study. The coefficients were considered, a priori, to represent high factor loadings at equal to or greater than 0.40.

Analysis of the Scientific Curiosity Inventory

One major and five subsidiary hypotheses were stated with respect to the Scientific Curiosity Inventory. The major hypothesis was that no significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a learner's scientific curiosity as measured by the Scientific Curiosity Inventory.

The Mann-Whitney U treatment produced a $U = 1029.50$ and a $Z = -1.665$ as computed by the IBM 1130 scientific subroutine package. The negative value of Z indicates the value is in the direction of the experimental group. Subject's scores and ranks are shown in Table 4. The z-score produced a confidence level of $p = 0.0475$. The null hypothesis was rejected in favor of the alternate. The SCIS Curriculum does significantly develop a learner's scientific curiosity.

The first subsidiary hypothesis stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's empirical curiosity. The U computed was equal to 1138.50 and

TABLE 4

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY "What Would You Do?" and "What Would You Like To Do?" Total

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	245	101.0	1	251	102.0
2	242	100.0	2	231	98.0
3	241	99.0	3	224	96.0
4	229	97.0	4	220	95.0
5	215	92.5	5	219	94.0
6	210	89.0	6	213	91.0
7	185	71.5	7	215	92.5
8	187	74.5	8	204	86.0
9	181	69.0	9	212	90.0
10	185	71.5	10	206	87.0
11	177	63.5	11	202	85.0
12	177	63.5	12	208	88.0
13	164	46.0	13	185	71.5
14	172	60.0	14	191	78.5
15	162	40.0	15	192	80.0
16	169	56.0	16	188	76.5
17	167	52.0	17	195	81.5
18	164	46.0	18	198	84.0
19	177	63.5	19	195	81.5
20	168	54.0	20	197	83.0
21	167	52.0	21	188	76.5
22	167	52.0	22	191	78.5
23	166	49.0	23	179	67.5
24	162	40.0	24	187	74.5
25	156	31.0	25	178	66.0
26	163	43.0	26	176	61.0
27	164	46.0	27	185	71.0
28	157	33.5	28	177	63.5
29	156	31.0	29	170	58.5
30	162	40.0	30	179	67.5
31	150	21.0	31	170	58.5
32	153	25.0	32	163	43.0
33	146	18.0	33	159	36.5
34	158	35.0	34	169	56.0
35	145	17.0	35	169	56.0
36	142	13.5	36	166	49.0
37	138	9.0	37	166	49.0
38	149	19.5	38	163	43.0

TABLE 4--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
39	142	13.5	39	155	28.5
40	132	7.0	40	156	31.0
41	130	5.0	41	157	33.5
42	118	4.0	42	159	36.5
43	117	3.0	43	155	28.5
44	114	2.0	44	160	38.0
			45	154	26.5
			46	149	19.5
			47	154	26.5
			48	152	23.5
			49	152	23.5
			50	144	16.0
			51	151	22.0
			52	143	15.0
			53	138	9.0
			54	140	12.0
			55	138	9.0
			56	139	11.0
			57	131	6.0
			58	95	1.0
$N_1 = 44$		$R_1 = 2018.5$	$N_2 = 58$		$R_2 = 3233$

Z = -0.930. Subject scores and ranks are shown in Table 5. The Z score produced a p = 0.1762. The null hypothesis was accepted.

Subsidiary hypothesis two stated no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's rational curiosity. The computed U = 1215.0 and Z = -0.412. Subject scores and ranks for this subscore are shown in Table 6. The Z score produced a p = 0.3372. The null hypothesis was accepted.

Subsidiary hypothesis three stated no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's authoritative curiosity. The computed U = 811.5 and Z = -3.143. Subject scores and ranks are shown in Table 7. The Z score produced a p = 0.0008. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's authoritative curiosity.

Subsidiary hypothesis four stated no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's general curiosity. The computed U = 1274.0 and Z = -0.013. Subject scores and ranks are shown in Table 8. The Z score produces a p = 0.4960. The null hypothesis was accepted.

Subsidiary hypothesis five stated no significant difference exists between the SCIS curriculum and the conventional

TABLE 5

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
"What Would You Do?" Empirical

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	45	90.5	1	46	93.0
2	46	93.0	2	45	90.5
3	47	96.0	3	39	64.5
4	42	81.5	4	41	74.5
5	41	74.5	5	49	101.0
6	43	86.0	6	41	74.5
7	43	86.0	7	39	64.5
8	36	58.0	8	30	27.5
9	32	37.5	9	41	74.5
10	37	62.0	10	33	44.0
11	47	96.0	11	40	68.0
12	42	81.5	12	48	99.0
13	24	10.0	13	30	27.5
14	43	86.0	14	29	22.5
15	41	74.5	15	32	37.5
16	32	37.5	16	36	58.0
17	40	68.0	17	41	74.5
18	36	58.0	18	47	96.0
19	40	68.0	19	42	81.5
20	42	81.5	20	44	88.5
21	44	88.5	21	34	50.0
22	37	62.0	22	48	99.0
23	28	19.0	23	37	63.0
24	40	68.0	24	33	44.0
25	22	6.0	25	30	27.5
26	42	81.5	26	24	10.0
27	48	99.0	27	34	50.0
28	36	58.0	28	33	44.0
29	30	27.5	29	34	50.0
30	32	37.5	30	41	74.5
31	12	1.0	31	32	37.5
32	22	6.0	32	32	37.5
33	30	27.5	33	21	3.5
34	50	102.0	34	41	74.5
35	31	32.5	35	34	50.0
36	28	19.0	36	27	15.5
37	34	50.0	37	32	37.5
38	42	81.5	38	34	50.0
39	28	19.0	39	25	12.0

TABLE 5--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	21	3.5	40	34	50.0
41	32	37.5	41	35	54.5
42	26	13.5	42	28	19.0
43	24	10.0	43	27	15.5
44	30	27.5	44	46	93.0
			45	20	2.0
			46	26	13.5
			47	40	68.0
			48	29	22.5
			49	30	27.5
			50	30	27.5
			51	36	58.0
			52	31	32.5
			53	23	8.0
			54	33	44.0
			55	28	19.0
			56	35	54.5
			57	33	44.0
			58	22	6.0
$N_1 = 44$		$R_1 = 2403.5$	$N_2 = 58$		$R_2 = 2793.8$

TABLE 6

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
"What Would You Do?" Rational

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	51	98.5	1	53	101.5
2	48	90.5	2	45	86.5
3	51	98.5	3	40	69.5
4	42	75.0	4	50	95.5
5	42	75.0	5	50	95.5
6	35	54.5	6	52	100.0
7	32	40.0	7	49	92.5
8	36	59.5	8	39	66.0
9	28	27.5	9	38	63.5
10	30	33.0	10	42	75.0
11	50	95.5	11	45	86.5
12	43	78.5	12	49	92.5
13	33	45.0	13	42	75.0
14	38	63.5	14	31	37.0
15	31	37.0	15	29	29.5
16	36	59.5	16	30	33.0
17	32	40.0	17	50	95.5
18	39	66.0	18	53	101.5
19	34	50.5	19	48	90.5
20	40	69.5	20	45	86.5
21	45	86.5	21	41	72.0
22	40	69.5	22	44	81.5
23	27	25.5	23	34	50.5
24	44	81.5	24	26	23.0
25	33	45.0	25	30	33.0
26	31	37.0	26	22	11.5
27	43	78.5	27	35	54.5
28	34	50.5	28	35	54.5
29	33	45.0	29	30	33.0
30	32	40.0	30	39	66.0
31	11	1.0	31	36	50.5
32	25	19.0	32	25	19.0
33	23	14.0	33	26	23.0
34	44	81.5	34	42	75.0
35	36	59.4	35	33	45.0
36	29	29.5	36	24	16.0
37	34	50.4	37	33	45.0
38	45	86.5	38	44	81.5
39	18	4.5	39	20	8.5

TABLE 6--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	18	4.5	40	36	59.5
41	23	14.0	41	28	27.5
42	23	14.0	42	36	59.5
43	12	2.0	43	27	25.5
44	20	8.5	44	40	69.5
			45	22	11.5
			46	19	6.0
			47	45	86.5
			48	20	8.5
			49	25	19.0
			50	30	33.0
			51	33	45.0
			52	33	45.0
			53	25	19.0
			54	35	54.5
			55	20	8.5
			56	26	23.0
			57	25	19.0
			58	16	3.0
$N_1 = 44$		$R_1 = 2204.8$	$N_2 = 58$		$R_2 = 3029.0$

TABLE 7

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
"What Would You Do?" Authoritative

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	29	95.0	1	22	77.0
2	15	38.5	2	22	77.0
3	29	95.0	3	23	80.0
4	19	63.5	4	29	95.0
5	17	51.5	5	17	51.5
6	10	16.0	6	31	98.5
7	11	19.5	7	28	92.5
8	16	45.5	8	24	83.5
9	17	51.5	9	16	45.5
10	4	2.0	10	35	102.0
11	19	63.5	11	26	89.0
12	13	25.0	12	26	89.0
13	20	70.5	13	24	83.5
14	15	38.5	14	17	51.5
15	9	12.5	15	16	45.5
16	22	77.0	16	8	9.5
17	12	21.5	17	33	101.0
18	12	21.5	18	32	100.0
19	16	45.5	19	30	97.0
20	15	38.5	20	25	87.0
21	17	51.5	21	27	91.0
22	31	98.5	22	19	63.5
23	20	70.5	23	21	73.5
24	24	83.5	24	16	45.5
25	20	70.5	25	19	63.5
26	5	4.0	26	13	25.0
27	18	45.5	27	19	63.5
28	15	38.5	28	20	70.5
29	14	31.0	29	15	38.5
30	14	31.0	30	21	73.5
31	11	19.5	31	19	63.5
32	19	63.5	32	10	16.0
33	10	16.0	33	15	38.5
34	14	31.0	34	24	83.5
35	16	45.5	35	13	25.0
36	14	31.0	36	14	31.0
37	15	38.5	37	19	63.5
38	24	83.5	38	26	89.0
39	8	9.5	39	8	9.5

TABLE 7--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	4	2.0	40	24	83.5
41	10	16.0	41	14	31.0
42	7	7.0	42	28	92.5
43	6	5.5	43	22	77.0
44	6	5.5	44	13	25.0
			45	17	51.5
$N_1 = 44$		$R_1 = 1801.5$	46	14	31.5
			47	18	56.5
			48	9	12.5
			49	19	63.5
			50	13	25.0
			51	19	63.5
			52	18	56.0
			53	22	77.0
			54	18	56.5
			55	10	16.0
			56	8	9.5
			57	15	38.5
			58	4	2.0
			$N_2 = 58$		

TABLE 8

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
"What Would You Do?" General

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	57	92.5	1	61	100.0
2	58	96.5	2	56	89.0
3	61	100.0	3	49	70.0
4	54	86.5	4	53	83.0
5	53	83.0	5	58	96.0
6	45	62.0	6	54	86.5
7	46	63.0	7	52	79.5
8	47	64.5	8	44	60.0
9	40	42.5	9	50	74.0
10	41	48.0	10	47	64.5
11	59	98.0	11	53	83.0
12	50	74.0	12	61	100.0
13	37	28.5	13	43	57.0
14	51	77.5	14	38	34.5
15	42	53.0	15	38	34.5
16	40	42.5	16	38	34.5
17	44	60.0	17	56	89.0
18	43	57.0	18	63	102.0
19	49	70.0	19	57	92.5
20	50	74.0	20	58	96.0
21	53	83.0	21	48	67.0
22	49	70.0	22	56	89.0
23	39	38.5	23	42	53.0
24	48	67.0	24	39	38.5
25	30	13.0	25	37	28.5
26	42	53.0	26	27	6.0
27	57	92.5	27	43	57.0
28	40	42.5	28	40	42.5
29	35	24.0	29	38	34.5
30	37	28.5	30	50	74.0
31	15	1.0	31	42	53.0
32	32	17.0	32	34	21.0
33	34	21.0	33	26	5.0
34	57	92.5	34	50	74.0
35	41	48.0	35	40	42.5
36	34	21.0	36	30	13.0
37	40	42.5	37	42	53.0
38	53	83.0	38	48	67.0
39	29	9.0	39	28	7.0

TABLE 8--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	21	2.0	40	41	48.0
41	34	21.0	41	37	28.5
42	29	9.0	42	41	48.0
43	23	3.5	43	37	28.5
44	30	13.0	44	51	77.5
			45	30	13.0
			46	29	9.0
			47	52	79.5
			48	32	17.0
			49	36	25.0
			50	34	21.0
			51	44	60.0
			52	38	34.5
			53	32	17.0
			54	41	48.0
			55	30	13.0
			56	38	34.5
			57	37	28.5
			58	23	3.5
$N_1 = 44$		$R_1 = 2280.5$	$N_2 = 58$		$R_2 = 2985$

textbook curriculum in developing a learner's interest in science. The computed U = 963.5 and Z = -2.112. The subject scores and ranks are shown in Table 9. The Z score produced a p = 0.0174. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's interest in science.

In summary, the major null hypothesis and two of the subsidiary hypotheses were rejected. Significant differences were found in favor of the experimental group with respect to scientific curiosity (total) authoritative curiosity, and for interest (Part II of the Curiosity Inventory).

Analysis of the Scale of Attitudes Towards Science and Scientists

One major and two subsidiary hypotheses were stated with respect to the responses on the Scale of Attitudes Towards Science and Scientists. The major hypothesis was that no significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing a learner's attitude towards science and scientists.

The Mann-Whitney U treatment produced a U = 789.0 and a Z = -3.783. The Z score produced a p = 0.00011. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's attitude towards science and scientists. Subject scores and ranks are shown in Table 10.

TABLE 9

GROUP SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
"What Would You Like To Do?" Interest

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	188	101.0	1	190	102.0
2	184	100.0	2	175	97.0
3	180	99.0	3	175	97.0
4	175	97.0	4	167	95.0
5	162	91.5	5	161	90.0
6	165	94.0	6	159	87.5
7	139	71.0	7	163	93.5
8	140	73.5	8	160	89.0
9	141	75.5	9	162	91.5
10	144	79.0	10	159	87.5
11	118	33.0	11	149	82.5
12	127	52.5	12	147	80.0
13	127	52.5	13	142	77.5
14	121	43.0	14	153	85.5
15	120	38.5	15	154	86.0
16	129	58.5	16	150	84.0
17	123	46.0	17	139	71.0
18	121	43.0	18	135	64.0
19	128	55.5	19	138	69.0
20	118	33.0	20	139	71.0
21	114	25.5	21	140	73.5
22	118	33.0	22	135	64.0
23	127	52.5	23	137	67.5
24	114	25.5	24	148	81.0
25	126	50.0	25	141	75.5
26	121	43.0	26	149	82.5
27	107	16.5	27	142	77.5
28	117	30.0	28	137	67.5
29	121	43.0	29	132	61.0
30	125	45.0	30	129	58.5
31	135	64.0	31	128	55.5
32	121	43.0	32	129	58.5
33	112	23.0	33	133	62.0
34	101	10.5	34	119	36.0
35	104	13.0	35	129	58.5
36	108	18.0	36	136	66.0
37	98	8.0	37	124	47.5
38	96	6.5	38	115	27.5
39	113	24.0	39	127	52.5

TABLE 9--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	111	22.0	40	115	27.5
41	96	6.5	41	120	38.5
42	89	3.0	42	118	33.0
43	94	4.5	43	118	33.0
44	84	2.0	44	109	20.0
			45	124	47.5
$N_1 = 44$		$R_1 = 2079$	46	120	38.5
			47	102	12.0
			48	120	38.5
			49	116	29.0
			50	110	21.0
			51	107	16.5
			52	105	14.0
			53	106	15.0
			54	99	9.0
			55	108	18.5
			56	101	10.5
			57	94	4.5
			58	72	1.0
			$N_2 = 58$		$R_2 = 3300.5$

TABLE 10

SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS
Total Group Scores and Ranks

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	62	107.0	1	60	104.5
2	61	106.0	2	60	104.5
3	59	102.5	3	59	102.5
4	58	99.0	4	58	99.0
5	58	99.0	5	58	99.0
6	58	99.0	6	57	95.5
7	57	95.5	7	55	89.5
8	56	92.5	8	54	86.5
9	56	92.5	9	54	86.5
10	56	92.5	10	53	82.5
11	56	92.5	11	53	82.5
12	55	89.5	12	52	77.5
13	54	86.5	13	52	77.5
14	54	86.5	14	51	72.0
15	53	82.5	15	51	72.0
16	53	82.5	16	50	67.0
17	52	77.5	17	50	67.0
18	52	77.5	18	50	67.0
19	52	77.5	19	50	67.0
20	52	77.5	20	48	58.5
21	51	72.0	21	48	58.5
22	51	72.0	22	48	58.5
23	51	72.0	23	47	52.5
24	50	67.0	24	47	52.5
25	49	63.0	25	47	52.5
26	49	63.0	26	46	47.0
27	49	63.0	27	46	47.0
28	48	58.5	28	46	47.0
29	48	58.5	29	46	47.0
30	48	58.5	30	45	40.0
31	47	52.5	31	45	40.0
32	47	52.5	32	45	40.0
33	47	52.5	33	45	40.0
34	46	47.0	34	45	40.0
35	44	33.5	35	45	40.0
36	44	33.5	36	45	40.0
37	44	33.5	37	45	40.0
38	43	30.0	38	45	40.0
39	42	27.5	39	44	33.5

TABLE 10--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	40	24.0	40	43	30.0
41	40	24.0	41	43	30.0
42	40	24.0	42	42	27.5
43	39	19.0	43	40	24.0
44	38	14.5	44	40	24.0
			45	39	19.0
			46	39	19.0
			47	39	19.0
			48	39	19.0
			49	38	14.5
			50	38	14.5
			51	38	14.5
			52	36	11.5
			53	36	11.5
			54	34	10.0
			55	33	9.0
			56	32	7.5
			57	32	7.5
			58	31	5.0
			59	31	5.0
			60	31	5.0
			61	30	3.0
			62	28	2.0
			63	25	1.0
$N_1 = 44$		$R_1 = 2853.5$	$N_2 = 63$		$R_2 = 2847$

The first subsidiary null hypothesis in this category was that no significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the learner's attitude towards science. The computed $U = 815.0$ and $Z = -3.625$. The Z score produced a $p = 0.00016$. The null hypothesis was rejected in favor of the alternate. The SCIS does significantly develop a positive attitude by the learner towards science. Subject scores and ranks are shown in Table 11.

