THE EFFECT OF INQUIRY-BASED TEACHING
ON THE ACHIEVEMENT OF
SEVENTH GRADE LIFE SCIENCE STUDENTS

MASTER'S PROJECT

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by

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DEDICATION

This work is dedicated to my husband, Eric. I appreciated all of his support, patience, and understanding while I was working on this project.
CHAPTER 1
INTRODUCTION
Purpose for the Study

In 1991, President Bush set a goal for American students to be the first in the world in science and mathematics by the year 2000. This was a very optimistic goal in light of the results of the first International Assessment of Educational Progress (Ahlgren, 1991). This study evaluated the science achievement of students in twelve countries. The American students participating in this study ranked last compared to students in other countries. In order for President Bush’s goal to be met, science educators will need to make dramatic adjustments.

One of the major reform efforts to improve science education is Project 2061 (American Association for the Advancement of Science [AAAS], 1989a). Project 2061 defines the knowledge and thought processes that are essential for all citizens in a scientifically literate society. A second AAAS publication (1993) describes in detail how students should move toward scientific literacy. A series of statements, called "benchmarks", list what students should know and be able to do at the end of grades
Examples of those are provided in Appendix A.

The philosophy of Project 2061, reflected in these benchmarks, includes many important ideas that are part of a teaching method known as inquiry. For example, AAAS promotes emphasizing connections between ideas and concepts, rather than teaching subject matter as a series of separate, isolated facts. Critical thinking skills and problem solving are developed, rather than concentrating only on vocabulary and memorizing. Such an emphasis lessens the amount of detail that students are expected to retain. These "new" methods are true to the nature of inquiry-based teaching (AAAS, 1989a; 1993).

Using inquiry-based teaching methods in the science classroom is essential because inquiry is the basis of all true scientific endeavors. AAAS (1989b) states that "...teaching related to scientific literacy needs to be consistent with the spirit and character of scientific inquiry and with scientific values" (p.45). Science educators using inquiry will immerse their students fully in the scientific process, allowing students to think and work as true scientists. Students will be actively collecting evidence and formulating hypotheses. They will be discovering science for themselves, rather than being told about science.
Although many educators feel the components of inquiry-based teaching should be used in science classrooms, most educators still rely on more traditional teacher directed methods. Many teachers feel that inquiry-based teaching restricts the amount of material they can cover because inquiry methods usually require more time than traditional methods. Also, most are not trained enough to properly carry out inquiry-based lessons (Henson, 1986).

However, these non-inquiry oriented classrooms may soon be changing. The Ohio Department of Education has created a Model Competency-Based Program (1995) that gives direction to school districts in developing local science programs. The purpose of this program is to move Ohio towards President Bush’s national goal for science achievement. Many aspects of this state model promote inquiry-based learning, such as:

♦ Science should be actively engaging—students should be asking their own questions and conducting their own investigations.
♦ There should be connections between physical, life, and earth/space science systems.
♦ Higher order thinking skills should be emphasized.

Furthermore, the model is broken into four strands, one of which is called “Scientific Inquiry.” It explores the tentative nature of our understanding about the world. It promotes observation, the collection and analysis of
information, and the connections between ideas. It encourages questioning and independent thinking.

Project Discovery is a statewide reform initiative for science and mathematics education that supports and uses strategies of teaching that meet these national and state standards for math and science education (Emerine & Haley, 1993). Project Discovery is funded by the National Science Foundation and the Ohio Board of Regents. This reform effort trains teachers in inquiry methods. The author was a participant of the West Region Project Discovery Program in 1994 and 1995. The summer institute provided investigations into content while modeling inquiry-based teaching. The follow-up sessions allowed participants to share their experiences and to provide further training in inquiry-based learning.

With the author's experience in inquiry-based teaching and with the push at both the national and state level for incorporating more inquiry in the science classroom, it was appropriate to investigate the effects of this teaching method on student achievement. The author had been using this method frequently in the classroom since the training at the Project Discovery institute. It was valuable to determine if this was truly an effective method to use in the science classroom.
Problem Statement

The purpose of this study was to analyze the effects of inquiry-based teaching methods on the achievement of seventh grade life science students.

