A STUDY OF AN EXPERIMENTAL PROGRAM OF INTEGRATED INDUSTRIAL ARTS-SCIENCE IN THE JUNIOR HIGH SCHOOL

Thesis for the Degree of Ed. D.

MICHIGAN STATE UNIVERSITY

Edward Louis Remick

1965

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By

Edward Louis Remick

AN ABSTRACT

Submitted to
Michigan State University
in partial fulfillment of the requirements
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DOCTOR OF EDUCATION

College of Education

1965

Approved ______________________________

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Problem. The main problem of this study was to investigate a curricular program which would aid pupils in the integration of theories, concepts, and principles of science and industry.

Procedure. This study attempted (1) to develop an integrated industrial arts-science curriculum based on the assumption that there was a definite relationship between science and industrial arts objectives, and (2) to compare the relative effectiveness of two methods of teaching at the eighth grade level.

The experimental design involved the selection of a sample (70) from the total population (428) of eighth grade students enrolled at C.W. Otto Junior High School in Lansing, Michigan, during the 1962-63 school year. This sample was randomly assigned to experimental and control groups of equal size. Initial comparison of these two groups was based upon data compiled from cumulative folders and scores recorded from STEP, Form 3A. These data were treated by using the "t" and "F" tests. Results of these statistical procedures revealed that there was no significant difference between the groups at the beginning of the program.

The control group was taught by the traditional science teaching method where the instructor prepared and gave lectures and demonstrations. The experimental group was involved in a teaching-learning situation where science and industrial arts objectives were integrated. Facilities used by the experimental group included the physical science and industrial arts laboratories. The control group used a regular science classroom.

Comparisons of academic achievement and the ability to apply theory in practical situations were made at the conclusion of the program. The evaluation instruments used to collect comparative data were the Sequential Tests of Educational Progress, Form 3B, and teacher constructed tests.

Results. A comparison of data as determined by the STEP, Form 3B was made following the experimental program. The statistical "t" test procedure revealed that there was a significant difference in the mean scores of the two groups. The mean score of the experimental group was significantly greater than the mean score of the control group.

The results of the teacher constructed tests were also compared and treated statistically through the use of the "t" test. This statistical analysis showed that there was considerable difference in the means of the control and experimental groups. The experimental group had made the more significant gain.

Conclusions. This study was intended to yield data pertaining to the effect an integrated industrial arts-science program would have on the achievement of eighth grade students. From the results of this study, it was concluded that the achievement of students in the integrated program was significantly greater than that of similar students enrolled in the regular program.

The integrated industrial arts-science method allowed for flexibility of instruction, involved considerable individual research, and incorporated manipulative activities on the part of individual students. Much of the responsibility for learning in the integrated program was placed on and accepted by the students. This involvement was a factor which accounted for high individual achievement of pupils in the experimental group.

The following recommendations were made concerning curriculum development and expansion:

1. That individualized activities by made an integral part of the science instructional program.

2. That more emphasis be placed on the need for and importance of interrelating theory and its practical applications.

3. That industrial arts techniques and experiences be incorporated in courses which deal with individualized experimentation.

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The writer wishes to express his appreciation to Doctor C. Blair MacLean, Chairman of his guidance committee, for advice, interest, and encouragement in the completion of this study.

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To the students who were the subjects in the study, the writer wishes to express his pleasure in having been privileged to work with them.

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CHAPTER I

INTRODUCTION

During the past few years of the period which has been known as the Sputnik Era, newspaper headlines and other communication media have called our attention to many problems. Among the more important are the population explosion, the possibilities of war, and the activities of industry. All three have resulted from a developing technology that has advanced at an exponential rate of staggering dimensions. The cautious observer has been both concerned and frustrated by his inability to refer to history for clues which could help him guide, control, or even understand the effects of science and industrial technology.[1]

Stanley has referred to this age as "an age of crisis where society is confused."[2] Much of the confusion stems from the fact that advances in the areas of science and industry have affected our value system, thus necessitating a continuous evaluation of societal goals.

The steady advances of science and industry have not only made it possible for man to produce new machines, new gadgets, and extraordinary plans for the future but have

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[1] Stuart Chase, "Bombs, Babies, Bulldozers," Saturday Review, XLVI, (January, 1963), pp. 21-23, 25.

[2] William Stanley, Education and Social Integration, (New York: Bureau of Publications, Columbia University, 1953), pp. 136-137.

emphasized materialistic objectives. Society has been faced with the problem of reorganizing a hierarchy of values so that it could achieve order and alleviate confusion. Wolfe states that future advances and progress of our society will be dependent upon the readiness of societies and their members to accept responsibilities and evaluate objectives.[1]

The function of the school as a social institution is to recognize cultural values and to interpolate those values in such a way that they are reflected in the behavior of the individual.

> General education should give the student a pervasive framework which will allow him to place in perspective present and future changes in his society. Here he should learn to evaluate critically new ideas and processes in terms of a heirarchy of values.[2]

In projecting some ideas about the task of education, McLure points out that science and industry have had considerable effect upon social and economic conditions within our society. He maintains that individuals must be given those educational experiences which will develop each individual's capacities so that the individual will be able to cope with problems encountered in everyday life.[3]

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[1] Dael Wolfe, America's Resources of Specialized Talent, (New York: Harper and Brothers, 1954), p. 283.

[2] Harold L. Hodgkinson, Education in Social and Cultural Perspectives, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), pp. 132-133.

[3] William P. McLure, "The Challenge of Vocational and Technical Education," Phi Delta Kappen, XLIII, (February, 1962), pp. 212-213.

According to Rarich and Read, contemporary societies have had to reassess and modify instruction in the schools to meet the perplexing problems of using scientific knowledge in its relation to industry and society.[1]

Since the first Sputnik was shot into orbit, great emphasis has been placed upon science, mathematics, and the area of industrial technology. A large part of this emphasis stems from criticism that was directed at the public schools. Some educational leaders and school administrators revised curriculums to meet this criticism and to satisfy resulting community pressures. Others have tries to evaluate their total school programs in an effort to build balance in all areas of the educational program. As a result many experimental programs were initiated in the hope that new curricular experiences and improved instruction would advance student achievements and thereby negate criticisms.

Bush reported on the efforts 708 administrators made to analyze their programs for the improvement of instruction. It was noted that a small number met the challenge of the critics. A general conclusion of the study suggested that greater effort was needed to upgrade those programs which were related to values and attitudes inherent in our scientific and industrialized culture.[2]

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[1] G.L. Rarich and John G. Read, "Criteria for Evaluating a Secondary School Program," Educational Administration and Supervision, XXXVI, (May, 1950), pp. 306-315.

[2] William T. Bush, "What Administrators Do To Improve Instruction," Phi Delta Kappen, XLI, (November, 1959), p.64.

This concern about the programs which must be developed to aid people in their understanding of science and its relationship to industry was discussed by the Educational Policies Commission. That committee suggested that students be given the opportunity to explore concepts and become actively involved in laboratory experiences.[1]

At about the same time, the National Society for the Study of Education reviewed the significance and implications of teaching innovations. Several studies were cited where teaching-learning situations provided for a wide range of interests, abilities, and student needs. These teaching-learning situations were not always restricted to specific subject matter areas. Consideration of the individual student's ability to unify and integrate experiences was exident in the design of programs which were reviewed.[2]

Because of the advance of scientific knowledge and industrial technology, contemporary societies have been confronted with the problem of providing those educational experiences which will aid students in their understanding of the areas of science and industrial arts. Discovery and invention have fostered new industries which demand highly skilled personnel for operation and research. In order to meet these demands, our schools must initiate instructional

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[1] Educational Policies Commission, Education for all American Youth, (Washington, D.C.: National Education Association, 1944), p. 24.

[2] National Society for the Study of Education, Forty-Sixth Yearbook, Part I, (Chicago: University Press, 1947), pp. 306-307.

programs that will contribute to contemporary objectives. Burkardt suggested that the schools provide opportunities and experiences which will help students acquire and develop those qualities which have proven to be of value in the areas of industry and science. He also suggested that a suitable place to introduce this type of program was the junior high school where students are receptive, are beginning their formal study of science and the field of industrial arts, are curious, are questioning new ideas to which they are being introduced, and are interested in why things happen.[1]

In teaching about industry and science, the traditional pattern has been to offer separate courses in the areas of industrial arts and science. When the objectives of these two subject matter areas are studied it is conceiveable that the two courses could be offered within one instructional program. A review of history concerning curriculum offerings, revealed that science has been concerned with theory and industrial arts with skills. Contemporary objectives call for an expansion of both fields; science should evolve theory and practive; industrial arts should be concerned with practice together with experimentation, theory, and research.

Because of the implication that the objectives of science and industrial arts were compatible, this study was begun.

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[1] Richard Burkardt, "General Education and Industrial Arts," Industrial Arts and Vocational Education, LI, (October, 1962), p. 22.

<u>Need for the Study</u>. During the past decade science and industry have had great impact on societal values and goals. In the attempt to help people understand and gain knowledge of these values and goals, educational systems utilized various techniques. The traditional types divided subject matter knowledge into segments, such as, mathematics, art, science, social studies, and industrial arts where the main emphasis was placed on content rather than on the integration of experiences and understandings. When these programs were evaluated, several conclusions were drawn. Prominent among these was the problem of determining effective teaching-learning situations where student needs are met by putting curriculum objectives in tune with contemporary societal demands.

The importance of science and industry in present day living makes it necessary to evaluate the curriculum areas of science and industrial arts within our schools. In a cursory study of science and industrial arts, considerable overlap is evident. Both areas are concerned with helping the individual understand scientific principles and their relationships to industrial technology. The development of manipulative skills in the use of tools and equipment necessary to accomplish research, experimentation, and fabrication, together with techniques in the area of problem-solving are considered as being important to both areas of learning.

A study of objectives revealed other relationships between industrial arts and science; (1) students are to be given opportunities for research, investigation, and experimentation, (2) the scientific method is to be used when problem-solving in the industrial arts lab, and (3) manipulative skills are to be developed in the shop as well as in the science lab where it is often necessary to construct equipment used in experimentation.

The interdependence of science and industrial technology in everyday life, together with the apparent interrelationship of science and industrial arts objectives within school programs, suggests that a curriculum could be designed which would provide unifying and integrating experiences.

Statement of the Problem. The main problem of this study was to investigate a curricular program which would aid students in the integration of theories, concepts, and principles of science and industrial technology.

The Purpose of the Study. This study was designed to (1) outline an instructional guide based on integrated science and industrial arts objectives, and (2) compare the relative effectiveness of two methods of teaching science at the eighth grade level. These two methods were compared with respect to (a) effectiveness in teaching factual information, and (b) practices designed to develop understanding and application of concepts.

Nature and Design of the Study. The approach used to realize the main objective of this study was the experimentation method. The experimental design involved (a) the selection of a sample from the total population of eighth grade students enrolled at the C.W. Otto Junior High School, (b) random assignment of that sample to either the experimental or control group sections, (c) administration of a pre-test to obtain data by which to determine whether any differences existed between the two groups, (d) application of a particular treatment to the experimental group, and (e) administration of a post-test used as a basis for comparison of results.

The sample consisted of 70 eighth grade pupils who attended C.W. Otto Junior High School, Lansing, Michigan, during the school year, 1962-63. One half of the randomly selected sample was assigned to the control group and the other half was assigned to the group which was involved in the integrated industrial arts-science course. An instructional guide which listed concepts and units was compiled and used as a general course outline for both the experimental and the control group. The experiment was designed to last for a period of two semesters. Alternate forms of STEP achievement tests were used to obtain pre-test and post-test data that were used in the statistical analysis.

Basic Assumptions

The basic assumptions for this investigation were as follows:

1. The methods and attitudes of science are ways of thinking and acting and as such can be taught.
2. The abilities inherent in the methods and attitudes of science and industrial arts can be evaluated.
3. The terms scientific method, methods of science, and problem-solving are used interchangeably.
4. The primary basis of the industrial arts course of study is modern-day industry.
5. Science and industrial arts are integral parts of general education.
6. A high degree of cooperativeness and compatability existed among the science teachers, the industrial arts teachers, and the administration of the school in which the experimental program was conducted.

Definition of Terms

Various terms are defined at appropriate places throughout this study. However, in order to facilitate understanding, it is desirable to clarify the meaning of certain terms at this time.

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Scientific Thinking. As used in this study, scientific thinking refers to procedures that are commonly accepted as the steps in the scientific method and to the scientific attitudes that are associated with that method.[1]

Generally, the term is perceived to be that which has reference to the individual's ability to (1) recognize and solve problems; (2) formulate and test hypotheses; (3) recognize cause and effect relationships; (4) interpret data; (5) draw conclusions; and (6) evaluate experimental procedures and practical situations which involve scientific implications.

Scientific Method. Scientific method or problem-solving approach considers science as a way of thinking and acting, a procedure as well as an organized body of knowledge accepted because of validated proof rather than "authoritative dicta."[2]

It is to be noted that five steps are usually included in what is often referred to as the scientific method. These steps include: (1) recognition of problems; (2) collection of data; (3) formulation of hypotheses; (4) testing of hypotheses; and (5) drawing of conclusions.

The problem-solving approach presupposes that answers are not given to the students in advance. Selected

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[1] Oreon Keeslar, "The Elements of Scientific Method," Science Education, XXIX, (December, 1945), pp. 273-278.

[2] John Dewey, How We Think, (Boston: D.C. Heath and Company, 1933), p. 301.

information and facts are emphasized as data to be used in solving problems and not as material to be memorized. The conclusions are evaluated in terms of consistent answers and solutions and then checked to test the validity of information gathered.

Industrial Arts Facilities. The Industrial Arts facilities referred to in this study consisted of a wood-centered laboratory equipped with workbenches, hand tools, a jig saw, a table saw, a band saw, a grinder, two lathes, and a portable electric hand drill. Metal working tools and machines were available for use in the construction of parts or equipment which incorporated metals.

