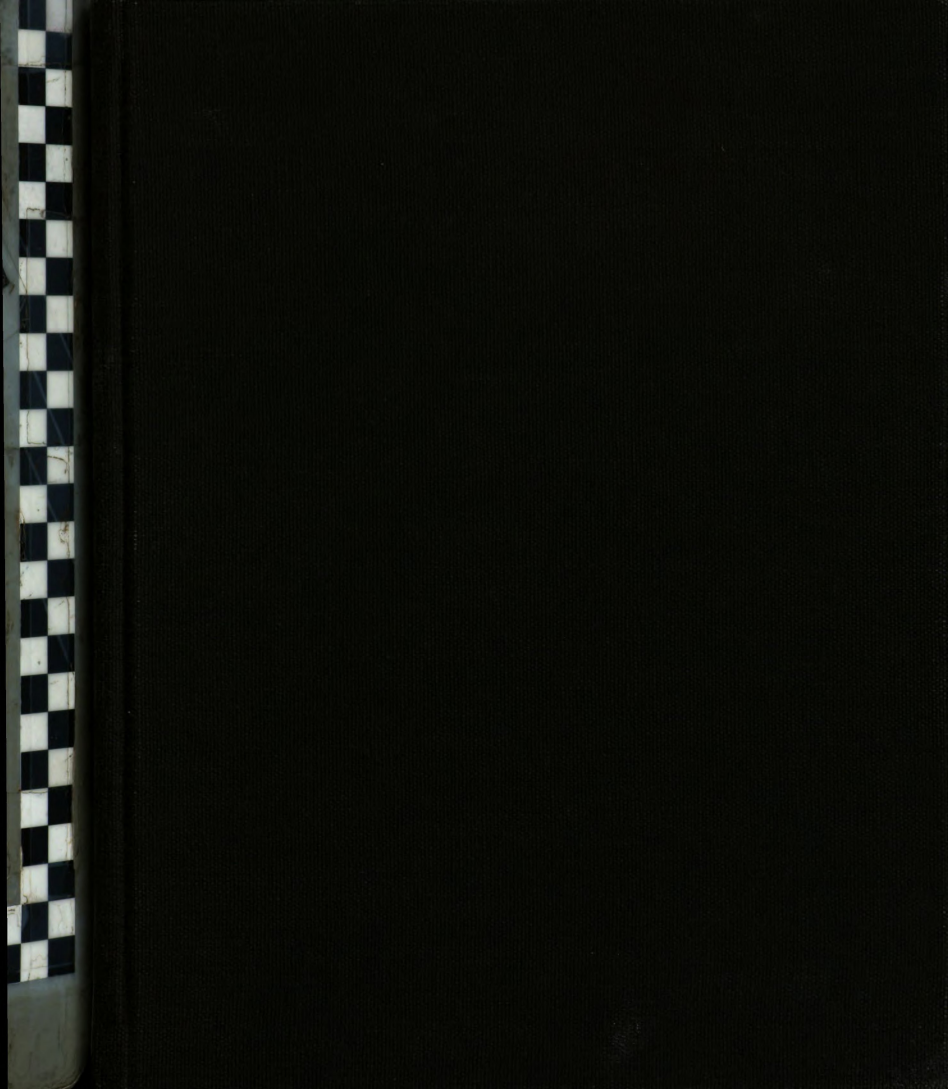
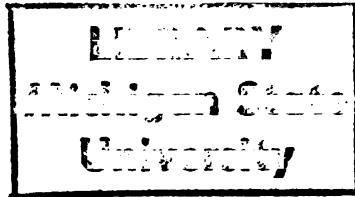






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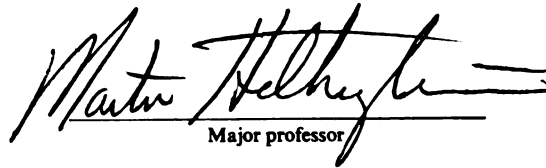
Inquiry as a method of teaching and
learning science in elementary school

presented by

Mohammad Abduljabbar Faraj

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**INQUIRY AS A METHOD OF TEACHING AND LEARNING
SCIENCE IN ELEMENTARY SCHOOL**

By

Mohammad Abduljabbar Faraj

A DISSERTATION

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

Department of Teacher Education

1986

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ABSTRACT

INQUIRY AS A METHOD OF TEACHING AND LEARNING SCIENCE IN ELEMENTARY SCHOOL

By

Mohammad Abduljabbar Faraj

This study is an attempt to investigate whether using the inquiry method in teaching science in the elementary schools in the State of Kuwait is better than using the existing traditional method. Therefore, the main part of this research is experimental in nature. The researcher worked with four teachers in two different schools, as well as 112 students in four classrooms. Two classrooms were taught by two teachers using the inquiry method, while the other two classrooms were taught by the other two teachers using the traditional method. During the teaching period of a unit about "Magnets" which lasted for 13 lessons, with each lesson having a duration of 45 minutes, the researcher observed the students in order to count the number of times they were involved in each of five essential science experiences which are observation, measurement, experimentation, interpretation of data, and prediction. When the teachers finished teaching the unit, the researcher gave a uniform exam to all of the students.

Analysis of data at the .05 level of confidence revealed that there was a significant statistical difference in favor

of the group that learned by the inquiry method in the number of times the students were involved in each of the five essential science experiences. Also, on the final test, the means of the scores of the students who learned by the inquiry method were higher than the means of the scores of the students who learned by the traditional method.

Other purposes of this study included the following:

1. Defining inquiry, scientific inquiry, and the steps in the scientific inquiry process.
2. Identifying the role of students, teachers, and supervisors in the inquiry process.
3. Identifying the healthy learning environment which serves best for conducting the inquiry process.
4. Comparing the inquiry method with the traditional method.
5. Elaborating on the advantages and the disadvantages of using the inquiry method in teaching elementary science.
6. What are the factors affecting teacher use of inquiry?

A brief description of the educational system in the State of Kuwait is also included in this study.

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

In the name of Allah the most merciful and the most beneficent

DEDICATION

To my wife Mariam

To my children Musaab, Muna, Maha and Muhanad

**To my entire family who provided me
with love and understanding**

ACKNOWLEDGEMENTS

Praise and thanks be to God, first and last, Lord and Cherisher of all the worlds who taught humankind everything they knew not.

It is not possible to credit all who have contributed toward accomplishment of this project. In expressing appreciation and recognizing the contributions of many, the writer would like to give particular recognition to those "special people" without whose inspiration, encouragement, guidance and help the completion of this study would not have been possible.

It is with great pleasure to express my gratitude to the members of my Guidance Committee, Dr. Charles Blackman and Dr. Robert Hatfield for their assistance and guidance during the course of my doctoral studies.

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Thanks and wishes are extended to all my colleagues and "Brothers" at the Islamic Center of Greater Lansing for their encouragement and prayers. Additionally, without the help of the teachers who participated in the project, this study would never have been completed. I thank each of them for so willingly giving of their time, energy and for their encouragement.

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Background of the Problem

If public education is to meet its obligation to society and to the individual, it must focus its attention on and direct its efforts toward the development of the autonomous individual. The autonomous individual cannot develop and move toward autonomy unless the formal learning setting is styled and structured in such a way as to be conducive to disciplined inquiry and self-directed learning.

If educators are to cope with the needs of learners living in an increasingly complex and changing world, they must cease programming the students with more and more information and focus on the learner and the processes involved in teaching the learner how to quest for knowledge and how to become self-directing (Gies, 1970).

If educators are to meet the challenge of providing the best type of educational experience possible for youngsters, then new programs will need to be developed and implemented with focus on the needs of learners as they strive toward becoming autonomous individuals (Gies, 1970).

Elementary students who are going to elementary schools now in 1986 will start and spend all of their adult lives in the 21st Century in an increasingly complex and changing world. Therefore, some of the major goals in education at this time should be to:

1. Educate youth to become rational citizens who are capable of thinking for themselves.
2. Prepare students for success in a world of unknown dimensions.
3. Provide students with a general awareness and appreciation for both science and the processes of science.
4. Help the children to acquire information and at the same time to develop a useful set of performance skills.

Thoughtful educationists have always been concerned with learning that goes beyond the mere taking in and storing away of someone else's knowledge. They have always searched for ways to help learners experience and build upon native curiosity, the drive to find out, to understand, and to know first hand (Miller, 1966). Therefore, they have been working hard to create, develop and/or introduce good science education programs especially at the elementary level, because through science and science education programs, students can study the world and make some sense of it. A good science education program in elementary schools lets children know the joy and excitement of finding answers, solving problems, doing meaningful activities, direct thoughtful questions, and seek answers by applying investigative techniques. A number of terms are presently being used to describe this teaching/ learning strategy. The

three most common terms are: teaching/learning by inquiry, teaching/learning by discovery, and teaching/learning by investigation (Victor, 1974).

As stated by Jacobson (1970):

More recently there has been a growing emphasis on inquiry in science education. At any rate, one of the major goals for elementary school pupils in the 70's, generally described, is the development of some skill in the use of the methods and processes of science. (p. 15)

Therefore, modern science curricula tend to reflect this main goal. Rowe (1972) wrote that, "All of the major elementary science programs extant today were designed to provoke children to inquire about relationships among natural phenomena" (p. 1).

For many years, the science education community has advocated the development of inquiry skills as an essential product of science instruction, and for an equal number of years science educators have met with frustration and disappointment. Several groups of concerned scientists and educators have developed modern curriculum programs such as: Biology Science Curriculum Study (BSCS), Science . . . A Process Approach (SAPA), Earth Science Curriculum Project (ESCP), Physical Science Study Committee (PSSC), CHEM Study, Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS).

These programs put a great emphasis on the investigative, exploratory phases of science, and the development of scientific inquiry skills.

The Problem

Since 1965, education in general and science education in particular have undergone a revolution in the Kuwaiti schools. Moreover, the early seventies marked a milestone in elementary science with the development of several innovative curricula in the different stages. Nevertheless, the Ministry of Education is still asking the teachers to concentrate their efforts on covering the content of the textbooks and to make their students recall information and be ready for the final exam. In spite of all the efforts which have been made by the Ministry of Education in different aspects such as revising the science textbooks at least once every three years, developing and improving the science curricula in the different stages, and spending more than 12% of the annual national income on education, the Kuwaiti students are not interested in studying science and very few Kuwaiti students are opting for the scientific curriculum. Therefore, the country still depends on experts and specialists from outside to run and operate its facilities.

In order to meet the increasing needs of scientific specialists of the society such as engineers, teachers, physicians, and pilots, it is suggested to use the inquiry method in teaching science in order to lead and attract more students toward studying science. The inquiry method will develop the research skills of the students; foster

scientific literacy, enable students to develop into adults capable of understanding the impact of science on society; develop communication skills such as uses of reference materials, writing, listening, speaking, reading and vocabulary development, along with the recording of scientific data which can readily be incorporated into the classroom lessons on research (Rice and Dunlap, 1982).

Further, students at the same time gain practice with science processes such as the use of tables and graphs, counting, measuring, problem solving, classifying, organizing data, and developing an understanding of the experimental method. Therefore, if teachers and other educators believe that it is important for students to develop these skills and develop their thinking powers to the greatest possible degree, then they will be interested in inquiry.

The Purpose of the Study

The major purpose of this study was to investigate, compare, and analyze the teaching procedures of two groups of science teachers. One group included two teachers, a male and a female, who received instruction and training in the best methods of teaching a unit on magnets to two third grade classes by the inquiry-discovery method. The second group included a like number of elementary science teachers who did not receive any training or instruction through this study and taught the same unit using the traditional textbook-centered method.

Although many studies have been done in this field in the United States, none had been done in Kuwait. Therefore, this study was done in order to bring the inquiry issue to interested educators in Kuwait.

Other purposes of this study included:

1. To define inquiry, scientific inquiry, and the different phases and steps in the scientific inquiry process.
2. To identify the learning environment which facilitates and encourages pupil inquiry and self-directed approaches to learning among elementary school pupils.
3. To identify the roles of the teacher, the student, and the supervisor in this strategy of learning/teaching process, i.e. inquiry.
4. To make a comparison between the inquiry method in teaching science and the traditional method.
5. To discuss the strengths and the weaknesses of this method of teaching science and how to overcome the difficulties which face the teachers and other educators while they apply it.
6. To try to learn why teachers in Kuwait have not yet started teaching by inquiry and what the difficulties they face.

During this researcher's experience in supervising 20 schools as well as meeting and discussing this matter with

many science supervisors, it was evident the science teachers were not using the inquiry method in their teaching very often (sometimes, they do unknowingly), either because they were not trained to be teachers or not trained to use the inquiry method in their teaching.

It is expected that this method of teaching science will be good for teaching general science on the elementary level as well as teaching separated science subjects in the advanced levels. Furthermore, it is expected that this method of teaching science will be of particular benefit to curriculum planners, supervisors, and classroom teachers who desire to improve their performance level and prepare the students for the next century.

Importance of the Study

This study was important for several reasons:

1. No study of its kind has been conducted before in Kuwait. This was confirmed by: (a) a thorough search of literature conducted by this researcher to find any studies related to this area of concern in Kuwait; (b) two separate interviews: the first with the General Supervisor of Science in the Ministry of Education in Kuwait, the second with the Chairperson of the Department of Science Education in Kuwait University.
2. Such information will be important for school teachers, supervisors, administrators, students and

curriculum planners. Science educators will be able to perform their functions more easily and effectively once they have a better understanding of their roles, duties, and goals.

The Research Questions and Data Collection

This study was designed to investigate the possibility of teaching science, particularly at the elementary level, using the inquiry method, and to find out the role that teachers, students, and supervisors should play in order to reach this goal. How can teachers become more effective? What contribution can they make towards helping the students master the subject matter more easily and effectively? What restraints are imposed upon their activities under the particular conditions of Kuwait? What are the drawbacks and problems that science teachers there face? How can science educators create and develop a learning environment which facilitates and encourages pupil inquiry and self-directed activities among elementary school pupils? What are the major advantages and disadvantages of the inquiry method of teaching science? And how can science educators overcome its deficiencies?

The method of researching these questions was through two different ways:

1. Reviewing related literature and recent trends in education.

2. Investigating, comparing and analyzing the teaching procedures of the two above mentioned groups of science teachers through observing their classes and comparing the scores of their students on the final exam.

This study was designed to determine whether the teachers trained to use the inquiry-discovery method were more willing and able to encourage their pupils to indulge in a significantly larger number of the "essential science experiences" (Wilson, 1967, p. 13), which include observation, measurement, experimentation, interpretation of data, and prediction, than those teachers who did not receive any training in using the inquiry method; and finally, to compare the final achievement test scores of the students who learned by the inquiry method and the scores of those who learned by the traditional method.

The Hypotheses

- H₀₁ There is no significant difference in the number of times pupils will provide the five "essential science experiences" in those classes which will be taught by teachers who are trained and educated to use the inquiry-discovery approach and those classes which are taught by the traditional, textbook-centered approach.
- H₀₂ There is no significant difference between the male experimental group who are taught by the inquiry-discovery method and the female experimental group who

are taught the same method in the final achievement test scores, i.e. male experimental group vs. female experimental group.

H₀₃ There is no significant difference between the male control group who learned by the traditional method and the female control group who learned by the same method in the final achievement test scores, i.e. male control group vs. female control group.

H₀₄ There is no significant difference in the scores of the students in inquiry-discovery classes and the scores of the students in traditional classes on the final test, i.e. male and female experimental group vs. male and female control group.

Procedure

To conduct this research, the researcher selected two schools (one for girls and one for boys) in the AL-Ahmadi educational zone in the State of Kuwait. From each school, two third grade science teachers were chosen; so there were four teachers and four classrooms involved in the study. One teacher from each school was selected to receive training and instruction on using the inquiry-discovery method in teaching a unit about magnets. This step took about three half days with each teacher. The second teacher in each school was asked to teach the same unit using the traditional textbook-centered method. The first group shall hereinafter be called

the inquiry or the experimental group while the latter group will be called the traditional or the control group.

Each of the four teachers was contacted personally for the purpose of explaining the nature and the goals of this study and to get their permission to observe their classes and to give their students a final test at the end of the unit. All 13 sessions in both inquiry groups were observed while 10 and 11 sessions in the boys' and girls' control group were observed respectively. Finally, the final exam scores of both groups were analyzed to yield a comparison between the traditional and the inquiry method.

Limitations of the Study

The limitations of the study were as follows:

1. This study was limited to only two schools within one educational zone in the State of Kuwait. There were only 112 students who were subjects of the study. Furthermore, the study was limited to only one unit of the science curriculum and only at the third grade level. Nevertheless, the researcher thinks that the results can be generalized to all third graders in the other two educational zones because of the centralized educational system in Kuwait.
2. The results of this study were dependent upon one post-test and many observations by the researcher, and the extent to which the investigator was

objectively able to interpret and describe the data.