Hypothesis

There will be no significant difference in the mean pre and post test scores of students who have been taught by inquiry methods.

There will be no significant difference in the mean pre and post test scores of the female students who have been taught by inquiry methods.

There will be no significant difference in the mean pre and post test scores of the male students who have been taught by inquiry methods.

Assumptions

In order to carry out this study, the researcher made the following assumptions. First, the researcher assumed that all students actively participated in the inquiry-based lessons. Second, the author assumed that all students tried their best on the pre and post tests. Third, the author assumed that the pre and post tests were valid and reliable. Finally, it was assumed that the students did not receive
any extra instruction or guidance on the unit outside of class.

Limitations

There were several limitations affecting this project. One limitation was that in using the T1 X T2 design, there was no control group (Isaac & Michael, 1995). Another limitation was the fact that this study was conducted at the end of the school year when student attention and participation may have declined. Also, the students were only exposed to the inquiry techniques for a period of two weeks. This may not have been an adequate length of time to get accurate results. The testing instruments were critiqued by the author and three other professional educators, but they were not standardized. Furthermore, the sample size was limited to twenty-two students.

The remaining limitations dealt with factors of the internal and external validity of the T1 X T2 design. Factors affecting internal validity were the effect of history, pretesting influence, and maturation. Factors affecting external validity included interaction effects of selection, pretesting, and the treatment.
Definition of terms

Inquiry-based teaching (IBT) includes teaching methods in which ideas are emphasized over the memorizing of vocabulary. These are student-oriented methods that are inductive in nature. Students become actively involved in the scientific method. It builds on what the students already know and it allows students to construct their own knowledge through active involvement with problems. Students are often involved in cooperative groups. Students learn the process of science, not just the content.

Life science is the study of living things.

Achievement is the number of questions answered correctly on a teacher-designed test.

Traditional science teaching methods (non-inquiry based) are teaching strategies that are teacher-led and rely heavily on lecture, textbooks, and note-taking.
CHAPTER II
REVIEW OF THE RELATED LITERATURE

Characteristics of Inquiry-Based Teaching

For many years, leading educators and psychologists such as John Dewey, Jerome Bruner, Robert Gagne, and Jean Piaget have stated that science is an inquiry-based subject. Inquiry-based teaching involves strategies that have, in fact, been used by science educators for many years. However, these inquiry-based strategies have often been confused with other teaching methods. For example, some educators have associated inquiry with discovery learning, activity-based instruction, and even hands-on learning. These methods all have some characteristics in common with inquiry strategies, but inquiry-based instruction has many distinct features (Haury, 1993).

In science education, inquiry-based teaching involves students in learning the process of science, not just the content (Henson, 1986; Haury, 1993; Eltinge & Roberts, 1993). Novak (1964), stated that, “Inquiry is the [set] of behaviors involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious” (p. 26). Therefore, in an inquiry-based
classroom, students will be doing activities and acquiring science skills while they are trying to gain understanding about something they find of interest. This implies that students will not have a clear understanding of concepts to be learned prior to conducting activities. The students will discover the concepts as they work through the activities (Lumpe & Oliver, 1991).

As students search for knowledge and understanding, they will be involved in an inductive process. Inquiry-based teaching starts by showing students specific facts or events and then allowing the students to collect information to lead them to more general theories (Joyce, Weil, & Showers, 1992). Therefore, learning is characterized by students discovering concepts by interacting with concrete examples of those concepts (Tanner, 1969). In this "discovery" approach, teachers act as guides or facilitators rather than as a definitive source of information. Students are first presented with a problem and then asked to speculate on ways to solve the problem, which may include designing or redesigning an experiment. As students come up with hypotheses and work through them, they will collect information to help them gain new understandings.