Student Experimentation. As used in this study, the term "student experimentation" referred to that type of activity where the development of concepts with a unit involved finding answerw to questions and discovering solutions to problems that students had selected as being important to the study of science and its relationship to industry. Study activities developed in this way should become more meaningful, motivation more genuine, and outcomes of a more practical nature.

Although the experimentation approach cannot be divided into definite steps or stages, certain basic elements can be noted. Some pronounced elements noted in this type of approach are: (1) general pre-planning of the unit by the teacher; (2) cooperative teacher-pupil planning of activities; (3) the compilation of concepts; (4) individual or group methods of testing hypotheses; and (5) data organized which will facilitate practical application of conclusions.

Scientific Attitudes. The term "scientific attitudes" was considered as being related to those acquired and conditioned patterns of behavior which motivate the individual. These patterns of behavior are based on "habits of responding which can be modified."[1]

Noll accepted this concept of attitudes to formulate what he termed "scientific habits of thinking and acting.

1. Habit of accuracy in all operations.
2. Habit of intellectual honesty.
3. Habit of open-mindedness.
4. Habit of suspended judgement.
5. Habit of looking for the true cause and effect relationships.
6. Habit of criticism."[2]

Particular attention was given to the acquisition of these habits when the individual student was conducting experiments and developing theories or concepts in the learning situations.

Traditional Method. Because so many teaching methods are labeled the "traditional method," it is imperative that the term as used in this study be more specifically identified. This type of teaching is conservative in nature in that students are directed or channeled to achieve those

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[1] Robert L. Ebel, "What is the Scientific Attitude?", Science Education, XXII, (January, 1938), pp. 1-5.

[2] Victor H. Noll, "Teaching Science for the Purpose of Influencing Behavior," Science Education, XX, (February, 1936), pp. 17-20.

objectives which the teacher has selected. The cultivation of individual abilities is subrogated to the acquisition of factual information on the part of the entire class group. Some of the differentiating characteristics of the traditional teaching method are as follows:

1. The procedures are essentially autocratic.

2. The major emphasis is on memorizing facts and acquiring basic skills.

3. The instructor assumes sole responsibility for the presentation of subject matter and the assignment of topics to be studied by students.

4. Concern is with mass or group instruction with the emphasis being placed on factual knowledge and manipulative skills.

5. Much of the teaching learning situation involves the use of pre-assigned questions found at the end of the unit or chapter.

6. Formal informational lectures are given by the teacher.

7. Most of the class discussion time is given to teacher-question and student-answer recitations.

8. The instructor conducts experiments and demonstrations with little or no student participation.

9. The instructor assumes authority and responsibility for grades based principally upon the results of factual recall type tests.

10. Set procedures are listed for laboratory experiences because outcomes and conclusions are predetermined.

<u>Integration</u>. Contrary to popular opinion, the term "integration" is not of recent origin; one that has been added to the dictionary of educational jargon. Knudsen called attention to the fact that Spencer used the word in

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1855 and that James used the term "integration" in some of his writings done in 1896.[1]

During the past few years the word integration has appeared with increasing frequency in educational literature. The use of the term has been confusing in that various concepts and meanings have been implied by the many writers. To a number of writers and readers the word integration has been used synonymously with correlation.[2] This use of the two words synonymously is incorrect, according to Reeve. He differentiates the terms by stating that correlation means to bring aspects of one or more subjects to support other subjects while each retains its content identity; whereas, integration takes place when two subject areas are used in a process to bring out interrelationships.[3]

Case, in an article describing integration, has stated that integration is the developing and rounding out of the whole personality of the child. This connation follows the psychological concept that the individual is the integrative agent and holds that the individual is the only one who can achieve integration.[4]

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[1] Charles W. Knudsen, "What Do Educators Mean by Integration?", Harvard Educational Review, VII, (January, 1937), pp. 15-26.

[2] L. Thomas Hopkins, Integration, Its Meaning and Application, (New York: D. Appleton-Century Co., 1937), Chapt. VI.

[3] W.D. Reeve, "Mathematics and the Integrated Program in Secondary Schools," The Mathematics Teacher, XXX, (April, 1937), pp. 155-166.

[4] R.D. Case, "The Platoon School Integrates," The School Executive, LVI, (June, 1937), pp. 385.

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Woodruff, in writing about teaching and mental activity, describes integration as the process of putting together parts of previously acquired experiences in various related fashions so that new concepts are evolved.[1]

In view of the present day interest in recognizing the individual rather than mere subject matter, the use of the term integration in the psychological and educational sense connotes bringing out the unity and relatedness of experiences so that a person can respond more effectively to various situations and problems. The concept of integration as used in this study will have reference to relating the areas of science and industrial arts technology by the individual while under the direction of the teacher and/or teachers involved. The teaching-learning plan has been developed within the realm of practical problems and situations so that the individual student will be able to understand the mutual dependence and interrelationship that exists between the scientific process, various aspects of industrial arts technology, and manipulative skills.

As an example, consider the laboratory situation. If a theory or some principle is to be tested, the practice must be correct and accurate. The scientific researcher who could not balance an equation certainly could not test that equation. The fabrication of testing apparatus could

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[1] Aashel D. Woodruff, The Psychology of Teaching, New York: Longmans, Green and Company, Inc., 1946), p. 114.

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not be accomplished unless the fabricator understood what theory was to be tested.

Concern in this study was for the integrated roles that science and industrial arts are to play in the teaching-learning situation. Neither subject matter area was to play a subordinate role as neither science theory nor industrial arts practice were dealt with as separate entities. In describing concepts of his organic philosophy, Wegener used the concepts theory and practice as an example of bipolarity.

> Theory and practice exemplify bipolarity within the educational process most clearly. It is apparent that theory and practice are partly separable, partly dependent, and relatively interdependent. Furthermore, theory and practice can be equated with knowing and doing, or the pursuits of abstract understandings and practical know-how.[1]

The organiz theory combines the bipolar role of organized subject matter into the total process of teaching-learning. Through a system of interweaving, the two parts reinforce one another resulting in achievement of the functions of education. The interweaving of subject matter theories and the application of subject matter principles and concepts are necessary to achieve complete understanding. The degree of understanding would be dependent upon the integration of experiences; the number of experiences interacting would be dependent upon the amount of association or transfer in which the individual participated.

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[1] Frank C. Wegener, The Organic Philosophy of Education, (Dubuque, Iowa: Wm. C. Brown, 1957), pp. 387-398.

Teaching-learning plan of procedure. When considering the teaching-learning situations, one cannot discount the fact that a teacher would have a larger number of experiences than a student due to the number of and involvement in experiences, interactions, and integrations that have taken place. From the Gestalt viewpoint this is one of the dilemmas in the process of teaching; the great difference of student and teacher on the experience continuum. Because of this differential, the teacher proceeds to develop many interpretations that are compatible with his own thinking but not to that of the student's. True, the student may be able to rattle off or feed back responses to the instructor without any real insight into the understandings of the concept or response. To the Gestaltist, learning is the development of insight, the ability to see wholes, and the reorganization or integration of experiences and perceptions into an organized unit or entity. The implications of such a viewpoint for education are that the courses should be well organized in terms of the total unit and its respective parts. Meaningful concepts must be interrelated with experiences that can be comprehended by the individual student.[1]

Utilizing the theories of organic philosophy and the Gestalt theory of learning, a teaching-learning plan used in the integrated industrial arts-science course was developed. The plan involved four major steps, which were (1)

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[1] E. Bayles, "The Idea of Learning as Development of Insight," Educational Theory, II, (February, 1952), pp. 65-71.

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orientation, (2) interaction of theory and practical aspects, (3) integration, and (4) real knowledge.

In the initial step, the teacher and the students were oriented through discussion of objectives and possible approaches that could be followed in the study of the unit. This step was also used as a period of motivation.

Step two could involve the interaction of theory and practice. Most of the theoretical concepts would be explored by reading, directed study, lecture-demonstrations, and general observations. The same concepts were used in the student experimentation phase where assembly and construction of apparatus provided results upon which sound conclusions could be drawn.

Through the interaction of theory and practical aspects of the teaching-learning plan of procedure, a minimum level of achievement was strived for on the part of each individual. It was at this point that students were helped to assimilate ideas from the realms of theory and activity. During this third step, the students should have gained insight into the relationship aspects of theory and practice regarding concepts that were being developed.

After having aided students assimilate ideas, evaluation techniques were applied to ascertain whether or not the objectives had been met. The degree to which each student achieved would reveal how well that individual could assimilate concepts.

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ORIENTATION

DEVELOPMENT OF CONCEPTS

Theoretical aspects (Interaction) Practical aspects

INTEGRATION

REAL KNOWLEDGE

Figure 1. Teaching-learning plan of procedure.

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Organization of the Study. Since a great deal of modern practice has been inherited from the past, Chapter II will be devoted to a resume of the literature dealing with science and industrial arts teaching in the United States since their inclusion in the curriculum. A review of various attempts made at reordering those courses of study will be included in Chapter II. The major emphasis of Chapter III will be the aspects of the experimental course where industrial arts facilities are used to implement application of science theory and research to classroom problems and procedures. An example of the procedure followed in the teaching-learning situation will be included. The design of the study and some of the organizational features of classes, the population and the sample will be reviewed in Chapter IV. Chapter V will be devoted to the statistical treatment of data and the methods of evaluation used to determine the effectiveness of the experimental course. Chapter VI will include the results of the study, implications, conclusions, and suggestions for further research.

Summary

The increased emphasis on science and technology which is taking place in our society has made it imperative that schools examine curriculum programs related to those two areas. The complex industrial society of today demands that people be able to interrelate experiences and understandings that confront them within the realm of industrial technology and scientific research. To meet these continuously increasing demands, schools must formulate programs which will contribute to the achievement of desired objectives.

A review of science and industrial arts curriculum offerings revealed that science has in the past been concerned with theory and industrial arts with skills. Contemporary objectives emphasize (1) that science instruction involves the application of theories in practical situations, and (2) that industrial arts be concerned not only with manipulative skills but with experimentation and research. The problem of initiating such a revitalized instructional program instigated this study.

This study attempted (1) to develop an integrated industrial arts-science curriculum based on the assumption that there was a definite relationship between science and industrial arts objectives, and (2) to evaluate the effectiveness of the experimental teaching-learning situation where industrial arts and science were integrated in a unitary course of study.

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CHAPTER II

REVIEW OF THE LITERATURE

Literature regarding the need for making the studies of science and industry more meaningful was presented in Chapter I. Many of the studies raised the question of what method or methods would be most effective in achieving prescribed goals.

New findings in the behavioral sciences suggest the need for continuous evaluation of methodology in the classroom.

This chapter reviews literature limited largely to (1) studies of science instruction since its inclusion in the school curriculum, (2) studies of the growth of industrial arts instruction, (3) proposals for improved science and industrial arts teaching, and (4) examples of experimental attempts to integrate industrial arts and science.

<u>Studies of Science Instruction Since Its Inclusion in the School Curriculum</u>. Science education today bears the imprint of the past. Objectives, organization, and practices reveal the influence of those past viewpoints, policies and theories. As the knowledge of psychology and pedagogy has grown, practices have changed. Change has been slow, and some current practices indicate evidences of long discredited theories.

The first secondary schools in America were basically authoritarian and anti-scientific. Science entered the

schools long after the establishment of the early Latin grammar schools. The scientific revolution and the need to understand the developing scientific and technological culture forced the introduction of science into the schools. The early programs varied in what they offered, but with the introduction of textbooks in the middle of the nineteenth century and the development of the modern high schools, standardization began to develop.[1]

With the report on the seven cardinal principles of education in 1918, a major reorganization of American secondary education toward more functional goals had its beginning.[2] Science education began to reshape accordingly with newer insights into psychology and pedagogy. During the first quarter of this century, a new philosophy and psychology placed a whole new meaning on theories of activity in education. Dewey emphasized the interrelatedness of experience and education. His writings have offered a complete and workable basis for activity in many subject areas.[3]

Over the past fifty years there have been several major reports and studies which have influenced the nature and practice of science teaching in the direction of

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[1] I.L. Kandel, History of Secondary Education, (Boston: Houghton Mifflin Company, 1930), pp. 411-412.

[2] Commission on the Reorganization of Secondary Education, Cardinal Principles of Secondary Education, (Bureau of Education, Bull. No. 35, Washington: Government Printing Office, 1918).

[3] John Dewey, "My Pedagogic Creed," N.E.A. Journal, (January, 1935), pp. 23-25.

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greater functionality. Horton's study which was concerned with the effectiveness of different teaching methods has been one of the most quoted. He compared a "problem-method" in which students did undirected laboratory activities, directed laboratory activities, and a demonstration activity. He concluded that no one method was preferable in so far as written factual examinations were concerned. However, in the evaluation of the "problem-method," it was noted that the students were better able to solve problems after they had become involved in various laboratory situations and activities.[1]

In a study conducted with pupils in an eighth and ninth grade general science course, Bedell concluded that the ability to recall and the ability to infer are different abilities. He also concluded that the pupils in the lower twenty-five percent of the intelligence range have great difficulty when they attempt to infer generalized science principles from typical general science situations and in such cases it would be of help to the student if he were involved in those situations which would make science principles more realistic. He suggested that studies be made which would investigate the worth of student participation in performing the experiments rather than mere student

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[1] Ralph E. Horton, Measurable Outcomes of Individual Laboratory Work in High School Chemistry. Contributions to Education, No. 303 (New York: Bureau of Publications, Teachers College, Columbia University, 1928), p. 103.

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observation of teacher performed experiments.[1]

In writing about theories of modern instruction, the Committee on the Function of Science in General Education of the Progressive Education Association stated:

> The value of problem-solving through laboratory work in the school does not lie in the factual knowledge that may result from it but in the attitudes and habits of reflective thinking it encourages and in the understanding it gives of how the knowledge of science gained by the student from description was attained in the first place.[2]

Atkin's study pertained to the effectiveness of the conventional teaching method as contrasted to that of a laboratory method involving a considerable amount of self direction with tenth grade biology students. He found that there was no difference in the attainment of factual knowledge which could be attributed to the methods of teaching used. The laboratory method involving self direction activities seemed to show superior merit with respect to scientific attitudes. No measurement was reported regarding manipulatory skills in the study.[3]

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[1] Ralph C. Bedell, The Relationship Between the Ability to Infer in Specific Learning Situations. Unpublished Doctor's Dissertation. (Columbia, Missouri: University of Missouri, 1934), p. 57.