The second subsidiary null hypothesis in this category was that no significant difference exists between the SCIS curriculum and the conventional curriculum in developing the learner's attitude towards scientists. The computed $U = 883.5$ and $Z = -3.19$. The Z score produces a $p = 0.0007$. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a positive attitude by the learner towards scientists. Subject scores and ranks are shown in Table 12.

To summarize, statistically significant differences were found for the total score, and on Part I and Part II of the Scale of Attitudes Towards Science and Scientists. The major null hypothesis and the two subsidiary hypotheses were rejected in favor of their alternates.

TABLE 11

GROUP SCORES AND RANKS FOR SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS
Part 1

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	30	107.0	1	29	105.5
2	29	105.0	2	26	90.5
3	27	98.0	3	27	98.0
4	27	98.0	4	27	98.0
5	27	98.0	5	26	90.5
6	25	81.5	6	26	90.5
7	28	103.0	7	23	62.5
8	27	98.0	8	23	62.5
9	25	81.5	9	24	71.5
10	25	81.5	10	25	81.5
11	28	103.0	11	24	71.5
12	22	53.5	12	25	81.5
13	24	71.5	13	26	90.5
14	25	81.5	14	21	42.5
15	23	61.5	15	26	90.5
16	25	81.5	16	24	71.5
17	27	98.0	17	25	81.5
18	22	53.5	18	26	90.5
19	26	90.5	19	21	42.5
20	24	71.5	20	23	62.5
21	23	62.5	21	21	42.5
22	28	103.0	22	21	42.5
23	24	71.5	23	22	53.5
24	25	81.5	24	22	53.5
25	24	71.5	25	21	42.5
26	21	42.5	26	22	53.5
27	23	62.5	27	20	33.5
28	24	71.5	28	26	90.5
29	22	53.5	29	22	53.5
30	24	71.5	30	21	42.5
31	21	42.5	31	21	42.5
32	19	27.5	32	21	42.5
33	25	81.5	33	0	21.5
34	22	53.5	34	20	33.5
35	22	53.5	35	19	27.5
36	18	21.5	36	23	62.5
37	24	71.5	37	16	10.0
38	23	62.5	38	19	27.5

TABLE 11--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
39	17	15.5	39	20	33.5
40	17	15.5	40	21	42.5
41	21	42.5	41	18	21.5
42	15	6.0	42	20	33.5
43	17	15.5	43	22	53.5
44	19	27.5	44	19	27.5
			45	11	2.0
$N_1 = 44$		$R_1 = 2946.5$	46	18	21.5
			47	17	15.5
			48	16	10.0
			49	19	27.5
			50	20	33.5
			51	16	10.0
			52	16	10.0
			53	18	21.5
			54	20	33.5
			55	18	21.5
			56	17	15.5
			57	15	6.0
			58	17	15.5
			59	15	6.0
			60	16	10.0
			61	14	4.0
			62	13	3.0
			63	10	1.0
			$N_2 = 63$		$R_2 = 2829.5$

TABLE 12

GROUP SCORES AND RANKS FOR PART II OF SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	32	103.0	1	31	96.0
2	32	103.0	2	31	96.0
3	32	103.0	3	33	106.0
4	31	96.0	4	31	96.0
5	31	96.0	5	31	96.0
6	33	106.0	6	31	96.0
7	29	83.5	7	29	83.5
8	29	83.5	8	31	96.0
9	31	96.0	9	31	96.0
10	31	96.0	10	29	83.5
11	28	76.0	11	28	76.0
12	23	32.5	12	28	76.0
13	30	88.5	13	27	69.0
14	29	83.5	14	27	51.0
15	30	88.5	15	25	88.5
16	28	76.0	16	24	39.5
17	25	51.0	17	26	62.0
18	30	88.5	18	25	51.0
19	26	62.0	19	24	39.5
20	28	76.0	20	27	69.0
21	28	76.0	21	25	51.0
22	33	106.0	22	27	69.0
23	27	69.0	23	26	62.0
24	25	51.0	24	25	51.0
25	25	51.0	25	25	51.0
26	28	76.0	26	25	51.0
27	26	62.0	27	24	39.5
28	24	39.5	28	26	62.0
29	26	62.5	29	20	19.0
30	24	39.5	30	23	32.5
31	26	62.0	31	24	39.5
32	28	76.0	32	24	39.5
33	22	27.0	33	24	39.5
34	24	39.5	34	27	69.0
35	22	27.0	35	25	51.0
36	26	62.0	36	26	62.0
37	20	19.0	37	22	27.0
38	20	19.0	38	29	83.5
39	25	51.0	39	25	51.0

TABLE 12--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	23	32.5	40	23	32.5
41	19	14.0	41	22	27.0
42	25	51.0	42	24	39.5
43	22	27.0	43	20	19.0
44	19	14.0	44	18	11.5
			45	20	19.0
$N_1 = 44$		$R_1 = 2842$	46	28	76.0
			47	21	23.0
			48	22	27.0
			49	22	27.0
			50	19	14.0
			51	18	11.5
			52	20	19.0
			53	20	19.0
			54	16	9.0
			55	13	2.0
			56	14	4.5
			57	15	7.0
			58	16	9.0
			59	14	4.5
			60	16	9.0
			61	14	4.5
			62	14	4.5
			63	12	1.0
			$N_2 = 63$		$R_2 = 2923$

Analysis of the Scores for the Tests of Creative Thinking--Figural

One major null hypothesis and four subsidiary null hypotheses with alternates were formulated in this category. Hypotheses were stated with respect to the scores on the Torrance Tests of Creative Thinking--Figural Form A.

The major hypotheses stated that no significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the learner's figural creative thinking. The computed U = 846.5 and Z = -2.433. The Z score produces a p = 0.0075. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's figural creative thinking. The subject scores and ranks are shown in Table 13.

Subsidiary null hypothesis one stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's figural fluency. The computed U = 996.5 and Z = -1.369. The Z score produces a p = 0.0853. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does develop a learner's figural fluency. Subject scores and ranks are shown in Table 14.

Subsidiary hypothesis two in this category stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing the learner's figural flexibility. The computed

TABLE 13

GROUP SCORES AND RANKS FOR TOTAL FIGURAL CREATIVE THINKING

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	140	40.0	1	141	41.5
2	105	15.0	2	152	55.0
3	87	6.0	3	135	36.0
4	98	12.0	4	88	7.0
5	229	95.0	5	157	62.0
6	156	60.5	6	131	31.5
7	174	73.5	7	94	10.0
8	117	21.0	8	73	3.0
9	252	99.0	9	120	22.5
10	151	53.0	10	171	71.5
11	223	94.0	11	72	2.0
12	186	81.5	12	83	5.0
13	137	38.0	13	156	60.5
14	152	55.0	14	149	50.0
15	183	79.5	15	132	33.5
16	212	91.0	16	150	51.5
17	90	8.0	17	131	31.5
18	200	85.5	18	106	16.0
19	160	64.0	19	130	29.5
20	142	43.5	20	153	57.0
21	186	81.5	21	180	77.0
22	179	76.0	22	141	41.5
23	178	75.0	23	132	33.5
24	108	17.5	24	234	96.0
25	154	58.0	25	218	92.0
26	152	55.0	26	134	35.0
27	113	19.0	27	161	65.0
28	171	71.5	28	129	27.5
29	174	73.5	29	200	85.5
30	183	79.5	30	168	69.0
31	147	48.5	31	221	93.0
32	146	46.5	32	145	45.0
33	235	97.0	33	201	87.0
34	155	59.0	34	204	89.0
35	203	88.0	35	91	9.0
36	205	90.0	36	190	83.0
37	163	67.0	37	129	27.5
38	162	66.0	38	159	63.0
39	147	48.5	39	125	25.0

TABLE 13--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	146	46.5	40	99	13.0
41	103	14.0	41	137	38.0
			42	124	24.0
			43	124	24.0
			44	240	98.0
			45	96	11.0
			46	197	84.0
			47	137	38.0
			48	62	1.0
			49	78	4.0
			50	150	51.5
			51	120	22.5
			52	170	70.0
			53	115	20.0
			54	108	17.5
			55	128	26.0
			56	165	68.0
			57	182	78.0
			58	130	29.5
$N_1 = 41$		$R_1 = 2394.5$	$N_2 = 58$		$R_2 = 2557.5$

TABLE 14

GROUP DATA FOR CREATIVE THINKING--
FIGURAL FLUENCY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	20	47.5	1	26	74.5
2	13	10.5	2	25	70.0
3	14	14.5	3	20	47.5
4	15	19.5	4	12	8.5
5	26	74.5	5	19	40.5
6	24	63.0	6	16	23.5
7	30	88.0	7	18	35.0
8	14	14.5	8	16	23.5
9	37	99.0	9	18	35.0
10	28	80.5	10	24	63.0
11	27	78.0	11	10	2.5
12	31	91.0	12	15	19.5
13	20	47.5	13	18	35.0
14	19	40.5	14	10	2.5
15	32	92.0	15	20	47.5
16	33	94.0	16	20	47.5
17	9	1.0	17	22	55.0
18	21	52.5	18	16	23.5
19	17	29.0	19	11	5.5
20	19	40.5	20	35	96.0
21	20	47.5	21	29	83.5
22	17	29.0	22	27	78.0
23	22	55.0	23	14	14.5
24	14	14.5	24	30	88.0
25	24	63.0	25	36	97.5
26	25	70.0	26	24	63.0
27	17	29.0	27	17	29.0
28	24	63.0	28	21	52.5
29	14	14.5	29	23	57.5
30	25	70.0	30	16	23.5
31	25	70.0	31	26	74.5
32	24	63.0	32	22	55.0
33	25	70.0	33	30	88.0
34	18	35.0	34	26	74.5
35	19	40.5	35	11	5.5
36	29	83.5	36	37	94.0
37	33	94.0	37	20	47.5
38	24	63.0	38	23	57.5
39	29	83.5	39	19	40.5

TABLE 14--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	27	78.0	40	13	10.5
41	17	29.0	41	15	19.5
			42	18	35.0
			43	20	47.5
			44	36	97.5
			45	14	14.5
			46	28	80.5
			47	15	19.5
			48	11	5.5
			49	11	5.5
			50	19	40.5
			51	17	29.0
			52	30	88.0
			53	24	63.0
			54	17	29.0
			55	30	88.0
			56	24	63.0
			57	29	83.5
			58	12	8.5
$N_1 = 41$		$R_1 = 2242.5$	$N_2 = 58$		$R_2 = 2707.5$

U = 974.5 and Z = -1.526. The Z score produced a p = 0.0606. The Z score was rejected in favor of the alternate. The SCIS curriculum does significantly develop the learner's figural flexibility. The subject scores and ranks are shown in Table 15.

Hypothesis three stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing the learner's figural originality. The computed U = 920.5 and Z = -1.909. The Z score produces a p = 0.0281. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop the learner's figural originality. The subject scores and ranks are shown in Table 16.

Subsidiary hypothesis four was a statement of no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing a learner's figural elaboration. The computed U = 977.5 and Z = -1.502. The Z score produces a p = 0.0668. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's figural elaboration. The subject scores and ranks are shown in Table 17.

The analysis of the subjects scores on the Torrance Test of Creative Thinking--Figural is summarized as follows: Statistically significant differences were found for the total score, figural fluency, figural flexibility, figural originality, and figural elaboration. The major null

TABLE 15

GROUP DATA FOR CREATIVE THINKING--
FIGURAL FLEXIBILITY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	12	17.0	1	25	94.5
2	45	99.0	2	27	98.0
3	12	17.0	3	19	62.0
4	15	34.5	4	10	6.5
5	21	74.0	5	12	17.0
6	16	41.5	6	14	29.5
7	21	74.0	7	11	12.0
8	13	23.5	8	14	29.5
9	26	96.5	9	16	41.5
10	22	81.0	10	21	74.0
11	24	92.0	11	10	6.5
12	21	74.0	12	13	23.5
13	14	29.5	13	18	54.0
14	17	48.0	14	13	23.5
15	24	92.0	15	15	34.5
16	23	87.5	16	13	23.5
17	9	3.0	17	19	62.0
18	17	48.0	18	16	41.5
19	12	17.0	19	6	1.0
20	16	41.5	20	22	81.0
21	15	34.5	21	23	87.5
22	13	23.5	22	19	62.0
23	18	54.0	23	10	6.5
24	14	29.5	24	26	96.5
25	17	48.0	25	21	74.0
26	19	62.0	26	20	68.5
27	17	48.0	27	17	48.0
28	22	81.0	28	19	26.0
29	11	12.0	29	18	54.0
30	18	54.0	30	15	34.5
31	23	87.5	31	21	74.0
32	20	68.5	32	19	62.0
33	20	54.0	33	22	81.0
34	18	54.0	34	19	62.0
35	18	54.0	35	11	12.0
36	23	87.5	36	22	81.0
37	23	87.5	37	15	34.5
38	18	54.0	38	19	62.0
39	20	68.5	39	16	41.5

TABLE 15--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	21	74.0	40	11	12.0
41	13	23.5	41	13	23.5
			42	16	41.5
			43	10	6.5
			44	19	62.0
			45	12	17.0
			46	22	81.0
			47	13	23.5
			48	10	6.5
			49	10	6.5
			50	16	41.5
			51	16	41.5
			52	24	92.0
			53	23	87.5
			54	11	12.0
			55	15	34.5
			56	22	81.0
			57	25	94.5
			58	7	2.0
$N_1 = 41$		$R_1 = 2250$	$N_2 = 58$		$R_2 = 2685.5$

TABLE 16

GROUP DATA FOR CREATIVE THINKING--
FIGURAL ORIGINALITY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	15	10.0	1	49	96.0
2	21	23.5	2	31	57.5
3	19	17.5	3	26	42.5
4	19	17.5	4	15	10.0
5	37	75.0	5	34	65.0
6	27	47.0	6	39	80.5
7	35	70.0	7	22	29.0
8	23	33.5	8	18	15.5
9	64	99.0	9	25	38.0
10	44	91.5	10	27	47.0
11	47	94.0	11	12	3.5
12	31	57.5	12	13	5.0
13	25	38.0	13	28	50.0
14	17	13.5	14	26	42.5
15	42	88.0	15	22	29.0
16	41	85.0	16	33	61.5
17	18	15.5	17	23	33.5
18	31	57.5	18	21	23.5
19	22	29.0	19	23	33.5
20	27	47.0	20	15	10.0
21	28	50.0	21	29	53.5
22	34	65.0	22	20	19.0
23	35	70.0	23	26	42.5
24	21	23.5	24	45	93.0
25	21	23.5	25	55	97.5
26	35	70.0	26	38	77.0
27	23	33.5	27	23	33.5
28	39	80.5	28	35	70.0
29	31	57.5	29	21	23.5
30	29	53.5	30	34	65.0
31	34	65.0	31	29	53.5
32	41	85.0	32	26	42.5
33	41	85.0	33	44	91.5
34	36	73.5	34	41	85.0
35	41	85.0	35	15	10.0
36	35	70.0	36	39	80.5
37	48	95.0	37	29	53.5
38	34	65.0	38	32	60.0
39	36	73.5	39	28	50.0

TABLE 16--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	33	61.5	40	12	3.5
41	21	23.5	41	21	23.5
			42	25	38.0
			43	14	6.5
			44	55	97.5
			45	14	6.5
			46	43	89.5
			47	21	23.5
			48	7	1.0
			49	17	13.5
			50	26	42.5
			51	26	42.5
			52	38	77.0
			53	23	33.5
			54	11	2.0
			55	38	77.0
			56	43	89.5
			57	39	80.5
			58	15	10.0
$N_1 = 41$		$R_1 = 2318.5$	$N_2 = 58$		$R_2 = 2631.5$

TABLE 17

GROUP DATA FOR CREATIVE THINKING--
FIGURAL ELABORATION

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	83	51.0	1	145	97.0
2	58	21.0	2	69	36.5
3	42	5.5	3	70	38.0
4	49	10.0	4	51	11.0
5	145	97.0	5	92	66.0
6	89	62.0	6	62	28.0
7	88	59.0	7	43	7.0
8	67	34.5	8	25	1.0
9	125	90.0	9	61	25.0
10	57	20.0	10	99	71.0
11	125	90.0	11	40	3.5
12	103	75.0	12	42	5.5
13	78	44.0	13	92	66.0
14	99	71.0	14	100	73.0
15	85	54.5	15	75	40.5
16	115	83.5	16	84	53.0
17	54	16.0	17	67	34.5
18	131	93.0	18	53	14.0
19	109	81.0	19	90	64.0
20	80	46.5	20	81	48.0
21	123	88.0	21	99	71.0
22	115	83.5	22	75	40.5
23	103	75.0	23	82	49.0
24	59	22.5	24	133	94.0
25	92	66.0	25	106	80.0
26	73	39.0	26	52	12.5
27	56	19.0	27	104	77.5
28	89	62.0	28	54	16.0
29	118	86.0	29	138	95.0
30	111	82.0	30	103	75.0
31	65	32.0	31	145	97.0
32	61	25.0	32	78	44.0
33	149	99.0	33	105	79.0
34	83	51.0	34	118	86.0
35	125	90.0	35	54	16.0
36	118	85.0	36	96	68.5
37	59	22.5	37	65	32.0
38	86	56.0	38	85	54.5
39	62	28.0	39	62	28.0

TABLE 17--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	65	32.0	40	63	30.0
41	52	12.5	41	88	59.0
			42	83	51.0
$N_1 = 41$		$R_1 = 2260.5$	43	80	46.5
			44	130	92.0
			45	55	18.0
			46	104	77.5
			47	88	59.0
			48	34	2.0
			49	40	3.5
			50	89	62.0
			51	61	25.0
			52	78	44.0
			53	45	8.5
			54	69	36.5
			55	45	8.5
			56	76	42.0
			57	87	57.0
			58	96	68.5
			$N_2 = 58$		$R_2 = 2688.5$

hypothesis and all four subsidiary null hypotheses were rejected in favor of their respective alternate hypotheses.