This type of active, inductive learning is consistent with the constructivist model of learning. As students experience events and try to make meaning out them, they
will continually change their mental frameworks; and, according to this model, they will learn or create new knowledge structures (Haury, 1993). Saunders (1992) presents a description of the constructivist learning model which clearly shows its similarity to inquiry-based teaching:

Cognitive activities such as thinking out loud, developing alternative explanations, interpreting data, participating in cognitive conflict (constructive argumentation about phenomena under study), development of alternative hypothesis, the design of further experiments to test alternative hypotheses from among competing explanations are all examples of learner activities which activate the constructivist learning model. (p. 140)

Inquiry-based teaching can be difficult to define. It involves students actively searching for understanding. As students inductively arrive at conclusions, they will be learning science content and processes as reflected in the constructivist model of learning.

**Approaches to Using Inquiry-Based Teaching**

Science teachers vary in how they attempt to involve their students in the active search for understanding that is characteristic of inquiry-based teaching. Some use very
structured methods. For example, Igelsrud and Leonard (1988) promote a method called "guided inquiry." Guided inquiry can be broken into four phases. During the first phase, the teacher provides an introduction stating the goals of the activity and relating them to what they have already worked on in the course. Often in the first phase of guided inquiry, teachers will use a discrepant event to introduce the problem (Joyce, Weil, & Showers, 1992; O’Brien, 1992; Wright & Govindarajan, 1992). A discrepant event is a puzzling situation or problem that evokes student curiosity. It is something that challenges the way students view events in the world and therefore creates an opportunity for intellectual discovery.

During the second phase of guided inquiry (Igelsrud & Leonard, 1988), the requisite materials and resources are listed so that students are aware of the parameters of the activity. The third phase leads the students through an investigation with step-by-step directions by the teacher. The minimum amount of information needed for student success is provided, so that students are still involved in some of the process and they are not simply following a "recipe." In the last phase, students respond to three different types of questions. First, they answer questions which require them to review and analyze the data. Secondly, they are led systematically through questions that will lead to the
development of a salient biological concept. Lastly, there may be some questions to help students relate this concept to the real world.

Guided inquiry is, thus, a mix between traditional "cookbook" strategies and the very unstructured inquiry approaches. It gives students the guidance they need to be successful, yet it still fosters their curiosity and lets them be involved in the process of science.

Many educators support a different approach to teaching science, one in which they provide the students with very few instructions during laboratory situations. Tinnesand and Chan (1987) suggest using "instruction-less labs that pose inviting puzzles for the students to solve" (p. 43). Students are not given a procedure to follow. Students design their own procedures based on what they have already studied. Another way that this approach differs from more traditional methods is that the labs follow the introduction of concepts. After the concepts are presented to the students, the students will demonstrate its application, rather than being asked to follow a "cookbook" lab to try to confirm scientific principles. When students are asked to design their own experiments, they can see mistakes that they make and correct them. As they share their data and experimental designs with the class, they can learn from each other and participate in true research. However, when
using this kind of unstructured method in the classroom, there is a potential for chaos and danger. Tinnesand and Chan (1987) suggest careful planning of the events leading up to the lab so that the teacher can be aware of hazards and help students avoid dangerous mistakes.

Still other instructors use heuristic devices to aid in the development of science skills (Germann, 1989 & 1991; Roth, 1990; Rubin & Tamir, 1988; Lawson, 1988). Germann (1991) advocates one particular method which he calls Directed Inquiry Approach to Learning Science Process Skills and Scientific Problem Solving [DIAL(SPS)2]. This method begins by helping prepare students with background information. This is done by using advance organizers, concept maps, and writing. Focusing techniques are then used to help students develop purpose statements, hypotheses, and experimental designs. Students keep track of all of this information in a Vee diagram (see Appendix E). The left-hand side of the Vee diagram summarizes the thinking and planning that goes into solving the problem, while the right side summarizes the experimental results. The phenomenon being investigated is listed at the point of the Vee. This Vee diagram is then used to help students write a discussion of the investigation.

No matter which type of inquiry-based teaching is used, all methods will involve collection and interpretation
of data in response to investigating and inquiring. All methods involve student-oriented, inductive strategies.