[2] Progressive Education Association, Science in General Education, Report of the Committee on the Function of Science in General Education, (New York: Appleton-Century Crafts, Inc., 1938), p. 317.

[3] Wesley Atkins, Some Probable Outcomes of Partial Self-Direction in Tenth Grade Biology. (Princeton: Princeton University Press, 1936). Reported in F.D. Curtis, Third Digest of Investigations in the Teaching of Science. Philadelphia: P. Blakiston's Son and Company, Inc., 1938), pp. 95-100.

Babitz and Keys matched eight chemistry classes and provided "direct and intensive instruction" dealing with the application of science principles to the experimental groups, while conventional methods of instruction were given the control groups. Every experimental group showed superiority to the control groups when tested on the application of principles and on the ability to identify the principles involved. Conclusions made included the fact that "the ability to apply principles is best learned through experiencing the thing to be learned."[1]

The individual laboratory experiment tends to be superior when experiments are problem-centered rather than cookbook procedures, according to Cunningham who analyzed thirty-seven studies dealing with the question of the superiority of the demonstration or the laboratory method of instruction.[2]

A doctoral study conducted by Mason involved working with college students enrolled in biological science. The investigation was concerned with the relative effectiveness of the scientific thinking method and the descriptive (lecture) method. He found that the two methods were equally effective with respect to the acquisition of factual

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[1] Milton Babitz and Noel Keys, "An Experiment in Teaching Pupils to Apply Scientific Principles," Science Education, XXIII, (December, 1939), pp. 367-370.

[2] Harry Allan Cunningham, "Lecture Demonstration versus Individual Laboratory Method in Science Teaching- A Summary," Science Education, XXX (March, 1946), pp.70-80.

information, of the overall objectives of the course, and of scientific attitudes. The scientific thinking method as used in laboratory instruction was more effective in developing certain abilities associated with scientific thinking than the descriptive method of lecture.[1]

In the last decade or two, high schools have increasingly offered additional science courses. In a study done by the U. S. Office of Education, a report was made of these offerings from a sample of 715 reporting high schools throughout the United States. Of the 715 reporting schools, about nineteen percent, reported additional or alternate science courses. The most common additional or alternate offering was described as an "applied-science" course.[2]

In a study carried on in the School of Education of New York University, Barnard compared the relative effectiveness of a lecture-demonstration method and a problem-solving method of teaching the biological portion of an orientation course in science. From comparisons made in the study Barnard concluded that the problem-solving method had statistically significant advantages with respect to achievement

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[1] John M. Mason, "An Experiment Study in the Teaching of Scientific Thinking in Biological Science at the College Level," Unpublished Doctor's dissertation. (East Lansing, Michigan: Michigan State College of Agriculture and Applied Science, 1950), pp. 255-256.

[2] Phillys G. Johnson, The Teaching of Science in Public High Schools. (U. S. Office of Education, Bulletin No. 9: Washington: Government Printing Office, 1950).

in problem-solving.[1]

A review of the literature pertaining to science education indicated that science instruction has undergone considerable change. Much emphasis was placed on the need for continuous evaluation of teaching methods in order that higher levels of achievement might be attained. The evidence suggested that science instruction include development of manipulative skills so that science concepts could be expanded by individual students.

Studies of the Growth of Industrial Arts Instruction. Industrial arts education had its beginning as an organized area within the educational systems in 1880 when Calvin Woodward opened the St. Louis Manual Training School. Within a few years, similar courses were organized in privately supported schools followed by rapid and widespread acceptance and inclusion in public school systems across the nation. After 1888, the Swedish sloyd, as it was developed by Salomon in Sweden, was introduced into this country by Larsson.[2] The sloyd type of handwork was modified by the differing needs of American youth and by 1930 the term "industrial arts" took the place of the original term "manual training." The use of the project method was most

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[1] J. Darrell Barnard, "The Lecture-Demonstration versus the Problem-Solving Method of Teaching a College Science Course." Science Education, XXVI (October-November, 1942), pp. 121-132.

[2] (E. Larsson), The Theory of Educational Sloyd, (New York: Silver Burdett and Company, 1906), pp. 125-150.

prevalent in that most school shops used mainly wood and constructed projects. As the change of instruction methods progressed from mere "exercises" to a series of useful articles arranged in progressive order of difficulty and increased attention was given to related information of industrial practices, the area of industrial arts became accepted as being a part of general education.[1]

During 1928, a committee on "Standards of Attainment in Industrial Arts Teaching" was appointed by the American Vocational Association. This committee consisted of the then prominent industrial education leaders interested in the area of industrial arts. This committee was concerned with what the pupil should know and be able to do in the field of industrial arts; the list may be found in _A Guide to Improving Instruction_.[2]

In the planning of the instructional program for the field of industrial arts, Ruley pointed out that all educators must have a sound philosophy on which to base their teaching. This philosophy should take into consideration the many types of responsibilities which the instructor as a teacher and a faculty member is obligated to accept and meet.[3]

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[1] Louis Newkirk and Wm. H. Johnson, _The Industrial Arts Program_, (New York: The Macmillan Company, 1948), pp. 14-15.

[2] American Vocational Association, _Improving Instruction in Industrial Education_. (Washington, D.C.: American Vocational Association, Inc., 1946), 96p.

[3] M.J. Ruley, "Responsibilities of Industrial Arts Instructors," _Industrial Arts and Vocational Education_, XXXXI, (January, 1952), p. 10.

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Schaffer was also concerned with the instructional program. He contended that the teaching-learning situation was important.

> Fulfilling the needs of our youth is certainly a serious problem. The need to learn about our society, our industrial society, is of prime importance. Where in our present curriculum might we find the equipment, materials, and processes that can best be adapted to adequately experience the problems of industry? The industrial arts shop is the answer.[1]

In commenting about how teachers are to meet the goals of education, Benjamin Willis, Superintendent of Chicago Schools, cited the necessity for a curriculum which is based upon a sequential development of content relating scientific discoveries and technological progress. He suggested that the teaching of industrial arts keep abreast of techniques and procedures which might be adapted to various instructional programs.[2]

A recent look at the problem of teaching of industrial arts designed to involve the viewpoints of teachers was done by the Industrial Arts and Vocational Education magazine. Some of the responses made to the problem concerning methods were:

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[1] Harvey Schaffer, "The Mass Production Technique of Teaching Industry," Industrial Arts and Vocational Education, XLVI, (December, 1957), pp. 309-310.

[2] Benjamin C. Willis, "Adult Education in a World Community," School Life, XLIV, (March, 1962), pp. 5-8.

> "More emphasis on...science and math... More problem-solving and experimentation activities...." L.H. Bengtson, Oklahoma State University.
>
> "Teachers must now use...(present) methods more effectively than ever before." Edwin W. Dyas, Stout State College.
>
> "The most notable change will take place in the professional concept of industrial arts...." Arthur W. Earl, Montclair State College.
>
> "Teaching methods for industrial arts must change--and soon!" Donald F. Hackett, Georgia Southern College.
>
> "Industrial arts teachers...need to become more expert in the use and application of each specific teaching method...." Arnold C. Piersall, Stout State College.
>
> "We must subject new methods to rigorous tests in the classroom." John M. Shemick, Pennsylvania State University.[1]

During the past few years, the ideas of team teaching and large group instruction have been tried in various situations in an attempt to increase teaching efficiency. Brown, Casimano, and Goodell are currently conducting a study to investigate the feasibility of using such techniques in the field of industrial arts. They hope that new concepts and practices will make industrial arts "more useful and meaningful."[2]

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[1] "Should Teaching Methods for Industrial Arts Change," Industrial Arts and Vocational Education, LI, (January, 1962), pp. 20-22.

[2] James Brown, Geno Casimano, and Jerome Goodell, "Team Teaching and Large Group Instruction in Industrial Arts." Industrial Arts and Vocational Education, LI, (April, 1962), pp. 20-23.

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In an effort to revitalize the industrial arts program, Arthur Earl suggested that the research-experimentation approach which is used in industry be modified and used in the industrial arts education program. He maintained that such a program is needed to help prepare young men for skilled positions in the technical areas of industry. He felt that the new approach would stimulate the student's activity as experiments are great motivational factors. No doubt the problem of providing for individual differences would be solved if the experiments were teacher-student planned. Such an approach which dealt with individuals should do much to alleviate the lack of interest in the area of industrial education.[1]

Marshal Schmitt, Industrial Arts Director-consultant of the U.S. Office of Education was aware of the problems in the industrial arts program when he called a number of industrial arts educators to Washington in 1960. The purpose of the conference was to provide a fresh look at the profession's problems and to stimulate a positive approach toward solving them. The results of the two-day workshop was published in a report entitled, Improving Industrial Arts Teaching. The report contained working papers dealing with the place of industrual arts in the American culture, objectives, teacher competencies, curriculum development,

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[1] Arthur W. Earl, "How to Use a Research-Experimentation Approach," Industrial Arts and Vocational Education, 49:23-25.

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and the relationship of industrial arts to other school-curriculum areas. The conference report did not suggest methods which might be used to implement the relationship of other areas into industrial arts.[1]

The method of instruction followed in the teaching of industrial arts has traditionally been centered around the construction of objects. Recent application of limited research findings has emphasized the evaluation of industrial arts objectives and instructional programs. As a result, many contemporary teaching-learning situations involve not only the building of projects but also the study of industrial technology and its relationship to other areas of learning.

Proposals for Improved Science and Industrial Arts Teaching. The review of the literature with respect to methods of teaching science has revealed a considerable amount of adverse commentary by noted educators and philosophers. Originally the textbook method was used almost exclusively.

Many years ago, Robinson wrote regarding the sole use of texts in teaching:

> Both the textbooks and manuals used in formal teaching....tend, almost without exception, to classify knowledge under generally accepted headings. They have a specious logic and orderliness which appeals to the academic mind. They

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[1] U.S. Office of Education, Improving Industrial Arts Teaching, (Washington, D.C.: Government Printing Office, 1962), 67p.

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> therefore, suit the teacher fairly well, but unhappily do not inspire the learners.[1]

The publication, "Science in General Education," was a rather lengthy committee report which stressed the importance of the methods of teaching science. The committee made an effort to show how science might be interrelated to other areas of the curriculum, thereby making science teaching-learning situations more meaningful, rather than mere textbook memorization.[2]

Walquist wrote concerning the integration of science and other subject matter areas:

> All will concede that (better integration) something has been gained when the teacher and the student are made conscious of the significance of one field in relation to other fields.[3]

Later in the same decade, Alfred Whitehead, the great philosopher and mathematician wrote concerning the teaching of subjects as parts to a whole:

> Let the main ideas which are introduced into a child's education be few and important, and let them be thrown into every combination possible. The child should understand their application

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[1] James Harvey Robinson, The Humanizing of Knowledge, (New York: Doubleday and Company, Inc., 1924), p. 67.

[2] Progressive Education Association, Science in General Education, (New York: D. Appleton Century Company, 1938), p. 591.

[3] John T. Walquist, The Philosophy of American Education, (New York: The Ronald Press Company, 1942), p. 162.

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> here and now in the circumstances of his actual life.
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> The mind is never passive; it is a perpetual activity, delicate, responsive to stimulus. You cannot postpone its life until you have sharpened it. Whatever interest attaches to you subject-matter must be evoked here and now; whatever powers you are strengthening in the pupil must be exercised here and now; whatever possibilities of mental life your teaching should impart, must be exhibited here and now.
>
> The solution which I am urging is to eradicate the fatal disconnection of subjects which kills the vitality of our modern curriculum.[1]

"We learn by doing," has long been associated with John Dewey, though there were many before him who fostered this idea. Dewey's idea of "doing" was never meant to be meaningless activity in the classroom, but rather the activity was to be related to other lessons. All laboratory sciences utilize this principle of the "experience" approach but too often the science instructor is hesitant to utilize other teaching personnel such as industrial arts instructors to further the experiences of youth.

Dewey maintained that the industrial arts laboratory could provide the opportunity for many experiences both direct and vicarious, and in the hands of a competent teacher would facilitate goal achievements.

> There is no distinction between experimental science for little children and the work done in the carpenter shop...

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[1] Alfred North Whitehead, The Aims of Education and Other Essays, (New York: New American Library, 1949), pp. 14, 18, 19.

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> children simply like to do things and watch to see what will happen. But this can be taken advantage of and can be directed into ways where it gives results of value.[1]

Similar support of this idea may be found in the Harvard Report.

> In the final section of this chapter we shall say something about the importance of shop training in general education. For those who intend to go into scientific or technological work, it has special relevance. The manipulation of objects, the use of tools, and the construction of simple apparatus all are required for entry into the world of experimentation. Even the pure mathematician is greatly aided by shop experience; the forms, contours and interrelations of three-dimensional objects provide a stimulus and satisfaction not to be achieved altogether within the limits of plane diagrams. The lack of shop training is at present a most serious deterrent to entry into all types of technological work and to college and postgraduate training in science, medicine, and engineering.[2]

Attempts at integration, unification, and interdisciplinary analysis have been made in response to noted inadequacies of the standard curriculum. Burnett suggested that functional science involve integration.

> Whatever the type of schedule this teacher is able to effect, he should make certain that his instruction integrates

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[1] John Dewey, School and Society, (Chicago: University of Chicago Press, 1899), p. 60.

[2] General Education in a Free Society, (Cambridge, Mass.: Harvard University Press, 1958), p. 160.

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> the various phases of learning activities into a meaningful and developmental whole.[1]

Struck advocated the concept that industrial arts be utilized to make other subject matter more meaningful and functional.