3. Another limitation emerged from the fact that the teachers involved in this study knew that the researcher was viewing and observing their lessons and that he would eventually compare the results of the four classes. This fact might have affected their performance as teachers or at least influenced them to not act normally.
4. For the above-mentioned reasons, the results obtained in this study may not be generalized freely to other countries, to other levels of schooling, or to other subjects. However, this study should provide methodological impetus for further research in this area.

Definitions

In this part of the study, the researcher discusses what the literature has said about the definitions of: inquiry, scientific inquiry, and the steps or the stages of scientific inquiry.

Inquiry

The dictionary suggested the following: inquire = to seek for or after by questions. Inquiry = the act of seeking information or knowledge--an investigation. In the literature, there are widely varying definitions for inquiry, but they all have the same essential ingredient of pupils

being inquisitive, curious, asking questions, pupils involvement in identifying and solving problems, developing higher level cognitive skills. Dewey (1938) defined inquiry as ". . . the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (p. 104-105). In another place Dewey defined inquiry as the "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (Gies and Leonard, 1970, p. 48). The Ad Hoc Committee on Undergraduate Teacher Education in their report in 1970 defined inquiry as "a process that moves in cycles from experience to conceptualization, from conceptualization to practice, and from practice to an evaluation that produces the data necessary for the step back to experience, thus repeating the cycle" (Ad Hoc Committee on Undergraduate Teacher Education Report, 1970).

Inquiry has loftily been described as a search for truth, knowledge, and information. Others have described inquiry in different ways. Suchman (1969) described inquiry as a search for meanings. He said, "Inquiry is a pursuit of more meaningful ways of interpreting ones own perceptions" (p. 4). Schwab (1963) perceived inquiry as ". . . researches which receive their conceptual principles from

others and treat these as matters of fact, not matters for test" (p. 50). Trowbridge (1967) defined inquiry as a search rather than the product (p. 28). Gagne (1963) stated that "inquiry is apparently a set of activities characterized by a problem-solving approach in which each newly encountered phenomenon becomes a challenge for thinking" (p. 144). According to Bingham et al. (1974) inquiry is "a set of activities directed towards solving an open number of related problems in which the student has as his principal focus productive enterprise leading to increased understanding and application" (349-351). A more recent definition of inquiry was stated by Massialas and Zevin as ". . . a behavior which is characterized by careful exploration of alternatives in seeking a solution to a problem" (Gies and Leonard, 1970, p. 48). Many science curricula, instructional materials, and methods textbooks have identified inquiry as very different activities and strategies with little agreement as to what constitutes scientific inquiry and what does not (Wilson and Koran, 1976). M.D. Herron (1971) attempted to classify the characteristics common to all definitions of inquiry. His composite definition of inquiry may be stated simply as "a method of learning which conditions students to recognize and to state problems in a manner that will allow them to pursue answers, and to recognize that these answers are both the final product and the starting point for further study" (p. 171).

Scientific Inquiry

~~Scientific inquiry~~ is a subset of general inquiry. Schwab (1963) identified scientific inquiry as, "That which is being offered by some educators as a paradigm on which to base a teaching strategy" (Kyle Jr., 1980, p. 123). Scientific inquiry was identified by Rachelson (1977) as "the method by which science arrives at its findings" (p. 109). Another definition of Rachelson (1977) was, "It is a two-component problem-solving process, These two components are hypothesis generation and hypothesis testing. A complete model of scientific inquiry must include descriptions of both hypothesis generation and testing" (p. 109). Welch, et al. (1981), in their article, "The Role of Inquiry in Science Education: Analysis and Recommendations" defined inquiry to be "A general process by which human beings seek information or understanding. Broadly conceived, inquiry is a way of thought. Scientific inquiry is concerned with the natural world and is guided by certain beliefs and assumptions" (p. 33). Dressel et al., (1960) stated that the most common elements listed in the definition of scientific inquiry include recognition of the problem; collection of relevant data; formulation of hypothesis, testing of hypothesis; and drawing conclusions" (p. 123).

The Steps and Stages of Scientific Inquiry

There are three basic phases in the inquiry learning process. These have been identified as: exploration, invention, and discovery.

Exploration. The first phase of the inquiry method is termed exploration. Exploratory activity is designed to encourage students to investigate a particular topic. They are asked to locate the pertinent information which has a bearing on the topic. The information collected by students may come from a variety of sources. They may draw on what has been found in earlier investigations, or resource materials, films applicable to the topic, or even presentations made by the teacher. Once they are satisfied that they have the necessary data, they are asked to arrange their findings in some kind of reasonable pattern. Often, this is accomplished only with some suggestion, clue, or other assistance from the teacher (Bibens, 1980, p. 87).

Invention. The second phase of the inquiry method is termed invention. It is in this phase that students are asked to consider what they believe they have learned from examining the content in the exploratory phase. After exposure to a series of examples which contain similar elements, students are encouraged to "invent" a rule which would encompass the examples they have studied. This is a procedure quite different from one in which the teacher presents the students with a rule, a theorem, or a principle,

demonstrates a problem by applying that principle, and then asks the learners to repeat the procedure with a number of similar problems which follow the rule they have memorized (Bibens, 1980, p. 87).

Discovery. This takes the class into the third phase of inquiry, discovery. It is in this phase that students discover the inadequacies of what they have invented. Does the rule they have evolved apply to all problems related to the concept under investigation? If it does not, then the students are to reconsider their invented rule, and modify it, so that it does have general application (Bibens, 1980, p. 87).

How do scientists conduct inquiry?

1. Inquiry begins with stimuli that are contrary to expectations, i.e. sensing a problem and deciding to find an answer for it.
2. The next step is to try to define the problem and to study the situation for all facts and clues bearing upon the problem.
3. Making the best tentative hypothesis as to the possible solution of the problem.
4. Selecting the most likely hypothesis.
5. Testing the hypothesis by inventing and planning one or more experiments and by carrying out these experiments.

6. Running check experiments involving the same experimental factors to verify the results observed in the original experiment.
7. Drawing a conclusion.
8. Making inferences based on this conclusion when facing new situations in which the same factors are operating. (Rachelson, 1977, p. 109).

Further Investigation of the Study

The presentation of this study is organized into five chapters. Chapter I was an introduction to the study which included the background of the problem, the purpose of the study, importance of the study, the research questions and data collection, the hypotheses, procedure, limitations of the study, and definitions. Chapter II will include a review of the literature related to the study, the roles of the teachers, students, and supervisors in the inquiry teaching-learning process, and finally, it will include a brief description of the educational system as well as the development of education in the State of Kuwait. Chapter III will present the methodologies and procedures employed in the investigation. A brief description of the research design will be included. Chapter IV is devoted to the presentation of the findings of the study. Finally, Chapter V will include a summary of the investigation, appropriate conclusions, and recommendations that are made on the basis of the findings of the study for further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

At the beginning of this chapter, the researcher would like to indicate that many terms have been used in this chapter. The words problem-solving, discovery, guided discovery, inquiry, and scientific inquiry are important terms in the language of elementary science education. An inspection of the literature indicates that they are often used interchangeably (Beaver, 1982). Therefore, during this review of literature, the researcher will try to take these words into consideration.

The idea of inquiry is not a new one. The fact is that inquiry is as old as Socrates and Aristotle. Throughout the years, many teachers have used it, and many are continuing to use it. Moreover, many books and numerous articles have been written throughout history in general and in the last several years in particular dealing with inquiry (Kaltsounis, 1971). One of the earliest arguments connecting the logic of inquiry with liberal education is found in a passage from Aristotle's Parts of Animals. He wrote:

Every systematic science, the humblest and the noblest alike, seems to admit of two distinct kinds of proficiency: one of which may be properly called scientific knowledge of the subject, while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair off-hand judgement as to the goodness or badness of the method used by a professor in his exposition. To be educated is in fact to be able

to do this It is plain then, that as in other sciences, so in that which inquiries into nature, there must be certain canons, by reference to which a hearer shall be able to criticize the method of a professed exposition.

For Aristotle an understanding of the logic (canons) of how inquiry is undertaken leads to the development of a rational mind capable of acting as critic in a field. (Connelly, 1972, p. 386)

Moreover, many educators have written about and discussed this method of teaching from different points of view. At the beginning of the 20th century, John Dewey (1916), in his book Democracy and Education, made one of the earliest and most significant protests against a curriculum based on the teaching of specific facts and generalizations. He maintained that true education is not only the transmission of accumulated knowledge, but also a process of assisting the development of certain natural tendencies of the child. One such tendency is to inquire; i.e. wanting and trying to find out. He also believed that such inquiry, together with learning how to search effectively for answers to questions raised, is more important than learning particular information. The development of such inquiry and procedures for seeking answers is useful to the pupil in any situation that might confront him. Dewey (1916) viewed facts as meanings that have already been established and that should be used as resources for conducting new inquiries, which lead to new information, concepts, and generalizations.

Dewey (1938) wrote a book called Logic: The Theory of Inquiry in which he mentioned that the scientific inquiry is hypothetical - deductive in nature. This view or interpretation would call for an explanation of a "larger view" of the area of concern, from which individual examples could then be drawn. But it emphasizes two necessary conditions which are usually slurred in statements of that position: (a) the necessity of observational determinations in order to indicate a relevant hypothesis and (b) the necessity of existential operational application of the hypothesis in order to institute existential materials capable of testing the hypothesis (p. 427).

Various levels of inquiry may also be identified. Schwab and Brandwein (1962), who are some of the leading proponents of inquiry teaching, explained two types or two levels of inquiry: "stable" inquiry and "fluid" inquiry.

1. Stable inquiry tends to "fill in the blank spaces in the growing body of knowledge. It proceeds down an established path which is governed by the existing principles and generalizations. Stable inquiry is not concerned with new principles" (Schwab and Brandwein, 1962). Stable inquiry treats scientific principles as facts; the principles, then, define the problem for the investigators. The investigators who receive their

conceptual principles from others, treat these principles as matters of fact, not matters for test (Fischler, 1965, p. 402).

2. "Fluid inquiry, on the other hand," they said, "refers to situations in which the principles themselves are the object of the research" (Nagalski, 1980, p. 26-27). Therefore, it can said that:

In fluid inquiry, the aim of research is to test the principles and ultimately revise them or invent replacements for them. The goal is not the immediate knowledge of the subject which use of the principles may lead to, but discovery of their limitations as intellectual tools of long-term programs of stable research. (Publiese, 1973)

It takes into account the new bits of information discovered by the stable inquirer and tries to discover or invent new relationships, new theories, new constructs which will open up a completely new line of inquiry for the stable inquirer. The fluid inquirer is not searching for the solution to a problem, but rather for the formulation of a theory which will bring about a new series of problems (Fischler, 1965, p. 402).

Moreover, Schwab (1963) also stated the following:

To teach science as inquiry means, first, to show students how knowledge arises from the interpretation of data. It means, second, to show students that the interpretation of data - indeed, even, the search for data - proceeds on the basis of concepts and assumptions that change as our knowledge grows. It means, third, to show students that because these principles and concepts change,

knowledge changes too. It means, fourth, to show students that, though knowledge changes, it changes for good reason - because we know better and know more than we knew before. (p. 40)

This then explains not only what inquiry is but also presents its goals.

Inquiry strategies more frequently engage the pupil in decision making regarding his own instruction. The pupil in this approach assumes an active role in activities relating to his own learning and generally interacts with his peers and his teacher to a large degree. The inquiry approach is a student-centered mode of instruction rather than teacher-centered (Hagen and Stansberry, 1969, p. 534).

Suchman (1961) advances the idea that inquiry provides a means to individualize or self-pace instruction so that students are able to learn what is relevant to them. According to Suchman, freedom and a responsive environment are necessary for self-directed inquiry. He contends that the ability to inquire and discover concepts autonomously is more basic than the attainment of concepts. It is implied that, through inquiry and the ability to individualize instruction, many of the problems associated with slow or turned-off learners will be resolved. There is also the belief that inquiry increases intellectual potency and aids in developing critical thinking abilities (Kyle, Jr., 1980).

In 1966, Suchman (1966) developed curriculum approaches which solely relied upon pupil questions: delimiting teachers to simple Yes or No answers.

Gagne (1963) in his article "The Learning Requirements for Enquiry" stated that "inquiry is apparently a set of activities characterized by a problem-solving approach in which each newly encountered phenomenon becomes a challenge for thinking" (p. 145).

Gagne (1965), in his book The Conditions of Learning, disagrees with the notion that says that the young person naturally attains more discoveries through inquiry and investigative schemes than does an experienced scientist because: (a) "for a budding student scientist, each new insight is a discovery," and (b) "he believes that to be an effective problem-solver, the individual must somehow have acquired masses of structural organized knowledge" (p. 170). Such knowledge is made up of content principles, not heuristic ones. Therefore, one can understand that Gagne is a proponent of guided learning who favors maximum guidance and acquisition of facts leading to the mastering of principles and problem solving. He said that "discovery without guidance makes the learning of concepts a terribly slow process" (Beaver, 1982, p. 30).

Similar to Gagne, Ausubel (1963) emphasized time as an element of guidance in stating that: "Autonomous discovery enhances intuitive understanding, but as a primary method of transmitting subject matter content, this approach is much

too time consuming and inefficient simply on a time cost basis." Ausubel pointed out that:

Any science curriculum worthy of the name must be concerned with the systematic presentation of an organized body of knowledge as an explicit end in itself. It is also completely unrealistic to expect that subject matter content can be acquired incidentally as a by-product of problem solving or discovery experience, as in the typical activity program or project method. (p. 282)

Ausubel (1963) also maintained that to be pedagogically realistic about discovery techniques, it must be conceded in advance that before students can "discover" concepts and generalizations reasonably efficiently, problems must be structured for them, and the necessary data and available procedures must be skillfully "arranged" by others, that is, simplified, selectively schematized, and sequentially organized in such a way as to make ultimate discovery almost inevitable. No research scholar or scientist has it quite this easy (Pugliese, 1973).

Moreover, meaningful learning presupposes that the learner employs a meaningful learning set, and that the material being learned is potentially meaningful (Ausubel, 1961). The fact that the learner is undergoing a learning process implies that scientific inquiry is not meaningful to the student. It is, therefore, absurd to have students believe that they are performing scientific inquiry - something which they are not capable of doing without a prior learning process. Ausubel (1961) stated that:

For meaningful learning to occur in fact, it is not sufficient that the new material simply be relatable to relevant ideas in the abstract sense of the term. The cognitive structure of the particular learner must include the requisite intellectual capacities, ideational content and experimental background. (p. 19)

Ausubel (1964) also noted that:

Most of what [a student] really knows and meaningfully understands . . . consists of insights discovered by others which have been communicated to him in a meaningful fashion Its's much less time-consuming to communicate and explain an idea meaningfully to others than to require them to rediscover it by themselves. (p. 291)

Finally, and according to Ausubel (1964), "learning by discovery has its proper place in the repertoire of accepted techniques available to teachers. For certain purposes and under certain conditions, it has a defensible rationale and undoubted advantages" (p. 291). Hence the issue is not whether it should or should not be used in the classroom, but rather for what purposes and under what conditions.

On the opposite side of Gagne and Ausubel, it was observed that Bruner (1965) favored learning by discovery with emphasis on structure and guidance as well as maximum inquiry and investigation on the part of the student. Bruner (1965) in his book The Act of Discovery maintained that:

Discovery - whether by a schoolboy doing it on his own or by a scientist cultivating the growing edge of his field - is in its essence a matter of rearranging or transforming evidence in such a way that one is enabled to go beyond the evidence so reassembled to new information. It may well be that an additional fact or shred of evidence makes this larger transformation possible. But it is

often not even dependent on new information. Emphasis on discovery helps the child to learn the varieties of problem solving and ways to transform information for better use and helps him learn how to go about the very task of learning. (p. 81)

Furthermore, Bruner (1963) in his book On Knowing hypothesized that:

Emphasis on discovery in learning has precisely the effect on the learner of leading him to be a constructionalist; to organize what he is encountering in a manner not only designed to discover regularities and relatedness, but also to avoid the kind of information drift that fails to keep account of the usage to which the information might be put. Emphasis on discoveries, indeed, helps the child to learn the varieties of problem-solving and helps him to go about the very task of learning. (p. 92)

Finally, Bruner (1964), in his work with children, encouraged them to question things and events as they saw them, while, during his work on inquiry and learning, he provided some major impetus to reviving the concern of question asking in children.

Sund and Trowbridge (1967) defined inquiry as a search rather than the product emphasizing teaching science and inquiry, and noted that the essence of inquiry teaching is arranging the learning environment to facilitate student-centered instruction, while giving sufficient guidance to ensure direction and success in discovering scientific concepts and principles.