**Preparation Necessary to Implement Inquiry-Based Teaching**

Many traditional science courses are based around a class textbook. Inquiry-based teaching is not textbook driven, but it is helpful to have a good inquiry textbook to aid with the planning of activities and to use as a reference (Costenson & Lawson, 1986). However, finding a good inquiry-oriented science textbook can be difficult. Several studies have been conducted on current science texts, using a variety of scales and methods to determine the amount of inquiry. Chiappetta, Sethna, and Fillman (1993) found that many middle school life science texts present stereotypical steps of the scientific method in an introduction chapter. Very little space is given to science as a way of thinking. These textbooks are full of definitions and facts and do not adequately show the process of inquiry in science. Similarly, Eltinge and Roberts (1993) found that many science texts depict science as a collection of facts rather than as a process and that they are more content-oriented than inquiry-oriented.

With the push for science education reform (for example, Project 2061 and the Ohio Model Competency-Based Program), textbook writers will hopefully begin including
more inquiry activities and presenting science as a way of thinking. Fay (1996) found two textbooks, Science Interactions and Biology Visualizing Life, that include a higher proportion of inquiry compared to other currently popular texts. Tamir and Lunetta (1981) devised a system to determine the amount of inquiry present in science laboratory handbooks.

Once a textbook has been decided upon, teachers need to look carefully at their district’s curriculum, and most likely, they will have to reduce the amount of material normally covered (Henson, 1986). Inquiry-based strategies often take longer because students must discover information for themselves, rather than just being told the information. By critically looking at the curriculum and picking out major central themes that are important to the subject, teachers can help students focus on what is important and reduce the amount of extraneous facts and details (Costenson & Lawson, 1986).

Another problem that must be addressed before implementing inquiry-based teaching is time management. The time needed for inquiry activities is often unpredictable and can vary from class to class (Henson, 1986; Costenson & Lawson, 1986). This is a problem which many teachers find uncomfortable at first, but once they practice inquiry methods and see the positive results they will, hopefully,
learn to become accustomed to this (Costenson & Lawson, 1986).

Although many teachers feel inquiry activities take too long and are too difficult to manage, proper training in inquiry methods can help them to be more comfortable (Costenson & Lawson, 1986; Henson, 1986). There are programs available at both the state and national level to give teachers the opportunity to learn about inquiry methods first hand. If it is not practical for some teachers to attend these programs, then they could talk to other teachers who are using inquiry-based teaching and conduct classroom visitations. Also, schools can adopt inquiry-based programs, such as Biological Sciences Curriculum Study (BSCS) program to help aid with the development and implementation of inquiry-based teaching (Grobman et al., 1964; BSCS, 1970).

During training, teachers should be made aware of the types of reinforcement that work best to promote inquiry behaviors. Edwards and Surma (1980) found that verbal reinforcement and mimicry (the parroting back of student answers) decrease the frequency of student inquiry behaviors. They found that referring to student ideas and input periodically during the instruction increased the amount of inquiry behaviors. Verbal reinforcement and mimicry were common behaviors exhibited by classroom
teachers, but teachers can undergo training to bring this behavior under conscious control.

Another important idea that teachers should be taught during inquiry training is that their job in the classroom is more of a facilitator and a catalyst rather than a "teller" (Costenson & Lawson, 1986). Teachers should be ready to deal with the unexpected and be comfortable with not always knowing where the class discussions will lead. Some teachers report that this lack of control makes them uncomfortable, but Costenson and Lawson state that:

The good inquiry teacher is skilled at dealing with the unexpected because he or she knows the subject matter well and how to utilize the unexpected to provoke further thinking and inquiry. One must not be afraid to say "I don’t know." Indeed, whenever inquiries can lead to answers good inquiry teachers will say "I don’t know" even when they do. (p. 154)

This may be a very different approach than many teachers are used to, but with practice, they should grow more comfortable with it.