> Industrial education is a pathway that helps to reduce the remoteness of school-work from life by bringing into the curriculum, content that is true to life and problems that develop attitudes, knowledges and skills that are needed for a better social order.[2]

In supporting such a concept, Maley presented one of the strongest arguments in favor of the application of mathematics and science in the industrial arts laboratories.

> Where else in the school is there the possibility for the integration and application of the mathematical, scientific, creative and manipulative abilities of youngsters to be applied in an atmosphere of references, resources, materials, tools, and equipment so closely resembling the society outside the school.[3]

Hanna and McAllister have described curricular changes which must be made to meet the need for young people to understand the physical world.

> Young people need to understand and learn how to control, whenever it is possible,

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[1] R. Will Burnett, Teaching Science in the Secondary School, (New York: Rinehart & Company, Inc., 1957), pp. 171-192.

[2] F. Theodore Struck, Creative Teaching, (New York: John Wiley & Sons, Inc., 1959), p. 3.

[3] Donald Maley, "Research and Experimentation in the Junior High School," The Industrial Arts Teacher, XIII, (March-April, 1959), pp. 12-13.

> the physical world and the universe. Books can help young people in their desire to understand and to control the physical world around them. Curiousity, the enthusiasm for knowledge, appears to be almost instinctive in man. After the immediate environment has been explored at first hand, the child begins to ask "why." The what, how, and why continue to be important in the developing human being unless that searching is so thoroughly discouraged in the process that the individual must abandon his seeking in self defense.[1]

Derthick, former U.S. Commissioner of Education, commented regarding the use of industrial arts facilities.

> What better opportunity is there for them to begin to experience problem solving than by using tools, materials, processes, and machines as a foundation for future study in science and technology?[2]

Engelbrektson emphasized the importance of a closer relationship between science and industrial arts and referred to two studies made in New York state. Even though the studies were made independent of one another, the outlines were very similar, where emphasis was placed on the construction of the project; "the heart of industrial arts instruction." Suggestions were made for lessons in scientific principles and the application of those principles in experimentation or research beyond the bounds of the industrial arts laboratory or the science classroom.

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[1] Geneva R. Hanna and Mariana K. McAllister, Books, Young People, and Guidance, (New York: Harper and Brothers, 1960), p. 73.

[2] Lawrence G. Derthick, "The New Image of Industrial Arts," Industrial Arts and Vocational Education, IXL, (September, 1960), p. 27.

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> Learning will not take place unless a change of attitude is experienced by the learner. It is not enough to present a specific capsule of subject matter, whether it be science or industrial arts... Application of subject matter learnings will insure a complete cycle in the thinking process, since concrete examples of attitude change can be observed. The construction of a project designed in such a way that it fosters and insures a change in attitude becomes a desirable educational goal.[1]

Calmus maintained that industrial arts is useful in making science "real." He presented facts to show that a course in laboratory techniques is useful to the student who may be aiming at dentistry, medicine, nuclear physics, or other technological or scientific employment.[2]

Ruley maintained that industrial education should contribute to the total education program and called for educational emphasis in the realm of the industrial arts teacher and facilities.

> Industrial Arts' greatest contribution to accelerated scientific education can be made through our offerings...
>
> As one views exhibits at science fairs, it will be found that a great many models have been built, or partially built in the industrial education laboratory, or with the help of the industrial education teacher.[3]

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[1] Sune Engelbrektson, "Correlating Industrial Arts and Science," The Industrial Arts Teacher, XX, (November-December, 1960), pp. 13-15.

[2] Abraham Calmus, "Industrial Arts is Vital in a Creative Science Program," School Shop, XX (January, 1961), pp. 7-8, 31-33.

[3] M.J. Ruley, "Blueprint for Industrial Education," Industrial Arts and Vocational Education, L, (December, 1961), pp. 14-16.

In reference to curricular changes, Plutte stated:

> The craftsman and the technician, or technologist, became members of a team with the professional engineer and scientist that now and in the future, will research and develop more and better technological products for consumers....The success of such a program is in the hands of (industrial arts) departmental personnel.[1]

Ziel called for a more closely related instructional program between science and industrial arts.

> Industrial arts, throughout the nation, has the unusual opportunity of interpreting the many scientific principles inherent in our technology and simulating these principles at work.[2]

The review of studies indicates that the improvement of science and industrial arts instruction is necessary. Several suggestions called for new approaches in teaching techniques which could make subject matter more meaningful and functional. Several theories of instructional programs were proposed which would emphasize the relationship of science theories and industrial arts activities.

Examples of Experimental Attempts to Integrate Industrial Arts and Science. The Bronx High School of Science in New York City has used a "Science Fair" and "Science Congress" for stimulating and discovering science talented

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[1] William Plutte, "The New Industrial Arts Frontier," Industrial Arts and Vocational Education, LI, (January, 1962), pp. 10-11, 60.

[2] Henry R. Ziel, "Interpreting the World of Work in the Industrial Arts Program," Industrial Arts and Vocational Education, LI, (September, 1962), pp. 2, 6, 7.

children in the elementary schools. In the case of the Science Fair, children are encouraged to exhibit their projects and experiments; these are judged and prizes are awarded. In the case of the Science Congress, young people are brought together for pupil demonstrations and talks. These pupils are presented a Science Congress Certificate, which later becomes a factor when their application for admission to the Bronx High School of Science is considered.[1]

Another type of science organization is described in the "Annual Report" of the Superintendent of the Cleveland Public Schools where "specially talented youth" have the opportunity to attend "rather highly specialized classes in particular subjects, such as physics and chemistry.[2]

In describing Parma's Secondary School Program, Detrick, Director of Industrial Education for the Parma, Ohio Schools, related:

> Students aiming at the technician field are able to schedule an hour and a half of the school day in shop situations organized to emphasize the application of science and mathematics in the respective fields of mechanics.[3]

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[1] Board of Education of the City of New York, Specialized High Schools in New York City, (1949), p. 33.

[2] Annual Report of the Superintendent of the Cleveland Public Schools, Cleveland, Ohio. (1945), p. 72.

[3] J.H. Detrick, "Comprehensive Education for Industrial Education," Industrial Arts and Vocational Education, LI, (March, 1962), pp. 43-45, 95.

Mehrens, Instructor of Industrial arts at Montgomery Blair High School, Montgomery County, Maryland reported on a course designed to provide formal school direction to the research of "experimentally minded" students as a part of industrial education. The experimental course was an effort to improve or develop skills, attitudes, and judgements required of the researcher. The course was named Industrial Science and was offered to the "exceptionally talented."[1]

Keeny instituted a class in experiments in industrial arts at the Montgomery Hills Junior High School. The program made available industrial arts tools, equipment, and materials with which the student could test and evaluate products, processes, and materials by applying scientific theories and procedures.[2]

Knight suggested two ways in which industrial arts might be helpful in stimulating and strengthening science education.

> There are two ways in which industrial arts can be helpful in stimulating and strengthening science education. First, through planning, demonstrations, fabrication and the study of related theory pertinent to shop activities....The second way....is by permitting students of science to use the

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[1] Harold E. Mehrens, "An Experiment with the Experimentally Minded," Industrial Arts and Vocational Education, LI, (November, 1962), pp. 22-24.

[2] (Dittoed paper) "Industrial Arts Research and Experimentation in the Junior High," Alan P. Keeny, Jr., Silver Springs, Maryland.

> shop facilities as experimental or research laboratories to supplement their regular classroom instruction.[1]

Hornbake recalled for educators the unique approach to learning as voiced by Comenius, Rousseau, Pestalozzi, and Froebel. The use of tangible media and the application of such learning principles to the world of work has a basis upon which the physical sciences should be built.

> Science, with its applications to industrial processes and to industrial products, has come to dominate our field of work....The "shop approach" is a good approach but the educational experiences must be included. Not only should there be greater technical orientation in the secondary school program, there should also be a re-structuring of the approach to teaching.[2]

Doutt and Scriven proposed an experimental course at the University Junior High School, Northern Illinois University, DeKalb, Illinois. The course was planned around science, mathematics, and industrial arts at the eighth grade level. It was to be taught in a three hour block of time and given to students in lieu of the three regular departmentalized courses. This "integrating program" was to provide experimental research in the combined subject areas.[3]

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[1] R.O. Knight, "Applied Science and Industrial Arts," Industrial Arts Teacher, XVII, (September-October, 1958), pp. 14-16.

[2] R. Lee Hornbake, "Professional Growth in Industrial Arts Education," The Industrial Arts Teacher, XLX, (November-December, 1959), pp. 13-15, 24-25.

[3] Richard F. Doutt and Eldon G. Scriven, "Science, Mathematics, and Industrial Arts," Industrial Arts and Vocational Education, IXL, (December, 1960), pp. 15-17.

The review of attempts to integrate industrial arts and science subject matter content into one learning unit revealed that industrial arts type of activity was helpful in stimulating and strengthening student interests in science. A wide variety of direct and incidental techniques have been the subject of experimentation but as yet no statistical analysis has been applied. The recognition that such programs could be of significance in the improvement of industrial arts and science instruction, warrants further investigation.

Summary. From the review of literature presented, some general conclusions were drawn. The conclusions were based on trends as well as the various reported studies.

1. Science education has paralleled the development of general education, having been initiated into the school program at the time when the Academy was being introduced as a formal school unit in this country. Science education has undergone considerable change due to newer concepts of pedogogy and psychology. Several of the studies indicated that the use of various teaching methods would enable the students to achieve a higher level of achievement in the area of science. Over the past fifty years there have been several major reports and studies which influenced the nature and practice of science teaching in the direction of functionality. Proposals were made for new patterns of teaching which would include development of manipulative

skills so that scientific theories could be applied and experimented.

2. Industrial arts was concerned with the practical application of hand skills when it was introduced into this country as Swedish Sloyd. The history of this subject area has been short; less than fifty years but progress in methods of instruction has been rapid. Many Industrial Arts educators have attempted to utilize the latest research findings in teaching-learning situations. As with other disciplines, industrial arts has been negligent in helping the individual relate industrial arts subject matter learnings and practices to other areas of the school curriculum. New ideas and theories which emphasize experimentation of instructional programs designed to interrelate areas of learning have been suggested by various leaders in the field for some time.

3. The review of the literature with respect to methods of teaching science and industrial arts revealed a considerable amount of adverse commentary. When the objectives of industrial arts and science were considered as having definite relationships, several theories of instructional methods were formulated. Reports were included about programs which made industrial arts tools, equipment, and materials available so that students could evaluate products and materials by applying scientific theories and principles. Other attempts reviewed included programs in which the

activity type of instruction used in industrial arts was used to advantage in the science program of instruction.

4. The reports of experimental combined subject matter approaches revealed that (a) more meaningful learning took place, (b) there was an increased interest in science and industrial arts, and (c) the research-experimentation approach to problem-solving was understood to a greater degree.

CHAPTER III

DESCRIPTION OF THE EXPERIMENTAL PROGRAM

In this chapter, discussion will be directed toward the experimental program schedule, course objectives, scope and sequence, an example of each of the two methods followed in the development of a concept, and some pertinent facts concerning the evaluation techniques used in ascertaining student grades. Included in the discussion of the two methods of teaching, is an outline of activities utilized for the development of a concept. It is to be noted that lectures and discussion topics are not detailed in this study.

Program Organization

This experimental program was offered in a two semester sequence during the regular 1962-63 school year. There were five fifty-five minute periods each week during the thirty eight week school year with an occasional assembly program substituted for the regular class period. Consequently, the total number of class hours for any one six-week marking period differed from semester to semester. All classes used in the study met during the same period of the day so that time spent in all classes was equated. This arrangement of time schedule made it possible to control the variable of class period time.

The students used in this study were assigned to two different sections. One section of sixty students designated the control group was taught by a science teacher who followed the traditional method of teaching. The other section was considered the experimental group. The experimental group of sixty students was divided into two subgroups; a science teacher was responsible for one subgroup and an industrial arts teacher was responsible for the other subgroup.

The two subgroups of the experimental class were often combined for the orientation of each unit. After the initial orientation, each subgroup met separately to develop the theory of scientific principles and their relationships to industrial technology. As the theories were studied and discussed, possible applications were listed by the students and teachers. Students were then directed to independently explore theory applications through experimentation.

Course Objectives

Objectives for the regular science course have been revised at different intervals. Examination of the *Science Curriculum Guide* revealed the most recent revision of course aims as:

> It shall be the general aim of eighth grade science to extend the science experiences and understandings of the student. To promote a keen interest in science through

observation, experiments, and projects. Individual curiosity and activity is to be encouraged.

The subject matter units of eighth grade science compliment the units of seventh grade science to cover all the major areas of general science.

Specific science objectives:

The science program in the junior high school should provide those experiences that would help young people to:

1. Develop an understanding and appreciation of the scientific method and the ability to use it in solving problems not only in school but in everyday life situations.
2. Learn some of the basic scientific concepts and principles which are needed in further study of the areas of science and technology.
3. Improve their ability to make accurate observations.
4. Learn how to collect, record and test facts.
5. Develop the ability to generalize based on facts and observations.
6. Develop the ability to present information and conclusions.
7. Understand the importance of conservation.
8. Learn to work cooperatively with others through group activities such as experiments, projects, and cooperative experimentation projects.
9. Appreciate the contributions of science and industry to modern living.
10. Acquire and use a vocabulary of scientific terms.
11. Develop some skill in applying knowledge of scientific principles to practical work situations.[1]

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[1] Science--A Curriculum Guide for Teachers (Lansing, Michigan. Public Schools of Lansing, Michigan, 1961), p. 6.

These objectives were used as guidelines for teaching in the science program involved in this study. In addition to the above, the following industrial arts objectives were incorporated in the integrated industrial arts-science program. This list of industrial arts objectives had been compiled in the C.W. Otto Junior High School Industrial Arts Guide.