Sund and Carin (1964) wrote:

Schools have . . . traditionally overemphasized this product of science, the subject matter, and

underemphasized or forgotten the process of science. A look at the process by which the subject matter is obtained reveals the dynamic nature of the scientific process, for facts become valid and cumulative only after they survive unrelenting scrutiny. Thus, scientific facts . . . although extremely necessary for any scientific investigation . . . are only a product of the greater contribution of modern science, the process of inquiry. (p. 4)

School should be practical and, thus, should strive to prepare youth for life outside the school confines in the 21st century. According to Sund and Trowbridge (1967):

The purpose of the inquiry approach is to involve the student in the processes a scientist really uses in discovering new knowledge. The objective is to have the student live, for a time, the life of a scientist. It is for this reason that the inquiry approach has also been called the discovery approach. (p. 28)

Many educators believe that when science is taught properly, it can contribute to these ends, to prepare students for life and to be life itself, especially when the learner is given the opportunity to practice in the classroom what he is learning and is going to use later. Sund and Carin (1964) discussed how they believed this could be done, saying:

Science education should stress the spirit of discovery characteristic of science. Both teachers and students find that science teaching and learning become a chore when approached as a series of facts to be memorized and regurgitated back on exams; nothing is more contrary to the spirit of science than the lecture-memorize-test method. This does not mean that concepts, theories, principals, and content areas are abandoned in our science curriculum; to the contrary, they can be learned better when approached from a discovery

method. The student, learning concepts, develops his skills in observing, checking, measuring, criticizing, and interpreting discoveries as well as other skills inherent in the prepared or scientific mind. Students cannot learn nor grasp the true spirit of science unless they engage in discovery. (p. 11)

Many educators advanced the idea that inquiry provides a means to individualize, or self-pace, instruction so that students are able to learn what is relevant to them. Suchman (1960) is one of these educators. His inquiry program was designed to enable the learner to direct and control his own learning. To do this the teacher must provide the climate and conditions necessary, structure the process, organize the sequence, and assist the pupil in evaluating his own progress. Thus the teacher is seen as a facilitator, and the child as a programmer of his own learning. The conditions which Suchman described as necessary for self-directed inquiry and which must be provided were: freedom and a responsive environment (Fish and Goldmark, 1966). He contended the ability to inquire and discover concepts autonomously is more basic than the attainment of concepts. It is implied that, through inquiry and the ability to individualize instruction, many of the problems associated with slow or turned-off learners will be resolved. There is also the belief that inquiry increases intellectual potency and aids in developing critical thinking abilities.

Suchman stated that:

Inquiry training is designed to supplement the ordinary science classroom activities. It gives the child a plan of operation that will help him discover causal factors of physical change through his own initiative and control and learn not to depend on the explanations and interpretations of teachers or other knowledgeable adults. He learns to formulate hypotheses, to test them through a verbal form of controlled experimentation, and to interpret the results. In a nutshell, the program is aimed at making pupils more independent, systematic, empirical, and inductive in their approach to problems of science. (p. 42)

Finally, there is no apparent reason that both inquiry skills and understanding of concepts cannot be learned by the discovery approach to elementary school science instruction. This conviction was expressed by Suchman (1960) when he stated the following rationale for the new science approach in 1962.

1. Learning through inquiry transcends learning which is directed wholly by the teacher or the textbook; the autonomous inquirer assimilates his experience more independently. He is free to pursue knowledge and understanding in accordance with his cognitive need and his individual level and rate of assimilation.
2. Inquiry is highly motivating because children enjoy autonomous activity particularly when it produces conceptual growth.
3. Concepts that result from inquiry are likely to have greater significance to the child because they have come from his own acts of searching and data processing. They are formed by the learner himself; and for that reason would be more meaningful to him, and hence more stable and functional. (Wilson, 1967, p. 38)

Inquiry implies question, the learner asks questions to satisfy his desires and his curiosity. Therefore, it can be said that learning by inquiry or by discovery is emotionally satisfying and rewarding to the learner. Fish and Goldmark (1966) affirmed this idea when they said:

The teacher who provides for discovery-learning is aware that she is nurturing pupil self-recognition. For she provides opportunity for the pupil to evaluate his learning experience and thus discover that he is learning and that learning is satisfying. She helps the pupil see a relationship between learning, responsibility, self-discipline, and increased independent action. (p. 14)

Moreover, Fish and Goldmark (1966) indicated another level to which inquiry can be taken. In this model, inquiry shifts from the level on which alternative methods of science inquiry are focal to the level on which decisions about which methods to select are focal. The new model is shown as follows:

- Level I: Alternative methods of science inquiry.
- Level II: Judgement about alternative methods of science inquiry.

In this approach to inquiry, pupils make the decisions and determine the methods to be used in their science inquiry, experience and face the results and consequences of their decisions, and assess and/or analyze the consequences by inquiring into the science inquiry methods which produce the consequences.

Furthermore, Fish and Goldmark (1966) added that inquiry can also be taken to a third level on which the pupils would then evaluate the criteria they have built.

Several concerned scientists and educators have written about modern curriculum programs with a major emphasis on the investigative phases of science, the exploratory phases of science, and the development of scientific inquiry skills. Such science curricula sought to create laboratory experiences that presented genuine problems of investigation for students of all abilities. Emphasis was placed on increasing students' critical thinking and on giving students some understanding of the nature of science.

Romey (1968) referred to the "Invitation to Enquiry" and explained that "experimentation and gathering data are essential to a science course and are usually interesting to students" (p. 31). He went on, adding that, "The procedure is truly scientific since it incorporates interpretations, generalization, and conclusion" (p. 31).

Hurd (1969) stated that "an education in science must prepare young people to learn on their own" and, that students should "expect to learn more after leaving school than they did in school" (p. 8). He cited this as one reason for the emphasis in education today on learning to learn, upon inquiry, and discovery techniques.

The best method for reaching this goal is to encourage students to question things and events as they saw them. The questioning process as a learning tool has been the concern of educators for a long time. Several curriculum developers have been using children's questions as a source of learning. Many educators such as Dale (1937) recommended pupil questions as being of great value in curriculum construction. Carner (1963) suggested that teachers be encouraged to involve children in the questioning process both verbally and non-verbally. In correspondence with the concern to encourage teachers to involve children in the questioning process, Susskind (1969) developed some instructional programs to increase the number and quality of pupil questions.

In conjunction with the emphasis on pupil questioning and the inquiry process, came a variety of conceptual and practical suggestions on improving teachers' abilities in designing learning environments conducive to pupil questioning. Wickless (1971) designed an in-service program to increase teacher ability to involve children in self- and social questioning. He found that following such in-service training, children did indeed ask more questions than their teachers. Further developing this approach was Suchman (1966). He developed curriculum approaches which solely

relied upon pupil questions, delimiting teachers to simple yes or no answers.

The Learning Environment Which Facilitates
and Encourages Inquiry

The operational spirit of inquiry is central to the development of the conceptual awareness that science is investigation. For the learner to comprehend the investigative aspects of science, he must be in a situation where he has the freedom to inquire (Weber, 1974).

A truly free person has internal freedom as well as external freedom. In regard to the external freedom, there is an atmosphere of mutual respect and trust that is revealed as the children move from one area of the room to another without seeking permission or disturbing others in their self-directed search for materials (Skeel and Decaroli, 1969). Therefore, the more rules and restrictions thrown in the way of the learner, the fewer choices he has and the less his activity resembles inquiry. It is obvious that the classroom teacher can be very influential in creating conditions that enhance motives to inquire. Probably the most important role is to protect the learner from pressures that get in the way of the emergence of positive motivational patterns. If a child is afraid of being wrong, he is concerned too much with doing what is expected of him to

wonder about why, or to enjoy the luxury of exploring ideas or taking exciting perceptual journeys (Suchman, 1965).

On the other hand, if the student does not feel the need to please the teacher with the correct answer, a climate for inquiry increases. A student who is encouraged to interact, whether his idea is right or the theory advanced is workable, has at least participated and will feel freer to initiate ideas in later inquiry episodes (Gies and Leonard, 1970).

Regarding internal freedom, scientific inquiry is essentially an attitude which is characterized by a unique freedom of the mind. The learner must be free to identify and pursue the problem as he sees it. His hypotheses must be his own; data must be obtained through methods of his choosing. Interpretations, predictions, and conclusions are based on his personal work. Inherent in this process is the feeling on the part of the student that this freedom does exist. The classroom atmosphere should convey this feeling to the learner (Weber, 1974). The learner should not feel that he has lost control of his own investigation through outside forces.

Along with freedom, a responsive environment is considered a crucial condition for inquiry. A lone child in a completely bare room may have all the freedom he wants, but his capacity to inquire is tremendously restricted by the fact that he has no means of gathering data. Even if his

ideas are rich and fluent, he is going to find it very difficult to engage in inquiry since he has no source of data to test his ideas or to generate new ones. The more the teacher puts into the immediate environment of the child to enable him to interact, gather information, and test ideas, the more responsive the teacher has made the environment. Classrooms that are loaded with materials of this kind, and in which children are free to utilize this responsiveness, are classrooms that have a great potential for inquiry (Suchman, 1965).

Finally, inquiry is most productive when it has direction and purpose. If all searching is diffused, there is never enough total mobilization of energy to penetrate a particular area of interest far enough to make a concerted gain in conceptual growth. The very young infant engages in fairly diffuse searching, and as a result the sensory motor type of learning he undertakes builds a kind of intuitive groundwork for later learning, but it does not penetrate any particular problem with great power. One of the things which enables older children to inquire more rigorously is that they have the power to sustain a focus upon a particular idea without being sidetracked too much by tangential issues.

One way to provide a focus is to confront the child with an event that puzzles him. Educators refer to such events as "discrepant" in the sense that they present a phenomenon that

does not coincide with the child's knowledge and understanding of the world. A gap is created between what the child perceives and what he knows. The discrepant event provides not only a motivation to inquire, but also a focal point toward which the process of inquiry can be aimed. Focusing, however, is not a one time activity. It is often necessary for a teacher to step into a situation in order to resharpen the focus of inquiry (Suchman, 1965).

It is important to notice that focusing is not a matter of giving approval or disapproval, but a question of redirecting the child's attention to discrepancies and thus sharpening the focus for the child so that inquiry can continue productively rather than ending in a quagmire of unjustified closure. This is where the teacher plays a very important role in providing the child with the wherewithal to build and test his theories (Suchman, 1965).

The Role of the Teacher in Inquiry-Centered Instruction

Certain facets of the teacher's role in inquiry-centered instruction have been implicit in the section above. But since this study was based on the assumptions that inquiry places new demands on the teacher, and that the classroom verbal interaction developed by the teacher is probably instrumental in achieving the necessary intellectual climate to foster inquiry, some related considerations are explained below.

In recent years, considerable attention has been focused on within-class teacher behaviors and the relationships between these behaviors and students' achievement. It is a well known fact that the teacher is the key to the inquiry process, or as Welch, et al. (1981) stated:

The teacher is the critical factor in achieving a desired state consistent with inquiry teaching. Effective teachers would value inquiry, would encourage an inquiry orientation in others, and would possess skills in enabling others to understand inquiry as a way of knowing. (p. 34)

To do this, the teacher must provide the climate and conditions necessary, structure the process, organize the sequence, and assist the pupils in evaluating their own progress. Thus, the teacher is seen as a facilitator.

As mentioned earlier, Suchman (1965) said that the two conditions necessary for self-directed inquiry which must be provided by the teacher are: freedom and a responsive environment. Students in the classroom must possess a protected freedom. As they gather data, formulate theories, and test these theories, they need to be protected from competitive pressures both from their peer group and from adult authority. A child must feel that when he is searching for new answers, no one will punish him.

It is to be remembered that scorn, derision, or even the disapproval of silence may be a form of punishment, and nobody can guarantee this right of protected freedom for the student except the classroom teacher. The teacher

purposefully creates a classroom atmosphere that will maximize opportunities for students to meaningfully identify the problem and then be able to move toward their solutions. In such an environment, the teacher provides guidance in dealing with the problem raised. As he moves from group to group, he encourages the pupils in their efforts, refocuses the search for information if necessary, notes areas of apparent strengths and weaknesses among the pupils, prods the thinking of a stymied inquirer, points the way to resources of knowledge and different interpretations of ideas, and establishes the necessary intellectual framework from which children learn to draw their own conclusions and to develop value systems. This role requires the teachers' willingness to listen to and accept from children a variety of possible answers instead of seeking the one right answer (Skeel and Decaroli, 1969).

Finally, Postman and Weingartner (1969), in their book, Teaching as a Subversive Activity characterized an inquiry teacher as follows:

1. The teacher rarely tells students what he thinks they ought to know.
2. His basic mode of discourse with students is questioning.
3. Generally, he does not accept a single statement as an answer to a question.
4. He encourages student-student interaction as opposed to student-teacher interaction. And generally he avoids acting as a mediator or judge of the quality of ideas expressed.
5. He rarely summarizes the positions taken on the learnings that occur.

6. His lessons develop from the responses of students and not from a previously determined logical structure.
7. Generally, each of his lessons poses a problem for students.
8. He measures his success in terms of behavioral changes in students. (Chapter 3)

Postman and Weingartner (1969) contended that:

The only kind of lesson plan that makes sense to the inquiry teacher is one that tries to predict, account for, and deal with the authentic responses of learners to a particular problem: the kinds of questions they will ask, the obstacles they will face, their attitudes, the possible solutions they will offer, etc. Thus, he is rarely frustrated by "wrong answers," false starts, irrelevant directions. These are the stuff of which his best lessons are made. In short, the "content" of his lessons are the responses of his students. (Chapter 3)

The Role of the Student in Inquiry-Centered Instruction

The inquiry problem is designed to enable the learner to direct and control his own learning, i.e., through this program that student is seen as a "programmer" of his own learning, and he is the center of the learning experience. The student should feel free to initiate the inquiry and to decide for himself what data will be needed to find this new set of explainers. He can generate his own theories, test them through experiments and through gathering suitable data and finally formulate his own conclusions. Furthermore, he should try to find the information that he needs while generating additional questions which will provide the incentive for further investigation.

The inquiry program gives the learner the opportunity to seek the information he wants, when he wants it, the opportunity to develop ideas and to discover ways of explaining what he observes with all of his senses. Therefore, the child in the inquiry class must learn to make reliable observations. He must be able to investigate objects in order to receive input, when possible, from all his senses. He must, after having been given the opportunity to interact with objects, be able to transform these input signals into some form of experience meaningful to him. It is also desirable that the student be able to translate his observations into a form meaningful to his peers and his teacher as well.

The student should not be limited to observations which use his senses. He should use extensions of these senses by using tools and instruments whenever possible. The student should be able to take each experience he has had and classify it in relation to his other experience, and by using his past experience and knowledge, he can tabulate many facts about the object he is studying now. Also, the student is free to add new experiences as they apply and reject those experiences which he can no longer support based on new input.

The inquiry method will be more beneficial and more effective when there is genuine pupil-teacher planning; when pupils help to set meaningful goals, help to formulate the

procedures necessary for achievement of the goals, help to develop and apply criteria for assessment of the progress, and formulate action plans, then, indeed, inquiry is in process (Miller, 1966).

Finally, Bibens (1980) stated:

Inquiry requires that students participate actively, and interact directly, with the content. The learner is not allowed to sit passively while the instructor reviews the main thrust of the learning experience for him. In essence, inquiry strongly suggests that the learner is his own teacher. (p. 90)

The Role of the Supervisor in Inquiry-Centered Instruction

Supervising elementary school science is a tremendous task, and defining the role of elementary school science supervisors has been a matter of controversy for many years. Nevertheless, the supervisors were carrying out some major tasks such as:

1. Part of the supervisor's role has been that of analyzing a classroom environment and assisting the teacher to achieve the goals of a course. His observations may indicate a need for more variety in materials, or different questioning patterns, or more emphasis on student participation (Azbell, 1977, p. 190).
2. The supervisor serves as a science instructor for the teachers in a school system and, either by himself or with the help of outside experts, often

a college professor, executes in-service programs in science education for teachers of the system (Tannenbaum, 1960).

3. The supervisor participates in preparing the curriculum for the elementary school science program or supervises its preparation or revision.
4. The supervisor serves as the guide for the classroom teacher, helping him see his shortcomings and helping him capitalize on his strength. Moreover, the supervisor serves as a science subject-matter consultant for the teachers as well as the students (Tannenbaum, 1960, p. 50).
5. The supervisor evaluates the work of the teachers in the area of science and reports to the Ministry of Education the efficiency of any given teacher.

In addition to these traditional tasks, the supervisor has many other jobs if he wants his teachers to teach by inquiry. He also needs additional skills to interpret new jobs that appear to be a unique reflection of inquiry methods. That is, the supervisor needs to know some of the essential requirements for inquiry and what to look for as an indication that inquiry is functioning. The initial role of the supervisor in the inquiry system is to detect the degree of acceptance of the inquiry problem by the students. If the degree of acceptance is too low, the teacher may need

assistance in the selection of inquiry problems that have more potential for student interest. There may be a need for more resources in visual stimuli, or simply more time, emphasis, and creativity on this aspect of the unit (Azbell, 1977).