After training it is important to have follow up sessions to help teachers deal with problems that arise. Grobman et al. (1964) suggest that teachers have regular meetings with other educators near them to share ideas and discuss any problems. They recommend visiting other
classrooms where inquiry-based teaching is occurring to observe solutions to problems. They also recommend team teaching when possible, so that the planning involved can be split between two teachers. Costenson and Lawson (1986) recommend setting up a central filing system of materials to minimize time spent on the development of inquiry activities. Even though it may take additional time to set up inquiry-based programs, each year the time commitment would decrease as the file of materials grew.

**Effects of Inquiry-Based Teaching**

**Effects on Achievement.** Several studies have found that inquiry-based teaching has a positive effect on science achievement. McCurdy and Hall (1990) found that college students enrolled in an inquiry-oriented Biological Sciences Curriculum Study (BSCS) style laboratory class scored significantly higher on biology content achievement tests than those students enrolled in a more directive traditional class. Furthermore, Shymansky et al (1990) found that inquiry-oriented programs in elementary and secondary schools had a positive effect on student achievement, process skills, and problem solving.

Tinnesand and Chan (1987) reported that inquiry-based programs helped students to develop critical thinking
skills. Lindberg (1990) stated that inquiry teaching helps to foster scientific literacy and process skills.

Shymansky (1984) found that students exposed to inquiry-based programs outperformed students exposed to traditional courses on process skills, analytical skills, and achievement. He found that students with high IQs or higher socioeconomic status responded more favorably to inquiry programs than students with low or average IQs or low socioeconomic groups. Even though he found all students outperforming the traditional students, Shymansky found that students from these groups outperformed their traditional counterparts by a greater margin.

Shymansky (1984) also found that in classes where the teachers had more than five years experience, the inquiry students outscored 88 percent of the students in the traditional classes. Furthermore, in classes where teachers had master’s degrees or higher, the average inquiry student outscored 94 percent of the traditional course students.

It was also found (Shymansky, 1984) that classes with mixed gender outperformed those that were predominantly male or predominantly female on all performance measures. This is noteworthy because it opposes the generally accepted assumption that males show a greater aptitude for science.

Germann (1989) reported that inquiry approaches such as [DIAL(SPS)2] help students with lower cognitive development
to perform better in science. He believes this is because students with lower cognitive ability need to have the guidance of the step-by-step approach to problem solving. He found that students with formal cognitive strategies were hindered by the slow pace of the [DIAL(SPS)2] system and did better when exposed to a more traditional program.

Effects on Attitudes of Students and Teachers.
Inquiry-based teaching has been found to have a positive effect on the attitudes of students towards science (Roth, 1990 & 1991; Kyle, 1985; Shymansky, 1984; Shymansky et al., 1990). Roth (1991) found that students enjoy and enroll in inquiry science classes more than traditional science classes because they enjoy the freedom of designing their own experiments. Kyle (1985) reported that over 75 percent of students involved in inquiry programs believe that science is fun, exciting, and interesting; whereas, over 50 percent of students in non-inquiry programs find science boring. He also found that the students in the inquiry programs wish they had more time for science in school. His study showed that students prefer a process approach to science rather than a traditional approach.

Kyle also looked at gender and found that in inquiry classes, males and females like life science equally well. In non-inquiry class he found that a significantly greater percentage of males chose science as their favorite subject,
whereas a significantly greater percentage of females listed science as their least favorite subject.

Jaus (1977) found that inquiry-based classes not only improve student attitudes towards science, but also towards school. After a twelve week science unit, elementary students who were exposed to the inquiry unit had significant positive gains in their attitudes towards school.

Lazarowitz (1976) found that teachers using inquiry had more favorable attitudes toward inquiry than non-users. Furthermore, the number of years of experience in using inquiry programs is related to more favorable attitudes toward inquiry methods.

**Effects of Inquiry-Based Teaching on Behavior.**

Tinnesand and Chan (1987) found that teachers using inquiry programs interact more with their students and that their students act more intelligently in their interactions with one another. Lazarowitz (1976) reported that teachers using inquiry were more student-oriented than subject-oriented and that the students were more cooperative in their interpersonal relationships.