Analysis of the Scores for the Tests of Creative Thinking--Verbal

One major null hypothesis and three subsidiary null hypotheses were stated for the category of verbal creative thinking. The hypotheses were relative to the scores by the subjects on the Torrance Tests of Creative Thinking--Form A.

The major hypothesis stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing the learner's verbal creative thinking. The computed $U = 1296.5$ and $Z = 0.245$. The Z score produced a $p = 0.4013$. The null hypothesis was accepted. The subject scores and ranks are shown in Table 18.

Subsidiary hypothesis one stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing the learner's verbal fluency. The computed $U = 1032.5$ and $Z = 1.973$. The Z score produced a $p = 0.0244$. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop the learner's verbal fluency. The subject scores and ranks are shown in Table 19.

Subsidiary hypothesis two stated that there was no significant difference between the SCIS curriculum and the conventional textbook curriculum in developing the learner's

TABLE 18

GROUP SCORES AND RANKS FOR TOTAL VERBAL CREATIVE THINKING

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	170	75.0	1	140	58.0
2	190	83.5	2	134	52.5
3	220	98.0	3	158	71.5
4	190	83.5	4	154	69.5
5	178	78.0	5	191	85.5
6	198	89.0	6	107	35.5
7	225	100.0	7	78	11.5
8	105	33.5	8	132	51.0
9	217	97.0	9	115	43.0
10	174	76.0	10	120	47.0
11	149	63.5	11	97	25.0
12	180	79.5	12	153	67.0
13	154	69.5	13	115	43.0
14	88	20.0	14	78	11.5
15	79	14.5	15	79	14.5
16	140	58.0	16	76	8.5
17	98	26.5	17	76	8.5
18	98	26.5	18	144	62.0
19	197	88.0	19	56	3.0
20	223	99.0	20	75	6.5
21	99	28.5	21	66	4.0
22	131	50.0	22	233	102.0
23	52	1.0	23	141	60.0
24	199	90.5	24	199	90.5
25	113	38.5	25	102	30.5
26	99	28.5	26	167	73.0
27	243	104.0	27	176	77.0
28	105	33.5	28	140	58.0
29	116	45.0	29	203	92.0
30	210	93.0	30	149	63.5
31	134	52.5	31	152	65.0
32	86	18.5	32	102	30.5
33	75	6.5	33	77	10.0
34	80	17.0	34	92	22.0
35	53	2.0	35	79	14.5
36	73	5.0	36	129	48.5
37	86	18.5	37	79	14.5
38	139	56.0	38	215	96.0
39	111	37.0	39	168	74.0

TABLE 18--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	192	87.0	40	236	103.0
41	94	23.0	41	182	81.0
42	115	43.0	42	191	85.5
43	107	35.5	43	91	21.0
44	114	40.5	44	103	32.0
45	96	24.0	45	113	38.5
46	114	40.5	46	228	101.0
			47	129	48.5
$N_1 = 46$		$R_1 = 2377.5$	48	138	55.0
			49	142	61.0
			50	153	67.0
			51	189	82.0
			52	211	94.0
			53	153	67.0
			54	180	79.5
			55	118	46.0
			56	213	95.0
			57	137	54.0
			58	158	71.5
			$N_2 = 58$		$R_2 = 3082.5$

TABLE 19

GROUP DATA FOR CREATIVE THINKING--
VERBAL FLUENCY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	68	57.0	1	87	82.0
2	85	80.0	2	77	74.0
3	99	96.0	3	87	82.0
4	76	72.0	4	76	72.0
5	67	56.0	5	92	89.0
6	79	76.0	6	48	34.0
7	100	97.5	7	35	10.5
8	42	24.0	8	63	52.0
9	100	97.5	9	49	36.5
10	72	66.0	10	59	50.5
11	74	70.0	11	44	28.5
12	73	68.0	12	71	62.5
13	71	62.5	13	53	42.5
14	42	24.0	14	37	15.5
15	29	5.5	15	46	30.0
16	58	48.5	16	40	20.0
17	43	27.0	17	42	24.0
18	42	24.0	18	69	58.5
19	89	86.0	19	26	3.0
20	109	102.0	20	35	10.5
21	37	15.5	21	29	5.5
22	56	46.0	22	107	101.0
23	25	2.0	23	71	62.5
24	88	84.5	24	95	93.0
25	35	10.5	25	55	44.0
26	47	31.5	26	81	77.0
27	116	104.0	27	83	78.5
28	48	34.0	28	73	68.0
29	56	46.0	29	93	90.5
30	96	94.5	30	71	62.5
31	53	42.5	31	91	87.5
32	35	10.5	32	49	36.5
33	33	8.0	33	36	13.5
34	31	7.0	34	39	17.5
35	22	1.0	35	47	31.5
36	28	4.0	36	71	62.5
37	39	17.5	37	40	20.0
38	65	53.5	38	94	92.0
39	42	24.0	39	87	82.0

TABLE 19--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	71	62.5	40	111	103.0
41	40	20.0	41	91	87.5
42	48	34.0	42	76	72.0
43	36	13.5	43	50	38.5
44	50	38.5	44	56	46.0
45	44	28.5	45	59	50.5
46	51	40.5	46	105	99.5
			47	65	53.5
$N_1 = 46$		$R_1 = 2113.5$	48	69	58.5
			49	58	48.5
			50	73	68.0
			51	93	90.5
			52	96	94.5
			53	78	75.0
			54	88	84.5
			55	51	40.5
			56	105	99.5
			57	66	55.0
			58	83	78.5
			$N_2 = 58$		$R_2 = 3346.5$

verbal flexibility. The computed U = 1286.5 and Z = -0.311. The Z score produced a p = 0.3783. The null hypothesis was accepted. The subject scores and ranks are shown in Table 20.

Subsidiary hypothesis three in this category was a statement that no significant difference existed between the SCIS curriculum and the conventional textbook curriculum in developing the learner's verbal originality. The computed U = 1100.5 and Z = -1.528. The Z score produced a p = 0.0630. The null hypothesis was rejected in favor of the alternate. The SCIS curriculum does significantly develop a learner's verbal originality. The subject scores and ranks are shown in Table 21.

To summarize, statistically significant differences were found between the experimental and control groups on scores for the Torrance Tests of Creative Thinking--Verbal in the categories of verbal fluency and verbal originality. The major null hypothesis was accepted and the subsidiary hypotheses for fluency and flexibility were rejected in favor of their respective alternates.

Analysis of Data for the Variables of Sex and I.Q. for Combined Groups

The scores of the subjects in both the experimental and control groups were combined and analyzed to observe the affects of sex differences and I.Q. The mean was computed in each of the four categories and scores above the mean were considered as high and scores below the mean were considered

TABLE 20

GROUP DATA FOR CREATIVE THINKING--
VERBAL FLEXIBILITY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	39	81.5	1	23	19.5
2	35	64.0	2	34	61.5
3	45	93.0	3	28	40.5
4	45	93.0	4	36	67.0
5	37	72.5	5	38	77.5
6	38	77.5	6	28	40.5
7	46	95.5	7	23	19.5
8	28	40.5	8	33	56.0
9	48	99.5	9	31	50.0
10	42	87.0	10	29	46.0
11	33	56.0	11	26	32.5
12	43	88.5	12	34	61.5
13	36	67.0	13	28	40.5
14	25	28.5	14	25	28.5
15	24	24.0	15	19	77.5
16	34	61.5	16	23	19.5
17	29	46.0	17	17	3.0
18	19	7.5	18	27	35.5
19	43	88.5	19	18	5.5
20	48	99.5	20	18	5.5
21	25	28.5	21	24	24.0
22	33	56.0	22	41	85.5
23	17	3.0	23	34	61.5
24	44	90.5	24	37	72.5
25	22	16.5	25	28	40.5
26	30	48.0	26	36	67.0
27	47	97.0	27	39	81.5
28	28	40.5	28	33	56.0
29	27	35.5	29	48	99.5
30	46	95.5	30	37	72.5
31	39	81.5	31	26	32.5
32	24	24.0	32	23	19.5
33	22	16.5	33	20	10.5
34	20	10.5	34	20	10.5
35	15	1.0	35	20	10.5
36	21	14.0	36	31	50.0
37	24	24.0	37	17	3.0
38	37	72.5	38	52	104.0
39	21	4.0	39	41	85.5

TABLE 20--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	37	72.5	40	48	99.5
41	24	24.0	41	38	77.5
42	36	67.0	42	38	77.5
43	25	28.5	43	21	14.0
44	26	32.5	44	28	40.5
45	29	46.0	45	33	56.0
46	32	52.0	46	50	103.0
			47	28	40.5
$N_1 = 46$		$R_1 = 2452.5$	48	36	67.0
			49	33	56.0
			50	37	72.5
			51	39	81.5
			52	44	90.5
			53	33	56.0
			54	45	93.0
			55	26	32.5
			56	49	102.0
			57	31	50.0
			58	40	84.0
			$N_2 = 58$		$R_2 = 3067.5$

TABLE 21

GROUP DATA FOR CREATIVE THINKING--
VERBAL ORIGINALITY

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
1	63	83.0	1	30	33.0
2	70	93.0	2	23	22.0
3	76	97.0	3	43	65.5
4	69	91.0	4	42	62.0
5	74	96.0	5	61	81.0
6	81	102.0	6	31	36.0
7	79	100.0	7	20	13.0
8	35	46.0	8	36	50.0
9	69	91.0	9	35	46.0
10	60	80.0	10	32	38.0
11	42	62.0	11	27	28.0
12	64	84.0	12	48	71.5
13	47	68.5	13	34	42.5
14	21	16.0	14	16	7.5
15	26	25.5	15	14	6.0
16	48	71.5	16	13	4.5
17	26	25.5	17	17	9.0
18	37	53.0	18	48	71.5
19	65	85.0	19	12	2.5
20	66	86.0	20	22	19.0
21	37	53.0	21	13	4.5
22	42	62.0	22	85	104.0
23	10	1.0	23	36	50.0
24	67	87.5	24	67	87.5
25	35	46.0	25	19	10.5
26	22	19.0	26	50	74.0
27	80	101.0	27	54	77.0
28	29	30.5	28	34	42.5
29	33	40.0	29	62	82.0
30	68	89.0	30	41	58.5
31	42	62.0	31	35	46.0
32	27	28.0	32	30	33.0
33	20	13.0	33	21	16.0
34	29	30.5	34	33	40.0
35	16	7.5	35	12	2.5
36	24	24.0	36	27	28.0
37	23	22.0	37	22	19.0
38	37	53.0	38	69	91.0
39	48	71.5	39	40	56.5

TABLE 21--Continued

Experimental			Control		
Student No.	Score	Rank	Student No.	Score	Rank
40	84	103.0	40	77	98.5
41	30	33.0	41	53	76.0
42	31	36.0	42	77	98.5
43	46	67.0	43	20	13.0
44	38	55.0	44	19	10.5
45	23	22.0	45	21	16.0
46	31	36.0	46	73	95.0
			47	36	50.0
			48	33	40.0
			49	51	75.0
			50	43	65.5
			51	57	78.0
			52	71	94.0
			53	42	62.0
			54	47	68.5
			55	41	58.5
			56	59	79.0
			57	40	56.5
			58	35	46.0
$N_1 = 46$		$R_1 = 2648.5$	$N_2 = 58$		$R_2 = 2816$

low. The mean I.Q. was computed for the total combined groups and those I.Q. scores above the mean were considered high and I.Q. scores below the mean considered low. Results of these computations are shown in Table 22.

TABLE 22

SUMMARY DATA FOR FOUR TEST INSTRUMENTS

Instrument	Mean	No. of Sub-jects	No. of Males	No. of Females	Avg. I.Q. for Group Responding
Scientific Curiosity Inventory (SCI)	172.3	102	50	52	115.0
Scale of Attitudes (SAS)	46.4	106	52	54	115.2
Creative Thinking Figural (CRTF)	148.5	99	49	50	115.0
Creative Thinking Verbal (CRTV)	137.5	104	50	54	115.6

From these data, 2 x 2 contingency tables were constructed and the chi square computed. Null hypotheses were stated for each of the categories and tested at the confidence level of $p \geq 0.10$.

Scientific Curiosity Inventory.

H_o There is no significant difference between boys and girls with respect to the responses on the Scientific Curiosity Inventory.

The frequencies of male, female, high and low scores are summarized in the following contingency table.

	Male	Female	Total
High SCI	25	15	40
Low SCI	25	37	62
Total	50	52	102 df = 1

The chi square was computed using the following formula:[1]

$$X^2 = \frac{N(IAD-BCI-\frac{N}{2})^2}{(A+B)(C+D)(A+C)(B+D)}$$

$$X^2 = \frac{102\left(1(25)(32)-(15)(25)1-\frac{102}{2}\right)^2}{(40)(62)(50)(52)}$$

$$X^2 = 3.93$$

The probability of occurrence under H_o for $X^2 \geq 3.93$ with df = 1 is $p<.02>.05$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. Boys have a higher degree of scientific curiosity than girls.

H_o There is no significant difference in I.Q. levels of subjects and scores on the Scientific Curiosity Inventory.

The frequencies for high and low I.Q. and high and low score on the Scientific Curiosity Inventory are shown below:

---

[1]Siegel, op. cit., pp. 104-111.

	High I.Q.	Low I.Q.	Total	
High SCI	22	18	40	
Low SCI	32	30	62	
Total	54	48	102	df = 1

The chi square was computed as follows:

$$X^2 = \frac{102\left(1(22)(30)-(18)(32)1-\frac{102}{2}\right)2}{(40)(62)(54)(48)}$$

$$X^2 = 0.04$$

The probability of occurrence under H_o for $X^2 \geq 0.04$, df = 1, is $p<0.90>0.80$. The p is more than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

Scale of Attitudes Towards Science and Scientists.

H_o There is no significant difference between boys and girls with respect to the responses for the Scale of Attitudes Towards Science and Scientists.

The frequencies of male, female, high and low score are summarized in the following contingency table:

	Male	Female	Total	
High SAS	31	24	55	
Low SAS	20	31	51	
Total	51	55	106	df = 1

The chi square was calculated as follows:

$$X^2 = \frac{106\left(1(31)(31)-(24)(20)1-\frac{106}{2}\right)^2}{(55)(51)(51)(55)}$$

$$X^2 = 2.46$$

The probability of occurrence under H_o for $X^2 \geq 2.46$ with df = 1 is $p<.10>.20$. The p is more than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

H_o There is no significant difference in I.Q. levels of subjects and scores on the Scale of Attitudes Towards Science and Scientists.

The frequencies for high and low I.Q. and high and low score on the Scale of Attitudes Towards Science and Scientists are shown in the contingency table below:

	High I.Q.	Low I.Q.	Total	
High SAS	32	24	56	
Low SAS	20	30	50	
Total	52	54	106	df = 1

The chi square was calculated as follows:

$$X^2 = \frac{106\left(1(32)(30)-(24)(20)-\frac{106}{2}\right)^2}{(56)(50)(52)(54)}$$

$$X^2 = 2.45$$

The probability of occurrence under H_o for $X^2 \geq 2.45$ with df = 1 is $p<.20>.10$. The p is more than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

Figural Creative Thinking.

H_o There is no significant difference between boys and girls with respect to the responses for the Figural Creative Thinking Tests.

The frequencies for male, female, and high and low scores for the figural tests are shown in the contingency table below:

	Male	Female	Total	
High CRTF	25	24	49	
Low CRTF	22	28	50	
Total	47	52	99	df = 1

The chi square was computed as follows:

$$X^2 = \frac{99\left(1(25)(28)-(24)(22)-\frac{99}{2}\right)^2}{(49)(50)(47)(52)}$$

$$X^2 = 0.35$$

The probability of occurrence under H_o for $X^2 \geq 0.35$ with df = 1 is $p<0.50>0.30$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

H_o There is no significant difference between I.Q. levels of the subjects and the subject responses on the Figural Creative Thinking Tests.