Finally, the supervisor should be sensitive to the kinds of topics that make good inquiry experiences. Because of the large amount of time that needs to be devoted to most inquiry units, problems should have the potential for in-depth study and should serve to illuminate the larger problems in science (Azbell, 1977).

Advantages of Learning by Inquiry

Although research to date has not shown conclusively that teaching and learning by inquiry leads to greater or better understanding of science concepts and conceptual schemes, it does point to several distinct benefits and advantages from using this technique (Victor, 1974). The inquiry-discovery approach is more a matter of the learner, "rearranging or transforming evidence in such a way that one is enabled to go beyond the evidence so assembled to additional new insights" (Bruner, 1961, p. 27).

Inquiry teaching is a type of instruction where the child becomes a participant, not a spectator. It focuses more attention on the children than on the teacher. It relieves children of the deadening boredom of learning science by rote teaching and experimentation or demonstration, and

encourages the child to rely more on his or her own resources and abilities. It gives the child a sense of accomplishment and promotes self-confidence. This, in turn, encourages curiosity for further learning (Victor, 1974).

Learning by inquiry is concerned not only with confirming the outcomes of another's research, but also with the methods of research. Through inquiry, students are conditioned to think critically and creatively and to generate their own conclusions based on observations they themselves collect. In effect, they become scientists themselves (Nagalski, 1980).

For the students, the most important result of learning through inquiry is a change in attitudes toward knowledge. As they engage in the dialogue of inquiry, they begin to view knowledge as tentative, rather than absolute; and they consider all knowledge claims as being subject to continuous revision and confirmation. As they try to provide their own answers to difficult questions about man and his environment, they begin to understand the complexity of verifying knowledge and the processes involved in it (Massialas, 1969).

Learning by inquiry attempts to teach children how to learn. Since this technique is highly activity-oriented, it tends to develop the child's competency in the use of process skills. It is also one of the better methods for promoting desirable scientific attitudes, appreciations, and interests (Victor, 1974). Moreover, a major goal in an inquiry-

centered classroom is providing pupils with an organized, improved method of contemplating and dealing with information. A characteristic of effective thinking is that it should be independent or autonomous (Benne, 1967). To achieve independent or autonomous thinking, activities must be provided that allow self-direction and the development of self-confidence.

As stated by Suchman (1966), "An inquiry-centered curriculum helps children to":

1. Become more familiar with the realistic world in which they live. They are dealing with concrete phenomena instead of abstractions that deprive them of first-hand realizations.
2. Relate realities to each other. When everything is discrete and isolate, meanings are low. When new meanings are related to old, adjacent and congruent meanings to each other, usable and applicable conceptual systems grow out of realities.
3. See that in creating knowledge, man is constructing order out of chaos. Meaning is an internal thing, not easily accessible, and is a far cry from the ultimate goal of achievement. Richness of life is correlated with level of meaning rather than with level of achievement. Persons who are not achievers can have high levels of meaning for their own experiences.
4. Develop the process by which man pursues greater meaning through manipulating and observing his environment. Out of this process he is in a better position to generate new ideas, new ways of ordering and interpreting the world around him.
(p. 24 and 64)

Langdon and Stout (1964) in their book, Teaching in the Primary Grades, emphasized Suchman's ideas and added that teaching by the inquiry-discovery approach is only a matter of capitalizing on one of children's strongest traits, curiosity. Children are natural experimenters and scientific

investigators. From babyhood on, children become acquainted with their environment by exploring it in various ways. They test almost anything accessible by feeling, studying, moving, handling, striking, and usually by tasting it. Older children continue to make use of their senses to discover new things. They are able to add the questioning technique and soon learn a number of ways to satisfy their almost insatiable curiosity by inquiry and discovery. An alert teacher will recognize the numberless discoveries he/she can help children make.

Finally, it is worth mentioning that methods of inquiry and discovery can be used profitably in classes that include students of different academic abilities. Massialas (1969) said that not only superior students, but also those who have lower than average IQ scores, prove to be capable of performing such intellectual operations as defining a problem, hypothesizing, drawing logical inferences, gathering relevant data, and generalizing. Given the appropriate psychological and cognitive climate, these students can perform on a high level and are as highly motivated as those having so-called superior abilities.

The Disadvantages of Learning by Inquiry and How to Overcome Them

Like every teaching strategy, inquiry teaching has its problems and disadvantages, as well as its advantages. A number of educators and psychologists have already given

warning about some inherent difficulties that teachers may encounter when using this technique. Some educators and psychologists caution that inquiry learning is not appropriate for younger children, especially those below the age of nine, because they believe that a strong background of science knowledge is a prerequisite for inquiry learning. Since the students do not have a high motivation to master intellectual tasks and they tend to be impulsive, the students leap at answers and fail.

Gagne (1965) supported this idea because he believed that to be an effective problem-solver or a discoverer, the individual must somehow have acquired masses of structurally organized knowledge. Such knowledge consists of content principles, not heuristic principles.

On the other hand, Skinner (1968) disagreed with Gagne, because he believed that the discoveries of the classroom bear only a vague resemblance to genuine scientific discoveries. Although the moment of discovery is important in the life of a scientist and may explain his dedication, it is necessarily a rare event and cannot explain the quality or nature of most of his behavior. But to a budding student scientist, each new insight is a discovery, and the young naturally attain more discoveries through inquiry and investigative schemes than does an experienced scientist.

This researcher believes that the goal of educators should not be to always teach by inquiry, but to allow

inquiry to occur in as many areas of the curriculum as possible. Many teachers and administrators claim that this teaching strategy is very noisy, unstructured, freewheeling, and almost totally student centered. These opinions may seem appropriate when one compares the inquiry method with the traditional method where all students quietly learn the same material. Inquiry teaching may be freer and less rigidly structured than traditional teaching, but it is not unstructured. Inquiry teaching is not completely student-centered or laissez faire. Inquiry teaching is more client-centered than centered directly upon tasks prescribed for students by a teacher. Moreover, it is an approach to learning that invites cooperative student-teacher planning.

Therefore, planning is a prime prerequisite for successful inquiry teaching and learning. Before entering the classroom, teachers must know specifically what they want to teach, how they think it should be taught, and how they are going to get the children involved in the process of learning. The use of questions is vital in inquiry teaching. The teacher should know in advance not only what questions to ask, but anticipate the kinds of questions the children may raise, so the teacher will be able to respond and proceed accordingly (Victor, 1974).

Another disadvantage is that learning by inquiry takes time. Although this point will be discussed later, it is important to mention that this point is vital if the teacher

wants their students to learn how to learn. On the other hand, it will be very difficult for the teacher to cover the whole science book in each level during the given period of time, especially in a centralized system like Kuwait. This researcher thinks that this is the main reason why many teachers avoid teaching by inquiry. To solve this problem, it is advisable to reduce the science curriculum in each level and/or to ask the teachers to use other more traditional teaching techniques when necessary.

Although many factors are operative in the promotion of inquiry, the role of the teacher in facilitating inquiry is the most important one.

Factors Affecting Teacher Use of Inquiry

The transition in teaching strategy from traditional to inquiry teaching and learning is not easy, but is not impossible. This goal can be achieved by revising the content, format, and approach in both the elementary science textbook series, as well as the elementary science methods in order to incorporate an activity-oriented teaching strategy that will enable the child to learn science as a process of inquiry. The obvious key to the accomplishment of this goal is the classroom teacher. No one would expect a group of students to develop an understanding of the processes involved in inquiry, evidence a willingness to utilize them, and move on into learning activities of a self-directing nature without the instruction, encouragement and application

by the classroom teacher in the formal learning situation (Gies and Leonard, 1970).

Many teachers avoid teaching science by inquiry because they are not prepared to do so. Esler (1970) summarized the reasons why many teachers avoid teaching science by inquiry when he wrote:

In spite of the emphasis placed upon it in professional literature, science textbooks, and teacher training programs, inquiry as a method for teaching science in our public schools has achieved only a very limited acceptance. Several reasons for this notable lack of success of the inquiry concept come quickly to mind.

1. There is a greater depth of understanding of subject matter required of the teacher.
2. It is necessary for the teacher to accept an often new and alien role of an indirect integrative leader.
3. Additional, difficult to master skills are required of the teacher. These skills are those of asking good questions and administering selective reinforcements to student response.
4. There are many failures by teachers in early attempts at conducting inquiry lessons.
5. The students do not know how to react to the often new and strange atmosphere of inquiry. (p. 454)

These difficulties, to some degree, explain the lack of general acceptance and indeed, the failure of inquiry processes in the science classrooms of our nation. They all are, however, overshadowed in importance by one overriding problem that in some measure contributes to each. This problem is the aura of uncertainty and general lack of understanding that surrounds the inquiry concept itself (Esler, 1970).

There are two ways for preparing teachers to use the inquiry method in teaching science: (a) preservice training, and (b) inservice training. In both cases the teacher should be given some courses in using the inquiry method in teaching science, the benefits of this method to the students, and the best ways to stress the use of inquiry in the classroom. Moreover, the teachers should be given the opportunity to practice this method of teaching in workshops or in teaching units of a curriculum to their peers in a form of micro-teaching.

In addition to this, Bagenotos (1975) suggested that:

The training of teachers should involve the issue of bureaucratic constraints on performing as a teacher-inquirer. Pre-service teachers aware of the limitations will either know better how to deal with them or choose not to teach at all. This component of training involves dealing with questions of power, norms of the school, teacher and student status, and the function of schooling. In short, pre-service teachers should gain the tools of analysis which enable them to determine the boundaries of their jurisdictions and the roles they are expected to occupy within the system in which they work. The further role of the teacher training institution is to create an informal support mechanism which continues its role after the student becomes a teacher. (p. 236)

Regarding inservice training, Flanders (1963) worked with 51 inservice teachers for nine weeks in order to persuade them to change their teaching to be more open-ended, to determine the usefulness of a program in which the teachers learn to assess their own problems of verbal influence, to experiment with different patterns, and to try to establish principles of influence from their own

experimentation. The effort was remarkably successful. The need for in-service in science continues primarily for the following reasons:

1. The constantly changing and expanding body of science knowledge.
2. Inadequate preservice programs.
3. The additional modifications of science curriculum improvement projects.
4. Ineffective or unavailable science consultant services.
5. The disparity between priorities for science in the elementary school and the requirements for scientific literacy in our society. (Helgeson, Blosser, and Howe, 1977, p. 97)

Finally, in comparing the two types of teaching methods, the traditional method versus the inquiry method, one can see the inquiry method takes more time, more materials, more planning, and more effort on the part of students as well as the teacher. If covering the textbook is perceived by the teacher as a major instructional goal, he/she will not be comfortable using inquiry strategies. The inquiry process does indeed use textbooks as a source of knowledge, but the process does not assume consistent adoption of the textbook's conclusions without further investigation of other interpretations. The teacher, therefore, must provide materials that present different points of view and be

objective in assessing their value (Skeel and Decaroli, 1969).

A Brief Description of the Educational System in the State of Kuwait

Introduction

Kuwait is located at the northwestern corner of the Arabian Gulf, i.e., at the northeastern corner of the Arabian peninsula. Kuwait is bounded by the Arabian Gulf on the east, Saudi Arabia on the south and the southwest, and by Iraq on the north and northwest. Its area is about 6200 square miles, with a population of 1.5 million. Only 45 percent of the population are Kuwaitis; while the rest of the population came from more than 120 different countries around the world.

Education in Kuwait

Actually, education represents the basic background for inclusive progress. The government of Kuwait realized that the human resource is the most important factor in the development of the country. Productivity output of such realization leads to hasty progress in all educational stages beginning in kindergartens and ending in secondary through the university level (Ministry of Planning the State of Kuwait, 1985). Therefore, the government of Kuwait is paying excellent attention and spending more than 12 percent of its annual income on education. This philosophy is reflected in

the following constitutional provisions which define the role of the state regarding the educational process:

Article 10:

The state cares for the young and protects them from exploitation and from moral, physical, and spiritual neglect. (The Constitution of the State of Kuwait, 1962, p. 7)

Article 13:

Education is a fundamental requisite for the progress of society, assured and promoted by the state. (The Constitution of the State of Kuwait, 1962, p. 7)

Article 40:

Education is a right for Kuwaitis, guaranteed by the state in accordance with law and within the limits of public policy and morals. Education, in its preliminary stages, shall be compulsory and free in accordance with law. Law shall lay down the necessary plan to eliminate illiteracy. The state shall devote particular care to the physical, moral, and mental development of the youth. (The Constitution of the State of Kuwait, 1962, p. 11)

Educational Development in Kuwait

Historically, early schools in Kuwait were religiously oriented. The mosques played a very important role in educating people in general, and youth in particular. At

that time the main curriculum was the Holy Quran, basic mathematics, reading and writing.

In 1912 the first formal school, Al-Mubarakiah, was opened. This school was supported by donations from merchants and traders. In the same year, the second public school, Al-Ahmadiyah, was opened to serve more people and to increase the number of subjects in the curriculum. They started teaching the English language in this school, besides other subjects such as history and geography.

In 1936, a Board of Education was founded. Since that date, there has been increased interest in education. The Board of Education started its work by requesting qualified teachers from Palestine to develop and assist with work in the schools.

Formal girl's education started in 1937. Before that time, girls were taught in homes by women interested in teaching the Quran and writing. By 1938, Kuwait had started sending her students abroad for further studies. In 1942, secondary or high school education commenced.

Educational Change

Education in the modern sense actually started after the initiation of the Ministry of Education immediately after achieving Kuwait's independence in 1961. The state accepted the responsibility to provide free education to every Kuwaiti from kindergarten to the university, including all types of

vocational and professional education as shown in Figure 2.1 (UNESCO, 1971).

In 1965, a law was issued by the government adopting universal compulsory education for every Kuwaiti child up to age 18, which covers kindergarten, elementary level, intermediate level, and secondary level.

The educational system - educational ladder includes the following stages:

1. Kindergarten: A two-year course, ages 4-6.
2. Elementary: A four-year course, ages 6-10.
3. Intermediate: A four-year course, ages 10-14.
4. Secondary: A four-year course, ages 14-18.
5. University of Kuwait.

In addition to the above mentioned stages, there are many institutions which accept students from both sexes either after the intermediate stage or after the secondary stage such as:

1. Technical School, after intermediate level.
2. Commercial Secondary School, after intermediate level.
3. Religious Institute, after intermediate level.
4. Commercial Institute, after secondary level.
5. Health Institute, after secondary or intermediate level.
6. Special Education Institute
7. Teacher Training Institute, after secondary level.

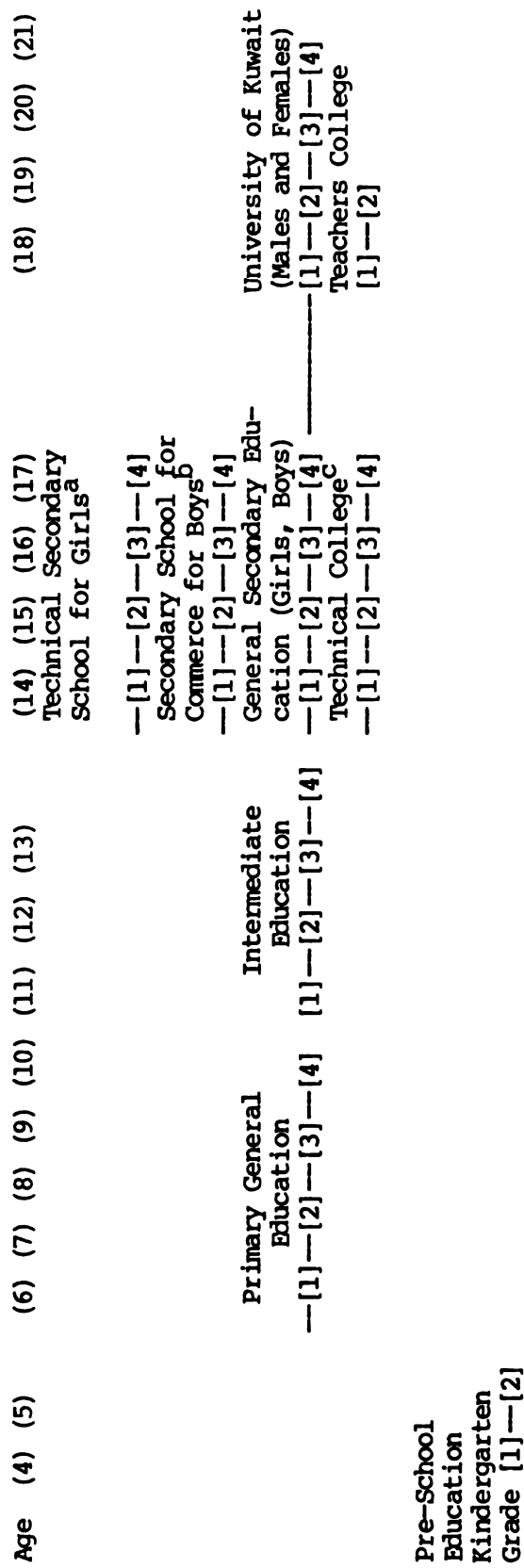


Figure 2.1

The Structure of the Educational System in Kuwait

^aEnrollment for the secondary stage has been suspended as from 1975-76 and replaced by the Commercial Institute for Girls (two years after the Secondary School Certificate).