Several researchers have found that inquiry methods increase the motivation level of science students. After using inquiry strategies, students will develop an internal motivation to learn more (Henson, 1986). Through inquiry
processes they learn how to learn, which is a very rewarding experience that will help them to become more self-confident (Voss & Brown, 1968). This motivation is also attributed to the fact that students are allowed such active participation (Igelsrud & Leonard, 1988), which gives them a sense of empowerment (Lindberg, 1990).
CHAPTER III
PROCEDURE

Subjects

The subjects were a group of twenty-two seventh grade students (ten girls and twelve boys), ranging in age from twelve to fourteen years old.

Setting

School. Students from one suburban junior high school took part in this study. The school consisted of approximately 420 eighth graders and 400 seventh graders. The school was divided into five teams. Each team was composed of approximately 160 students who shared the same core group of teachers. The students involved in this study were from one of the science classes on one of the seventh grade teams.

Community. The school system in which this study took place was located in a suburban area of southwest Ohio. There were six elementary schools, one junior high school, and one high school in the community. This suburban community was composed of various racial, social, and economic groups. Most of the residents were Caucasian, but
there were significant numbers of African-Americans and Asian-Americans. The proportions of these different backgrounds were accurately reflected in the student population under study since there was only one junior high in this district. Each of the represented backgrounds was evenly distributed to each team as much as possible.

Data Collection

Construction of Instrument. The researcher administered a pretest and a posttest covering objectives from a botany unit (see Appendix B). The items on the test came from material in the district’s adopted life science textbook, Focus on Life Science (Heimler, 1989). Some of the items were directly taken from the tests provided by the textbook and some were designed by the researcher. Many of the items had been used in the last three years with the researcher’s former students and had been clarified as needed. The test was critiqued by three other professionals.

Administration of the Instrument. The botany pretest was administered to the researcher’s third period seventh grade life science class prior to the unit. Following the study of plants using inquiry-based teaching methods, these students took a posttest. The pre and posttests were similar in design. The tests required the students to read
and answer several types of questions: fill-in-the-blank, matching, completing a table, and essay. A copy of the test can be found in Appendix C of this study.

Design

The researcher used the classical T1 X T2 design (Isaac & Michael, 1995). The pretest to measure achievement of knowledge of a unit in botany was represented by T1. The independent variable, inquiry-based lessons, was represented by X. The posttest to measure achievement of knowledge of the same unit in botany was represented by T2.

Treatment

The independent variable for this study was using an inquiry-based approach to teach botany. The subjects were taught a botany unit using inquiry-based lessons during 40-minute periods for two weeks (see Appendix D). The subjects were presented with problems regarding plants, and the subjects designed experiments to investigate these problems. The subjects were also involved in researching information about plants and participating in role-playing, discussions, and other hands-on investigations. The subjects used these inquiry-based lessons to work toward mastering the content objectives of the botany unit being studied.
CHAPTER IV

RESULTS

Presentation of Results

The researcher computed the mean and the standard deviation for the pretest and posttest scores of the science achievement test. A t-test for dependent samples at the 0.001 level of significance was also calculated. The results were broken down into all students, female students, and male students. The results are shown in TABLES 1, 2, and 3.

### TABLE 1

**MEAN, STANDARD DEVIATION, AND T VALUE OF SCIENCE ACHIEVEMENT SCORES OF SEVENTH GRADE STUDENTS TAUGHT BY INQUIRY METHODS**

<table>
<thead>
<tr>
<th>TEST</th>
<th>N</th>
<th>( \bar{X} )</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>22</td>
<td>9.91</td>
<td>5.86</td>
</tr>
<tr>
<td>Posttest</td>
<td>22</td>
<td>29.91</td>
<td>4.53</td>
</tr>
</tbody>
</table>

\[ t = 18.77 \quad \text{p} < 0.001 \quad \text{df} = 21 \]
TABLE 2

MEAN, STANDARD DEVIATION, AND T VALUE OF SCIENCE ACHIEVEMENT SCORES OF FEMALE STUDENTS TAUGHT BY INQUIRY METHODS

<table>
<thead>
<tr>
<th>TEST</th>
<th>N</th>
<th>X</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>10</td>
<td>9.00</td>
<td>4.65</td>
</tr>
<tr>
<td>Posttest</td>
<td>10</td>
<td>29.90</td>
<td>5.28</td>
</tr>
</tbody>
</table>

\[ t = 12.52 \quad p < 0.001 \quad df = 9 \]