> The industrial arts program at the Junior High School level is an exploratory program. The main purpose of industrial arts is to help the student gain general industrial experiences having knowledge, skill, and quidance values. Industrial arts is an important part of general education because:
>
> 1. It helps the individual develop coordination between theory and practice.
> 2. It offers practical experiences using various materials used in industry.
> 3. It provides information about industry, workers, and employment opportunities.
> 4. It provides for practical applications of learnings gained through other subject matter areas.
> 5. It promotes the development of cooperative attitudes and leadership qualities.
> 6. It strives to develop proper safety attitudes and habits of workmanship.
> 7. It contributes to the student's knowledge relative to selection and use of consumer products.
> 8. It allows for individual expression of ideas.[1]

Scope and Sequence

Utilizing the science study guide, the listed objectives, and previously constructed course outlines,

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[1] C.W. Otto Junior High School Industrial Arts Guide. Compiled in 1961. (Unpublished).

seven major areas of instruction were established for use in the experimental program: (1) Energy and Machines, (2) Gravity, (3) The Solar System, (4) Geology--The Earth's Surface, (5) Heat, (6) Weather, and (7) Electricity. These areas of instruction were organized to include an introductory statement and a list of concepts which were to be developed. An outline for the development of the program was compiled in the form of an Instructional Guide.[1] This Instructional Guide was followed by the instructors involved in this study. No data was compiled as to how extensively or intensively it was used.

The development of the general pattern for the program and course content led to the problem of selection of teaching methods to be used. As previously stated, the purpose of this study was to determine the relative effectiveness of two different methods of teaching science at the eighth grade level: (1) the traditional science teaching method, and (2) the integrated industrial arts-science teaching method.

The Traditional Method of Instruction. A definition of the term "traditional method" was included in the Definition of Terms.[2] The actual teaching-learning situation

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[1] See Appendix I, page 87.

[2] See Chapter I, page 12.

procedures employed in the control group that used the traditional method is described here.

The teaching method was planned to stress factual information of the unit concept; E-1:Matter is anything that takes up space and has weight.

An outline of the activities engaged in for the development of Concept E-1 follows:

I. Lectures by the instructor:

A. States of matter
B. Physical changes in the states of matter
C. Chemical changes in the states of matter
D. Comparisons and characteristics of matter
E. Solutions and liquids
F. Composition of matter

II. Teacher directed class discussions

III. Study periods and reading assignments

IV. Teacher performed demonstrations:

A. Physical change of matter - ice cube to water
B. Chemical change of matter - sugar added to water to form a solution

This outline was used as a guide in the selection of subject matter content. The instructor did not follow the activities in any specific sequence. The instructor initiated and directed the activities as he desired. Students were not encouraged to do any extra reading or problem solving activities other than those included in the outline.

<u>The Student-experimentation Method of Instruction.</u> As explained in the Definition of Terms,[1] the use of student-

[1] See Chapter I, page 9.

experimentation placed emphasis upon the problem solving approach. There are certain characteristics of this type of instruction which can be enumerated. Some of the pertinent elements are: (1) cooperative pupil-teacher planning, (2) extensive individual and/or group participation in concept development, (3) the scientific method of solving proglems and answering questions is extensively used, and (4) the teaching-learning situations are highly individualized to provide enrichment opportunities.

An example of this teaching method, in the form of an outline of activities pursued in the development of the concept "Matter is anything that takes up space and has weight," follows:

I. Initiating the Unit by the instructor
  A. Presentation of a problem
  B. Compilation of student observations
  C. Formulation of answers or hypotheses
  D. Gathering information and experimentation
  E. Drawing conclusions and checking solutions
  F. Application of information achieved

II. Group discussion topics
  A. Techniques in the use of measuring tools
  B. Techniques of making observations
  C. Descriptions used in the comparison of matter
  D. Molecular structure of matter
  E. Effects of energy on matter. (Physical and chemical)

III. Individualized instruction
  A. Use of measuring tools
  B. Manipulation of supplies and equipment
  C. Construction of models and solid shapes
  D. Experimentation with chemical and physical changes in the states of matter

The outline given above was followed step by step in the development of the first concept so that students would adopt a desired approach to student experimentation. As the program progressed, activities were conducted in random order dependent upon individual progress and the availability of tools, equipment, and supplies. Most of the concepts were evolved by individual students in cooperation with the instructor. Students were encouraged to identify and develop related sub-problems. Suggestions were introduced by the instructor whenever it was felt that a student might benefit more by directed experiences.

In the development of concepts where the building of parts or the complete apparatus was needed, the facilities of the industrial arts laboratory were utilized. The composition and use of materials, an understanding of basic planning principles, and the relationship of scientific theory to practical industrial applications were stressed during the period of student experimentation and concept development. Basic manipulative skills in the handling of tools and materials played an important role in the total program of integrating science and industrial arts.

As the experimental program progressed, it became increasingly apparent that pupils had to do a great deal of independent study and research in the development of concepts. This was especially true with respect to the selection of materials and the proper use of tools. In

order to help the individual perform more effectively outside the immediate supervision of the instructors, a Student Experimentation Procedure Form was developed.[1]

Because of the highly individualized type of instruction required, the industrial arts teacher served as the main advisor relative to material selection, the planning and building of various pieces of equipment, and the supervision of testing procedures. The science instructor served as advisor in the selection of problems, the formulation of hypotheses or possible solutions, and in the explanation of technical science principles. Both teachers were available to help the individual student plan procedures, compile results, draw conclusions, and aid in the process of evaluation.

Much of the responsibility for searching out facts, organizing them, and making practical application was placed on the individual student. The information gained and the results of experiences were reported to the whole class at various intervals as the concepts were developed. As these activities were being carried out it was necessary for the teachers to evaluate student progress.

Evaluation Techniques. Many evaluating devices were used by the instructors such as teacher-made oral and written tests, standardized tests, (STEP-Science) observations of pupils as they conducted research in the quest

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[1] See Appendix A, page 112.

for knowledge and subsequent solutions or answers to questions and problems, and through the analysis of procedure forms and reports. Each student was encouraged to evaluate his own progress and achievement. This was accomplished through individual student-teacher conferences.

It was necessary to ascertain letter grades for each pupil during the course of the school year. The basic evaluation procedure included: (1) review of objectives, (2) the use of individual pupil and teacher conferences, (3) the compilating of test questions based upon factual information and examples of application through the use of practical problem situations, and (4) a method of recording results. Each pupil was requested to keep a notebook in which the concepts, reports, study guides, diagrams, tests, and notes on experimentation were compiled. Also within the contents of that notebook was a checklist of weekly activity grades that included (1) quantity and quality of work, (2) use of tools and equipment, (3) use of materials and supplies, (4) problem solutions, (5) recitation and group discussion, (6) promptness, and (7) effort. The notebook, tests, project activities, and weekly grades were considered in the determination of individual report card grades.

Summary.

The significant features of the experimental program studied in this investigation were:

1. The experimental program was offered during both semesters of the 1962-63 school year.

2. The objectives used as guidelines for the control group were those listed in "Science--A Curriculum Guide for Teachers,"[1] as adopted by the Lansing Public Schools.

3. The objectives used as guidelines for the course taught under experimental teaching conditions included those used in the control group and the objectives integrated from the area of industrial arts.

4. The traditional method of teaching was characterized by formal lectures, study periods, and teacher directed class discussions. Student participation in demonstration activities is very limited.

5. The student-experimentation instructional approach emphasized extensive student participation in all activities. Whenever it was necessary to construct experimental apparatus, the industrial arts facilities were utilized.

6. A description of several evaluation techniques was included.

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[1] Science--A Curriculum Guide for Teachers (Lansing, Michigan. Public Schools of Lansing, Michigan, 1961), p. 6.

CHAPTER IV

ORGANIZATIONAL FEATURES OF THE INVESTIGATION

<u>Scope of the Investigation</u>. The main purpose of this investigation was to compare the relative effectiveness of two different methods of teaching science at the eighth grade level. This study was organized so that identifiable groups of students were taught by a particular method of instruction. The instructional organization was based upon the traditional science teaching method and the integrated industrial arts-science teaching method. The course guide was based upon the objectives of seven science units of instruction and selected objectives of industrial arts that would help students develop the relationships of science to industry.

The discussions included in this chapter are (1) a description of the experimental design, (2) the teaching-learning situation, (3) the population and sample, and (4) sampling techniques.

<u>The Experimental Design</u>. The experimental design included one independent variable; method of teaching (the traditional vs. industrial arts-science integrated). The dependent variables were (1) informational achievement, and (2) the ability to apply theory in practical situations.

<u>The Teaching-learning Situation</u>. The groups involved in the study met during the seventh period of the school

day. The pupils enrolled in the traditional teaching-learning situation were taught in a regular science classroom by an experienced science teacher who used the approach previously described as traditional.

The students taught under the industrial arts-science method were aided by the instructor in reaching conclusions regarding a method of inquiry that could be utilized to accumulate knowledge concerning selected concepts. The instructor's role was to suggest, recommend, and generally guide learning activities.

The industrial arts-science class met in the physical science laboratory and in the industrial arts laboratory. The utilization of these two laboratories made it possible for students to do extensive individual experimentation. In addition, the integrated industrial arts-science class was taught by an experienced science teacher and an industrial arts teacher who had previous science teaching experience.

In summary, salient design features of the teaching-learning situations used in this study were: (1) the investigation was planned so that identifiable groups of students were taught by a particular method for the entire seven unit program, (2) the teaching facilities used in the study were (a) a traditional science classroom, and (b) a combination of the physical science and the industrial arts laboratories, (3) all classes involved in the study met during the same time period of the day, and (4) both groups covered the same science units. However, the traditional science class did not receive instruction in the area of industrial arts.

Population and Sample. The entire student body of eighth grade students could not be made available for this investigation. As a result, a sample technique was used that produced a control and experimental group of sixty students each.

The survey of practices used in similar studies revealed a number of techniques that have been utilized.

Melby and Lein suggested the use of ordinary classes of unselected students without modifications in studies where comparisons are to be made regarding achievement under two different methods of teaching.[1]

Noll equated two groups of college students for a comparative study by matching individuals on percentile rank as determined by results on American Psychological Tests and on honor point ratio of previous college work.[2]

Halvorsen considered that the six classes he used in his study were equated and used only the scores made on the

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[1] Ernest O. Melby and Agnes Lein, "A Practical Technique for Determining the Relative Effectiveness of Different Methods of Teaching," Journal of Educational Research, XIX, (April, 1929), pp. 255-264.

[2] Victor H. Noll, "The Effect of Written Tests Upon the Achievement in College Classes; An Experiment and A Summary of Evidence," Journal of Educational Research, XXXII, (January, 1939), pp. 345-348.

Nelson High School English Test as the prime basis for comparison.[1]

Courtis contended that groups could not be matched reliably without taking into consideration the factor of "growth culture." However, he equated the second grade pupils used in his study as being of the same age even though his data revealed that they varied as much as eight months.[2]

Yurkewitch, in a controlled experiment conducted with two classes of twenty-seven pupils in each group, used the criterion of intelligence for matching the two groups. He revealed that those two groups did not vary more than three points.[3]

Gnagey used two sophomore Educational Psychology classes where the students were assigned at random for his experimental study.[4]

VanderLinde equated twelve pairs of experimental and control classes on the basis of comparing the I.Q. scores

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[1] N.O. Halvorsen, "An Experiment Comparing the Effectiveness of Two Methods of Indicating Errors in Student Themes," Research Report No. 35, (Cedar Falls, Iowa: Iowa State Teachers College, 1939), pp. 1-2.

[2] S.A. Courtis, "Criteria for Determining the Equality of Groups," School and Society, XXXV, (June, 1932), pp. 874-878.

[3] J.T. Yurkewitch, "A Controlled Experiment on the Contract-Discussion Method of Teaching vs. the Recitation Method in U.S. History," Unpublished Masters Thesis, (Pennsylvania State College, 1933), p. 32.

[4] William J. Gnagey, "The Comparative Effects of Small Group vs. Teacher-Led Discussion Sessions Upon Student Achievement and Perception in Educational Psychology," Journal of Educational Research, LVI, (September, 1962), p. 29.

for significance of mean differences through the use of the "t" test.[1]

A review of techniques used in selecting the sample from the total population including those cited above, led to the decision that the process of randomized selection would result in a representative sample of the population.[2]

Sampling Technique. In the selection of the sample, the table of random numbers was used. This table consisted of five blocks, twenty four rows, and thirty nine columns. The point of entry was determined by numbering a series of white poker chips from 00 to 39. The chips marked 00 to 05 were placed in a box and shaken vigorously to insure mixing. Chip number 02 was withdrawn thus indicating that the table would be entered in block two. Then the chips numbered 00 to 24 were placed in the box and mixed. Chip number 24 was withdrawn. This specified that row 24 was to be used. Chips numbered 00 to 39 were then placed in the box and thoroughly mixed. One was withdrawn that read 12, signifying that column 12 be used. The random drawing of chips established the point of entry into the random numbers table as being: Block 2, row 24, column 12. The number found in the table was 6. The sixth student name from the eighth grade class

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[1] Louis VanderLinde, "An Experimental Study of the Effect of the Direct Study of Quantitative Vocabulary on the Arithmetic Problem-Solving Ability of Fifth Grade Students," Unpublished Doctoral Thesis, (Michigan State University, 1962), p. 57.

[2] Allen L. Edwards, Experimental Design in Psychological Research. New York: Holt, Rinehart and Winston, 1960, pp. 332-336.

list was selected to start the sample list. Two lists of sixty students were compiled; one for the control group, the other for the experimental group.

The process of selecting the sample by randomization decreased sample variation. This sample variation could be further decreased through class scheduling by limiting the humas bias element, and through the selection of reliable evaluating instruments.

The classes used in the study were scheduled to meet during the seventh period of the day to eliminate time variance. This class meeting time schedule also reduced sample error and variability because specialized electives such as band, typing, industrial arts, and dramatics were not offered during the seventh period.

The teachers involved in the study agreed to follow the guide in the selection of subject matter used in the classes. This tended to reduce the human bias element on the part of the instructors.