The frequencies for high and low I.Q. and high and low scores for the figural tests are summarized in the contingency table below:

	High I.Q.	Low I.Q.	Total	
High CRTF	24	23	47	
Low CRTF	26	26	52	
Total	50	49	99	df = 1

The chi square was computed as follows:

$$X^2 = \frac{99\left(1(24)(26)-(23)(26)1-\frac{99}{2}\right)^2}{(47)(52)(50)(49)}$$

$$X^2 = 0.009$$

The probability of occurrence under H_o for $X^2 \geq 0.009$ with df = 1 is $p<0.98>0.95$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

Verbal Creative Thinking.

H_o There is no significant difference between boys and girls with respect to the responses for the Verbal Tests of Creative Thinking.

The frequencies for male, female, and high and low scores on the Verbal Tests of Creative Thinking are summarized in the contingency table below:

	Male	Female	Total	
High CRTV	18	29	47	
Low CRTV	32	25	57	
Total	50	54	104	df = 1

The chi square was computed as follows:

$$X^2 = \frac{104\left(1(18)(25)-(29)(32)1-\frac{104}{2}\right)^2}{(47)(57)(50)(54)}$$

$$X^2 = 2.61$$

The probability of occurrence under H_o for $X^2 \geq 2.61$ with df = 1 is $p<.20>0.10$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted.

H_o There is no significant difference between I.Q. levels of the subjects and the subjects responses on the Verbal Creative Thinking Tests.

The frequencies for high and low I.Q. and high and low scores on the Verbal Creative Thinking Tests are summarized in the contingency table below:

	High I.Q.	Low I.Q.	Total
High CRTV	33	16	49
Low CRTV	18	37	55
Total	51	53	104 df = 1

The chi square was computed as follows:

$$X^2 = \frac{104\left(1(33)(37)-(18)(16)-\frac{104}{2}\right)^2}{(49)(55)(51)(53)}$$

$$X^2 = 11.08$$

The probability of occurrence under H_o for $X^2 \geq 11.08$, df = 1, is $p<.001$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was

rejected. I.Q. is indicated to have an effect upon a subject's verbal creative thinking score.

Analysis of Data for the Variables of Sex and I.Q. for Experimental and Control Groups Separately

Scientific Curiosity Inventory.

H_o There is no significant difference between boys and girls with respect to the responses on the Scientific Curiosity Inventory.

The frequencies for male, female, high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group	Male	Female		
High SCI	6	7	13	
Low SCI	18	13	31	
Total	24	20	44	df=1

Control Group	Male	Female		
High SCI	19	8	27	
Low SCI	7	24	31	
Total	26	32	58	df=1

The chi square was computed as follows:

$$X^2 = \frac{44\left(1(6)(13)-(18)(7)1-\frac{44}{2}\right)^2}{(13)(31)(24)(20)} \qquad X^2 = \frac{58\left(1(19)(24)-(8)(7)-\frac{58}{2}\right)^2}{(27)(31)(26)(32)}$$

$$X^2 = \frac{29744}{193440} \qquad X^2 = \frac{8069482}{696384}$$

$$X^2 = 0.15 \qquad X^2 = 11.58$$

The probability of occurrence under H_o for $X^2 \geq 0.15$ with df = 1 is p = 0.70. The p is greater than that required for significance at p = 0.10, therefore the null hypothesis was accepted for the experimental group.

The data for the control group produced a $X^2 = 11.58$ and the probability of occurrence under H_o for $X^2 \geq 11.58$ with df = 1 is $p > 0.001$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. Boys in the control group do exhibit a higher degree of scientific curiosity than the girls in the group.

H_o There is no significant difference between I.Q. levels of the subjects and the subjects responses on the Scientific Curiosity Inventory.

The frequencies of high and low I.Q. and high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group

	High I.Q.	Low I.Q.	
High SCI	5	7	12
Low SCI	17	15	32
Total	22	22	44 df=1

Control Group

	High I.Q.	Low I.Q.	
High SCI	17	11	28
Low SCI	15	15	30
Total	32	26	58 df=1

The chi square was computed as follows:

$$X^2 = \frac{44\left(1(5)(15)-(17)(7)1-\frac{44}{2}\right)^2}{(12)(32)(22)(22)} \qquad X^2 = \frac{58\left(1(17)(15)-(15)(11)1-\frac{58}{2}\right)^2}{(28)(30)(32)(26)}$$

$X^2 = 0.12$ $\qquad$ $X^2 = 0.23$

The data for the experimental group produced a $X^2 = 0.12$ and the probability of occurrence under H_o for $X^2 \geq 0.12$ with df = 1 is $p > .50 < .70$. The p is greater than that required for

significance at p = 0.10, therefore, the null hypothesis was accepted for the experimental group.

The control group data produced a $X^2 = 0.23$. The probability of occurrence under H_o for $X^2 = 0.23$ with df = 1 is $p<.50<.70$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the control group.

Scale of Attitudes Towards Science and Scientists (SAS).

H_o There is no significant difference between boys and girls with respect to the responses on the Scale of Attitudes Towards Science and Scientists.

The frequencies for male, female, high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group

	Male	Female	
High SAS	16	15	31
Low SAS	7	6	13
Total	23	21	44 df=1

$$X^2 = \frac{44\left(1(16)(6)-(15)(7)1-\frac{44}{2}\right)^2}{(31)(13)(23)(21)}$$

$$X^2 = \frac{44(9-22)^2}{131649} = \frac{7436}{131649}$$

$$X^2 = 0.56$$

Control Group

	Male	Female	
High SAS	15	9	24
Low SAS	13	25	38
Total	28	34	62 df=1

$$X^2 = \frac{62\left(1(15)(25)-(13)(9)1-\frac{62}{2}\right)^2}{(24)(39)(29)(34)}$$

$$X^2 = \frac{3194798}{922896}$$

$$X^2 = 3.46$$

Using the data for the experimental group, the probability of occurrence under H_o for $X^2 = 0.56$ with df = 1 is $p<.30<.50$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the experimental group.

The data for the control group produced a $X^2 = 3.46$. The probability of occurrence under H_o for $X^2 = 3.46$ with df = 1 is $p<.50<.10$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. Boys in the control group have a more positive attitude towards science and scientists than the girls in the control group.

H_o There is no significant difference between I.Q. scores of the subjects and the subjects scores on the Scale of Attitudes Towards Science and Scientists.

The frequencies for high and low I.Q. and high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group

	High I.Q.	Low I.Q.	
High SAS	16	17	33
Low SAS	5	6	11
Total	21	23	44 df=1

Control Group

	High I.Q.	Low I.Q.	
High SAS	16	7	23
Low SAS	15	24	39
Total	31	31	62 df=1

$$X^2 = \frac{44\left(1(16)(6)-(17)(5)1-\frac{44}{2}\right)^2}{(33)(11)(21)(23)} \qquad X^2 = \frac{62\left(1(16)(24)-(15)(7)1-\frac{62}{2}\right)^2}{(23)(39)(31)(31)}$$

$$X^2 = \frac{5324}{175329} \qquad X^2 = \frac{3813248}{862017}$$

$$X^2 = 0.03 \qquad X^2 = 4.42$$

The data for the experimental group produced a $X^2 = 0.03$. The probability of occurrence under H_o for $X^2 = 0.03$ with df = 1 is $p<.80<.90$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the experimental group.

The data for the control group produced a $X^2 = 4.42$. The probability of occurrence under H_o for $X^2 = 4.42$ with df = 1 is $p<.02<.05$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. Students in the control group with a high I.Q. score higher on the Scale of Attitudes Towards Science and Scientists than students with low I.Q. score.

Figural Creative Thinking.

H_o There is no significant difference between boys and girls with respect to the responses on the test for figural creative thinking.

The fluencies for male, female, high and low scores for the experimental group and control group are summarized in the following contingency tables:

Experimental Group

	Male	Female	
High CRTF	14	11	25
Low CRTF	7	9	16
Total	21	20	41 df=1

$$X^2 = \frac{41\left(1(14)(9)-(7)(11)-\frac{41}{2}\right)^2}{(25)(16)(21)(20)}$$

$$X^2 = \frac{33292}{115500}$$

$$X^2 = 0.29$$

Control Group

	Male	Female	
High CRTF	11	13	24
Low CRTF	15	19	34
Total	26	32	58 DF=1

$$X^2 = \frac{58\left(1(11)(19)-(15)(13)1-\frac{58}{2}\right)^2}{(24)(34)(26)(32)}$$

$$X^2 = \frac{13050}{678912}$$

$$X^2 = 0.02$$

For the experimental group, the probability of occurrence under H_o for $X^2 = 0.29$ with df = 1 in $p<.50<.70$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the experimental group.

For the control group, the probability of occurrence under H_o for $X^2 = 0.02$ with df = 1 is $p<.70<.80$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the control group.

H_o There is no significant difference between I.Q. levels and subjects scores on the figural creative thinking tests.

The frequencies for high and low I.Q., and high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group

	High I.Q.	Low I.Q.	
High CRTF	11	12	23
Low CRTF	7	11	18
Total	18	23	41 df=1

$$X^2 = \frac{41\left(1(11)(11)-(7)(12)1-\frac{41}{2}\right)^2}{(23)(18)(18)(23)}$$

$$X^2 = 0.07$$

Control Group

	High I.Q.	Low I.Q.	
High CRTF	13	11	24
Low CRTF	19	15	34
Total	32	26	58 DF=1

$$X^2 = \frac{58\left(1(13)(15)-(19)(11)1-\frac{58}{2}\right)^2}{(24)(34)(32)(26)}$$

$$X^2 = 0.02$$

For the experimental group, the probability of occurrence under H_o for $X^2 = 0.07$ with df = 1 is $p<.70<.80$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the experimental group.

For the control group, the probability of occurrence under H_o for $X^2 = 0.02$ with df = 1 is $p<.80<.90$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the control group.

Verbal Creative Thinking.

H_o There is no significant difference between boys and girls with respect to the responses on the tests for verbal creative thinking.

The fluencies of male, female, high and low scores for the experimental and control groups are summarized in the following contingency tables:

Experimental Group

	Male	Female	
High CRTV	5	12	17
Low CRTV	19	10	29
Total	24	22	46 df=1

$$X^2 = \frac{46\left(1(15)(10)-(19)(12)1-\frac{46}{2}\right)^2}{(17)(29)(24)(22)}$$

$$X^2 = 4.24$$

Control Group

	Male	Female	
High CRTV	13	17	30
Low CRTV	13	15	28
Total	26	32	58 df=1

$$X^2 = \frac{58\left(1(13)(15)-(13)(17)1-\frac{58}{2}\right)^2}{(30)(28)(26)(32)}$$

$$X^2 = .0007$$

For the experimental group, the probability for occurrence under H_o for $X^2 = 4.24$ with df = 1 is $p<.02<.05$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. With respect to this group, girls in the experimental group score higher than boys in the experimental group on the tests for verbal creative thinking.

For the control group, the probability for occurrence under H_o for $X^2 = 0.007$ with df = 1 is $p<.90<.95$. The p is greater than that required for significance at p = 0.10, therefore, the null hypothesis was accepted for the control group.

H_o There is no significant difference between I.Q. levels and the scores on the verbal tests of creative thinking.

The frequencies for high and low I.Q., and high and low scores for the experimental and control group are summarized in the following contingency tables:

Experimental Group

	High I.Q.	Low I.Q.	
High CRTV	12	8	20
Low CRTV	10	16	26
Total	22	24	46 df=1

$$X^2 = \frac{46\left(1(12)(16)-(10)(8)1-\frac{46}{2}\right)^2}{(20)(26)(22)(24)}$$

$$X^2 = 1.34$$

Control Group

	High I.Q.	Low I.Q.	
High CRTV	21	8	29
Low CRTV	8	21	29
Total	29	29	58 df=1

$$X^2 = \frac{58\left(1(21)(21)-(8)(8)1-\frac{58}{2}\right)^2}{(29)(29)(29)(29)}$$

$$X^2 = 9.93$$

For the experimental group, the probability of occurrence under H_o for $X^2 = 1.34$ with df = 1 is $p<.20<.30$. The p is greater than that required for significance at p = 1.10, therefore, the null hypothesis was accepted for the experimental group.

For the control group, the probability of occurrence under H_o for $X^2 = 9.93$ with df = 1 is $p<.001<.01$. The p is less than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. With respect to the control group, the subjects with a high I.Q. score higher on the verbal tests of creative thinking than subjects with a low I.Q.

Summary of I.Q. and Sex Variable Analysis

The experimental and control groups were combined and the chi square statistic was used to analyze the variables of I.Q. and sex. With respect to the combined groups,

significant differences were found between sex and the scores of the Scientific Curiosity Inventory, and I.Q. and the scores for verbal creative thinking.

Significant differences were found when the groups were treated separately as follows:

(1) For the experimental group, girls score higher on the verbal creative thinking tests than boys.

(2) For the control group, differences were found for sex and scientific curiosity, sex and scientific attitude, I.Q. and scientific attitude, and I.Q. and verbal creative thinking.

Factor Analysis of the Four Test Instruments

Principal components factor analysis with varimax rotations to insure orthogonality of factors was used in the factor analysis. Scores on seven divergent thinking scores (figural fluency, figural flexibility, figural originality, figural elaboration, verbal fluency, verbal flexibility, and verbal originality), two attitude scores (attitude towards science, and attitude towards scientists, and five curiosity scores (empirical, rational, authoritative, general curiosity, and interest) from the combined groups were used in the analysis. The 1130 IBM computer was used to compute the matrixes using the P-stat statistical package. Means and standard deviations for the fourteen variables are summarized in Table 23.

The 14 x 14 correlation matrix is provided in Table 24. Inspection of the correlation matrix reveals that all five of the curiosity subscores are correlated with other

TABLE 23

MEAN AND STANDARD DEVIATION FOR FOURTEEN VARIABLES

	Variable	Mean	Standard Deviation
1.	Scientific Curiosity Inventory--Empirical (SCIE)	34.8	7.93
2.	Scientific Curiosity Inventory--Rational (SCIR)	34.4	10.02
3.	Scientific Curiosity Inventory--Authoritative (SCIA)	17.4	7.13
4.	Scientific Curiosity Inventory--General (SCIG)	42.3	10.32
5.	Scientific Curiosity Inventory--Interest (SCII)	130.0	24.60
6.	Attitude Towards Science (SASS)	21.7	4.17
7.	Attitude Towards Scientists (SATS)	24.4	5.26
8.	Creative Thinking Figural Fluency (CRTF)	21.2	6.71
9.	Creative Thinking Figural Flexibility (CRTX)	17.1	4.71
10.	Creative Thinking Figural Originality (CRTO)	29.1	10.77
11.	Creative Thinking Figural Elaboration (CRTE)	83.6	28.65
12.	Creative Thinking Verbal Fluency (CTVF)	64.8	23.21
13.	Creative Thinking Verbal Flexibility (CTVX)	32.5	9.05
14.	Creative Thinking Verbal Originality (CTVO)	42.1	20.27

TABLE 24

MATRIX OF CORRELATION COEFFICIENTS FOR FOURTEEN VARIABLES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. SCIE	1.00													
2. SCIR	0.81	1.00												
3. SCIA	0.32	0.71	1.00											
4. SCIG	0.92	0.95	0.61	1.00										
5. SCII	0.36	0.49	0.42	0.47	1.00									
6. SASS	0.18	0.16	0.01	0.16	0.24	1.00								
7. SATS	0.21	0.26	0.09	0.23	0.26	0.64	1.00							
8. CRTF	0.03	0.19	-0.04	0.02	0.04	-0.02	0.13	1.00						
9. CRTX	0.14	0.14	0.15	0.14	0.11	-0.02	0.11	0.88	1.00					
10. CRTO	0.02	0.05	0.10	0.04	0.09	0.13	0.21	0.72	0.74	1.00				
11. CRTE	0.10	0.01	-0.07	0.08	0.12	0.10	0.13	0.44	0.40	0.51	1.00			
12. CTVF	0.02	0.10	0.08	0.05	0.15	0.06	0.11	0.09	0.12	0.05	-0.08	1.00		
13. CTVX	0.12	0.16	0.02	0.13	0.21	0.12	0.23	0.09	0.18	0.09	-0.07	0.86	1.00	
14. CTVO	0.01	-0.01	-0.09	-0.01	0.03	0.17	0.17	0.14	0.15	0.09	0.02	0.79	0.81	1.00

curiosity variables. The seven divergent thinking scores are all also correlated with each other. The figural scores are correlated with figural scores and verbal scores with verbal scores. The attitude scores are also correlated with the attitude scores.

The principal components factor analysis extracted four factors. The fourteen variables under study measure four traits. The varimax rotated factors are presented in Table 25. The four factors extracted were:

Factor I: Scientific Curiosity (loadings on all five curiosity scores).

Factor II: Figural Divergent Thinking (loadings on all four of the figural test scores).

Factor III: Verbal Divergent Thinking (loadings on all three of the verbal test scores).

Factor IV: Scientific Attitude (loadings on both scientific attitude scores).

The contribution of each factor to the total communality are shown at the bottom of Table 25. Factor I accounts for 37.2 percent of the variance, Factor II for 31.7 percent, Factor III for 18.1 percent, and Factor IV for 9.3 percent of the total variance. The percent variance for the four factors was added and 96.3 percent of the total variance is accounted for by the four factors.

The rotated factors presented in Table 25 are amenable to interpretation. Inspection of the matrix suggest four independent and distinct factors. Factor I is a curiosity factor. The scores for the empirical, rational, authoritative,

and general sections all have high loadings on Factor I. The interest scores (Part II of the inventory) has a relatively high loading, 0.49. The high loadings indicate that the scores may be added and treated as a total score. A further indication is that the high loading of the general curiosity variable, 0.98 suggests this score could be used as an estimate of the scores on part I of the inventory.