^bEnrollment for the secondary stage has been suspended as from 1975-76 and replaced by the Commercial Institute for Boys (two years after the Secondary School Certificate).

^cEnrollment for the secondary stage has been suspended from 1975-76 and replaced by the Institute of Kuwait for Applied Technology as from 1976-77.

8. Technical and vocational institute, after secondary level.

The following table illustrates the considerable increase in the numbers of schools, students, and teachers between 1945-46 and 1984-85.

Table 2.1

Number of Government Schools,
Students, and Teachers

<u>Scholastic Year</u>	<u>Number of Schools</u>	<u>Number of Students</u>	<u>Number of Teachers</u>
1945/46	17	3,635	142
1960/61	134	45,157	2,255
1970/71	230	138,747	9,085
1975/76	326	201,907	15,472
1980/81	481	302,610	22,885
1984/85	568	361,715	26,594

Source: Central Statistical Office, Ministry of Planning, Annual Statistical Abstract, 1975 and 1985.

The organization of the Ministry of Education is built upon the basis of centralization. It directly controls the schools and educational units. Education for boys and girls are separate at elementary, intermediate, and secondary levels, while in kindergarten and the university level co-education has been implemented.

Summary

Inquiry is not only a method of teaching, but it is also an approach to learning which is based on sound and

established concepts and is directed toward achievement in content areas as well as toward development of rational powers. A greatly simplified interpretation of inquiry might suggest that it requires direct involvement of the student with subject content in the learning process, and in the quest for meaning and understanding. This implies active student participation, and emphasizes understanding rather than merely knowing about subject area (Bibens, 1980).

The idea of inquiry is neither new nor strange. Imaginative teachers have been doing it for years. Moreover, all children start learning as pure inquirers by asking a lot of questions concerning things around them. Therefore, teachers, especially at the elementary level, should try to arrange instructional conditions so that pupils become seekers after meaning, users of information, discoverers of general principles, validators of first conclusions, and builders of values as well as memorizers of facts, concepts, and more general ideas (Miller, 1966). Inquiry teaching provides the technique for creative and imaginative teachers to present the curriculum in a manner palatable to each student. Inquiry does not try to make each student fit the format implied by the conventional curriculum or the test series.

A major challenge facing those in teacher education is that of relevance--deciding what is worth knowing, helping students find out where they are headed, and realistically

explaining what a course is all about and the meaning it has for their lives. Difficult? Yes! But, the difficulty is not an excuse to cling to traditional policies and practices, because unless the pupil perceives the material as relevant, no significant learning will take place. No one will learn anything they do not want to learn. Ideally, educators should teach their classes from the questions their students raise, i.e. let the students help develop the curriculum from their questions. In any learning environment, the teacher and the learner must serve, complement, and derive meaning from each other (Minneman, 1972).

Nevertheless, it should be noticed that inquiry is not a magic formula. It is not best used at all times nor is it suited to every single learning objective. Inquiry requires practice, patience, and persistence both on the part of the teacher and on the part of the student. Used with direction, it can be a valuable tool in developing a self-directed learner who is capable of pursuing the unknown until he is satisfied (Gies and Leonard, 1970).

1. The classroom teacher is the key to the accomplishment of the goals of the inquiry process. He/she acts as a facilitator who helps and protects the learner from any kind of pressure which might prevent the learner from becoming involved in the inquiry process. The teacher should provide the

climate and conditions necessary to sustain the inquiry once it has been initiated by the learner.

2. The science supervisor plays an important role in the learning process. He/she participates in preparing and developing the science curriculum, helping teachers to develop a better understanding about the curriculum and its objectives, and in most cases, the supervisor serves as a science instructor for the teachers. Therefore, the supervisor can create some opportunities in order to train and encourage the teachers to be more involved in the inquiry process.
3. A free and responsive environment is considered a crucial condition for inquiry. In such an environment, the student should feel free to move from one activity to another, ask his/her teacher, share ideas with his/her peers, etc. On the other hand, the more rules and restrictions thrown in the way of the learner, the fewer choices he/she has, and the less his/her activity resembles inquiry.

This chapter also pointed out the roles of students, teachers, and supervisors; and discussed the advantages, as well as the disadvantages of learning and teaching by the inquiry approach and how to overcome these disadvantages. There was a discussion concerning why the teachers may avoid teaching with the inquiry method. Furthermore, a brief

description of the educational development and the educational system in Kuwait was included.

CHAPTER III

METHODOLOGY AND DESIGN OF THE STUDY

This research is an experimental study to determine the feasibility of using the inquiry method to teach a unit on magnets to third graders in two elementary schools (one for boys and one for girls) in the State of Kuwait (see Appendix A). This unit was designed to be taught in 13 sessions, each 45 minutes in duration. The subjects were four third grade classes (two from each school) with a total number of 112 students.

The subjects in two experimental classes (one from each school, with a total number of 55 students) were taught by two teachers who received instruction and training in using the inquiry-discovery method (see Appendix B). On the other hand, the subjects in two control classes with a total number of 57 students were taught the same unit by two teachers who did not receive instruction or training through this study in using the inquiry-discovery method and were using the traditional textbook-centered method.

Definition of Terms

The definitions of terms which follow are presented to aid in the interpretation and clarification of this study.

Inquiry: A process in which pupils focus on a problem and in their search for solutions go through a number of steps ranging from hypothesizing to formulating conclusions.

Inquiry-Discovery Method: A method of teaching which has as its basic strategy the involvement of the learners and teacher in a searching process, one in which solutions to problems are sought, tested and evaluated.

Gentry (1965) suggested the following definition of the discovery method. "A teaching method whereby a student is presented instances of objects or events, through which run common relationships or common elements and is asked to discover the common relationships or elements" (p. 16).

Traditional Textbook-centered Method: A method of teaching in which the teacher plans and directs the learning experiences depending on a textbook. Emphasis is placed almost solely on the learning of subject matter.

The Five Essential Science Experiences: Observation, Measurement, experimentation, interpretation of data, and prediction.

Wilson (1967) defined the five essential science experiences as follows:

1. Observation: Observations can be made in many other ways than visually. The pupil may resort to methods such as feeling, squeezing, poking and rubbing and be considered observing. Observation

is generally considered the first action taken by the learner in acquiring a new understanding.

2. Measurement: Measurement is similar to observation with the exception that measurement is quantitative and can be taken more than once in the same manner and receive approximately the same results.
3. Experimentation: The relationship between experimenting and observing can be summarized by saying that experimenting demands that observation and/or measurement be made, but observing and measuring do not demand that experiments be performed.

There must be a carefully defined situation which those participating in the operation understand and that which all agree will not be further understood unless "something" is done (an experiment). Experimentation is really an attitude on the part of the experimenter; it is an attitude which leads the investigator to ask himself what he has to do in order to change the types of observations and/or measurements he can make.

4. Interpretation of Data: When the activity of data interpretation is viewed in its entirety, it can

best be described as making sense out of what you have found.

Data are the information which are derived from an experiment or observation. In order for data to be interpreted they must be available for inspection. This fact explains that the data must be arranged in such a way that there exists the possibility of their telling the interpreter a story.

5. Prediction: When predictions are made, they are made in order to foretell what will happen; an estimate of the events to take place and/or results to be achieved. A hypothesis is an assumption to allow the validity of a fact to be tested, and a prediction is the utilization of tested facts in order to foretell the future behavior of an individual, the results of an experiment, or the outcome of an event. (p. 49-51)

Data Collection

This researcher observed all 13 sessions in the experimental classes in both schools, while ten and 11 sessions in the boys' and girls' control groups were observed, respectively. The teaching of this unit started on November 14, 1985 and ended on December 12, 1985. At the

end of the unit, all subjects received a common final test, which was developed by the researcher (see appendix C).

The data for H_0 were collected through observations which took place during the teaching process of the unit where all four groups were observed and the frequency of the students' involvement in the essential science experiences during each session were counted in tables like Table 3.1.

Table 3.1

Sample Observation Sheet

<u>Essential Science Experiences</u>	<u>Frequency</u>	<u>Proportion</u>
Observation		
Measurement		
Experimentation		
Interpretation of Data		
Prediction		
Total		

When the observations were completed, the frequency of each experience was computed to proportion and then the normal standardized deviate z score was computed for each pair of categories. This study contains four pairs of categories which are male control group versus male experimental group, female control group versus female experimental group, male control group versus female control group, and male and female control group versus male and female experimental group. The formula used to compute the z scores was the following:

$$z = \frac{P_1 - P_2}{\sqrt{\frac{x_1 + x_2}{N_1 N_2} \left[1 - \frac{x_1 + x_2}{N_1 + N_2} \right]}}$$

where:

- P_1 and P_2 = Proportions in each category
- x_1 and x_2 = The frequencies in each category
- N_1 and N_2 = The total frequencies for each variable

The data for the null hypotheses H_{02} , H_{03} , and H_{04} were collected from the final test results (see Appendix D). For each class, the mean of the final test scores was computed. Comparisons between the different groups will be shown on graphs. Therefore, there will be one graph for each of the following:

1. Female control group versus male control group.
2. Female experimental group versus male experimental group.
3. Female experimental group versus female control group.
4. Female and male experimental group versus female and male control group.

Moreover, for the purpose of explaining the results in a broader way there will be some additional graphs such as:

1. A comparison between the experimental groups and the control groups.

2. A comparison between the male experimental group and the male control group.

For all of the null hypotheses, the level of significance was established at $\alpha = .05$.

Validity of the Final Test

Mosher and Kalton (1972) defined validity by saying that, "it is the ability of the survey instrument to measure what it sets out to measure" (p. 356). Furthermore, they mentioned that a researcher and/or a team of workers in a particular area with enough knowledge can judge the validity of the research instrument. They said, "The assessment of content validity is essentially a matter of judgement; the judgement may be made by the surveyor or, better, by a team of judges engaged for the purpose" (p. 356).

The validity of the final achievement test was enhanced by consulting and seeking advice from four science supervisors and the science general supervisor in Al-Ahmadi educational zone in Kuwait. Unfortunately the reliability of the final test was not tested because of some difficulties and shortage in time. Nevertheless, it was found that if a measure has excellent validity, then it must also be reliable (Oppenhiem, 1966, p. 69-70).

Research Hypotheses

Four null hypotheses were tested:

- H₀₁ There is no significant difference in the number of times pupils will use the "five essential science

experiences in those classes which were taught by teachers who were trained to use the inquiry-discovery approach, as contrasted with classes which were taught by teachers who were using the traditional textbook-centered approach.

- H₀2 There is no significant difference between the means of the test scores of the male experimental group who learned by the inquiry-discovery method and the female experimental group who learned by the same method; i.e., male experimental group vs. female experimental group.
- H₀3 There is no significant difference between the means of the test scores of the male control group who learned by the traditional method and the female control group who learned by the same method, i.e., male control group versus female control group.
- H₀4 There is no significant difference between the means of the test scores of the experimental groups (for both sexes) and the control groups; i.e., male and female experimental groups vs. male and female control groups.

Description of the Sample

The two schools selected for this study were not located far from each other in a suburban area in Al-Ahmadi educational zone. Each school accepted students from the first through the fourth grade. The girls' school contained 28 classrooms with a population of 791 students, while the boys' school contained 32 classrooms with a population of 875 students. For both schools, approximately 98 percent of the students were Kuwaiti. All students involved in the study were between 8 1/2 - 9 1/2 years old, except one girl in the girls' experimental class who was about 13 years old. Based on income, education, and lifestyle, the community

would be considered predominantly middle class with about a 60 : 40 ratio of lower middle to upper middle.

Teachers

In selecting teachers to participate in this study, several criteria were used. Teachers were to be non-Kuwaiti, with at least ten years of experience and should have a record for being excellent teachers. This judgement was based on a unanimous decision reached by the science supervisor and the school principal at the end of each scholastic year when they evaluate the teachers.

The reason teachers were to be non-Kuwaiti was because there were no Kuwaiti teachers with more than five years of classroom experience. Moreover, since most of the teachers in the schools are not Kuwaiti, it is easier to generalize the results of a study when it deals with non-Kuwaiti teachers. The reason teachers were to be experienced and have good records for being excellent teachers was to reduce the likelihood of discipline problems detracting from their teaching experience. Two female teachers from the girls school and two male teachers from the boys school who were teaching science at the third grade level were found to satisfy all criteria, and all of them expressed an interest and willingness to participate in this study. Moreover, the two experimental teachers were hopeful that this new experience would help them to become better teachers.

This researcher's experience in being in science classrooms both as a teacher and as a science supervisor gave him the opportunity to watch and observe both the students and their teacher at the same time while in a classroom. All four teachers were accustomed to having visitors in their classrooms such as the school principal, the science supervisor and/or other science teachers in the school. All four teachers who participated in this study knew that the investigator was a science supervisor who was studying in the United States for the degree of doctor of education. Therefore, all four teachers had been informed that the purpose of this study was not to evaluate their teaching efficiency or their performance, but to learn more about their decisions, thoughts, and feelings while teaching science using the inquiry-discovery method and the traditional textbook-centered method. Thus, the most important goal of this study was to compare the two different approaches of teaching science.

Teacher Training

The researcher spent three half-days of in-service training sessions with each of the two experimental teachers individually (see Appendix B). The main purpose of the training was to plan and to discuss the best ways of using the inquiry-discovery approach in teaching the unit of magnets. The training sessions included discussions of how

to encourage the students to ask more questions, depend on themselves during the learning process, encourage students' involvement in the "essential science experiences" (which are observation, measurement, experimentation, interpretation of data, and prediction) to aid teachers to understand the nature of inquiry learning through the activities of the students, and to assist teachers in designing and conducting inquiry centered lessons applicable to children's varying intellectual levels. Moreover, the sessions included checking and preparing all of the materials which might be needed during the teaching of the unit and providing whatever was missing.

During the preparation sessions, both experimental teachers, in the opinion of the researcher, were enthusiastic, creative and industrious, possessed superior intellectual ability, were fast learners, and were willing to test and try new ideas. Both teachers were flexible in behavior and fluent in creating ideas. Prior to the teaching of the unit, both teachers were questioned about their plans for the unit. Teachers' plans were also checked on a daily basis unless no new plans had been made.

Besides the previous mentioned sessions, other consultation times were held weekly during the study to discuss the field notes which had been taken during the daily observation of the experimental classes. These

sessions included discussions of how to encourage critical responses from the students, reminding the teachers of their roles and the roles of their students during the study; defining the objectives and goals; and predicting some behaviors that pupils could and/or must achieve during the coming week.

Variables

This study involved two main independent variables and only one dependent variable (outcome).

The Independent Variables

There were two independent variables:

1. The sex of the students (school) which consisted of two categories: (a) girls and (b) boys.
2. The treatment or method of teaching, which also had two categories: (a) experimental and (b) control.

There were two female classes (one experimental and one control) with a total number of 55 students. Twenty-seven students were in the experimental class, while the rest were in the control class. The experimental group learned by the inquiry-discovery method while the control groups learned by the traditional textbook-centered method.. Also, there were two male classes (one experimental and one control) with a total number of 57 students. Twenty-eight students were in

the experimental class, while the rest were in the control class.

The Dependent Variable

This was the score of the students on the final achievement test which contained 20 questions--each question was equal to one point. Therefore, the minimum score was zero and the maximum score was 20. However, the range of scores for the subjects involved in the study was between 6 and 20.

Three questions of interest were posted for this study:

1. Is there a significant statistical difference between the girls and the boys in their scores on the final achievement test?
2. Is there a significant statistical difference in the scores of the final achievement test between the experimental group and the control group?
3. Does the effect of the treatment (experimental versus control) depend on the sex of the students?

To answer the above questions, the second, the third and the fourth null hypotheses were restated as follows:

- H₀₁ There will be no significant effect of the sex variable.
- H₀₂ There will be no significant effect of the treatment variable.
- H₀₃ The effect of the treatment does not depend on the sex of the students.