The technique of randomization, discussed earlier, was utilized to prevent the human element of bias from contaminating the sample. This method of sampling played a significant role in the assignment of controls. However, the possibility of bias on the part of students could pose a threat to the study. For example, student bias that is a result of knowing that they are participating in an experiment may have an effect upon attitudes toward a program. This bias could become so great that the final outcomes of the study might be distorted. In this study, the students were not informed that the course was a part of an experimental program. They did realize that the science course was being taught in a different manner but so was Mathematics. Many students and their parents were undoubtedly aware of the nation-wide emphasis being placed on science and accepted the experimental program as a routine change.

The possibility of bias in the selection of the instrument used to evaluate the experimental program could be just as detrimental as the human bias element. The selection and use of proven standardized tests reduced the possibility of bias in the evaluation of this program. The standardized tests used in this study were: The Sequential Tests of Educational Progress--Science, Form 3A and 3B. The tests were machine scored and the results were tabulated by people other than the instructors involved in the investigation. However, these tests did not measure precisely in terms of the entire set of objectives. It was necessary for the instructors to devise unit tests based on practices of test construction outlined by Newkirk and Greene.[1]

<u>Summary - Population and Sampling Techniques</u>. The use of the entire population for this study was not possible. Therefore, the technique of randomized sampling was utilized

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[1] Louis V. Newkirk and Harry A. Greene, <u>Tests and Measurements In Industrial Education</u>, (New York: John Wiley and Sons, 1946), pp. 91-105.

to select a representative sample from the eighth grade student population. After the sample had been selected, it was divided into two groups with sixty students in each of the control and experimental groups.

The control group was taught under the traditional method whereas the experimental section was taught under conditions where industrial arts and science were integrated.

Procedures to reduce variation of the sample that represented the total population were explained. These procedures involved class scheduling, instructor and student bias, the selection of the sample, and predilection in the selection of evaluation instruments.

The source and treatment of data are discussed in the next chapter.

CHAPTER V

SOURCES AND TREATMENT OF DATA

One of the basic assumptions of this study was that a comparison could be made between two approaches to teaching-learning about science and industry. This comparison should show that one method was superior or more effective than the other.

Data used in making the comparisons were obtained from the individual student's cumulative records and test results. These measures of the ability and performance levels of the experimental and control groups were necessary to ascertain homogeneity of the groups. As was explained earlier (Chapter IV), no attempt was made to match the two groups used in this study.

Comparison of Groups at the Beginning of the Study.

Data used in making the initial comparison included (1) scores achieved on the California Mental Maturity Test as they were recorded in the cumulative records of each student, and (2) the scores for each individual on the Sequential Tests on Educational Progress - Science Form 3A. This data common to both the control group and the experimental group were analyzed to determine how the means of the test scores compared in intelligence, achievement, and/or aptitude.

The means of the scores made by the experimental group were compared with the means of the scores made by the control group on the California Mental Maturity Test and the Sequential test of Education Progress - Science Form 3A to ascertain whether any differences in ability or background achievement existed between the two groups. This comparison was made by following the statistical procedure known as the "t" test.[1] Results of the comparison indicated that the means were almost the same (Table 1). When the statistical procedure was applied, the difference in means was not significant. Therefore the null hypothesis that no significant difference existed between the groups on ability and background achievement was retained.

The mean scores of the control and experimental groups were then tested to determine whether the two groups were homogeneous. The "F" test for homogeneity of variance was applied. A nonsignificant value for F_{05} was obtained and the conclusion was drawn that the two sample variances were estimates of the same population variance.

Since the results showed a nonsignificant value of "t" and homogeneity of variance when the "F" test was applied, it was concluded that the control group and the experimental group were taken from the same population. (Refer to Table I).

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[1] Quinn McNemar, Psychological Statistics. (New York: John Wiley and Sons, Inc., 1955), p. 87.

TABLE I

COMPARISON OF GROUPS AT THE BEGINNING OF THE PROGRAM

Test	No.	Group	Mean	S^2	t	F
California Mental Maturity	30	C	104.87	178.24	.31	1.82*
	40	E	104.08	142.37	.	
STEP Science	30	C	32.43	39.16	.36	1.49*
	40	E	33.05	58.51	.	

*Neither t or F values are significant at the .01 Level of Confidence.

Comparison of Groups at the End of the Study. A comparison of the academic achievement of the experimental and control groups was made following the completion of the seven unit experimental program. The basis for this comparison was obtained from the results of a standardized test. The Sequential Test of Educational Progress, Science Form 3B was the achievement battery employed to measure academic achievement. In addition to the STEP Science test battery, teacher constructed unit tests were administered and then evaluated (Table II). These tests attempted to measure retention of factual information and the student's ability to apply industrial arts and science concept. The teacher constructed unit tests utilized objective and subjective.

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evaluation techniques.[1]

The results of the tests were processed and treated statistically upon completion of the investigative study. The "t" test for the significance of the differences between means was employed to determine if the differences between the levels of achievement in the two groups represented real rather than chance differences.[2]

Table II presents the comparative statistics of the two groups at the conclusion of the experimental program. These statistics include the means of STEP and teacher constructed unit tests.

TABLE II

Test	No.	Group	Mean	t
STEP Science	30	C	35.00	4.24*
	40	E	54.70	
Unit tests	30	C	33.12	13.20*
	40	E	45.62	

*Significant at .05 level of Confidence

[1] See Appendix C, page .

[2] Allen L. Edwards, Experimental Design in Psychological Research. (New York: Holt Rinehart and Winston, 1960), pp. 332-3360.

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Statistical comparisons of the achievement of the experimental and control groups, as measured by the STEP test and the Unit Tests led to the rejection of the null hypothesis that there was no significant difference in the achievement means of the two groups being compared.

For the experimental group the difference in the means on the pre and post STEP tests was 12.57, whereas the difference in the means on the same test was 1.26 for the control group.

Summary

The data used for making the comparisons in this investigative study were obtained through the use of the STEP (Sequential Tests of Educational Progress, Science Form 3A and 3B), and teacher constructed unit tests. At the start of the program the STEP (Form 3A) was administered. The results of this test and the results gathered from individual cumulative records were used to determine homogeneity of the experimental and control groups. The statistical comparisons of data have been shown in Table I. Results of the "t" test indicated that there was no significant difference in the means of the two groups. The calculated F as obtained through the use of the "F" (Fisher) test was not significant. The results of the "t" and "F" tests indicate that the means of the two groups were about equal and that the two sample variances were homogeneous at the beginning of this study.

Table II showed a tabulation of the STEP, Form 3B, test and Unit test administered to both the control and the experimental groups at the conclusion of the study. In analysing the gains made by the two groups, it was found that the experimental group made a significant gain. The differences of means were found to be statistically significant then the "t" test was applied.

The statistical treatment revealed that this difference in means was highly significant. The conclusion could then be drawn that the industrial arts-science teaching-learning approach was superior as a method of instruction when compared to the traditional science teaching method.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Increased emphasis on science and industrial technology has made it imperative that schools examine curriculum programs related to those areas. Discovery and invention have fostered new industries which demand more skilled personnel for operation and research. To meet these increasing demands, schools should study and then formulate programs that will effectively contribute to the achievement of desirable objectives. This can be done by providing experiences through which students can acquire and develop qualities which are important to industrial technology and scientific endeavor. Our present complex society demands that a person interrelate areas of experience when attempting to solve problems. However, many members of today's society are unable to integrate scientific principles with the processes of modern industry. If the purpose of education is to meet such a challenge then the educative process must include knowledge and experiences which will enable individuals to achieve success in everyday living.

Educators in both fields of industrial arts and science have expressed concern regarding the use of instructional methods which would emphasize interrelating theory and practice. These educators suggest that schools eliminate rote type of learning and substitute an approach that

would relate theory and practical application. Although much has been written about this idea of integrating the study of science and industry, no conclusive studies have been made nor have any statistical analysis been made.

The Problem. The main problem of this study was to investigate a curricular program which would aid students in the integration of scientific principles and industrial technology. This study attempted (1) to develop an integrated industrial arts-science curriculum based on the assumption that there is a definite relationship between science and industrial arts objectives, and (2) to compare the relative effectiveness of two methods of teaching. These two methods were compared with respect to effectiveness in teaching factual information and practices designed to develop understanding and the application of concepts.

Samples in the Study. Two eighth grade class groups were selected through the use of the random numbers table. One group was designated as the control group and the other as the experimental group. The control group was taught using traditional science teaching methods whereas the experimental group was involved in a teaching-learning situation where industrial arts and science objectives were integrated.

Experimental Design. The experimental design included one independent variable; method of teaching (traditional vs. integrated industrial arts - science). The dependent

variables were informational achievement and the ability to apply theory in practical situations.

It was predicted that the student's understanding of science and industry would be enhanced when industrial arts techniques were utilized to facilitate practical applications of science principles. This study was designed to consider the levels of achievement of groups involved in the experimental program. The levels of group achievement were ascertained through the use of teacher constructed unit tests and STEP standardized tests.

Comparison of Groups at the Beginning of the Study. Data common to both the experimental and control groups were analyzed to determine how the means of the groups compared in intelligence, achievement, and aptitude prior to undertaking the experimental program. These data were obtained from the cumulative record of each student and the administration of STEP tests, Science Form 3A. Comparison was made through the use of the "t" test for differences of means and the "F" test to determine homogeneity of variaance. Results of the comparisons indicated that there was no significant difference in the means of the two groups and that the two sample variances were estimates of the same population. The conclusion was then drawn that the two groups were not significantly different as far as intelligence and ability were concerned.

Results. A comparison of the academic achievement of the experimental and control groups was made upon completion of the seven units of instruction. The STEP test (Sequential Tests of Educational Progress, Form 3B) was employed to measure this achievement. Statistical analysis revealed the differences of the means to be significant when the "t" test was applied. The experimental group mean achievement score was significantly higher than the mean achievement score of the control group on the same test.

The results of the teacher constructed unit tests were then compared and treated statistically through the use of the "t" test. This statistical analysis revealed that there was considerable difference in the means of the two groups. The experimental group had achieved the more significant gain.

Conclusions. Statistical comparisons of the results of two instructional methods revealed that the integrated industrial arts-science method was more effective in helping students understand the interrelationships of science and industry. The students involved in the integrated program were more capable of applying science theories to practical situations.

Other pertinent conclusions drawn as a result of this investigative study include:

1. The pupils enrolled in the experimental group

became involved in manipulative activities which required considerable individual research.

2. The experimental teaching-learning situation allowed for flexibility of instruction, use of equipment, and student activities.

3. Faculty and administrative personnel accepted the experimental program as an evolutional step in the improvement of teaching both areas of industrial arts and science.

4. The number of incidents where science principles were explained in industrial arts classes increased.

5. The industrial arts facilities were utilized after school hours by mathematics and science students who built experimental apparatus.

6. Programs in which teachers cooperate in planning and execution produce enthusiastic participation on the part of teachers and often is reflected in the attitude of the students.

7. The number of so-called college prep students enrolled in industrial arts courses increased.

Implications and Observations. Some of the inferences drawn from the results and conclusions of this investigative study are:

1. Students involved in practical application of theory must be allowed to do considerable individual work.

Future instructional programs in the areas of industrial arts and science must make provision for individualized study and experimentation.

2. Flexibility in the development of concepts is necessary so that pupils will not be restricted to the predetermined answer or cook-book type of experiment. The method of inquiry should be considered of more importance than the end result.

3. Broad industrial arts experiences would be helpful to all students. These students would not be limited in construction activities whenever they were developing an experiment or project.

4. Aid in the interrelating of knowledge and experiences would help students integrate learnings. It is pertinent that courses of study be designed to incorporate theoretical and practical aspects of the total curriculum.

A number of observations and/or speculations could be made regarding the conduct of the experimental program. Among these, the following are noteworthy:

1. Initially, students had difficulty in planning for experimentation. It was necessary to provide detailed instructions at the beginning of the program. This need for specific direction undoubtedly stemmed from previous educational experiences.

A more detailed plan of orientation probably would have decreased time spent. Specifically, greater emphasis and clarification of the problem approach and its inherent high degree of freedom for independent study might have helped.

2. The length of the class periods together with varying degrees of student achievement on independent problems resulted in some difficulty for the instructor. It was hard to observe the achievement of each member of the class each day.

Greater flexibility in class scheduling could have provided more class time at certain developmental stages. This flexibility might have made it possible for the teacher to more effectively plan and help students, particularly those who seldom raised questions about their experiments.

3. If preliminary planning had been undertaken with greater knowledge of course content previously experienced by students, duplication of teaching efforts could have been reduced or redirected.

For example, the experiments on magnetism were eliminated when it was realized that students had already acquired the desired knowledge. On the other hand, certain concepts about energy and machines were expanded.

Suggestions for Further Research. The limitations set for this study necessitated the omission of many problems that are still unanswered with respect to the nature of methodology and attitudes of teaching science and industrial arts. The materials used in this study were experimental and consequently represent a limited attempt to gather information and develop instructional techniques that might be adapted to such a program.

As is true with all types of inquiry, this type of research may well raise as many problems as it resolves. Among these problems are those related to:

1. The nature of the skills and abilities inherent in the methods of industrial arts instruction which might be used in conjunction with other subject matter areas.

2. The construction of valid and reliable evaluation techniques, particularly those related to application of theory.

3. The development of instructional materials which could be used for quick reference by teachers and students.

4. A follow-up study to determine whether students who had not previously taken industrial arts would elect industrial arts courses after they had been enrolled in the integrated industrial arts-science course.