TABLE 3

MEAN, STANDARD DEVIATION, AND T VALUE OF SCIENCE ACHIEVEMENT SCORES OF MALE STUDENTS TAUGHT BY INQUIRY METHODS

<table>
<thead>
<tr>
<th>TEST</th>
<th>N</th>
<th>X</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>12</td>
<td>10.67</td>
<td>6.61</td>
</tr>
<tr>
<td>Posttest</td>
<td>12</td>
<td>29.92</td>
<td>3.80</td>
</tr>
</tbody>
</table>

\[ t = 13.76 \quad p < 0.001 \quad df = 11 \]

The writer rejected all three null hypotheses which stated that there would be no significant difference in pre and posttest science achievement scores of students who had been taught by inquiry methods. A significant difference was found. This difference was attributed to the treatment.
Discussion of Results

The results of this study supported the findings of Shymansky, et al. (1990). The inquiry methods used in the treatment did appear to increase science achievement. Female and male students both seemed to benefit equally from the inquiry-based methods as found in the research of Shymansky (1984).

It would appear as if using inquiry methods to actively involve students in the scientific process does help them to learn science concepts. There was no control group so it may be difficult to determine whether or not inquiry-based methods worked better than other more traditional methods. However, the increase in mean between pre and posttest scores was so large (200%) that it could be stated, at the very least, that inquiry methods are one very effective way to teach science.
CHAPTER V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Inquiry-based teaching is currently at the center of many science education reform movements. It is believed that students will understand science better if they are involved in true scientific endeavors, rather than just passively listening to information presented by the teacher. The purpose of this study was to analyze the effects of inquiry-based teaching on the achievement of seventh grade life science students. It was hypothesized that there would be no significant difference between the pre and posttest scores of students who had been taught by inquiry methods.

A group of twenty-two students was given a pretest. They were then involved in inquiry-based lessons for two weeks. Students were actively involved in science processes such as designing experiments, making observations, and interpreting data. At the end of the two-week period, the students were given a posttest.

There was a significant difference in the pre and posttest scores of the students at the 0.001 level. The
mean test scores significantly improved after the inquiry-based lessons.

Conclusions

Inquiry-based teaching appears to be an effective method to use in seventh grade science classrooms. This method will remain a part of the author’s teaching methodology. It is especially advantageous because students are actively involved in the learning process.

Recommendations

Because inquiry methods differ so much from traditional methods, it may be difficult for some students to become comfortable with this teaching method. Therefore, it is probably best to introduce students to inquiry methods early in the year. They will gradually become accustomed to the nature of these methods. It is also recommended that teachers receive training before attempting to implement inquiry programs.

These results indicate that inquiry-based methods can be used as an effective method in seventh grade science classes. It would be advantageous to conduct more extensive studies on inquiry-based methods using more rigorous designs which included control groups. Also, it would be interesting to study the effect of inquiry-based methods on
different age groups. Perhaps inquiry methods could be even more effective in junior high if students had more exposure to these methods in elementary school. It would also be beneficial to investigate whether or not inquiry works best for students with certain learning styles.

More detailed studies investigating which types of inquiry-based methods are the most beneficial are recommended. Also, it would be interesting to study the best combination of different teaching methods to determine how often inquiry methods should be used.

This future research would be very advantageous to current science education reform movements. Inquiry-based teaching has been shown to be a valuable science teaching method with potential to increase the science achievement of junior high students.
Science in the middle grades should provide students with opportunities to enrich their growing knowledge of the diversity of life on the planet and to begin to connect that knowledge to what they are learning in geography. That is, whenever students study a particular region in the world, they should learn about the plants and animals found there and how they are like or unlike those found elsewhere. Tracing simple food webs in varied environments can contribute to a better understanding of the dependence of organisms (including humans) on their environment.