TABLE 25

ORTHOGONAL FACTOR MATRIX (VARIMAX)

Variable	Factor I	II	III	IV
1. SCIE	0.84	0.05	0.00	0.18
2. SCIR	0.96	0.02	0.05	0.09
3. SCIA	0.73	-0.01	-0.01	-0.12
4. SCIG	0.98	0.04	0.01	0.11
5. SCII	0.49	0.06	0.10	0.23
6. SASS	0.09	0.02	0.06	0.74
7. SATS	0.16	0.13	0.12	0.71
8. CRTF	-0.02	0.91	0.09	-0.04
9. CRTX	0.11	0.90	0.13	-0.07
10. CRTO	0.02	0.81	0.04	0.12
11. CRTE	0.01	0.54	-0.09	0.16
12. CTVF	0.06	0.00	0.91	-0.01
13. CTVX	0.11	0.04	0.92	0.11
14. CTVO	-0.06	0.07	0.86	0.14
Characteristic Roots	3.76	2.69	2.23	1.04
Percent Variance	37.2	31.7	18.1	9.3
Total % Variance	96.3			

The loadings on Factor II suggest a divergent figural factor. All loadings on this factor are near zero except those loadings for the figural creative thinking tests. The

high loadings on this factor suggest that the sub-scores on the test could be added to yield a total score.

Factor III is a divergent verbal factor. The high positive loadings for verbal fluency, flexibility, and originality indicates that the scores may be added and treated as a total score.

Factor IV is a scientific attitude factor. The only high loadings on this factor are from the scores on the Scale of Attitudes Towards Science and Scientists, Parts 1 and 2. Loadings indicate that the scores may be added and treated as a total score.

CHAPTER V

INTERPRETATION OF DATA

The problem investigated by this study was the affect of the Science Curriculum Study upon children who were involved with that curriculum for six years. Specifically, the affect upon scientific curiosity, scientific attitude, and creative thinking was studied. The study was primarily concerned with comparing the performance by two groups of students on the Scientific Curiosity Inventory, the Scale of Attitudes Towards Science and Scientists, and the Torrance Tests of Creative Thinking, Figural and Verbal. The group designated as the experimental group had experienced only the SCIS curriculum for six years and the group designated as the control group had experienced only a conventional textbook curriculum for six years. Comparisons of the groups were made relative to the variables of sex and I.Q.

The two groups were selected from schools which were similar in their structural organization and in curricular design. The educational experiences of the two groups of students were similar except for the way they had experienced science. Additionally, the subjects were selected from the middle socio-economic stratum and their chronological ages

had approximately the same distribution.

The subjects' responses on each of the instruments were tallied and compared. The scores were statistically analyzed in three categories. First, the Mann-Whitney U statistic was used to compare scores of the experimental and control group and the decision was made whether to accept or reject four major null hypotheses and fourteen subsidiary null hypotheses.

The second analysis was in two parts. The chi square statistic was used to analyze the responses of the subjects when both the experimental and control groups were combined. This analysis was with respect to the variables of I.Q. and sex. The chi square analysis was used further to analyze responses on the test instruments using the data from the experimental and control group separately.

A third analysis with the application of a principal-axis factor analysis was performed on the scores of the combined groups. This last factor analysis was performed using the data from the fourteen subscores on the test instruments.

Statistical Tests of the Hypotheses of the Study

The subjects' responses on each of the instruments were tallied and compared. Scores were statistically analyzed and the decision was made whether to accept or reject the null hypothesis. A summary of these data is shown in Table 26.

TABLE 26

SUMMARY OF TESTS OF SIGNIFICANCE

Test Instrument	Confidence Level ($p \leq 0.10$)	Difference
Scientific Curiosity Inventory Total	p=0.0475	significant
Empirical	p=0.1762	not significant
Rational	p=0.3372	not significant
Authoritative	p=0.0008	significant
General	p=0.4960	not significant
Interest (Part II)	p=0.0174	significant
Scale of Attitudes Total	p=0.00011	significant
Science (Part I)	p=0.00016	significant
Scientists (Part II)	p=0.0007	significant
Figural Creative Thinking Total	p=0.0075	significant
Figural Fluency	p=0.0853	significant
Figural Flexibility	p=0.0630	significant
Figural Originality	p=0.0281	significant
Figural Elaboration	p=0.0668	significant
Verbal Creative Thinking Total	p=0.4013	not significant
Verbal Fluency	p=0.0244	significant
Verbal Flexibility	p=0.3783	not significant
Verbal Originality	p=0.0630	significant

Significant differences were found at $p < .10$ level of confidence for three of the four test instruments in the investigation. Further significant differences were found at $p < .10$ level of confidence for nine of the fourteen subscores of the four test instruments.

Three of the four major null hypothesis were rejected in favor of the respective alternate hypothesis. Ten of the fourteen subsidiary null hypotheses were rejected in favor of their respective alternates. The following alternate hypotheses were accepted.

1. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of scientific curiosity than children who have not had the same experience.

2. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of authoritative scientific curiosity than children who have not had the same experience.

3. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of scientific interest than children who have not had the same experience.

4. Children who had studied the SCIS curriculum for six years develop a significantly more positive attitude towards science and scientists than children who have not had the same experience.

5. Children who had studied the SCIS curriculum for six years develop a significantly more positive attitude toward science than children who have not had the same experience.

6. Children who had studied the SCIS curriculum for six years develop a significantly more positive attitude towards scientists than children who have not had the same experience.

7. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of figural creative thinking than children who have not had the same experience.

8. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of figural fluency than children who have not had the same experience.

9. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of figural flexibility than children who have not had the same experience.

10. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of figural originality than children who have not had the same experience.

11. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of figural elaboration than children who have not had the same experience.

12. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of verbal fluency than children who have not had the same experience.

13. Children who had studied the SCIS curriculum for six years develop a significantly higher degree of verbal originality than children who have not had the same experience.

The data from this study indicate that the SCIS curriculum is accomplishing the objective of helping children form a positive attitude towards science and scientists. The enhancement of curiosity is an outcome of the SCIS curriculum. Children in the SCIS curriculum not only develop a higher interest in science, but also persist in that interest. Support for this conclusion is shown in the scores for the Authoritative section and the Interest section of the Curiosity

Inventory. Data are also conclusive with respect to the child's development of a high level of scientific curiosity.

Results of the analysis of the creative thinking tests indicate clearly that a child who has experienced the SCIS curriculum develops figural creative thinking more than the child who has not had the same experience. A child who has experienced the SCIS curriculum will generate more ideas (fluency), more original ideas (originality), and be better able to elaborate upon a basic idea (elaboration) than children not having the same experience. Whether or not the experimental group is superior to the control group with respect to developing the ability to generate different ideas (flexibility), is not clear. With respect to figural flexibility the SCIS curriculum is clearly superior to the conventional textbook curriculum.

Interpretation of the Analysis of the Variables of Sex and I.Q.

The scores on the four test instruments by both the experimental and control groups were combined and statistically analyzed. The combination of the scores allowed for an investigation of the affect of the variables of sex and I.Q. with the treatment variable (SCIS) held constant. A second analysis was done using the scores of the experimental group and control group separately. The nature of this analysis allowed for comparison within the two groups with respect to the affect of the sex and I.Q. variables.

The findings for the total group (experimental and control groups combined) demonstrated no statistically significant difference for the comparison of I.Q. and scientific curiosity, I.Q. and scientific attitude, and I.Q. and figural creative thinking. Present measurements of I.Q. appear to be independent of scientific curiosity, scientific attitude, and figural creative thinking.

There were no significant differences in the analysis of scores for the total group for the comparison of sex and scientific attitude, sex and figural creative thinking, and sex and verbal creative thinking. Boys and girls appear to perform equally well in the areas of scientific attitude, verbal creative thinking, and figural creative thinking.

Statistically significant differences were found with the scores of the total group with respect to sex and scientific curiosity, and I.Q. and verbal creative thinking. The indications are that boys develop a higher degree of scientific curiosity than girls and high I.Q. children develop a higher level of verbal creative thinking than children with a lower I.Q. level.

The analysis of the scores of the experimental group and control group separately resulted in the acceptance of the null hypothesis of no significant difference for the experimental group in the comparison of (1) sex and scientific curiosity; (2) I.Q. and scientific curiosity; (3) sex and scientific attitude; (4) I.Q. and scientific attitude;

(5) sex and figural creative thinking; (6) I.Q. and figural creative thinking; and (7) I.Q. and verbal creative thinking. Only in the comparison of sex and the scores in verbal creative thinking was the null hypothesis rejected. Girls in the experimental group score significantly higher on the verbal creative thinking tests than boys.

Based upon the analysis of the experimental group's scores, present measurements of I.Q. are independent of scientific curiosity, scientific attitude, figural creative thinking, and verbal creative thinking. Sex is independent of scientific curiosity, scientific attitude, and figural creative thinking.

The analysis of the control group scores show no significant differences for the categories of sex and figural creative thinking, I.Q. and figural creative thinking, and sex and verbal creative thinking. Statistically significant differences were found for the categories of sex and scientific curiosity, sex and scientific attitude, I.Q. and scientific attitude, and I.Q. and verbal creative thinking. In the control group, the boys develop a higher degree of scientific curiosity and a more positive attitude towards science and scientists than girls. Further, with respect to the control group, high I.Q. pupils develop a more positive attitude towards science and scientists and develop a higher level of verbal creative thinking than low I.Q. pupils.

The test of statistically significant differences for the combined groups experimental group, and control group are summarized in Table 27.

TABLE 27

SUMMARY OF TESTS OF SIGNIFICANCE FOR SEX, I.Q. AND INSTRUMENT SCORES

Comparison	Experimental Group Difference	Control Group Difference	Total Group Difference
Sex and SCI	Not significant	Significant	Significant
Sex and SAS	Not significant	Significant	Not significant
Sex and CTF	Not significant	Not significant	Not significant
Sex and CTV	Significant	Not significant	Not significant
I.Q. and SCI	Not significant	Significant	Not significant
I.Q. and SAS	Not significant	Significant	Not significant
I.Q. and CTF	Not significant	Not significant	Not significant
I.Q. and CTV	Not significant	Significant	Significant

Inspection of Table 27 reveals a pattern in the data. First, the measures of figural creative thinking (CTF) are independent of sex and I.Q. Support for this interpretation is seen in the data that no significant differences exist in the total group, experimental group, or the control group with respect to the sex and I.Q. variables. The significant differences reported in Table 26 can be attributed to the SCIS curriculum. The SCIS curriculum does develop figural creative thinking, figural fluency, figural flexibility, figural originality, and figural elaboration to a higher level than the conventional textbook curriculum.

Significant differences were found for the sex and scientific curiosity category (SCI) for the total group and the control group. However, no significant difference was found in the sex and SCI category for the experimental group. Interpretation of these data would indicate that a student's scientific curiosity is developed regardless of sex if that student has experienced the SCIS curriculum.

No significant differences were found for the combined groups on scientific attitude (SAS) when those scores were compared to the variables of sex and I.Q. The same finding is also shown for the experimental group. By comparison, the control group analysis produced significant differences in the sex and scientific attitude and the I.Q. and scientific attitude categories. The findings indicate that sex and I.Q. are independent of scientific attitude in the experimental group, but not in the control group. The finding for sex and scientific attitude for the experimental and total group is consistent with the findings of Motz.[1] However, the control group finding that boys have a more positive attitude than the girls is not. This may indicate that the conventional textbook program causes boys to develop a more positive attitude towards science and scientists than girls and that the SCIS curriculum develops a positive attitude regardless of sex. The I.Q. and scientific attitude finding

---

[1]Motz, op. cit.

for the experimental group is contrary to the Motz study whereas the finding for the control and combined is not. Evidently, the SCIS develops a low I.Q. child's scientific attitude equally as well as a high I.Q. student. By comparison, the attitude scores of the children who had experienced the conventional textbook curriculum are affected by I.Q. level. The higher I.Q. students of this group tend to develop a more positive scientific attitude than the low I.Q. student.

The findings for verbal creative thinking (CTV) are particularly interesting. First, the analysis for the total group scores on sex and verbal creative thinking shows no significant difference. This finding is inconsistent with the Torrance studies reported in Chapter II.[2] The analysis of the control group scores also yields no significant difference, yet, the analysis for the experimental group shows a significant difference in favor of the girls. Girls in the experimental group score higher on the verbal tests of creative thinking than boys. The experimental group is evidently performing in a way that is consistent with other studies of creative thinking whereas the control group is not.

The analyses for the total group and control group shows a significant difference relative to I.Q. and verbal creative thinking. There was no significant difference

---

[2] Torrance, op. cit.

between I.Q. level and verbal creative thinking scores in the experimental group. The finding for the experimental group is again consistent with the Torrance studies of I.Q. and creative thinking whereas the total and control group are not.[3] Indications are that if a child has experienced the SCIS curriculum, I.Q. is independent of verbal creative thinking.

Interpretation of Factor Analysis

The factor analysis of the fourteen variables (subscores on the four test instruments) indicate that scientific curiosity, scientific attitude, figural creative thinking, and verbal creative thinking are separate and distinct factors. The analysis leads to the interpretation that a structure exists in each of these categories and each test instrument measures the characteristic structure independent of the other test instruments.

The factor matrix presented in Table 25, Chapter IV, shows high loadings on four factors. The four factors extracted were Factor 1--scientific curiosity, Factor 2--figural divergent thinking, Factor 3--verbal divergent thinking, and Factor 4--scientific attitude. The fourteen subscores of the four test instruments measure these four traits.

Further interpretation of the matrix indicates that the instruments used in this study measure what the instruments

---

[3] Ibid.

were designed to measure. Each instrument has loadings that are separate and distinct and within the scope of this research study, measures only those factors for which there are high loadings.

The factor analysis indicates that subjects in this study form mental structures which may be called scientific curiosity, scientific attitude, figural divergent thinking and verbal divergent thinking. The development of these four mental structures is affected by the way in which the subject experiences science.

With respect to the four major hypotheses and fourteen subsidiary hypotheses of this study, the structures of scientific curiosity, scientific attitude, and figural divergent thinking are more highly developed in a child who has experienced the SCIS curriculum as compared to a child who has experienced a conventional textbook program. The results are not clear with respect to verbal divergent thinking.

The SCIS curriculum does develop verbal fluency and originality to a higher level than the conventional textbook program. These two variables have high loadings on the verbal divergent factor. There was no significant difference between the experimental group and control group with respect to verbal flexibility and total score on verbal creative thinking. Perhaps the high loading of verbal flexibility (0.92) must carry more weight than the other two subscores on the verbal creative thinking test.

In addition to the combined group analysis two separate matrixes were computed to inquire into the nature of the factors for the experimental and control group, separately. The computed matrixes are presented in Appendix E. Examination of these matrixes reveal that the four factors of scientific curiosity, scientific attitude, verbal divergent thinking, and figural divergent thinking are separate and distinct in both the experimental and control groups. This is consistent to the factor matrix computed for the total group.

Comparison of Subjects Attitude Scores to Professional Scientists

During the course of the analysis of the data in this investigation, the observation was made that the mean of the experimental group scores on the Scale of Attitudes Towards Science and Scientists was higher than the mean of the control group. The decision was made to compare the subjects scores on the Attitude Scale to a group of professional scientists. The group chosen for comparison to the SCIS group of sixth grade students consisted of 32 college professors of chemistry, physics, biology, and geology.

The null hypothesis that no significant difference existed between the SCIS sixth grade group and the professional group with respect to scores on the Scale of Attitudes Towards Science and Scientists was tested. A t test was used to test the null hypothesis at the $p = 0.10$ level of

confidence. A t-value of 1.296 was required for significance at the p = 0.10 level.

The t was computed using the following formula:[4]

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2 + s_2^2}{N_1 + N_2}}}$$

where X_1 = mean of professional group

X_2 = mean of comparison group

s_1^2 = variance of the professional group

s_2^2 = variance of comparison group

N_1 = number in the professional group

N_2 = number in the comparison group

The degree of freedom for the t test was computed by the following formula: degree of freedom (df) = $N_1 + N_2 - 2$.

The variance was computed by

$$s^2 = \frac{N\Sigma X^2 - (\Sigma X)^2}{N(N-1)}$$

where X = raw score
N = number in the group

Scores and data for the SCIS group, the professional group and conventional textbook group are shown in Appendix F. The computed mean for the professional group was 50.9; the SCIS group was 50.2; and the conventional textbook group was 42.0.

---

[4]George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, 1966), p. 168.

The variance for the professional group was computed as follows:

$$s^2 = \frac{(32)(83602) - (2656900)}{32\ (31)}$$

$$s^2 = \frac{18364}{992}$$

$$s^2 = 18.5$$

The variance for the SCIS group was determined by:

$$s^2 = \frac{(44)(2209) - (111529)}{44(43)}$$

$$s^2 = 14333$$

$$s^2 = 7.8$$

The t-value for the professional group and SCIS group was computed in the following manner:

$$t = \frac{50.9 - 50.2}{\sqrt{\frac{18.5}{32} + \frac{7.8}{44}}}$$

$$t = \frac{0.70}{0.87}$$

$$t = 0.80$$

$$df = 32 + 44 - 2$$

$$df = 74$$

The $t = 0.80$ with $df = 74$ is less than that required for significance at $p = 0.10$, therefore, the null hypothesis was accepted. There is no significant difference between the sixth grade SCIS group and the professional group with respect to scores of the Scale of Attitudes Towards Science and Scientists.