Summary

The setting of this study was at Al-Ahmadi educational zone in the State of Kuwait. The sample was composed of 112 third grade level students studying in four classes in two different schools. The subjects were divided into two experimental groups who learned by the inquiry method and two control groups who learned by the traditional method. Data were collected through two methods: (a) observations and (b) a final achievement test. The null hypotheses were tested to compare between the two methods of teaching. Chapter IV will be devoted for the in-depth analysis of the data and for the findings of the study.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The goal of this study was to investigate the appropriateness of the inquiry method for teaching science in the elementary level in the State of Kuwait. The sample included 112 third grade students in two schools from Al-Ahmadi Educational Zone in the State of Kuwait. The students were learning in four classrooms in two schools--one for boys and one for girls. They were taught by four teachers. A male and a female teacher were using the inquiry-discovery method in teaching two classrooms (experimental group) while a like number of teachers were using the traditional textbook-centered method in teaching in the other two classrooms (control group). Four hypotheses were formulated:

- H₀₁ There is no significant difference in the number of times pupils will use the "five essential science experiences in those classes which were taught by teachers who were trained to use the inquiry-discovery approach, as contrasted with classes which were taught by teachers who were using the traditional textbook-centered approach.
- H₀₂ There is no significant difference between the means of the test scores of the male experimental group who learned by the inquiry-discovery method and the female experimental group who learned by the same method; i.e., male experimental group vs. female experimental group.
- H₀₃ There is no significant difference between the means of the test scores of the male control group who

learned by the traditional method and the female control group who learned by the same method, i.e., male control group versus female control group.

- H₀₄ There is no significant difference between the means of the test scores of the experimental groups (for both sexes) and the control groups; i.e., male and female experimental groups vs. male and female control groups.

Two different methods were used to collect data for this study. Observation was the method used to test the first hypothesis, and a final test was developed to measure the achievement of the subjects for the purpose of testing the second, the third, and the fourth hypotheses.

The researcher observed all of the lessons taught by both teachers who used the inquiry-discovery method in teaching the experimental groups. During these lessons, it was noticed that there was more involvement and participation of the students in both experimental classes than in the control classes when doing their experimental tasks either individually or with a group. Some tasks proved more difficult than others; nevertheless, student participation and involvement was noticeable throughout the unit. Also, it was obvious that some students participated much more frequently than others, but in general, all of the students were involved in the process. All of them raised their hands frequently to respond to questions, to ask questions, to share ideas, or to volunteer information.

Concerning the teachers in the inquiry-discovery classes, both teachers performed more like directors than

lecturers or demonstrators. However, the female teacher was more enthusiastic and more animated in her teaching than the male teacher. Outside of the classroom, she was always asking for suggestions to improve her teaching. Inside the classroom, she often posed problems and questions which encouraged the recognition of new patterns or rules. Moreover, she was always encouraging students to get involved in the different activities she had in her lessons.

In general, both experimental teachers were cheerful, patient, and in control. In both classrooms, praise was given to the class as well as to the individuals when the teachers were particularly pleased with what their classes had said or done. There were only a few times during the unit when the experimental teachers made overt efforts to regain student attention or to keep them in control.

Treatment of the Data

During the observations of 13 forty-five minute science lessons in two experimental classes; and observations of 10 and 11 lessons in the control classes, the researcher counted the number of times students in these classrooms were involved in one of the five essential science experiences. When the observations were completed, a composite score for each experience was derived for each class. These composite scores were then computed to proportions as will be shown in the tables.

H₀₁ There is no significant difference in the number of times pupils will use the "five essential science experiences in those classes which were taught by teachers who were trained to use the inquiry-discovery approach, as contrasted with classes which were taught by teachers who were using the traditional textbook-centered approach.

To test the first hypothesis, the following tables were developed. Table 4.1 shows the number and proportion of male and female students who used the five essential science experiences in the experimental science classes.

Table 4.1

Observation of Use of the Five Essential Science Experiences in the Experimental Classes

Essential Science Experience	Male		Female	
	Number	Proportion	Number	Proportion
Observation	198	.548	256	.469
Measurement	24	.066	30	.055
Experimentation	76	.211	178	.326
Interpretation of Data	45	.125	48	.088
Prediction	18	.050	34	.062
TOTAL	361		546	

Table 4.2 shows the number and proportion of male and female students who used the five essential science experiences in the control science classes.

Table 4.3 shows a comparison between the four classes involved in the study regarding the number of times that the five essential science experiences occurred in each classroom.

Table 4.2

Observation of Use of the Five Essential Science
Experiences in the Control Classes

Essential Science Experience	Male		Female	
	Number	Proportion	Number	Proportion
Observation	102	.622	124	.639
Measurement	3	.018	4	.021
Experimentation	35	.213	41	.211
Interpretation of Data	21	.128	20	.103
Prediction	3	.018	5	.026
TOTAL	164		194	

Table 4.3

The Number of Observations of Use of the Essential
Five Science Experiences in the Four Classes

Essential Science Experience	Experimental		Control	
	Male	Female	Male	Female
Observation	198	256	102	124
Measurement	24	30	3	4
Experimentation	76	178	35	41
Interpretation of Data	45	48	21	20
Prediction	18	34	3	5
TOTAL	361	546	164	194

Table 4.4 shows a comparison between the female experimental group and the female control group. The comparison was done by computing the z scores for each science experience. The normal standardized deviate z scores were calculated at the .05 level of confidence to see

if there were any significant differences between the two methods of teaching for the same sex (female). A value of 1.96 or greater was required to show any significant difference.

Table 4.4

Proportions and z Scores for the Observation of the
Use of the Five Essential Science Experiences
of the Female Experimental Group and the
Female Control Group

Essential Science Experiences	Female Experimental Proportion	Female Control Proportion	Differences in Proportion	z
Observation	.469	.639	.170	4.069*
Measurement	.055	.021	.034	1.943
Experimentation	.326	.211	.115	3.014*
Interpretation of Data	.088	.103	.015	.621
Prediction	.062	.026	.036	1.928

*Significant at .05

A z score for comparison of proportions of 4.069 was obtained from the category of observation. This fell above the established level of significance, and was interpreted to show a significant difference in favor of the experimental group. They had 256 tallies or 2.065 as many times as the control group total of 124.

For the category of measurement, a z score of 1.943 was obtained. This fell below the established level of significance and was interpreted to show no statistical

difference. Nevertheless, it is important to notice the total number of measurement experiences tallied for each group. The experimental group had 30 tallies or 7.5 times as many as the control group.

For the category of experimentation, a z score of 3.014 was obtained. This fell above the established level of significance and was interpreted to show a significant difference in favor of the experimental group. The experimental group had 178 tallies or 4.341 times as many of these experiences as the 41 tallied for the control group.

For the category of interpretation of data, a z score of .621 was obtained. This fell below the established level of significance and was interpreted to show no statistical difference. Yet, the experimental group had 48 tallies versus 20 tallies for the control group, or 2.4 times as many of these experiences in the control group.

For the category of prediction, a z score of 1.928 was obtained. Although this value fell below the established level of significance, it is important to take note of the total number of prediction experiences tallied for each group. The experimental group had 34 tallies or 6.8 times as many as the control group total of 5.

Similarly, a comparison between the male experimental group and the male control group will be shown in Table 4.5.

A z score was computed for each science experience at the 0.05 level of significance.

Table 4.5

Proportions and z Scores for the Observation of the
Use of the Five Essential Science Experiences
of the Female Experimental Group and the
Female Control Group

Essential Science Experiences	Male Experimental Proportion	Male Control Proportion	Differences in Proportion	z
Observation	.548	.622	.074	1.588
Measurement	.066	.018	.048	2.308*
Experimentation	.211	.213	.002	.0520
Interpretation of Data	.125	.128	.003	.096
Prediction	.050	.018	.032	1.734

*Significant at .05

A z score for comparison of proportions of 1.588 was obtained from the category of observation. This fell below the established level of significance and was interpreted to show no statistical difference. But, the experimental group had 198 tallies or 1.941 times as many as the control group total of 102.

For the category of measurement, a z score of 2.308 was obtained. This fell above the established level of significance and was interpreted to show a significant difference in favor of the experimental group. The experimental group had 24 tallies or 8 times as many as the control group total of 3.

For the category of experimentation, a z score of .052 was obtained. This fell below the established level of significance and was interpreted to show no statistical difference. Nevertheless, it was noticed that the experimental group had 76 tallies or 2.171 times as many of these experiences as the 35 tallied for the control group.

For the category of interpretation of data, a z score of .096 was obtained. Although this fell below the established level of significance and was interpreted to show no statistical difference, it is important to notice the total number of these experiences occurred in the experimental class which had 45 tallies or 2.143 times as many as the control group total of 21.

A z score of 1.734 was obtained for the category of prediction, which was considered below the established level of significance. An examination of the total number of frequencies for each group showed that the experimental group had 18 tallies or 6 times as many prediction experiences as the control group's total of 3.

Finally, a comparison between both experimental groups (male and female) and both control groups is presented in Tables 4.6 and 4.7. Firstly, in Table 4.6, frequencies and proportions for the observation of the essential science experiences which occurred in both classes of the experimental group and both classes of the control group are presented.

Table 4.6

Frequencies and Proportions of Essential Science
Experiences in Both Experimental and Control Groups

Experiences	Frequencies for Both Experimental Groups	Proportion for Both Experimental Groups	Frequencies for Both Control Groups	Proportion for Both Control Groups
Observation	454	.501	226	.631
Measurement	54	.060	7	.020
Experimentation	254	.280	76	.212
Interpretation of Data	93	.103	41	.115
Prediction	52	.057	8	.022
TOTAL	907		358	

Secondly, Table 4.7 shows a comparison between both experimental groups and both control groups by computing the z scores for each science experience at the .05 level of confidence.

Table 4.7

Proportions and z Scores for the Observation
of Both Experimental Groups and Both Control Groups

Experiences	Proportion for Both Experimental Groups	Proportion for Both Control Groups	Differences in Proportion	z
Observation	.501	.631	.130	4.177*
Measurement	.060	.020	.040	2.992*
Experimentation	.280	.212	.068	2.481*
Interpretation of Data	.103	.115	.012	.625
Prediction	.057	.022	.035	2.639*

*Significant at .05

A z score for comparison of proportions of 4.177 was obtained for the category of observation. This value was considered significant in favor of the experimental group with larger proportion. An examination of the total number of frequencies for each group showed that the experimental group had 454 tallies, or 2.01 times as many as the control group tallies of 226.

A z score of 2.992 was obtained for the category of measurement. This value was considered significant because it was a higher value than that established for the .05 level. This difference was in favor of the experimental group. The experimental group had 54 tallies, or 7.71 times as many as the control group total of 7.

For the category of experimentation, a z score of 2.481 was obtained. This value fell above the established level of significance and was interpreted to show a significant statistical difference in favor of the experimental group which had 254 tallies or 3.34 times as many as the control group total of 76.

The category of interpretation of data obtained a z score of .625 and was considered too low to show a statistical difference. Nevertheless, it is important to take note of the total number of interpretation of data experiences tallied for each group. The experimental group

had 93 tallies, or 2.27 times as many of these experiences as the control group total of 41 frequencies.

For the category of prediction, a z score of 2.639 was obtained. Since this value fell above the established level of significance, it was interpreted to show a significant statistical difference in favor of the experimental group. An examination of the total number of frequencies for each group showed that the experimental group had 52 tallies, or 6.5 times as many prediction experiences as the control group total of 8.

Finally, it is interesting to note that the total number of the essential science experiences observed for the experimental group (male and female) was 907 while the total number of the same experiences observed for the control group (male and female) was 358. This is a difference of 2.536 times in favor of the experimental group.

For testing the second, the third and the fourth hypotheses, the researcher depended on the results of the final achievement test (see the scores in Appendix D).

To test the hypotheses, the two-way analysis of variance (ANOVA) was utilized.

Table 4.8 shows the three tests for the three null hypotheses given on page 76.

Table 4.8

Analysis of Variance (ANOVA) for Testing Sex
and Treatment Effects

Effect	Sum of Squares	Degrees of Freedom	T-test	Significance of F
Sex (school)	.749	1	.093	.761
Treatment	209.376	1	25.951	.001*
Interaction (Sex by Treatment)	.214	1	.027	.871
Residual	871.347	108		

*Significant at .05

It is clear from Table 4.8 that treatment, i.e. method of teaching makes a significant statistical difference at .05 level, while sex does not. Therefore, H_{01} was not rejected while H_{02} was rejected.

To see the direction of the effect which makes the significant statistical difference (the treatment), means and number of subjects were broken down by sex and treatment as shown in Table 4.9

Table 4.9

Means of Scores and Number of Subjects on the
Achievement Test Broken Down by Sex and Treatment

	Treatment		
	Experimental	Control	Total
Female	Mean = 16.07 Number = 27	Mean = 13.36 Number = 28	Mean = 14.69 Number = 55
Male	Mean = 15.82 Number = 28	Mean = 13.17 Number = 29	Mean = 14.47 Number = 57
Total	Mean = 15.95 Number = 55	Mean = 13.26 Number = 57	Mean = 14.58 Number = 112

It can be seen from the above table that the experimental group did better on the final achievement test than the control group. This is reflected by the means of the two groups because the experimental group had a mean of 15.95 while the control group had a mean of 13.26.

Moreover, this difference was also true for each sex category, because the mean of the female experimental group was 16.07 while the mean for the female control group was 13.36. Also, the mean for the male experimental group was 15.82 while the mean for the male control group was 13.17.

On the other hand, looking at means for the two sexes within the same treatment, one can notice that the differences between the two means were relatively small. This confirms the previous result of not rejecting the H_{01} hypothesis and rejecting the H_{02} hypothesis.

To have a better understanding of the effect of each independent variable (sex and treatment) and the relationship

between them, some graphical representations of the data are provided. Figure 4.1 shows a comparison between the female control group and the male control group.

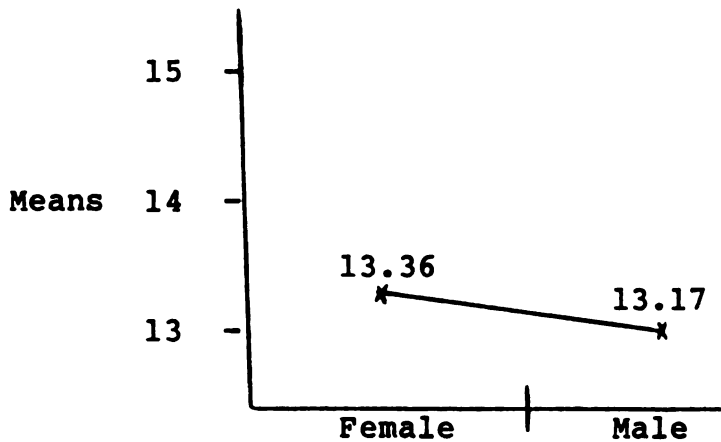


Figure 4.1

A Comparison Between the Female Control Group
and the Male Control Group

Since the line between the two means is almost horizontal, there is almost no difference between the two sexes who learned by the same method. Therefore, the H_0 hypothesis was not rejected. This result is further confirmed by Figure 4.2 which shows a comparison between the female experimental group and the male experimental group.



Figure 4.2

A Comparison Between the Female Experimental Group
and the Male Experimental Group

On the other hand, Figures 4.3 and 4.4 show the comparisons between the two different groups (experimental and control) within the same sex.

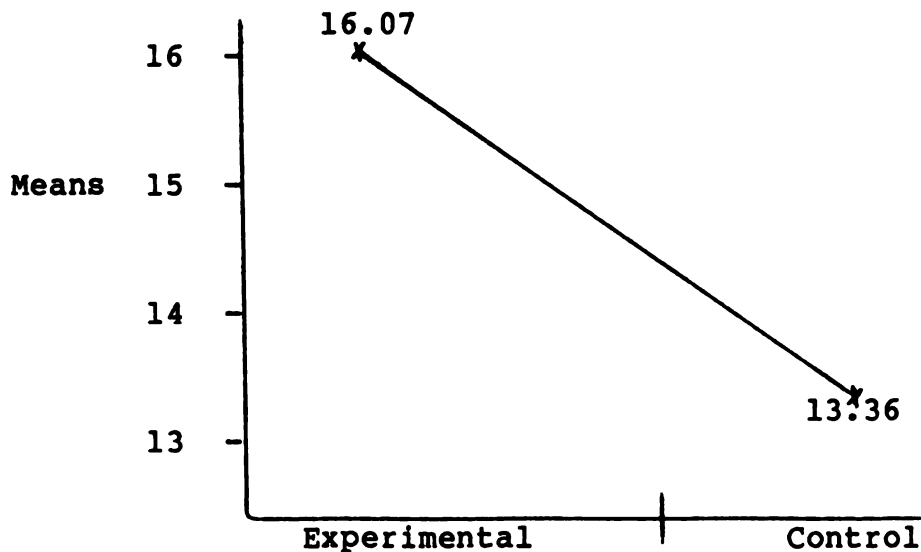


Figure 4.3

A Comparison Between the Female Experimental Group
and the Female Control Group

It is clear from Figure 4.3 that there is a big difference between the two female groups who learned by two different methods. This result is further confirmed by looking at Figure 4.4 which shows a comparison between the male experimental group and the male control group.