5. The use of an industrial arts teacher to serve as a consultant in courses designed for student experimentation.

6. The nature of student attitudes towards the integration of studies concerning science and industry.

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APPENDIX A

INSTRUCTIONAL GUIDE

INSTRUCTIONAL GUIDE

The Unit of Instruction

Perhaps the first problem to be met in a new unit is that of introduction. The teacher should select that procedure which will best meet the needs of the pupils and should feel that a flexible program of activities is essential to a vital teaching-learning situation. Observation of classroom teaching usually shows that insufficient time is spent in raising problems before the pupils begin their study of the unit. At least one full period should be spent in making the concept titles meaningful and challenging to the pupils. The application of science principles and concepts is the desired outcome rather than the memorization of principles or concepts. The basic concepts are developed through teacher-pupil activities described herein as student experimentation in terms of what can be done in the industrial arts laboratory. From the list of activities and experiments suggested, the teacher together with the student should select those activities which best meet the needs of each class. Many of the experimentation activities would be particularly suitable as enrichment for the more capable pupil.

Pupils should do as many experiments as possible to have first hand, concrete experiences in techniques and methods. Many of these can be done with simple equipment made in the shop laboratory. After submitting a written

report and an explanation of their observations and conclusions to the class as a whole, they should be allowed to share other experiences with individuals or groups. Many techniques should be demonstrated by the teacher to show the way in which science and shop equipment is handled. Pupils should be responsible for keeping good descriptive records and for developing careful observational habits.

The treatment of the units and their basic concepts will differ from group to group. For some groups the major emphasis would be on the practical aspects; for others the topics would be broader in scope with the emphasis on abstract understandings.

Developing concepts. The method of developing a concept will of course depend on what kind of concept is being developed. If the concept involves the characteristics of a group of materials or items, where various members of the group are described; then the characteristics common to all members are pointed out. If a relationship is the concept being developed, examples of the relationship are discussed; then a generalization about this relationship is made from the examples. If the concept is the principle by which a device or process works, the development is usually as follows: (1) what the device or process does or what it is used for, (2) what its parts are and how they are arranged, (3) how it is made to work, and (4) a step-by-step explanation of what happens when it works.

Throughout this course of study, experiments and problems relative to concepts have been introduced wherever possible. This has been done for two reasons: (1) all learning must be based on the pupil's background of perceptual experience, that is, on information that the pupil can attain with his own senses, and (2) the pupil should acquire the attitude that if he has questions, he can do an experiment or make an observation which will help answer his questions or aid in solving his problems. The concepts and their subtopics present the assimilative material needed by the pupil to arrive at an understanding of the major problems of the unit. Suggested experimental topics are introduced whenever it is felt that the student may attain information by direct experience.

Most of the experiments are in a new form that requires a higher degree of pupil participation than can be had from the traditional recipe or cookbook type of experiment found in science texts. In the traditional experiment, the pupil is given detailed directions telling him exactly what to do. As a result, he often has little or no idea of the how or why of the method of experimenting that he is using. In the new type, or creative experiment, the pupil is given a minimum of direction. He is asked to plan, explain, interpret, and verify. Usually, a statement illustrates the materials needed and the procedure to be followed. Questions direct the pupil's observations, help him make inferences, test the correctness of his inferences, draw his conclusions, and apply these conclusions to new situations. The results of each experiment should be reported to the entire class.

In schools where time is limited, it may be necessary to shorten the course somewhat. This can best be done by covering some units rapidly, without stopping for detailed development, while others may be more carefully developed with all the suggested activities carried out. However, it is not wise to omit units or parts of units.

Methods of Instruction. The methods of instruction which can be employed are of great value to the instructor as well as the students when they are varied and supplemented by various teaching aids and devices. In determining which supplemental aids can be used to the greatest advantage, we must consider that individuals differ in their needs, interests, physical and mental capacities, aptitudes, and abilities.

It is in this area of individualized instruction that industrial arts teachers profess to bring about maximum individual growth and where the industrial arts teacher can be of valuable assistance to the science teacher in relating science and industrial arts geared to the individual. Such individualized instruction is a reaction against unjustifiable uniformity, against the lock-step procedure, against the wastefulness of daily lesson direction aimed at the average class student. However, individualized instruction is not a cure-all so it may be good or bad. Poor teaching by any method is still poor teaching and must be improved. Merely following certain teaching plans does not necessarily mean that maximum individual growth will be achieved.

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1a. ENERGY

INTRODUCTION:

You are a living thing. Have you ever wondered what would happen to you if part of the things which surround you would be taken away? How would you be affected, if heat or electricity were taken away? They are forms of energy, the same as that which we refer to when we say that we need energy to participate in sports.

The food that we eat contains chemical energy which is made available in the tissues of our bodies. This chemical energy may be transformed into mechanical energy by our muscles. It is evident to us that this energy is the capacity to do work. Chemical energy is also possessed by coal, oil, and other fuels and this energy may be released by burning of the fuels and then converted into other forms of energy.

The wind has the ability to move dirt. Flowing water will turn a wheel. A weight may be pushed off a table. Water retained behind a dam when released may turn a wheel and produce electrical or mechanical energy. These are but a few of the many conditions under which we may demonstrate that energy is the capacity to do work.

We shall be concerned during the next few weeks with the use, the forms, the source of energy, transformation of energy and the countless applications of man's ingenuity in producing and using the changes of energy from one form to the other.

OBJECTIVES:

A. The experiences of this unit should help pupils grow in their ability to:

1. Understand the nature of energy.

2. Understand the nature and structure of matter.

3. Appreciate the work done by scientists.

4. Understand the importance of energy control.

5. Understand the relationship of matter and energy.

B. The unit should be planned and executed so that the following concepts will emerge:

1. Matter is anything that takes up space and has weight.

2. Energy under control can help better our way of life.

3. A force is a push or pull.

4. Resistance is an opposing force.

5. Energy is the ability to do work.

6. Work is done when a force overcomes a resistance or opposing force and moves something.

7. Most work is done and energy used in overcoming four different kinds of resistance: (1) gravity, (2) friction, (3) molecular forces, and (4) inertia.

8. Whenever an object is lifted, the resistance of gravity must be overcome.

9. Whenever an object is moved horizontally, the resistance of friction must be overcome.

10. Molecular force is caused by forces of attraction between the molecules of matter.

11. Inertia is resistance to a change in motion or a position of rest.

12. Energy has many different forms.

13. Under certain conditions, matter can be changed into energy or energy into matter.

14. Under proper conditions, each form of energy can be transformed into another form.

15. There are two kinds of energy; Kinetic and potential.

16. Our main source of energy is the sun.

17. The Law of the Conservation of Matter-Energy.

18. Atomic energy is one of Man's newest servants.

1b. MACHINES

INTRODUCTION:

The beauty of nature has always made a strong appeal to man; yet he is more than an admirer of nature's wonders--he is also a creator. His inventive genius has been exercised in the making of many machines. Simple at first, these tools to aid man in his hand labor and hunting have advanced through the ages to the highly complicated machinery produced by experts today. In ancient times man did all his work with his hands. Gradually he learned to make and use tools and machines which enabled him to do his work more easily and to accomplish tasks that would otherwise have been next to impossible.

Before we can understand how to get the most out of machines in this mechanical age, we must learn some of the fundamental laws upon which all machines operate. These fundamental principles are the means which help us to plan additional uses for the machines we already have and to

develop new machines for tasks which cannot be done successfully by the old ones.

When we speak of machines, most of us think of automobiles, airplanes, or other complex devices. Actually, each of these large devices consists of a combination of a great many smaller and simpler devices. In order that we may observe and understand the basic scientific laws by which all machines must operate, we will consider the most elementary forms of the mechanical helpers. These have become so much a part of our lives that we can hardly imagine what it would be like to be without them.

Consideration will be given to uses of machines and the relationship between energy, machines, and work.

OBJECTIVES:

A. The experiences of this unit should help pupils grow in their ability to:

1. Understand the principles of simple machines.
2. Understand the forces which make machines work.
3. Appreciate the many mechanical devices which are used daily.
4. Understand the relationship of energy, power, and work.
5. Understand the relationship between simple and complex machines.
6. Recognize the importance of being able to put the many principles of science to work in the field of industry.

B. This unit should be so planned and carried out that the following concepts will emerge:

1. Machines have several uses, but they never produce energy unless energy is put into them.

2. There are two basic types of simple machines, lever and inclined plane.

3. The lever has three main points on which force is applied.

4. The inclined plane is widely used as a method of raising or lowering weights.

5. The mechanical advantage of a machine is the number of times the machine increases a force.

6. The efficiency of a machine is the percentage of the energy which the machine turns into useful work.

7. The direction of motion can be changed by use of machines.

8. Complex machines are made by using different arrangements of simple machines.

9. Work is measured in terms of foot-pounds.

10. Energy from fuel is often used to run machine.

11. Machines do not decrease the amount of work to be done or save us work. (Save muscular energy and time.)

12. Friction which consumes a great deal of energy can be reduced by using lubricants.

13. The rate of doing work is called force.

2. GRAVITY

INTRODUCTION:

Gravitation is the attraction that masses of matter have for each other. The sun's gravitation holds the planets in their paths. Gravitational attraction between heavenly bodies holds the stars to their courses. The moon's gravity pulls at the oceans and causes the tides to rise and fall.

Gravitation is the same thing as gravity. But we use the word gravity to mean the attraction of the earth for small objects near its surface. When someone holds a heavy object in his hand, it seems to pull his hand toward the floor. When he releases the object, gravity makes it fall down to earth instead of upward into the air. It allows people to walk, because it acts against the forces of their steps, and holds them to the earth. Without gravity, an individual could spring from the earth and move upward until he bumped into some object. If gravitation could suddenly be turned off like an electric light, the universe would come apart.

In this unit we shall be concerned with characteristics of gravity and how we measure it. How can man make use of such a force as gravity? What must be done to overcome gravity?

OBJECTIVES:

A. The experiences of this unit should help pupils grow in their ability to:

1. Understand the characteristics of gravity.
2. Understand the systems of weights.
3. Understand the principle of gravitation.
4. Understand how gravity is put to use in our world. (Reference should be made to previous unit.

B. This unit should be so planned and carried out that the following concepts will emerge:

1. Weight is a comparison of the pull of gravity on an object to another known weight.
2. There are two systems of weights based on the kilogram as a standard: (a) metric, and (b) English.

3. The density of any material is the weight of a certain volume of that material.

4. The pull of gravity on materials is known as density.

5. Water and air exert force because of gravity.

6. Water supply systems often use gravity to supply pressure.

7. Gravity causes air pressure.

8. Atmospheric pressure causes suction.

9. The use of atmospheric pressure is dependent upon a partial vacuum.

10. The siphon is used to transfer a liquid from a higher vessel to a lower vessel.

11. Any object placed in a fluid is bouyed up by a force equal to the weight of the fluid that it displaces.

12. The density of a liquid is measured by means of a hydrometer.

13. The density of gases determines whether they will rise or settle.

14. Air occupies space.

3. SOLAR SYSTEM

INTRODUCTION:

Astronomy is the scientific study of the heavenly bodies and their motions. It is one of the oldest of the sciences, if not the oldest. The earliest man watched the skies and wondered about what they saw there. As they looked up from their hunting and their campfires, they must have notices how the sun and the stars rose in the east and swept slowly and mahestically across the great dome of the

sky to sink below the western horizon. Men who lived in the northern hemisphere must have observed that the sun appeared to move south in winter and north in summer. This motion was especially important to them because it accompanied the changes in the seasons.

Even the earliest man tried to explain what they saw in the heavens, but for thousands of years their explanations were crude and often false. The earth seemed small and flat to them. The sun, moon, planets, and stars seemed close and appeared to be moving while the earth was stationary. The ancient Egyptians, Greeks, and Romans had considerable knowledge of astronomy. They named the constellations and fashioned myths about them.

The study of space has greatly changed man's picture of the universe. We know now that the earth is round and that it is part of the solar system. Distances in the universe are so vast that the light from the nearest star takes over four years to reach us. The recent explorations of space have just begun to help astronomers in their quest of information concerning space.

Ideas concerning movements of heavenly bodies and their effects on the earth and man's being will be discussed in this unit.

OBJECTIVES:

A. The experiences of this unit should help students grow in their ability to:

   1. Understand the vastness of space.

2. Appreciate orderliness and regularity as seen in the movements of heavenly bodies.

3. Understand the movements of the earth in relation to time, seasons, eclipses, and tides.

4. Time is determined by the earth's movements.

5. Position on the earth is indicated by latitude and longitude.

6. Time is a matter of circles and movement. This time is calculated in degrees and measured on the earth.

7. The inclination of the earth's axis results in the seasons.

8. The universe includes everything that exists.

9. Groups of stars that form imaginary pictures in the sky are known as constellations.

10. Observations of a celestial body are made through a telescope.

11. Radar is the name for a system of measuring distance and direction by reflected radio waves.

12. A spectroscope is used to study the composition of the sun.

13. The movements of the delestial bodies depend upon gravitational attraction and centrifugal force.

14. Matter attracts other matter.

4. GEOLOGY - THE EARTH'S SURFACE

INTRODUCTION:

The earth is very old. It probably has been in existance for about four billion years. During that time much has happened to it. Lava has flowed from cracks and volcanoes. Streams of ice have moved down mountainsides or spread over prairies and hills. Seas have advanced across sinking continents, while layers of sand and mud settled on their bottoms. Later those sea bottoms turned into land, where rain and streams wore rocks away or frost slit them into pieces. At other times land heaved or crumpled, while molten stuff like lava filled pockets deep underground. There it formed such rocks as granite or produced ores of iron, copper, and other minerals.

Geology is the science that deals with these changes, as well as their results. It also determines when they happen and it traces living things of ancient ages, and describes their surroundings on land, in fresh water, or in the sea. Special divisions of geology deal with ores of minerals, with the causes of volcanic eruptions, and with various other subjects.

The earth, as we know, is a ball of rock and water surrounded by air. This ball is about 8,000 miles in diameter. It belongs with eight other balls, called planets, all of which revolve around the sun.

The study of the Earth's surface should prove to be very interesting. An attempt to answer such questions as: of what is the earth's surface composed, and what effects does the earth's movements have on the daily life of man?, should bring out some pertinent facts.