A second t test was calculated using the data from the conventional textbook group as compared to the professional group. The null hypothesis that no significant difference exists between the conventional textbook group and professional group with respect to scores on the Scale of Attitudes Towards Science and Scientists was tested at the 0.10 level of confidence.

The variance for the conventional textbook group was computed as follows:

$$s^2 = \frac{63(2646) - (124439)}{63(62)}$$

$$s^2 = \frac{42259}{3906}$$

$$s^2 = 10.8$$

The t was calculated in the following manner:

$$t = \frac{50.9 - 42.0}{\sqrt{\frac{18.5}{32} + \frac{10.8}{63}}}$$

$$t = \frac{8.9}{.87}$$

$$t = 10.23$$

$$df = 32 + 63 - 2$$

$$df = 93$$

The t = 10.23 with df = 93 is greater than that required for significance at p = 0.10, therefore, the null hypothesis was rejected. The professional group scored significantly higher on the Scale of Attitudes Towards Science and Scientists than the sixth grade conventional textbook group.

The findings in the comparison of the professional group to the sixth grade SCIS group indicates that, as measured by the Scale of Attitudes Towards Science and Scientists, the SCIS sixth grade group is as positively oriented towards science and scientists as the professional group. In view of the other findings reported in this study relative to scientific attitude, the SCIS curriculum not only develops a positive attitude in children towards science and scientists, but their development of attitude is on a level approximately equal to a group of professionals. As expected, the attitudes of the professional group was significantly higher than the conventional textbook group.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study was designed to investigate the influence of the Science Curriculum Improvement Study on scientific curiosity, scientific attitude, and creative thinking. The investigation was conducted by comparing scores on four test instruments of students who had experienced the SCIS curriculum for six years with students who had experienced a conventional textbook curriculum for the same length of time. The analysis of the data from the four test instruments presented in Chapter IV and the interpretation of the data presented in Chapter V leads to the following conclusions:

1. The SCIS develops a higher degree of scientific curiosity, develops a more positive attitude towards science and scientists, and develops a higher level of figural creative thinking than pupils in a conventional textbook curriculum regardless of sex and I.Q. level.

2. The SCIS curriculum does develop a pupil's scientific curiosity to the level that he persists in that curiosity and has a higher level of interest than the conventional textbook curriculum. Further, the SCIS curriculum

develops a higher level of scientific curiosity than the conventional textbook curriculum regardless of the I.Q. level of the child or whether the child is male or female.

3. The SCIS curriculum develops in a pupil a more positive attitude towards science and scientists than a pupil who has not experienced SCIS. Those pupils who have studied the SCIS curriculum for six years form attitudes toward science and scientists that are not distinguishable from practicing scientists. Those pupils who studied science from a conventional textbook curriculum for six years do not develop such attitudes. The attitude development in the pupils who have had the SCIS curriculum is independent of sex and I.Q., whereas, I.Q. and sex affect attitude development of pupils who have experienced a conventional textbook curriculum.

4. The SCIS curriculum develops a student's figural creative thinking to a higher level than the conventional textbook curriculum. The student is more fluent, flexible, and original in his thinking and better elaborates upon a basic idea than students who have experienced the conventional textbook program. Variables of sex and I.Q. are indicated to be independent of figural creative thinking development for both the SCIS curriculum and the conventional textbook curriculum.

5. There is no significant difference between the experimental group and the control group with respect to verbal creative thinking. Indications are that the variable

of verbal creative thinking is affected by I.Q. and sex. I.Q. is independent of the development of verbal creative thinking with regard to the SCIS curriculum, however, I.Q. affects the way in which a pupil scores on verbal creative thinking tasks in the conventional textbook curriculum. Sex is independent of the development of verbal creative thinking with regard to the conventional curriculum, but not in the SCIS curriculum. The SCIS curriculum develops a student's verbal fluency, and originality to a higher level than the conventional textbook curriculum. Findings indicate that the student who has experienced SCIS will generate more ideas and more original ideas than a student who has not had the same experience.

6. Girls who have experienced the SCIS curriculum develop as high a degree of scientific curiosity and scientific attitude as boys who have had the same experience. Further, girls in the SCIS curriculum develop a more positive attitude towards science than boys or girls in a conventional textbook curriculum.

7. I.Q. is indicated to be independent of a subject's performance on figural creative thinking tasks whether or not the subject has experienced the SCIS curriculum. I.Q. is also independent of a subject's performance on verbal creative thinking tasks if the subject has experienced the SCIS curriculum. A child's verbal creative thinking is indicated to be related to I.Q. if the child has experienced the conventional textbook curriculum.

8. The variables of scientific curiosity, scientific attitude, figural divergent thinking, and verbal divergent thinking are independent and distinct factors. Each factor represents an underlying mental structure and students who have experienced the SCIS curriculum develop the structures of scientific curiosity, scientific attitude, and figural divergent thinking to a higher degree than students who have experienced a conventional textbook curriculum.

9. The attention of education is currently focused upon accountability. One definition of accountability in science would be the development in students of attitudes towards science and scientists that favorably agree with those attitudes of practicing scientists. From that frame of reference, the data presented here clearly demonstrates that the SCIS program has high educational accountability.

Generally, the results of this study, if viewed with the rationale developed in Chapter I, would indicate that the SCIS curriculum is superior to the conventional textbook curriculum in developing scientific curiosity, scientific attitude, and figural creative thinking. The findings indicate that the SCIS program is educationally beneficial and superior to a textbook program. Further, the SCIS curriculum is accomplishing the objective stated for the program of leading children to form positive attitudes towards science.

The SCIS program states that scientific literacy is the overall objective of the program. The SCIS defines

scientific literacy as a blend of a person's basic knowledge, investigative experience, and attitude.[1] The program states further that children seek to organize and advance their thinking and develop a disciplined curiosity and form positive attitudes towards science as they explore phenomena and learn to cope confidently with new and unexpected findings. In this respect, according to the SCIS, they "resemble scientists."[2] The comparison of the SCIS group to the professional scientist group with respect to attitude towards science and scientists indicates that the SCIS curriculum is accomplishing the objective of scientific literacy.

The Weber and Renner[3] study of science process development, if viewed in light of the findings of this present study, also indicates the development of scientific literacy. The group of students used in the Weber and Renner study was the same group as the SCIS group (experimental group) used in this present study. The SCIS group scored higher on the Science Process Test than the conventional textbook group. The processes measured by the Science Process Test, i.e., observing, measuring, classifying, predicting, experimenting, and interpreting data define scientific literacy. Support for this statement is due to the finding that the SCIS group

---

[1]Science Curriculum Improvement Study, Sample Guide, op. cit., p. 6.

[2]Ibid.

[3]Weber and Renner, op. cit.

of students scored higher on the process test and that same group of students are indistinguishable from the professional scientists with respect to attitudes towards science and scientists.

Recommendations

The findings of this study lead the investigator to make the following recommendations:

1. Elementary school teachers, administrators, and supervisors are all concerned about scientific curiosity, scientific attitude, and creative thinking. They should, therefore, closely consider the SCIS curriculum for use in their schools. The beneficial results from such a program should weigh heavily upon the decision as to what experiences to provide children.

2. This study seems somewhat hampered by the use of I.Q. measures as a comparison tool. A study of the level of the creative thinking tasks and Piaget's levels of development would probably be a fruitful investigation. Investigations into the relationships of creative thinking and stages of intellectual growth are also indicated.

3. Affective behavior may be long term or short term process. A long range study of students carrying into their adolescent years could indicate the long term residual effects of attitude in areas other than science. The SCIS students in this study were indicated to have a positive attitude

towards science. A study of the effect of further science courses in the junior and senior high school would help understand the long range affect upon attitude and curiosity.

4. An expanded replication of this study to provide a broader basis for making conclusions is recommended. The investigator recommends a large, diverse population be selected for inclusion in such a study. This may include different grade levels, socio-economic levels, and different geographic areas.

5. A study of the relationship of curiosity, attitude, and science process development is recommended. The literature yields studies that have been performed relative to the process of science and these studies seem to have elements that are common to the factors studied in this investigation. Also, components of creative thinking seem closely allied to the essential experiences of science-observing, measuring, classifying, experimenting, data interpretation, predicting, and model building.

BIBLIOGRAPHY

Books

Allport, Gordon W. "Attitudes." Reading in Attitude Theory and Measurement. Edited by Martin Fishbein. New York: John Wiley and Sons, Inc., 1967.

Almy, Millie. Logical Thinking in Second Grade. New York: Teachers College Press, Columbia University, 1970.

American Association for the Advancement of Science. Science--A Process Approach, Commentary for Teachers. Washington, D.C.: American Association for the Advancement of Science, 1965.

Campbell, Donald T., and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally and Company, 1963.

Furth, Hans G. Piaget and Knowledge. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1969.

Getzels, Jacob W., and Jackson, Philip W. "The Highly Intelligent and the Highly Creative Adolescent." Scientific Creativity: Its Recognition and Development. Edited by Calvin W. Taylor and Frank Barron. New York: John Wiley and Sons, Inc., 1963.

Gowan, John Curtis. "What Makes a Gifted Child Creative--Four Theories." Creativity: Its Educational Implications. Edited by J. C. Gowan, G. D. Demos, and E. P. Torrance. New York: John Wiley and Sons, Inc., 1967.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill Book Company, 1965.

Guilford, J. P. Psychometric Methods. New York: McGraw-Hill Book Company, 1954.

Hurd, Paul D., et al. "Science Education for Changing Times." Rethinking Science Education. Fifty-ninth Yearbook of the National Society for the Study of Education, Part I. Chicago: University of Chicago Press, 1960.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart, and Winston, 1964.

Karplus, Robert, and Thier, Herbert D. A New Look at Elementary School Science. Chicago: Rand McNally and Company, 1967.

Krathewohl, David R.; Bloom, Benjamin S.; and Masia, Bertram B. Taxonomy of Educational Objectives: Affective Domain. New York: David McKay Company, Inc., 1964.

Nunnally, Jum C. Psychological Tests and Multivariate Statistics. New York: McGraw-Hill Book Company, Inc., 1964.

Nunnally, Jum C. Tests and Measurements. New York: McGraw-Hill Book Company, 1959.

Piaget, Jean. Psychology of Intelligence. Patterson, N.J.: Littlefield, Adams, and Company, 1963.

Renner, John W.; Stafford, Don G.; and Ragan, William B. Teaching Science in the Elementary School. New York: Harper and Row, Publishers, 1973.

Siegel, Sidney. Non-Parametric Statistics. New York: McGraw-Hill Book Company, Inc., 1956.

Torrance, E. Paul. Education and the Creative Potential. Minneapolis, Minn.: The University of Minnesota Press, 1963.

Torrance, E. Paul. "Explorations in Creative Thinking in the Early School Years." Scientific Creativity: Its Recognition and Development. Edited by Calvin W. Taylor and Frank Barron. New York: John Wiley and Sons, Inc., 1963.

Periodicals

Bruce, Larry R. "A Study of the Relationship Between the SCIS Teacher's Attitude Toward the Teacher-Student Relationship and Question Types." Journal of Research in Science Teaching, Vol. 8, No. 2, 1971.

Diederich, Paul B. "Components of the Scientific Attitude." The Science Teacher, February, 1967.

Glass, Gene V. "The Wisdom of Scientific Inquiry on Education." Journal of Research in Science Teaching, Vol. 9, Issue 1, 1972.

Haney, Richard E. "The Development of Scientific Attitudes." The Science Teacher, Vol. 31, No. 8, December, 1964.

Klopfer, Leopold E. "Effectiveness and Effects of ESSP Astronomy Units--An Illustrative Study of Evaluation in a Curriculum Development Project." Journal of Research in Science Teaching, Vol. 6, 1969.

Landry, Richard G. "The Factorial Orthogonality of the Torrance Tests of Creative Thinking and the Culture-Fair Intelligence Test." College of Education Record, University of North Dakota, Vol. 57, No. 2, November, 1971.

Lowry, Lawrence. "Development of An Attitude Measuring Instrument for Science Education." School Science and Mathematics, Vol. LXVI, No. 5, May, 1966.

Raun, Chester E., and Butts, David P. "The Relationship Between the Strategies of Inquiry in Science and Student Cognitive and Affective Behavioral Change." Journal of Research in Science Teaching, Vol. 5, 1968.

Stafford, Donald G., and Renner, John W. "SCIS Helps the First Grader to Use Logic in Problem Solving." School Science and Mathematics, February, 1971.

Vitrogan, David. "A Method for Determining a Generalized Attitude of High School Students Toward Science." Science Education, Vol. 51, No. 2, March, 1967.

Weber, Marvin C., and Renner, John W. "How Effective is the SCIS Program." School Science and Mathematics, November, 1972, pp. 729-734.

Wilson, John H., and Renner, John W. "The New Science and the Rational Powers: A Research Study." Journal of Research in Science Teaching, VI, 1969.

Pamphlets and Manuals

Educational Policies Commission. The Central Purpose of American Education. Washington, D.C.: National Education Association, 1961.

Educational Policies Commission. Education and the Spirit of Science. Washington, D.C.: National Education Association, 1966.

Educational Service Incorporated. Introduction to the Elementary Science Study. St. Louis: Webster Division, McGraw-Hill Book Company, 1966.

Karplus, Robert, ed. What Is Curriculum Evaluation--Six Answers. Berkeley: Science Curriculum Improvement Study, 1968.

Renner, John W.; Stafford, Donald G.; Weber, M. C.; Coffia, W. J.; and Kellogg, Donald H. Research Studies of SCIS Success in the Classroom. Chicago: Rand McNally and Company, 1972.

Science Curriculum Improvement Study. Sample Guide. Chicago: Rand McNally and Company, 1970.

Torrance, E. Paul. Torrance Tests of Creative Thinking, Norm-Technical Manual. Princeton, N.J.: Personnel Press, Inc., 1966.

Warner, W. Lloyd; Meeker, Marchia; and Eells, Kenneth. Social Class in America: Manual of Procedure for the Measurement of Social Status. Harper Torchbook ed. New York: Harper and Brothers, Publishers, 1960.

Unpublished Materials

Allen, Leslie Robert. "An Examination of the Classifactory Ability of Children Who Have Been Exposed to One of the "New" Elementary Science Programs." Unpublished doctoral dissertation, University of California, 1967.

Chalmer, Freda. "The Effect of Selected Frostig Visual Perception Units on First Grade Children's Achievement on the Science Curriculum Improvement Study Unit Material Objects." Unpublished doctoral dissertation, State University of New York at Buffalo, 1969.

Coffia, William. "The Effects of an Inquiry-Oriented Curriculum in Science on a Child's Achievement in Selected Academic Areas." Unpublished doctoral dissertation, University of Oklahoma, 1971.

Deady, Gene M. "The Effects of an Increased Time Allotment of Student Attitudes and Achievements in Science." Paper presented at the annual meeting of the National Association for Research in Science Teaching, Minneapolis, Minn., March 5-8, 1970. ERIC ED039126.

Motz, LaMoine L. "The Development of an Instrument to Evaluate Sixth and Ninth Grade Students' Attitudes Toward Science and Scientists." Unpublished doctoral dissertation, University of Michigan, 1970.

Partin, Melba S. "An Investigation of the Effectiveness of the AAAS Process Method Upon the Achievement and Interest in Science for Selected Fourth Grade Students." Unpublished doctoral dissertation, University of Southern Mississippi, 1967.

Ransom, Wayne E. "Effect of Science--A Process Approach on Creative Thinking and Performance in Selected Processes of Science in the Second Grade." Unpublished doctoral dissertation, Syracuse University, 1968.

Richardson, Rayman P. "Development and Use of the SCI Inventory to Measure Upper Elementary School Children's Scientific Curiosity and Interest." Unpublished doctoral dissertation, The Ohio State University, 1971.

APPENDIX A

RELIABILITY DATA FOR THE SCIENTIFIC CURIOSITY INVENTORY

Reliability Determination for the Scientific Curiosity Inventory

The reliability coefficients for Part I, Part II, and total scores for the Scientific Curiosity Inventory were determined by the Rulon method.[1] The formula used in the Rulon method is:

$$r_{tt} = 1-s^2d/s^2t$$

where r_{tt} if the reliability coefficient and s^2d is the variance between the individual scores from two test halves (odd and even items). The symbol for the total variance of the two test halves is s^2t.

The data obtained from the subjects used in the determination are summarized in Table 28. The X and Y column represent the two half-test-scores. The X column represents the number of odd items correct and the Y column is the number of even items correct. The dj column is the difference between the two half-test scores. The d^2j column is the difference squared. The total score for each subject is shown in column tj and the total score squared is represented by the t^2j column.

The individual score variance was determined by the following equation: $S^2d = \frac{d^2j}{N} - (\frac{dj}{N})^2$

where d^2j is the total squared half-test score difference; dj is the total difference in half-test scores; and N is the

---

[1]David Magnusson, Test Theory (Reading, Mass.: Addison-Wesley Publishing Company, 1966), p. iii.

number of subjects. Thus from the data in Table 28:

$$s^2d = \frac{141}{30} - \left(\frac{49}{30}\right)^2$$

$$s^2d = 4.70 - 2.66$$

$$s^2d = 2.04$$

The total score variance, s^2t is determined by the equation:

$$s^2t = \frac{t^2j}{N} - \left(\frac{tj}{N}\right)^2$$

where t^2j is the sum of subject scores squared; tj is the sum of subject scores, and N is the number of subjects.