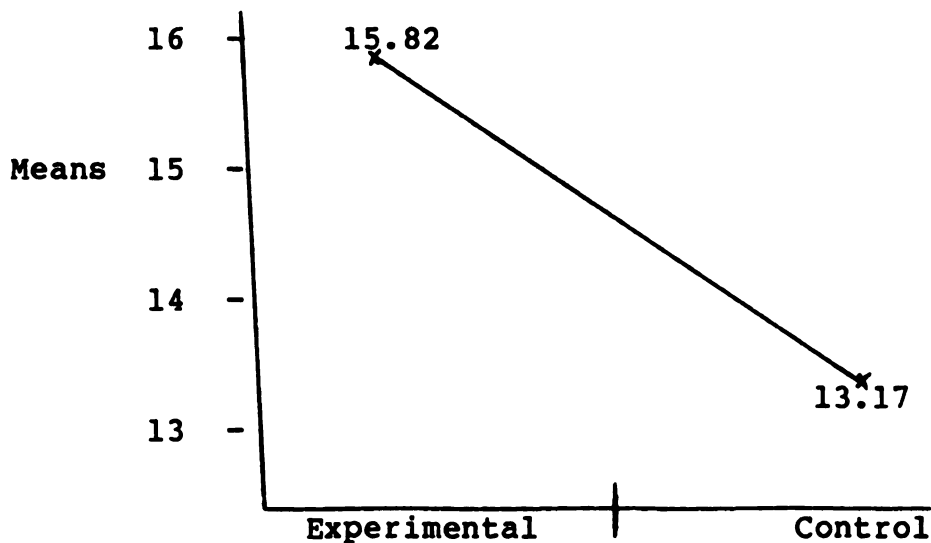


Figure 4.4

A Comparison Between the Male Experimental Group
and the Male Control Group

Finally, the means of the four groups (two experimental and two control groups) are shown in one figure which shows a clear comparison between them (see Figure 4.5).

It can be seen from Figure 4.5 that there is a significant difference between the experimental group and the control group. This result is further confirmed by Figure 4.6 which shows the differences between the means for each group.

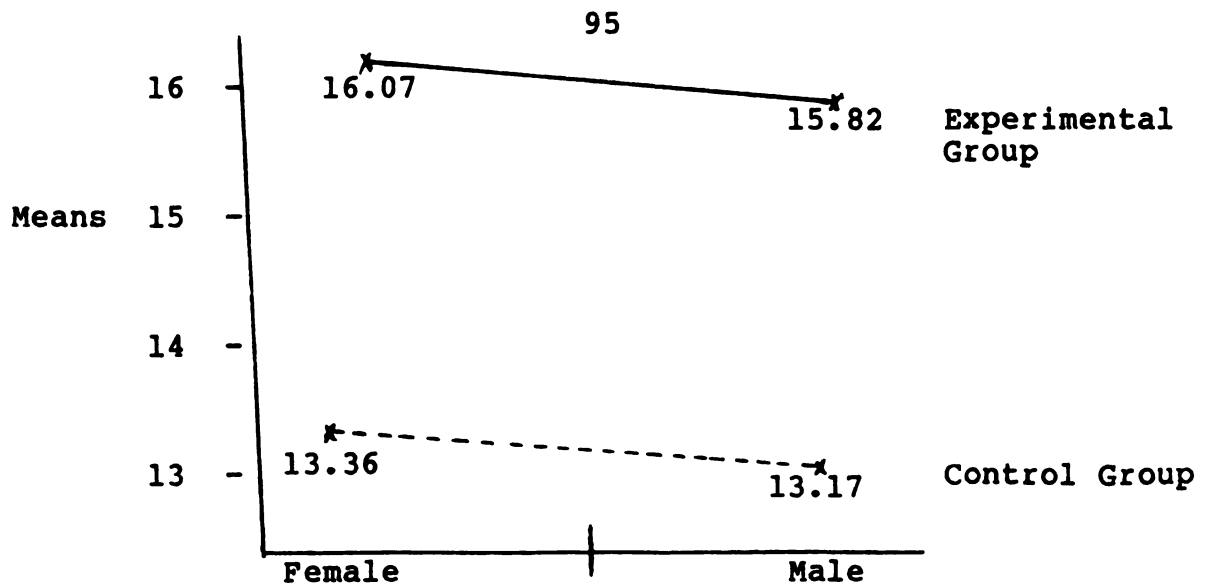


Figure 4.5

A Comparison Between the Experimental Groups and the Control Groups

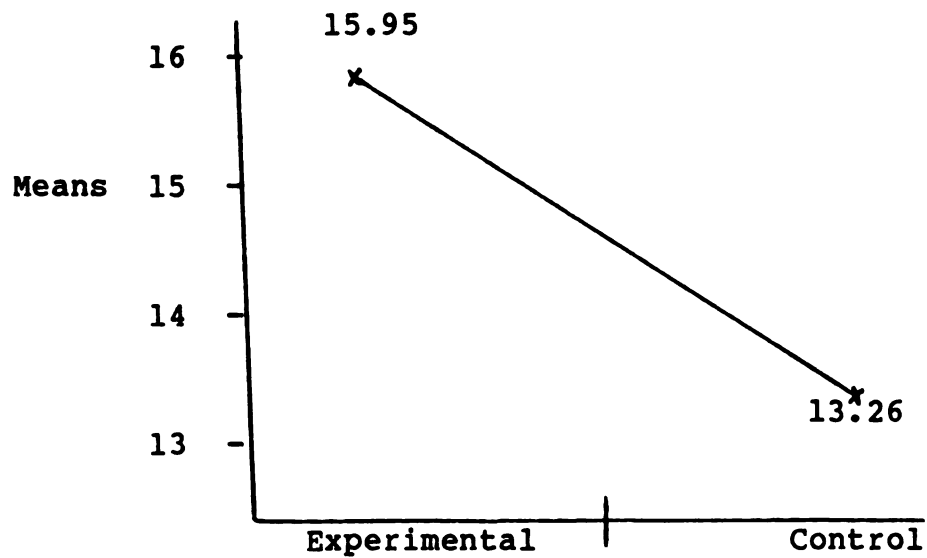


Figure 4.6

A Comparison Between the Mean Scores of Both Experimental Groups and Both Control Groups

Summary

In this chapter, the three main hypotheses of this study were tested. The results indicated that there was a statistically significant difference in the number of times pupils were involved in one or more of the essential science experiences in favor of the students in the experimental class. This indicated that the first null hypothesis was rejected.

For the second hypothesis, the results indicated that there was no significant statistical difference between the female experimental group and the male experimental group regarding their scores on the final achievement test. Therefore, this null hypothesis was not rejected.

For the third hypothesis, the results showed that there was a statistically significant difference between the experimental group (for both sexes) and the control group (for both sexes) regarding their scores on the final achievement test. Therefore, the third null hypothesis was rejected.

Chapter V will be devoted to the summary, conclusions, and recommendations.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was three-fold. First, to determine whether or not there was a significant statistical difference between the experimental classes and the control classes in the number of times when students indulged in one or more of the five essential science experiences. The second purpose of the study was to determine whether or not there was a significant statistical difference between the male experimental group, who learned by the inquiry-discovery method, and the female experimental group who learned by the same method in the final achievement test scores. The third purpose was to determine whether or not there was a significant statistical difference between the experimental group (of both sexes) and the control group in the final achievement test scores.

The sample for this study included 112 students (55 female students in the two classes in the first school, and 57 male students in the two classes in the second school). One female classroom and one male classroom were considered as the experimental group, while the other two classes were considered as the control group. The experimental groups were taught by two teachers who received instruction in using the inquiry-discovery method, while the control groups were

taught by two teachers using the traditional textbook-centered method. Both observations and a final achievement test were used to test the three hypotheses of the study.

By observing the students in the four classrooms, data were gathered about the number of times the students in each classroom were involved in one of the five essential science experiences (observation, measurement, experimentation, interpretation of data, and prediction). The data were then statistically treated to determine whether or not differences existed. Analysis of the data and computing the z scores revealed that there was a significant statistical difference between the experimental group and the control group in all of the essential science experiences, except prediction, in favor of the experimental group. The total frequency of the essential science experiences in the two experimental classes was 907 or 2.536 times as many as the 358 frequencies for the other two control classes.

Regarding the second hypothesis, the scores of the students on the final test were analyzed and through the analysis of variance, sex (male and female) was not found to be significantly related to the achievement ability of the students. Finally, through the last analysis, it was also found that there was a significant statistical difference in the mean of scores between the experimental classes and the control classes in favor of the experimental group, which

indicated that the method of teaching makes a difference; therefore, confirming the third hypothesis of the study.

Conclusions

Based on the findings of this study and within the limitations of this research, the following conclusions were drawn:

1. The amount of time for training the teachers who were involved in teaching science by inquiry was not long enough to make the teachers exactly understand the main points of the process. The beginning teachers believed that an effective inquiry lesson had occurred if many students participated in a discussion. While inquiry instruction includes increasing the amount of student talk, that is not enough. The talk must be purposeful as well. Therefore, this study was affected by the participants' understanding of each item and step of teaching science by inquiry.
2. (Students play a major role in this teaching strategy. They participate actively and interact directly with the content. The inquiry program is designed to enable the learner to direct and control his/her own learning. He/she acts as a programmer of his own learning and he/she is the center of the learning experience. He/she is free

to initiate the inquiry and to decide for himself/herself what data will be needed to find this new set of explainers. In essence, inquiry strongly suggests that the learner is his/her own teacher.

3. There was no significant statistical difference in the means of the scores of the male experimental group and the female experimental group. Therefore, the second null hypothesis was not rejected.
4. There was no significant statistical difference in the means of the scores of the male control group and the female control group. Therefore, the third null hypothesis was not rejected.
5. There was a significant statistical difference between the experimental group of both sexes and the control group of both sexes regarding their scores on the final test. Therefore, the fourth null hypothesis was rejected.

Recommendations

Currently, the inquiry method is not utilized extensively in teaching sciences in the elementary schools of the State of Kuwait. During the experimental part of this research, the researcher noticed that the two science teachers had positive attitudes toward the inquiry method. It was indicated through many discussions with the teachers

that lack of some materials, misperceptions of the Ministry's position, lack of encouragement on the part of the supervisors, and most important, lack of time and the length of the curriculum were responsible for not using the inquiry approach in teaching science. Therefore, this researcher would like to provide these recommendations in order to increase the use of the inquiry method in teaching science.

Recommendations for the Ministry of Education

Recommendations for the Ministry of Education are as follows:

1. The Ministry of Education should give special attention to the future of the country through encouraging the teachers to use the inquiry method in their teaching in order to produce capable citizens who will be living all of their adult lives in an advanced world in the 21st century.
2. The Ministry of Education should arrange for some training programs for the teachers (in-service) with flexible schedules, and with definite goals and objectives. A follow-up program should be provided by the supervisors in order to maintain the outcomes of the training.
3. The Ministry of Education should decrease the amount or the size of the curriculum in order to

provide more time for the teachers to use the inquiry method in their teaching.

4. The Ministry of Education, with the cooperation of the Ministry of Information, might also broadcast programs on radio and television about the goals, objectives, and the importance of the inquiry method so parents and children will be aware of its educational values. Moreover, they can cooperate together in producing some science lessons for use as models for training teachers.
5. The Ministry of Education should encourage the teachers to exchange and share experiences with their peers by arranging some visits to their classes and by observing their teaching.

Recommendations for the Teachers

The recommendations for the teachers are as follows:

1. The teachers should practice asking more open-ended questions during their teaching in order to make their students think more and to help them seek knowledge and information through the inquiry process.
2. Teachers should not hesitate or be shy about asking the science supervisor or any other resource person for help in order to develop their inquiry method skills.

3. A teacher should learn from his peers and colleagues by visiting other classes as well as inviting others to his classes. Afterwards, he should hold a discussion session so that ideas and information could be exchanged.
4. The teachers should have clear goals and objectives for every lesson, and they should try to achieve these goals and objectives through the inquiry process.
5. The teachers should prepare the required materials for the whole unit in advance in order to have enough time to request the materials which are necessary for the unit, but not available in the school.
6. The teachers should participate in any opportunity for in-service training about inquiry in order to learn more and/or in order to update their practices and activities.
7. The science teachers should review the periodical list of films and try to utilize suitable films in their teaching.
8. The teachers should try their best to use the inquiry method as much as possible and also to encourage their students to acquire the inquiry

skills by involving them in the essential science experiences during the science lessons.

Recommendations for Further Research

Given that the number of participants in this study was small (112 students and four teachers), and that there were other limitations to the study, replication of this study is recommended. Research should be conducted to replicate the findings of this study using a larger number of subjects; other levels of schools such as the intermediate level or the secondary level; and/or to teach other subjects, such as social studies or mathematics. Nevertheless, as a result of this study, several questions can be proposed for further research.

1. Would a longer period of both preservice and inservice training and educating teachers in using and utilizing the inquiry method bring about desired changes in teaching strategies of the elementary science teachers?
2. If the science method courses being taught in the College of Education in Kuwait University included courses about inquiry, would the teachers adapt inquiry approaches more readily?
3. Do characteristics such as size of family and parental education and attitudes affect the

achievement ability or level of the students who learn by inquiry?

4. In case of a larger sample size, i.e. more teachers and more students, what would the results be?

These studies, if conducted, would build a framework for future decisions by educators and administrators in the Ministry of Education in the State of Kuwait.

A P P E N D I C E S

A P P E N D I X A
U N I T O N M A G N E T S

Unit on Magnets

Lesson 1

What Does a Magnet Attract?

One Session

Objectives:

1. To help students understand that magnets attract materials made of iron.
2. To encourage the students' curiosity and their love of reading and knowing.
3. To let the students conduct experiments to see and find out what a magnet attracts and what they do not attract.
4. To guide and help the students in writing their observations and the results of the experiments in a simply way.
5. To let the students conduct experiments to separate things made of iron from other things.

Materials:

Pieces of paper, magnets, nails, iron filings, match boxes, pieces of stone, erasers, gold rings, paper clips, pieces of chalk, corks, combs, pieces of different metals, pins, buttons, pencils.

Procedure:

1. The teacher divides the class into groups each of two students.
2. Provide each group with the above materials and ask them to conduct experiments.
3. Each student should write his observation after each experiment.
4. The teacher asks a final question about what a magnet attracts.

General Conclusion:

Magnets attract things made of iron.

Assignments:

1. List seven things in your classroom which can be attracted by a magnet.
2. List ten things in your house which can be attracted by a magnet.
3. List five machines which contain magnets (you can read magazines, books, or ask your parent).

Evaluation:

1. You lost some iron pins in the sandbox. How can you collect them again?
2. How can you distinguish between a bar of iron and a bar of copper?
3. How can you distinguish between a magnet and a bar of iron?

Lesson 2

Do Magnets Differ?

One Session

Objectives:

1. To help students be aware that magnets differ in shapes, sizes, forms and strength.
2. To help students acquire some skills like drawing some magnets.
3. To encourage students to share ideas and work positively with others.
4. To encourage the students to search for knowledge and answer questions through experimentation and observation.
5. To let the students conduct experiments to distinguish between strong and weak magnets.

Materials:

Different kinds of magnets, magnets with the same size and shape but different strengths, pins, iron filings, a loop film (magnets), nails.

Procedure:

1. The teacher divides the class into groups each of two students.
2. Provide each group with the above materials and ask them to conduct some experiments to distinguish between strong and weak magnets.
3. Students conclude that strong magnets can attract more pins or nails or iron filings than weak magnets.
4. Students predict that all magnets can attract materials made of iron.
5. Students draw the different forms of magnets.
6. The class reviews the loop film and asks questions.

7. The class writes their observations and conclusions in a simple way.

General Conclusion:

Magnets differ in their strength. Therefore, a strong magnet attracts a greater number of nails or pins than a weak magnet.

Evaluation:

1. Draw three different shapes or forms of magnets.
2. How can you compare between two magnets in terms of strength?

Lesson 3

Does a Magnet Attract From a Distance?

One Session

Objectives:

1. To make the students aware that magnets can attract materials without touching them.
2. To help students understand that a strong magnet can attract from a longer distance than that of a weak magnet.
3. To encourage the students to read more materials other than the textbook.
4. To help the students develop some inquiry skills like measuring a distance or the size of a magnet.
5. To help and guide the students in writing their observations and conclusions in a simple and acceptable way.