OBJECTIVES:

A. The experiences of this unit should help students grow in their ability to:

1. Understand that Geology as a science deals with changes of the earth's surface.

2. Understand the effects of erosion on the earth's surface.

3. Realize that there are several theories about how the earth was formed.

4. Understand the source and economic value of rocks, minerals and fuels.

B. This unit should be planned and carried out so that the following ideas will emerge:

1. The earth's surface was once rock of some kind.

2. There are three main groups of rocks.

3. The changes in rocks caused by exposure to the weather are called weathering.

4. The soil of our earth is one of our most valuable resources.

5. Useful materials can be obtained from the earth's crust.

6. The earth's surface is constantly changing.

7. Water causes two different kinds of erosion.

8. Water moves materials because of gravity and forms flood plains and deltas.

9. Wind can cause changes in the earth's surface.

10. Glaciers have altered the surface of the earth.

11. Sudden destructive changes in the earth's surface are produced by volcanoes and earthquakes.

12. The cooling of the earth was accompanied by a shrinking and wrinkling of its surface, which carved mountains and valleys.

13. There are three kinds of diastrophic movements.

5. HEAT

INTRODUCTION:

Many of our activities are influenced by surrounding heat conditions. The amount of heat that is present affects the kind of clothes we wear, the food we eat, the work we do, and the kind of homes we live in. For example, if you live in a place where you have cold winters and warm summers, your home is built so the heat can be supplied to it in the winter and kept from it in the summer. You dress so that much of the heat of your body is kept in the winter and given off in the summer. Heat must be applied to much of your food to make it edible.

If you would try to imagine what would happen to the world and everything in it if our sources of heat were suddenly taken from us you can see the importance of heat to our lives. If the sun which is estimated to have a temperature of about 12,000°F. at the surface, should cool, all life would be extinguished and the earth would become a cold, dead mass like the moon.

Heat is both an enemy and servant of man. If too much heat is applied to any part of our body at one time, a severe burn may be the result. On the other hand, if heat is applied at the right place at the right time it helps to heal the body. In sufficient quantity heat can cause a locomotive to run, an airplane to fly, a ship to cross an ocean, and other machines to do work.

The questions concerning the sources of heat, how we can best use heat energy, and how to control heat will be studied in this unit.

OBJECTIVES:

A. The experiences of this unit should help students grow in their ability to:

1. Understand the importance of heat.

2. Understand the difference between heat and temperature.

3. Understand the laws of heat energy.

4. Recognize that the Law of Conservation of Energy applies to heat energy.

B. This unit should be so planned and carried out that the following concepts will emerge:

1. Our source of heat energy is the sun.

2. The intensity of heat is measured by a thermometer.

3. The Fahrenheit and Centigrade scales are the most commonly used scales on thermometers.

4. Heat transfer from molecule to molecule within materials is called conduction.

5. Heat transfer by a fluid in motion is called convection.

6. The transfer of heat by radiant energy is called radiation.

7. Heat is released when a liquid freezes or a gas condenses.

8. Heat is absorbed when a solid melts or a liquid evaporates.

9. Fuels are burned to produce heat.

10. Heating the home may be done by various principles involving the travel or transfer of heat.

11. Petroleum has become the chief source of energy for fuels.

12. Insulating materials restrict the passage of heat.

13. Heat can be controlled by a thermostat.

14. Materials having different colors absorb or reflect heat at different rates.

15. If the degree of heat of matter is determined by movement of molecules, then as molecules of a substance are heated, the molecules will move faster, increasing the space between them, and causing expansion of the substance.

16. Knowledge of heat energy is widely used in industry.

17. Internal combustion engines produce power by burning an inflammable mixture in a cylinder. In any transfer of energy into heat energy, or of heat energy into other forms of energy, the heat energy is proportional to the amount of transformed energy.

18. Heat units are measured in terms of calories and British Thermal Units. (BTU's)

6. WEATHER

INTRODUCTION:

Weather includes all the daily changes in temperature, wind, moisture, and air pressure. It affects everyone. Today's weather may make us feel hot or cold. We may get soaking wet in a sudden shower, or have to struggle through deep snow. Bright sunshine may make the day cheerful and happy. Dark, dull clouds may make us sad and unhappy. Too much rain can cause floods. Too little rain may kill farm crops.

We cannot change the weather, but we can adjust ourselves to it. We put on raincoats when it rains, and boots when it snows. We heat our homes in winter and cool them in hot weather.

Weather plays an important part in our human activities. The farmers need good weather so that crops will grow and ripen. Storms or sudden frosts can destroy valuable crops. This raises the prices we pay for food at our neighborhood stores. Weather even affects sales in department stores. Fewer people shop in rainy or stormy weather. Transportation and communication also suffer in bad weather.

Weather forecasting helps us fit our plans to future weather. We can hear weather forcasts on the radio, watch them on television, and read them in the newspaper. The weatherman's forecasts may save lives and dollars and also prevent discomforts to individuals. Weathermen track destructive hurricanes and tell people when to expect floods. They also help families plan picnics, vacations, and other activities.

In this unit we shall attempt to analyze weather and its effects, how we measure temperature, wind velocity, precipitation, and air pressure. What are the factors that are considered in the forecasting of weather?

OBJECTIVES:

A. The experiences of this unit should help students grow in their ability to:

1. Understand the factors which determine weather and climate.

2. Realize the value of weather forecasting and how they are made.

3. Understand and be able to use weather map information.

4. Read and interpret weather instruments.

5. Understand the influence that weather and climate have on our lives and industry.

B. This unit should be so planned and carried out that the following concepts will emerge:

1. Man's activities are influenced by the weather.

2. The air is a mixture of gases; about 4/5 nitrogen, 1/5 oxygen, and with small amounts of other gases such as argon, neon, carbon dioxide, and water vapor.

3. Warm air rises and cold air sinks, thus producing a flow of air over the earth's surface.

4. Wind direction is caused by temperature change.

5. Air movement is caused by convection currents.

6. Water vapor condenses when air is cooled below the dew point.

7. Clouds are of many types and furnish some suggestions in weather forecasting.

8. Precipitation results when saturation is reached.

9. Evaporation rate is dependent upon air temperature and humidity.

10. Changes in the weather occur along fronts where two different masses of air meet.

11. Storms are produced by the flow of air from high pressure areas to low pressure areas.

12. Changes in temperature, movement of air, and moisture cause weather. These things meteorologists consider in predicting weather.

13. Various instruments are used to measure and record different weather conditions.

14. The direction of the wind is determined through the use of a weather vane.

15. An anemometer is used to measure the speed of wind.

16. Humidity is the amount of moisture in the air and is measured by the hygrometer.

17. Atmospheric pressure is measured by a barometer in units known as millibars.

18. Weather predictions are made by studying maps, records, and charts. (The Beaufort Wind Scale)

19. Climate is the average (long term) weather in any region.

7. ELECTRICITY

INTRODUCTION:

Although electricity has been used for a relatively short time, it has already transformed our way of life. Transportation by train, ship, airplane, car, truck, bus, and elevator requires the use of electricity. Practically every industry and almost every phase of modern agriculture depend upon its use.

Communication by telephone, telegraph, radio, moving pictures, and television is electric powered. More and more use is made of electricity in our homes for lighting, heating, cooking, and washing.

A modern city needs dependable electric power as much as it needs a good water supply. Yet, while most people know something about the pressure and current flow of the water supply, how many can tell the difference between a volt and an ampere?

Magnetism and electricity, which are quite different forms of energy, are similar in many ways, and are always associated with each other. Just how are they related? In this unit you will find the answers to this and many other questions.

OBJECTIVES:

A. The experiences of this unit should help students grow in their ability to:

1. Understand the electron theory of electricity.
2. Understand electrical circuits and currents.
3. Realize the effects of electric currents.
4. Use electricity and electrical appliances properly and with safety.
5. Understand how electricity is measured and sold.
6. Understand the principles of electro-magnetism and its various applications.

B. This unit should be so planned and carried out that the following concepts will emerge:

1. Electric current is a stream of electrons which when detached from the atoms of certain elements can be passed through a conductor.
2. Electrical current can be produced by using generators, chemical action, heat (thermo-electric), light (photoelectric), pressure (piezoelectric), and nuclear reactions.
3. The electric circuit is a complete conducting path for electron flow.
4. Conductors and insulators are used to keep the electric current flowing in the circuit.
5. The amount of current flowing through a circuit depends on the resistance and the electrical pressure.
6. To work properly, an appliance needs the right kind and amount of current.

7. Electric power is measured in watts which is the base upon which we purchase electrical energy.

8. An electric current produces heat.

9. Fuses are safety devices used in electrical circuits. (Include modern innovations)

10. To avoid electric shocks, the body should be kept from becoming part of a circuit. (Discuss safety aspects and first-aid)

11. A circuit usually has four parts: a source of electrical energy, an appliance that uses this energy, a good conductor that connects the parts, and a device to control electron flow.

12. Circuits are connected in series or parallel.

13. Ohm's law and its adaptations.

14. Types and uses of various electric lighting systems.

15. Composition of dry cells and storage batteries.

16. The principles of magnetism have been put to use in the development of generators, motors, and electromagnetic induction machines and instruments.

APPENDIX B

STUDENT EXPERIMENTATION PROCEDURE

STUDENT EXPERIMENTATION PROCEDURE

A. State and define the problem.

B. Collect facts and information.

C. Make up several hypotheses or possible answers.

D. Select the best answer on the basis of what is known.

E. Plan experiments or series of observations.

F. Complete the experiment or gather the information and record results.

G. Check the procedure to make certain the method used was correct.

H. Draw up a temporary conclusion.

I. Retest the conclusion--do the experiment again.

J. Draw up a theory and make a practical application.

In all cases there is a problem to be solved. Then there are the materials that are used in the method or procedure that is to be carried out. During the course of the experiment observations will lead to the conclusion or answer to the problem. In many cases it will be easy to see how a practical application can be made of the conclusion (theory) that was reached.

WARNING!!

BASE CONCLUSIONS ONLY ON THE FACTS THAT HAVE BEEN DISCOVERED IN THE EXPERIMENT. SOMETIMES IT IS EASY TO REACH A FALSE CONCLUSION ON THE BASIS OF YOUR ACTUAL OBSERVATIONS. FOR THIS REASON RETEST!

APPENDIX C

UNIT TEST ON ENERGY

Name ____________________ Date ______________

Multiple choice: Place the letter which precedes the correct answer in the blank at the left of the statement.

(d) 1. Energy may be defined as the capacity for (a) exerting force (b) action (c) great power (d) doing work (e) producing motion.

(b) 2. The energy possessed by a falling rubber ball at the middle of its drop is: (a) heat energy (b) partly kinetic and partly potential (c) potential (d) kinetic (e) impossible to predict because the ball is elastic.

(c) 3. Inertia is the tendency of bodies to (a) disentegrate or fall apart (b) destroy energy (c) retain their motion in a straight line (d) give off energy or heat (e) become magnetized.

(d) 4. A ball is thrown up into the air. As it rises, there is an increase in its (a) acceleration (b) velocity (c) kinetic energy (d) potential energy (e) momentum.

(a) 5. Potential energy is (a) energy of position (b) energy of motion (c) heat energy (d) force.

(e) 6. Energy is (a) work (b) force (c) pull or push (d) power (e) ability to do work.

(a) 7. Inertia is the tendency of moving bodies to (a) move in the direction of an applied force (b) return to the state of rest (c) transform matter into energy (d) attract other bodies.

(c) 8. If a pile driver lifted to a height "H" drives a pile into the ground a distance "S"; then if it is lifted to a height of 2 "H" it will drive the pile into the ground a distance of (a) S (b) 1 1/2 S (c) 2 S (d) 2 1/2 S (e) 4 S.

(a) 9. An object at rest is capable of performing work if (a) its potential energy is greater than zero (b) it has any potential energy whether greater than or less than zero (c) its potential energy is less than its kinetic energy.

Completion: In the blank at the left of the statement, write the answer which should be placed where the question mark appears.

(energy) 1. ? is the ability to do work.

(sun) 2. Our main source of energy is the ? .

(friction) 3. Because of ? , one material always resists being moved over another.

(cohesion) 4. ? is the force that holds the molecules of a material together.

(adhesion) 5. ? is the force that makes one material stick to another.

(inertia) 6. A moving object has the ? of motion.

(energy) 7. Heat and mechanical are two different forms of ? .

(Kinetic) 8. The energy of moving matter is called ? energy.

(potential) 9. The energy an object has because of position is ? energy.

(potential) 10. Chemical energy is a form of ? energy.

Explain what you would do to prove:

A. That sanding the surface of a block would make it easier to drag it across a table top. (Experimental procedure and techniques)

B. That a block of cement placed on the edge of a table has energy. (Experimental procedure and techniques)

C. That energy may be changed from one form to another. (Experimental procedure and techniques)

Give an example which would illustrate each of the following:

(burning a fuel)	1.	Transformation of chemical energy to heat energy.
(damming a stream)	2.	Transformation of kinetic energy to potential energy
(a suspended weight)	3.	An object having potential energy
(a falling weight)	4.	An object having kinetic energy
(grease, oil, lubricant)	5.	A substance used in overcoming friction between gears
(cracking)	6.	Lack of cohesion on a sidewalk
(sliding cars)	7.	Lack of adhesion on an icy highway
(cracks - crumbling)	8.	Lack of cohesion in a building material
(no type or marks)	9.	Lack of adhesion on this paper

(a boulder -flywheel)	10. Inertia of rest
(a speeding object or weight swinging)	11. Inertia of motion
(scales)	12. A method used to measure differences in gravitational forces

Name one use you could make of the following:

1. Inertia of motion (use of flywheel to continue follow-through)
2. Inertia of rest (anchoring an object)
3. Resistance of friction (braking system)
4. The force of gravity (weighting objects - holding things in place)
5. The force of cohesion (making a cable)
6. The force of adhesion (fabricating objects)
7. Centrifugal force (separating milk and cream)
8. Heat energy to mechanical energy (combustion engines)
9. Inertia of running water (generating electricity)
10. A known weight (use of balance scales)

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