Using the data from Table 28:

$$s^2t = \frac{2937}{30} - \left(\frac{287}{30}\right)^2$$

$$s^2t = 97.90 - 91.58$$

$$s^2t = 6.32$$

By substitution,

$$r_{tt} = 1 - \frac{2.04}{6.32}$$

$$r_{tt} = 1 - 0.33$$

$$r_{tt} = 0.67$$

TABLE 28

DATA FOR RELIABILITY DETERMINATION
Scientific Curiosity Inventory
Part I

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	4	6	-2	4	10	100
2	6	4	2	4	10	100
3	6	5	1	1	11	121
4	5	7	-3	4	12	144
5	6	5	1	1	11	121
6	2	6	-4	16	8	64
7	7	7	0	0	14	196
8	4	4	0	0	8	64
9	4	6	-2	4	10	100
10	2	3	-1	1	5	25
11	8	7	1	1	15	225
12	2	3	-1	1	5	25
13	2	4	-2	4	6	36
14	5	5	0	0	10	100
15	4	4	0	0	8	64
16	3	7	-4	16	10	100
17	4	5	-1	1	9	81
18	4	7	-3	9	11	121
19	4	4	0	0	8	64
20	3	5	-2	4	8	64
21	7	7	0	0	14	196
22	3	4	-1	1	7	49
23	6	7	-1	1	13	169
24	3	4	-1	1	7	49
25	6	4	2	4	10	100
26	8	3	5	25	11	121
27	4	6	-2	4	10	100

TABLE 28--Continued

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
28	3	3	0	0	6	36
29	3	8	-5	25	11	121
30	3	6	-3	9	9	81
N = 30			dj = 49	d^2j = 141	tj = 287	t^2j = 2938

The reliability coefficient for Part II was determined using the Rulon method as follows. Using the data in Table 29:

1. $s^2d = \frac{299}{30} - \left(\frac{73}{30}\right)^2$

$s^2d = 9.97 - 5.90$

$s^2d = 4.07$

2. $s^2t = \frac{11679}{30} - \left(\frac{541}{30}\right)^2$

$s^2t = 389.30 - 325.08$

$s^2t = 64.22$

By substitution,

$$r_{tt} = 1 - \frac{4.07}{64.22}$$

$r_{tt} = 1 - 0.06$

$r_{tt} = 0.94$

The reliability coefficient for the total of Parts I and II was determined using the same method. The data from Table 30 yields the following calculations:

1. $s^2d = \frac{306}{30} - \frac{(66)^2}{(30)}$

$s^2d = 10.20 - 4.84$

$s^2d = t.36$

2. $s^2t = \frac{24518}{30} - \frac{(804)^2}{(30)}$

$s^2t = 817.27 - 718.24$

$s^2t = 99.03$

By substitution:

$$r_{tt} = 1 - \frac{5.36}{99.03}$$

$r_{tt} = 1 - 0.05$

$r_{tt} = 0.95$

TABLE 29

DATA FOR RELIABILITY DETERMINATION
Scientific Curiosity Inventory
Part II

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	8	5	3	9	13	169
2	6	3	3	9	9	81
3	2	3	-1	1	5	25
4	12	10	2	4	22	484
5	6	7	-1	1	13	169
6	12	9	3	9	21	441
7	7	7	0	0	14	196
8	11	4	7	49	15	225
9	13	10	3	9	23	529
10	17	16	1	1	33	1089
11	21	20	1	1	41	1681
12	2	2	0	0	4	16
13	8	3	5	25	11	121
14	13	9	4	16	22	484
15	4	2	2	4	6	36
16	16	12	4	16	28	784
17	14	12	2	4	28	784
18	19	17	2	4	36	1296
19	2	2	0	0	4	16
20	10	9	1	1	19	361
21	8	10	-2	4	18	324
22	5	12	-7	49	16	289
23	7	8	-1	1	15	224
24	13	7	6	36	20	400
25	2	3	1	1	5	25
26	8	6	2	4	14	196
27	11	11	0	0	22	484
28	12	8	4	16	20	400
29	9	9	0	0	18	324
30	15	10	5	25	25	625
			$\Sigma dj=73$	$\Sigma d^2j=299$	$\Sigma tj=541$	$\Sigma t^2j=11679$

TABLE 30

DATA FOR RELIABILITY DETERMINATION
Scientific Curiosity Inventory
Total Parts I and II

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	12	11	1	1	23	529
2	12	7	5	25	19	321
3	8	8	0	0	16	256
4	17	17	0	0	34	1156
5	12	12	0	0	24	576
6	14	15	-1	1	29	841
7	14	14	0	0	28	784
8	15	8	7	49	23	529
9	17	16	1	1	33	1089
10	19	19	0	0	38	1444
11	29	27	2	4	56	3136
12	4	5	-1	1	9	81
13	10	7	3	9	17	289
14	18	14	4	16	32	1024
15	8	6	2	4	14	196
16	19	19	0	0	38	1444
17	16	17	-1	1	33	1089
18	23	24	-1	1	47	2209
19	6	6	0	0	12	144
20	13	14	-1	1	26	729
21	15	17	-2	4	32	1024
22	8	16	-8	64	24	576
23	13	15	-2	4	23	784
24	16	11	5	25	27	729
25	8	7	1	1	15	225
26	16	9	7	49	25	625
27	15	17	-2	4	32	1024
28	15	11	4	16	26	676
29	9	9	0	0	18	324
30	15	10	5	25	25	625
			dj=66	Σd^2j=306	Σtj=804	Σt^2j=24518

APPENDIX B

RELIABILITY DATA FOR SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS

Reliability Determination for the Scale of Attitudes Towards Science and Scientists

The reliability coefficients for Part I, Part II, and the total of Part I and Part II were calculated using the Rulon method as presented in Appendix A.[2] The following formula were used:

$$r_{tt} = 1 - \frac{S^2d}{S^2t} \quad \text{where } S^2d = \frac{d^2j}{N} - \left(\frac{dj}{N}\right)^2 \text{ and}$$

$$S^2t = \frac{t^2j}{N} - \left(\frac{tj}{N}\right)^2$$

Using the data from Table 31, the r_{tt} for Part I was calculated as follows:

1. $S^2d = \frac{262}{30} - \left(\frac{76}{30}\right)^2$

   $S^2d = 8.73 - 6.40$

   $S^2d = 2.33$

2. $S^2t = \frac{15406}{30} - \left(\frac{670}{30}\right)^2$

   $S^2t = 513.53 - 498.63$

   $S^2t = 14.90$

By substitution:

$$r_{tt} = 1 - \frac{2.33}{14.90}$$

$$r_{tt} = 1 - 0.16$$

$$r_{tt} = 0.84$$

---

[2] Magnusson, ibid.

TABLE 31

DATA FOR RELIABILITY DETERMINATION
Scale of Attitudes Towards
Science and Scientists
Part I

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	10	14	-4	16	24	576
2	9	14	-5	25	23	529
3	10	10	6	0	20	400
4	12	15	-3	9	27	729
5	13	14	-1	1	27	729
6	10	12	-2	4	22	484
7	10	14	-4	16	24	576
8	5	8	-3	9	13	169
9	10	9	1	1	19	361
10	7	11	-4	16	18	324
11	12	15	-3	9	27	729
12	10	12	-2	4	22	484
13	10	16	-6	36	26	676
14	11	15	-4	16	26	676
15	10	11	-1	1	21	441
16	7	11	-4	16	18	324
17	8	11	-3	9	19	361
18	10	10	0	0	20	400
19	9	10	-1	1	19	361
20	12	14	-2	4	26	676
21	14	13	1	1	27	729
22	8	11	-3	9	19	361
23	10	13	-3	9	23	529
24	13	15	-2	4	28	784
25	10	15	-5	25	25	625
26	12	15	-3	9	27	729
27	9	10	-1	1	19	361
28	10	13	-3	9	23	529
29	11	12	-1	1	23	529
30	8	7	-1	1	15	225
N=30			$\Sigma dj=76$	$\Sigma d^2j=262$	$\Sigma tj=670$	$\Sigma t^2j=15406$

Using the data in Table 32, the reliability coefficient for Part II was computed as follows:

1. $s^2d = \frac{122}{30} - \left(\frac{52}{30}\right)^2$

$s^2d = 4.07 - 2.99$

$s^2d = 1.08$

2. $s^2t = \frac{20206}{30} - \left(\frac{770}{30}\right)^2$

$s^2t = 673.53 - 658.95$

$s^2t = 14.58$

By substitution:

$$r_{tt} = 1 - \frac{1.08}{14.58}$$

$r_{tt} = 1 - 0.07$

$r_{tt} = 0.93$

The data in Table 33 was used to calculate the reliability coefficient for the total of Part I and Part II. The calculations are shown below:

1. $s^2d = \frac{394}{30} - \left(\frac{84}{30}\right)^2$

$s^2d = 13.13 - 7.84$

$s^2d = 5.29$

2. $s^2t = \frac{70410}{30} - \left(\frac{1438}{30}\right)^2$

$s^2t = 2347.0 - 2297.3$

$s^2t = 49.70$

By substitution:

$$r_{tt} = 1 - \frac{5.29}{49.70}$$

$r_{tt} = 1 - 0.11$

$r_{tt} = 0.89$

TABLE 32

DATA FOR RELIABILITY DETERMINATION
Scale of Attitudes Towards
Science and Scientists
Part II

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	16	14	2	4	30	900
2	16	13	3	9	29	841
3	10	11	-1	1	21	441
4	15	16	-1	1	31	961
5	13	10	3	9	33	529
6	12	11	1	1	23	529
7	13	14	-1	1	27	729
8	10	10	0	0	20	400
9	14	14	-1	1	27	729
10	14	14	-2	4	26	676
11	16	16	-1	1	31	961
12	14	14	1	1	29	841
13	14	14	-1	1	27	729
14	16	16	-2	4	30	900
15	11	11	-1	1	21	441
16	11	11	-2	4	20	400
17	9	9	3	9	21	441
18	10	10	3	9	23	529
19	12	12	-4	16	20	400
20	11	11	3	9	25	625
21	15	15	-1	1	29	841
22	10	10	-1	1	19	361
23	11	11	3	9	25	625
24	16	16	-2	4	30	900
25	16	16	-3	9	29	841
26	15	15	-3	9	27	729
27	15	14	1	1	29	841
28	12	11	1	1	23	529
29	16	15	1	1	31	961
30	12	12	0	0	24	576
N 30			$\Sigma dj=52$	$\Sigma d^2j=122$	$\Sigma tj=770$	$\Sigma t^2j=20206$

TABLE 33

DATA FOR RELIABILITY DETERMINATION
Scale of Attitudes Towards
Science and Scientists
Totals Parts I and II

Student	Odd Half X	Even Half Y	dj	d^2j	tj	t^2j
1	26	28	-2	4	54	2916
2	25	27	-2	4	52	2704
3	20	21	-1	1	41	1681
4	27	31	-4	16	58	3364
5	26	24	2	4	50	2500
6	22	23	-1	1	45	2025
7	23	28	-5	25	51	2601
8	15	18	-3	9	33	1089
9	23	23	0	0	46	2116
10	19	25	-6	36	44	1936
11	27	31	-4	16	58	3364
12	25	26	-1	1	51	2601
13	23	30	-7	49	53	2809
14	25	31	-6	36	56	3136
15	20	22	-2	4	42	1764
16	16	20	-4	16	36	1296
17	20	20	0	0	40	1600
18	23	20	3	9	43	1849
19	17	22	-5	25	39	1521
20	26	25	1	1	51	2601
21	28	28	0	6	56	3136
22	17	21	-4	16	38	1444
23	24	24	0	0	48	2304
24	27	31	-4	16	58	3364
25	23	31	-8	64	54	2916
26	24	30	-6	36	54	2916
27	24	24	0	0	48	2304
28	22	24	-2	4	46	2116
29	27	27	0	0	54	2916
30	20	19	1	1	39	1521
N=30			$\Sigma dj=84$	$\Sigma d^2j=394$	$\Sigma tj=1438$	$\Sigma t^2j=70410$

APPENDIX C

CHARACTERISTICS OF THE SAMPLES USED IN STUDY

TABLE 34

CHARACTERISTICS OF EXPERIMENTAL GROUP

Subject	Sex	I.Q.	Age Months	Socio-Economic	Subject	Sex	I.Q.	Age Months	Socio-Economic
1.	M	134	134	22	33.	F	118	145	32
2.	F	86	143	52	34.	M	123	147	29
3.	F	131	145	34	35.	F	120	135	47
4.	M	101	145	42	36.	M	122	143	26
5.	F	135	144	32	37.	F	112	138	21
6.	M	133	135	25	38.	M	99	145	32
7.	M	115	142	39	39.	F	117	145	28
8.	M	117	145	44	40.	M	107	144	37
9.	M	111	142	52	41.	M	115	135	30
10.	F	107	137	25	42.	F	108	138	34
11.	M	129	133	28	43.	M	101	146	36
12.	M	118	136	29	44.	F	124	145	43
13.	F	125	138	23	45.	F	104	139	41
14.	M	110	147	29	46.	M	114	143	29
15.	F	129	142	28					
16.	M	97	138	41					
17.	M	102	152	46					
18.	F	118	145	40					
19.	F	113	138	44					
20.	F	114	151	30					
21.	M	107	142	32					
22.	F	113	136	36					
23.	F	126	138	30					
24.	M	81	153	39					
25.	F	127	145	30					
26.	F	118	146	39					
27.	F	102	141	30					
28.	M	116	138	34					
29.	M	117	141	25					
30.	M	114	136	36					
31.	M	103	135	33					
32.	F	118	135	39					

Number of Males = 24
Number of Females = 22
Mean I.Q. = 114
Mean Age = 141 months (11 yrs. 9 mo.)
Mean Socio-Economic Status = 34.2 (Middle)

TABLE 35

CHARACTERISTICS OF CONTROL GROUP

Subject	Sex	I.Q.	Age Months	Socio-Economic	Subject	Sex	I.Q.	Age Months	Socio-Economic
1.	F	123	136	34	33.	M	127	136	34
2.	M	90	155	34	34.	M	106	137	38
3.	M	140	136	39	35.	M	138	138	38
4.	F	114	132	30	36.	F	100	138	23
5.	F	106	140	34	37.	M	128	140	30
6.	F	102	145	34	38.	M	131	141	29
7.	M	126	133	37	39.	M	130	145	30
8.	F	125	133	30	40.	F	112	144	23
9.	M	113	138	26	41.	F	116	142	30
10.	F	106	137	26	42.	F	105	150	31
11.	F	118	138	27	43.	F	138	140	18
12.	M	93	157	34	44.	M	116	141	30
13.	F	101	142	42	45.	M	140	144	34
14.	F	132	149	34	46.	M	133	135	34
15.	M	121	138	20	47.	F	123	146	18
16.	M	129	143	23	48.	M	105	135	26
17.	M	98	150	35	49.	F	110	143	34
18.	M	127	141	3	50.	M	99	141	34
19.	M	104	140	39	51.	M	100	144	48
20.	M	92	144	52	52.	M	136	141	30
21.	F	134	133	30	53.	F	114	135	39
22.	F	114	140	45	54.	M	121	140	34
23.	M	105	136	36	55.	M	108	147	31
24.	F	131	136	30	56.	F	124	135	18
25.	M	138	135	18	57.	F	110	147	32
26.	F	121	143	34	58.	F	80	145	38
27.	F	112	143	27	59.	M	101	140	26
28.	F	115	136	30	60.	F	118	143	42
29.	F	128	139	52	61.	F	114	146	39
30.	F	125	140	24	62.	F	117	146	44
31.	F	91	150	25	63.	F	115	143	34
32.	F	126	140	30					

Male = 29
Female = 34
Mean I.Q. = 116
Mean Age = 138 (11 years 6 months)
Mean Socio-Economic Status = 32.1 (Middle)

APPENDIX D

TOTAL SCORES ON FOUR TEST INSTRUMENTS

TABLE 36

SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
EXPERIMENTAL GROUP

Student	Empirical	Rational	Authoritative	General	Interest	Total
1.	45	51	29	57	188	245
2.	46	48	15	58	184	242
3.	47	51	29	61	180	241
4.	42	42	19	54	175	229
5.	41	42	17	53	162	215
6.	43	35	10	45	165	210
7.	43	32	11	46	139	185
8.	36	36	16	47	140	187
9.	32	28	17	40	141	181
10.	37	30	4	41	144	185
11.	47	50	19	59	118	177
12.	42	43	13	50	127	177
13.	24	33	20	37	127	164
14.	43	38	15	51	121	172
15.	41	31	9	42	120	162
16.	32	36	22	40	129	169
17.	40	32	12	44	123	167
18.	36	39	12	43	121	164
19.	40	34	16	49	128	177
20.	42	40	15	50	118	168
21.	44	45	17	53	114	167
22.	37	40	31	49	118	167
23.	28	27	20	39	127	166
24.	40	44	24	48	114	162
25.	22	33	20	30	126	156
26.	42	31	5	42	121	163
27.	48	43	18	57	107	164
28.	36	34	15	40	118	157
29.	30	33	14	35	121	156
30.	32	32	14	37	125	162
31.	12	11	11	15	135	150
32.	22	25	19	32	121	153
33.	30	23	10	34	112	146
34.	50	44	14	57	101	158
35.	31	36	16	41	104	145
36.	28	29	14	34	108	142
37.	34	34	15	40	98	138
38.	42	45	24	53	96	149
39.	28	18	8	29	113	142
40.	21	18	4	21	111	132
41.	32	23	10	34	96	130
42.	25	23	7	29	89	118
43.	24	12	6	23	94	117
44.	30	20	6	30	84	114
MEAN	35.6	33.9	15.0	42.4	122.1	167.5