Materials:

Magnets, iron filings, pins, rulers, pencils, sheets of paper.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Students start by placing some of the iron filings on the sheet of paper and placing the magnet in a place where no effect on the iron filings will appear. Slowly they start to move the magnet toward the iron filings until it starts to be attracted. Place a mark at the end of the magnet on the sheet of paper.
3. Students measure the distance between the magnet and the iron filings.
4. Repeat steps 3 and 4 using magnets with different strengths and write the observations.

General Conclusion:

Magnets attract materials without touching them. Strong magnets attract things from longer distance than weak magnets do.

Evaluation:

1. How can one distinguish between a weak and a strong magnet?
2. Which is longer, the distance between a strong magnet and an object or the distance between a weak magnet and the same object?

Lesson 4

Does the Power of Magnets Go Through Things?

One Session

Objectives:

1. To help students understand that the force of a magnet can pass through materials such as papers, glass, wood, etc.
2. To help students be aware that the penetration of the force of a magnet through a material depends on the thickness of the material.
3. To encourage the students' curiosity and their love of reading and knowing.
4. To encourage students to share ideas and work positively with others.
5. To encourage the students to conduct experiments and to write these observations and conclusions.

Materials:

Magnets, pins, iron filings, mirrors, pieces of wood, papers.

Procedure:

1. Divide the students into groups and provide each group with the above-mentioned materials.
2. The students start to do more experiments to see how the magnetic force can penetrate the different materials by placing a pin or some iron filings on the different materials and start to move the magnet from under the material.
3. Repeat the second step with the other materials.

General Conclusion:

Magnets power or forces can penetrate different materials. The penetration power depends on the thickness of the material.

Evaluation:

1. What will happen if the material was very thick?
2. Does the magnet force penetrate iron?

Lesson 5

Do Magnets Attract Through Water?

One Session

Objectives:

1. To help the students understand that magnets attract through water.
2. To encourage the students' curiosity and love of reading.
3. To encourage the students to depend on experimentations and observations in seeking more knowledge.
4. To help students conduct some experiments and write their observations and conclusions in a correct form.

Materials:

Beakers filled with different liquids such as water, alcohol, oil, kerosene, nails, pins, magnets, ropes.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Guide the students to drop the nails or the pins in the different beakers and ask them to think how they can take them back from the beakers.
3. Let the students conclude that they can tie the magnets with ropes and hang it in the beakers to attract the nails or the pins.
4. Help the students to write their observations and conclusions in a simple and correct way.

General Conclusion:

Magnets attract through the different liquids.

Evaluation:

1. How can you take some pins from a beaker of oil without getting your hand wet or dirty?
2. Does the magnetic force through the liquids differ from one liquid to another?

Lesson 6

How Many Poles Does a Magnet Have?

One Session

Objectives:

1. To help students understand that the strength of magnets concentrates at the ends.
2. To help students understand that the end of a magnet is called a "pole."
3. To encourage the students to repeat some experiments in order to be sure of their results and conclusions.
4. To guide and help students to conduct some experiments which help them notice that the poles of a magnet have the strongest attraction power.
5. To make students become aware of how to protect and maintain magnets.

Materials:

Magnets, pins, nails, iron filings.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Help and guide the students to conduct some experiments to find out that the strength of a magnet concentrates near its end.
3. Give the students chances to repeat the experiments with different materials and to write their observations and conclusions.
4. Draw their attention to count the number of nails which are at the end of a magnet and to compare that number with those which are toward the middle of the magnet.

General Conclusion:

The strength of a magnet concentrates toward its end.

Evaluation:

1. How many poles does a magnet have?
2. Where do you find the strongest point on a magnet?
3. Is there any magnet with just one pole?

Lesson 7

What are the Magnets Poles Called?

One Session

Objectives:

1. To help students understand that each magnet has two poles, north pole and south pole.
2. To help students notice and understand that a free suspended magnet takes a certain direction.
3. To encourage students to seek knowledge through experimentation and observation.
4. To help students write their observations and conclusion.

Materials:

Iron bars, magnets, ropes, hangers

Procedures:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Let the students hang a magnet by the rope from its middle to see its direction.
3. To encourage students to seek knowledge through experimentation and observation.
4. To help students write their observations and conclusions.

Materials:

Iron bars, magnets, ropes, hangers

Procedures:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Let the students hang a magnet by the rope from its middle to see its direction.

3. Ask the students to move the magnet bars and let them settle again and compare between the old and the new direction.
4. Let the students replace the magnet in the previous step with an iron bar and compare between the two directions.
5. Let the students write their observations and conclusion.

General Conclusions:

A magnet has two poles, a north pole and a south pole.

Evaluation:

1. How can you determine the two poles of an unknown magnet?
2. How can you distinguish between a magnet and an iron bar if you have no magnetic materials?
3. If you hang a metal bar freely and that bar was settled in the east-west direction, can that bar be a magnet?

Lesson 8

How Can a Magnet be Used to Know the Direction

Two Sessions

Objections:

1. Help the students to practice using the scientific method to solve problems.
2. To help the students in constructing some simple equipment such as a compass.
3. To encourage the students' outside reading and searching for knowledge and information.
4. To help the students to use the magnet in knowing the four basic directions, north, south, east, and west.

Materials:

Strong small magnets, corks, ropes, rulers, compasses, hangers, deep dishes half filled with water, a film about "teaching the beginners about the four directions" movie #1492.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials except the film.
2. Try to ask some questions to remind the students about the two poles of the magnet.
3. Try to guide them to think how they can decide, during the night, where the direction east is.
4. Let the students conduct some experiments to know the north direction (by two ways).
5. Ask the students, "If we know the north direction, can we figure out the other directions? "
6. Help them to stop and point to the different directions by using their hands.
7. Let the students examine the compasses and try to draw a picture of it and try to use it.

8. Let the students write their observations and conclusions.

Evaluation:

1. List the names of the different types of transportation means man use.
2. What do most of the travellers use to know their direction?
3. Why is the top cover of a compass made of glass?
4. What is the container of the compass made of? Why?

Lesson 9

What Are the Reactions Between Magnets?

One Session

Objectives:

1. To help students be aware of the different kinds of reactions between the magnets' poles.
2. To help the students to understand that there is a repulsion power between similar or alike poles, and attraction power between the unlike poles.
3. To encourage the students' curiosity to read more about magnets and to seek knowledge and information.
4. To help the students in their experiments to reach the conclusion.
5. To help the students to write their observations and conclusions in a simple and correct way.

Materials:

Magnets, magnetic needles on hangers, hangers, ropes

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Let the students take one magnet in each hand and try to get them near each other.
3. Let them change the direction of one of the magnets and notice the difference in the reaction between the two magnets.
4. Let the students hang one magnet and then try to get the other magnet near the poles of the suspended one and take note of the different reactions.

General Conclusion:

The similar poles of magnets repulse while the different poles attract each other.

Evaluation:

1. What will happen when you get a magnet near an iron bar?
2. What will happen when you get a magnet near a copper bar?
3. What will happen when you get a magnet near another magnet?
4. If you have a magnet but you do not know where the north and south poles are, how can you find out?

Lesson 10

How Can You Make Your Own Magnet?

One Session

Objectives:

1. To help the students understand that it is possible to get a magnet by stroking a nail or a piece of iron in one direction with the end of a strong magnet.
2. To make the students be aware that a magnet is made of iron.
3. To let the students conduct some experiments to transfer an iron bar or a nail to a magnet.
4. To help the students to write the results and the observations in a simple way.

Materials:

Magnets, nails, pieces of iron, iron filings, magnetic needles.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Try to remind the students by asking them questions about the properties of a magnet.
3. Help them to conduct some experiments such as trying to get a nail to attract the iron filings and write your observation.
4. Try to guide them to stroke the nail in one direction with the end of a magnet, then let them try it again with the iron filings and write their observations.

General Conclusion:

An iron nail or an iron bar can be changed to a magnet by stroking.

Evaluation:

1. Can you transfer an iron nail to a magnet by stroking it with a magnet in two directions?
2. Can you change an iron nail to a magnet by stroking it in one direction with both poles of a magnet?
3. Can you change a cooper bar to a magnet?

Lesson 11

How Many Kinds of Magnets Are There on the Earth?

Two Sessions

Objectives:

1. To help the student to understand that there are two kinds of magnets that exist on earth: natural magnets and artificial magnets.
2. To help the students be aware that artificial magnets are made of iron.
3. To make the students test both natural and artificial magnets in order to understand that they have the same properties.
4. To let the students examine the natural magnet and its properties.

Materials:

Natural magnets, artificial magnets, iron filings, movies about magnets.

Procedure:

1. Divide the students into groups and provide each group with the above mentioned materials.
2. Let the students compare between the two kinds of magnets to find out that they have the same properties.
3. Help the students to write their observations and conclusions in a correct way.
4. Review the different movies about magnets without letting the students hear the sound and then discuss with them about what they saw.

General Conclusions:

1. There are two kinds of magnets: natural and artificial.
2. Artificial magnets are made of iron.
3. All magnets have the same properties.

Evaluation:

1. What are the similarities and differences between the natural magnets and the artificial magnets?
2. Why did they call the natural magnet by this name?

A P P E N D I X B
T E A C H E R T R A I N I N G

Teacher Training

A program to prepare and train the science teachers who were involved in the study on how to use the inquiry method in their teaching was prepared. The program was divided into three sessions. During these sessions, discussions and activities were focused on some major areas such as: the nature of the study, the purposes of the study, and the roles of the teacher. Moreover, during the first session, a list of the required materials was developed to determine whether the needed materials were available and to provide and/or request whatever extra materials were needed. Also, the first session was devoted to discussing and explaining the nature and the purposes of the study to each teacher individually, which could be summarized in the following: This study is a part of the investigator's research requirement to complete his doctoral degree in education at Michigan State University in the United States, and that, all teachers, schools, and students participating in the study will remain anonymous. Furthermore, it was clear to all teachers that this study had nothing to do with the evaluation process of their teaching.

During this study the two experimental teachers were informed that they should try their best to use and encourage their students to be involved in the inquiry method of teaching/learning science. Inquiry is a process in which

pupils focus on a problem and in their search for a solution go through a number of steps ranging from hypothesizing to formulating conclusions. Therefore, the teacher should use an inquiry-centered instruction as much as possible.

Inquiry-centered instruction is an instruction which has as its basic strategy the involvement of the learners and their teacher in a searching process, one in which solutions to problems are sought, tested and evaluated. The basic purpose of this instruction is to develop in the learners the ability to systematically search and evaluate ideas.

Objectives of the Training:

J.F. Newport (1965) suggested the following:

1. To help students develop scientific attitudes such as:
(a) develop the attitudes of willingness to suspend judgement, to consider new evidence and to change an opinion or conclusion because of later evidence, and
(b) develop an attitude of inquiry.
2. To help young people gain some understanding of methods used in the sciences.
3. To help the student to learn what it is like to work and study in science.
4. To help the students develop a better understanding of the natural, physical world.
5. To help the students develop fundamental skills of inquiry such as: observing through the use of all the

senses, measuring, communicating information accurately, both orally and in written form and manipulating science equipment and instruments, etc.

6. To help the students develop an appreciation of the contributions of science and of the work of scientists.

The Role of Teachers:

Session two and session three were devoted to discussing the role of teachers and the importance of involving the students in the process of learning in order to aid the students in developing problem-solving skills. There are many teaching techniques used in teaching science as inquiry. Esler (1970) described two teaching techniques used in dealing with inquiry activities.

The first technique is a teacher question - student answer mode. This teaching technique calls for a high degree of skill in asking open-ended questions and directing the resulting variety of student responses toward understanding of a predetermined scientific principle. To do this the teacher must call upon the refined use of selective reinforcement, accept and clarify student responses and at the same time move the discussion toward the desired goal.

A second inquiry teaching technique might be termed student question - teacher answers questions which are posed by the students. The most difficult task of the teacher employing this technique is to refrain from supplying more

information than is reasonably called for. To safeguard against this, many teachers require the students to pose questions that may be answered by yes or no responses.

Experimentation may also be considered an inquiry technique provided the investigator who has no prior knowledge of the expected outcome of the investigation. He must be involved in a problem-solving situation, the goals of which are determined and clarified by inquiry (Esler, 1970).

Esler also mentioned that there are many introductory procedures from which the teacher can choose one or more to implement the inquiry session such as:

1. Discrepant Event - A discrepant event is one that offends the senses of the observer. It represents an unexpected outcome of a physical condition. The discrepancy may be natural or one contrived by the teacher.
2. Anecdote (with demonstration) - While verbally relating the anecdote the teacher may perform the acts described.
3. Invitation to Inquiry - Invitation to inquiry is a general category of procedures for inquiry that requires no demonstration. Several procedures that fall within this general category are subsequently described.

- A. Anecdote - The anecdote without a demonstration takes place when the teacher relates a problem situation to the class and directs an inquiry session wherein the students attempt the solution.
- B. Interpretation of Data - A second method of initiating inquiry without resorting to demonstration is to present to a class some data in the form of a chart, graph, or table and direct an inquiry session which attempts to interpret the data and draw generalizations therefrom.
- C. Pictorial Stimulator - A third method of stimulating investigation by inquiry without resorting a demonstration is by pictorial stimulation. Problem situations are depicted by pictures, filmstrips, movies, or other visual media. Inquiry techniques are employed to solve the problem presented in this way (Esler, 1970).

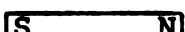
Finally, teachers should keep in mind that there is no one magic method which can be considered as the best way for teaching science by inquiry. Teachers should be able and ready to combine more than one approach and method during the same period or lesson depending on the problem and the situation.

A P P E N D I X C
F I N A L A C H I E V E M E N T T E S T

Final Achievement Test

Part I

Answer the following questions by underlining the correct answer.

1. Magnets have [one shape or form - 3 forms - different forms]
2. A strong magnet [attracts many - attracts few - does not attract] nails.
3. A free suspended magnet takes [east-south, west-south, north-south] direction.
4.   [attract - repel - nothing happens]
5.   Chalk [attract - repel - nothing happens]
6.   [attract - repel - nothing happens]
7.   Ruler [attract - repel - nothing happens]
8.   [attract - repel - nothing happens]
9.   Golden Ring [attract - repel - nothing happens]

Part II

Answer the following questions by putting either ✓ or ✗ by the number of each statement.

1. Magnets differ in their strengths.
2. Magnets do not attract nails through water.
3. Magnets attract nails without touching them.
4. Scouts use compasses in order to know their directions.
5. The strength of a magnet concentrates near its middle.
6. The two ends of a magnet are called poles.
7. There are two kinds or types of magnets natural and artificial.
8. A compass does not contain a magnet.
9. A copper bar may be magnetized by stroking it in one direction with the end of a strong magnet.

Part III

Complete each sentence with suitable words.

1. A region around a magnet and characterized by the existence of a detectable magnetic force at every point in the region is called

2. This region can be determined by using -----

A P P E N D I X D

**T H E S C O R E S A N D S T A T I S T I C A L
A N A L Y S I S O F B O T H G R O U P S**

The Scores and Statistical Analysis of
Both Groups

**The Scores and the Statistical Analysis of the Girls in the
Experimental Group**

20, 20, 19, 19, 19, 18, 18, 18, 17, 17,
17, 17, 17, 16, 16, 15, 15, 15, 15, 15,
14, 14, 14, 13, 12, 12, 12.

The total number of students = 27
The sum of the scores = 434
The mean of the scores = 16.074
The variance = 5.76
The standard deviation = 2.4
The mode = 17 and 15
The median = 16
The range = 8

**The scores and the statistical analysis of the boys in the
experimental group**

20, 19, 19, 19, 18, 18, 18, 18, 17, 17,
17, 17, 17, 16, 16, 16, 16, 16, 15, 15,
15, 14, 13, 13, 12, 12, 11, 9

The total number of students = 28
The sum of the scores = 443
The mean of the scores = 15.281
The variance = 7.187
The standard deviation = 2.68
The mode = 17 and 16

The median = 16

The range = 11

The scores and the statistical analysis of the girls in the control group

19, 19, 18, 18, 17, 16, 16, 16, 15, 15,

14, 14, 14, 13, 13, 13, 12, 12, 12, 12,

11, 11, 10, 10, 9, 9, 8, 7

The total number of students = 28

The sum of the scores = 374

The mean of the scores = 13.357

The variance = 10.9

The standard deviation = 3.3

The mode = 13

The median = 13

The range = 12

The scores and the statistical analysis of the boys in the control group

18, 18, 17, 17, 17, 16, 16, 15, 15, 14,

14, 14, 14, 13, 13, 13, 13, 13, 12, 12,

12, 12, 11, 10, 10, 10, 9, 8, 6

The total number of students = 29

The sum of the scores = 382

The mean of the scores = 13.172

The variance = 9

The standard deviation = 3

136

The mode = 13

The median = 13

The range = 12

R E F E R E N C E S

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