TABLE 37

SCORES FOR SCIENTIFIC CURIOSITY INVENTORY
CONTROL GROUP

Student	Empirical	Rational	Authoritative	General	Interest	Total
1.	46	53	22	61	190	251
2.	45	45	22	56	175	231
3.	39	40	23	49	175	224
4.	41	50	29	53	167	220
5.	49	50	17	58	161	219
6.	41	52	31	54	159	213
7.	39	49	28	52	163	215
8.	30	39	24	44	160	204
9.	41	38	16	50	162	212
10.	33	42	35	47	159	206
11.	40	45	26	53	149	202
12.	48	49	26	61	147	208
13.	30	42	24	43	142	185
14.	29	31	17	38	153	191
15.	32	29	16	38	154	192
16.	36	30	8	38	150	188
17.	41	50	33	56	139	195
18.	47	53	32	63	135	198
19.	42	48	30	57	138	195
20.	44	45	25	58	139	197
21.	34	41	27	48	140	188
22.	48	44	18	56	135	191
23.	37	34	21	42	137	179
24.	33	26	16	39	148	187
25.	30	30	19	37	141	178
26.	24	22	13	27	149	176
27.	34	35	19	43	142	185
28.	33	35	20	40	137	177
29.	34	30	15	38	132	170
30.	41	39	21	50	129	179
31.	32	36	19	42	128	170
32.	32	25	10	34	129	163
33.	21	26	15	26	133	159
34.	41	42	24	50	119	169
35.	34	33	13	40	129	169
36.	27	24	14	30	136	166
37.	32	33	19	42	124	166
38.	34	44	26	48	115	163
39.	25	20	8	28	127	155
40.	34	36	24	41	115	156

TABLE 37--Continued

Student	Empirical	Rational	Authoritative	General	Interest	Total
41.	35	28	14	37	120	157
42.	28	36	28	41	118	159
43.	27	27	22	37	118	155
44.	46	40	13	51	109	160
45.	20	22	17	30	125	154
46.	26	19	14	29	120	149
47.	40	45	18	52	102	154
48.	29	20	9	32	120	152
49.	30	25	19	36	116	152
50.	30	30	13	34	110	144
51.	36	33	19	44	107	151
52.	31	33	18	38	105	143
53.	23	25	22	32	106	138
54.	33	35	18	41	99	140
55.	28	20	10	30	108	138
56.	35	26	8	38	101	139
57.	33	25	15	37	94	131
58.	22	16	4	23	72	95
MEAN	34.5	35.1	19.4	42.9	132.9	175.0

TABLE 38

SCORES FOR SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS--EXPERIMENTAL GROUP

Student	Part I	Part II	Total
1.	30	34	62
2.	29	32	61
3.	27	32	59
4.	27	31	58
5.	27	31	58
6.	25	33	58
7.	28	29	57
8.	27	29	56
9.	25	31	56
10.	25	31	56
11.	28	28	56
12.	22	23	55
13.	24	30	54
14.	25	29	54
15.	23	30	53
16.	25	28	53
17.	27	25	52
18.	22	30	52
19.	26	26	52
20.	24	28	52
21.	23	28	51
22.	28	33	51
23.	24	27	51
24.	25	25	50
25.	24	25	49
26.	21	28	49
27.	23	26	49
28.	24	24	48
29.	22	26	48
30.	24	24	48
31.	21	26	47
32.	19	28	47
33.	25	22	47
34.	22	24	46
35.	22	22	44
36.	18	26	44
37.	24	20	44
38.	23	20	43
39.	17	25	42
40.	17	23	40
41.	21	19	40
42.	15	25	40
43.	17	22	39
44.	19	19	38
MEAN	23.5	26.7	50.2

TABLE 39

SCORES FOR SCALE OF ATTITUDES TOWARDS SCIENCE AND SCIENTISTS
CONTROL GROUP

Student	Part I	Part II	Total	Student	Part I	Part II	Total
1.	29	31	60	33.	8	27	45
2.	26	33	59	34.	20	25	45
3.	27	31	58	35.	19	26	45
4.	27	31	58	36.	23	22	45
5.	26	31	57	37.	16	29	45
6.	26	29	55	38.	19	25	44
7.	23	31	54	39.	20	23	43
8.	23	31	54	40.	21	22	43
9.	24	29	53	41.	18	24	42
10.	25	28	53	42.	20	20	40
11.	24	28	52	43.	22	18	40
12.	25	27	52	44.	19	20	39
13.	26	25	51	45.	11	28	39
14.	21	30	51	46.	18	21	39
15.	26	24	50	57.	17	22	39
16.	24	26	50	48.	16	22	38
17.	25	25	50	49.	19	19	38
18.	26	24	50	50.	20	18	38
19.	21	27	48	51.	16	20	36
20.	23	25	48	52.	16	20	36
21.	21	27	48	53.	18	16	34
22.	21	26	47	54.	20	13	33
23.	22	25	47	55.	18	14	32
24.	22	25	47	56.	17	15	32
25.	21	25	46	57.	15	16	31
26.	22	24	46	58.	17	14	31
27.	20	26	46	59.	15	16	31
28.	26	20	46	60.	16	14	30
29.	22	23	45	61.	14	14	28
30.	21	24	45	62.	13	12	25
31.	21	24	45	63.	10	9	19
32.	21	24	45				
				MEAN	20.4	21.6	42.0

TABLE 40

SCORES FOR FIGURAL CREATIVE THINKING
EXPERIMENTAL GROUP

Student	Fluency	Flexibility	Originality	Elaboration	Total
1.	020	012	015	083	140
2.	013	045	021	058	105
3.	014	012	019	042	087
4.	015	015	019	049	098
5.	026	021	037	145	229
6.	024	016	027	089	156
7.	030	021	035	088	174
8.	014	013	023	067	117
9.	037	026	064	125	252
10.	028	022	044	057	151
11.	027	024	047	125	223
12.	031	021	031	103	186
13.	020	014	025	078	137
14.	019	017	017	099	152
15.	032	024	042	085	183
16.	033	023	041	115	212
17.	009	009	018	054	090
18.	021	017	031	131	200
19.	017	012	022	109	160
20.	019	016	027	080	142
21.	020	015	028	123	186
22.	017	013	034	115	179
23.	022	018	035	103	178
24.	014	014	021	059	108
25.	024	017	021	093	154
26.	025	019	035	073	152
27.	017	017	023	056	113
28.	024	022	039	089	171
29.	014	011	031	118	174
30.	025	018	029	111	183
31.	025	023	034	065	147
32.	024	020	041	061	146
33.	025	020	041	149	235
34.	018	018	036	083	155
35.	019	018	041	125	203
36.	029	023	035	118	205
37.	033	023	048	059	163
38.	024	018	034	086	162
39.	029	020	036	062	147
40.	027	021	033	065	146
41.	017	013	021	052	102
MEAN	23.0	18.6	31.7	86.9	160.2

TABLE 41

SCORES FOR FIGURAL CREATIVE THINKING
CONTROL GROUP

Student	Fluency	Flexibility	Originality	Elaboration	Total	Student	Fluency	Flexibility	Originality	Elaboration	Total
1.	026	025	049	145	141	30.	016	015	034	103	168
2.	025	027	031	069	152	31.	026	021	029	145	221
3.	020	019	026	070	135	32.	022	019	026	078	145
4.	012	010	016	051	088	33.	030	022	044	105	201
5.	019	012	034	092	157	34.	026	019	041	118	204
6.	016	014	039	062	131	35.	011	011	015	054	091
7.	018	011	022	043	094	36.	033	022	039	096	190
8.	016	014	018	025	073	37.	020	015	029	065	129
9.	018	016	025	061	120	38.	023	019	032	085	159
10.	024	021	027	099	171	39.	019	016	028	062	125
11.	010	010	012	040	072	40.	013	011	012	063	099
12.	015	013	013	042	083	41.	015	013	021	088	137
13.	018	018	038	092	156	42.	018	016	025	083	142
14.	010	013	026	100	149	43.	020	010	014	080	124
15.	020	015	022	075	132	44.	036	019	055	130	240
16.	020	013	033	084	150	45.	015	012	014	055	096
17.	022	019	023	067	131	46.	028	022	043	104	197
18.	016	016	021	053	106	47.	015	013	021	088	137
19.	011	006	023	090	130	48.	011	010	007	034	062
20.	035	022	015	081	153	49.	011	010	017	040	078
21.	029	023	029	099	180	50.	019	016	026	089	150
22.	027	019	020	075	141	51.	017	016	026	061	120
23.	014	010	026	092	132	52.	030	024	038	078	170
24.	030	026	045	133	234	53.	024	023	023	045	115
25.	036	021	055	105	218	54.	017	011	011	069	108
26.	024	020	038	052	134	55.	030	015	038	045	128
27.	017	017	023	104	161	56.	024	022	043	076	165
28.	021	019	035	054	129	57.	029	025	039	087	182
29.	023	018	021	138	200	58.	012	007	015	096	130
						MEAN	20.7	16.2	27.5	79.4	143.8

TABLE 42

SCORES FOR VERBAL CREATIVE THINKING
EXPERIMENTAL GROUP

Student	Fluency	Flexibility	Originality	Total
1.	068	039	063	170
2.	085	035	070	190
3.	099	045	076	220
4.	076	045	069	190
5.	067	037	074	178
6.	079	038	081	198
7.	100	046	079	225
8.	042	028	035	105
9.	100	048	069	217
10.	072	042	060	174
11.	074	033	042	149
12.	073	043	064	180
13.	071	036	047	154
14.	042	025	021	088
15.	029	024	026	079
16.	058	034	048	140
17.	043	029	026	098
18.	042	019	037	098
19.	089	043	065	197
20.	109	048	066	223
21.	037	025	037	099
22.	056	033	042	131
23.	025	017	010	052
24.	088	044	067	199
25.	035	022	035	098
26.	047	030	022	099
27.	116	047	080	243
28.	048	028	029	105
29.	056	027	033	116
30.	096	046	068	210
31.	053	039	042	134
32.	035	024	027	086
33.	033	022	020	075
34.	031	020	029	080
35.	022	015	016	053
36.	028	021	024	073
37.	039	024	023	086
38.	064	037	037	139
39.	042	021	048	111
40.	071	037	084	192
41.	040	024	030	094
42.	048	036	031	115
43.	036	025	046	107
44.	050	026	038	114
45.	044	029	023	096
46.	051	032	031	114
MEAN	58.9	32.3	45.4	136.6

TABLE 43

SCORES FOR VERBAL CREATIVE THINKING
CONTROL GROUP

Student	Fluency	Flexibility	Originality	Total	Student	Fluency	Flexibility	Originality	Total
1.	087	023	030	140	30.	071	037	041	149
2.	077	034	023	134	31.	091	026	035	152
3.	087	028	043	158	32.	049	023	030	102
4.	076	036	042	154	33.	036	020	021	077
5.	092	038	061	191	34.	039	020	033	092
6.	048	028	031	107	35.	047	020	012	079
7.	035	023	020	078	36.	071	031	027	129
8.	063	033	036	132	37.	040	017	022	079
9.	049	031	035	115	38.	094	052	069	215
10.	059	029	032	120	39.	087	041	040	168
11.	044	026	027	097	40.	111	048	077	236
12.	071	034	048	153	41.	091	038	053	182
13.	053	028	034	115	42.	076	038	077	191
14.	037	025	016	078	43.	050	021	020	091
15.	046	019	015	079	44.	056	028	019	103
16.	040	023	013	076	45.	059	033	021	113
17.	042	017	017	076	46.	105	050	073	228
18.	069	027	048	144	47.	065	028	036	129
19.	026	018	013	056	48.	069	036	033	138
20.	035	018	022	075	49.	058	033	051	142
21.	029	024	013	066	50.	073	037	043	153
22.	107	041	085	233	51.	093	039	057	189
23.	071	034	036	141	52.	096	044	071	211
24.	095	037	067	199	53.	078	033	042	153
25.	055	028	019	102	54.	088	045	047	180
26.	081	036	050	167	55.	051	026	041	118
27.	083	039	054	176	56.	105	049	059	213
28.	073	033	034	140	57.	066	031	040	137
29.	093	048	062	203	58.	083	040	035	158
					MEAN	67.6	31.4	38.7	137.7

APPENDIX E

FACTOR MATRIXES FOR EXPERIMENTAL AND CONTROL GROUPS

TABLE 44

ORTHOGONAL FACTOR MATRIX (VARIMAX)
FOR THE CONTROL GROUP

Variable	Factors 1	2	3	4
SCIE	0.86	0.13	0.16	0.06
SCIR	0.96	0.04	0.10	0.16
SCIA	0.75	0.01	-0.02	0.16
SCIG	0.97	0.09	0.12	0.11
SCII	0.45	0.14	0.14	0.33
SASS	0.11	-0.06	0.07	0.76
SASP	0.35	0.08	0.12	0.70
CRTF	0.12	0.88	-0.01	-0.17
CTFX	0.27	0.86	0.00	-0.16
CRTO	0.01	0.81	-0.18	0.20
CTFE	-0.03	0.64	-0.03	0.12
CTVF	0.13	-0.08	0.89	0.10
CTVX	0.16	-0.03	0.90	0.11
CTVD	0.04	-0.08	0.88	0.02

TABLE 45

ORTHOGONAL FACTOR MATRIX (VARIMAX)
FOR THE EXPERIMENTAL GROUP

Variable	Factors 1	2	3	4
SCIE	-0.07	0.87	-0.11	0.05
SCIR	0.00	0.96	0.00	0.04
SCIA	-0.07	0.64	0.14	-0.01
SCIG	-0.06	0.98	-0.04	0.05
SCII	0.06	0.46	0.09	0.48
SASS	0.03	0.11	0.01	0.70
SASP	0.08	-0.10	0.07	0.65
CRTF	-0.19	-0.14	0.90	0.10
CTFX	0.30	-0.06	0.88	-0.01
CRTO	0.30	0.11	0.85	-0.05
CTFE	-0.13	0.09	0.42	0.11
CTVF	0.96	-0.08	0.18	0.01
CTVX	0.94	0.04	0.12	0.07
CTVD	0.87	-0.13	0.14	0.13

APPENDIX F

COMPARISON OF PROFESSIONAL SCIENTISTS

TABLE 46

ATTITUDE SCORES FOR PROFESSIONAL, SCIS AND CONVENTIONAL TEXTBOOK GROUPS

SCIS			Professional			Textbook		
Subject	Score X	X^2	Subject	Score X	X^2	Subject	Score X	X^2
1	62	3844	1	42	1764	1	60	3600
2	61	3721	2	56	3136	2	59	3881
3	59	3481	3	46	2116	3	58	3364
4	58	3364	4	60	3600	4	58	3364
5	58	3364	5	55	3025	5	57	3209
6	58	3364	6	57	2209	6	55	3025
7	57	2209	7	43	1849	7	54	2916
8	56	3136	8	54	2916	8	54	2916
9	56	3136	9	53	2809	9	53	2809
10	56	3136	10	39	1521	10	53	2809
11	56	3136	11	41	1681	11	52	2704
12	55	3025	12	50	2500	12	52	2704
13	54	2916	13	51	2601	13	51	2601
14	54	2809	14	56	3136	14	51	2601
15	53	2809	15	47	2209	15	50	2500
16	53	2809	16	54	2916	16	60	2500
17	52	2704	16	30	900	17	50	2500
18	52	2704	18	62	3844	18	50	2500
19	52	2704	19	63	3969	19	48	2304
20	51	2601	20	58	3364	20	48	2304
21	51	2601	21	57	3249	21	48	2304
22	51	2601	22	57	3249	22	47	2209
23	50	2500	23	53	2809	23	47	2209
24	49	2401	24	44	1936	24	47	2209
25	49	2401	25	46	2116	25	46	2116
26	49	2401	26	58	3364	26	46	2116
27	49	2401	27	48	2304	27	46	2116
28	48	2304	28	52	2704	28	46	2116
29	48	2304	29	48	2304	29	45	2025
30	48	2304	30	50	2500	30	45	2025
31	47	2209	31	51	3281	31	45	2015
32	47	2209	32	59	2401	32	45	2025
33	47	2209				33	45	2025
34	46	2116				34	45	2025
35	44	1936				35	45	2025
36	44	1936				36	45	2025
37	44	1936				37	45	2025
38	43	1849				38	44	1936
39	42	1764				39	43	1849
40	40	1600				40	43	1849

TABLE 46--Continued

SCIS			Professional			Textbook		
Subject	Score X	X^2	Subject	Score X	X^2	Subject	Score X	X^2
41	40	1600				41	42	1764
42	40	1600				42	40	1600
43	39	1521				43	40	1600
44	38	1444				44	39	1521
						45	39	1521
						46	39	1521
						47	39	1521
						48	38	1444
						49	38	1444
						50	38	1444
						51	36	1296
						52	36	1296
						53	34	1156
						54	33	1089
						55	32	1024
						56	32	1024
						57	31	961
						58	31	961
						59	31	961
						60	30	900
						61	28	784
						62	25	625
						63	19	361
N=44	$\Sigma X=2209$	$\Sigma X^2=111529$	N=32	$\Sigma X=1630$	$\Sigma X^2=83602$	N=63	$\Sigma X=2646$	$\Sigma X^2=124439$
	$\bar{X}=50.2$			$\bar{X}=50.9$			$\bar{X}=42.0$	