Students should begin to extend their attention from external anatomy to internal structures and functions. Patterns of development may be brought in to further illustrate similarities and differences among organisms. Also, they should move from their invented classification systems to those used in modern biology. That is not done to teach them the standard system but to show them what features biologists typically use in classifying organisms and why. Classification systems are not part of nature. Rather, they are frameworks created by biologists for describing the vast diversity of organisms, suggesting relationships among living things, and framing research questions. A provocative exercise is to have students try to differentiate between familiar organisms that are alike in many ways—for example, between cats and small dogs.

By the end of the 8th grade, students should know that

- One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy–rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.

- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

- Similarities among organisms are four. 1 in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.

- For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring.

- All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.
These objectives were given to the students.

**Study Guidelines**

**Chapter 8—Plants**

1. For respiration and photosynthesis, be able to describe:
   ♦ materials used  
   ♦ substances formed  
   ♦ where it occurs in plants  
   ♦ necessary conditions  
   ♦ energy changes
2. Be able to recognize equations for photosynthesis and respiration. Describe what the equations mean.
3. Describe characteristics of vascular plants.
4. List the functions of roots, leaves, and stems.
5. Describe what chlorophyll is used for.
6. Give information about the life of a tree based on its tree rings.
7. List properties that make plants different from animals.
8. Explain how vascular plants transport materials.
9. Describe the function and location of these plants tissues: xylem, phloem, cambium.
10. List the differences between the two types of stems (woody and herbaceous).
11. Describe the function of stomata and guard cells.
12. Define transpiration.
13. Give a definition of a seed. Explain what each part of the seed turns into or what its function is.
14. Explain whether or not plants need light to germinate and grow.
15. Explain why deciduous leaves change color and drop off in the fall.
16. Explain the difference between evergreen and deciduous trees.
17. Describe common tropisms in plants.
APPENDIX C

PRE AND POST TEST FOR BOTANY UNIT

Fill in the blank with the correct answer:

1. Plants with vessels are called___________________________ plants.

2. List two functions of roots:
   1)____________________________________________________________________
   2)____________________________________________________________________

3. What is the function of leaves?_________________________________________

4. The green pigment used to make food in photosynthesis is called____________________

5. Tree growth rings are___________________ in wet years and_________________________ in dry years. (Describe the difference in SIZE of rings.)

MATCHING (Questions 6 - 18): Write the letter of the correct definition in the blank.

6. ____ cambium  a. hard, rigid stems
7. ____ phloem  b. plant tissue that transports water from the roots to other plant parts
8. ____ xylem  c. growth tissue that makes new xylem and phloem cells
9. ____ herbaceous  d. soft, green stems
10. ____ woody  e. tube-like cells that transport food from leaves to other parts of the plant (food flows down this vessel)

11. ____ stomata  a. releasing energy from food
12. ____ guard cell  b. controls size of stomata openings
13. ____ transpiration  c. loss of water vapor through stomata
14. ____ respiration  d. tiny openings in epidermis of a leaf

15. ____ stimulus  a. response of a plant to a stimulus
16. ____ tropism  b. response to light
17. ____ phototropism  c. response to gravity
18. ____ gravitropism  d. something in the environment that causes a reaction

Name the processes represented by the following equations:

19. ________________ 6 CO₂ + 6 H₂O + sun's energy ----------------> C₆H₁₂O₆ + 6 O₂

20. ________________ C₆H₁₂O₆ + 6 O₂ ----------------> 6 CO₂ + 6 H₂O + energy

21. In the above equations, CO₂ stands for carbon dioxide. What does C₆H₁₂O₆ stand for?__________________
2. Complete the table below by answering the questions in the left column for each process. Write your answers in the correct space. **DO NOT** use symbols. **WRITE OUT WORDS!** For example, write "water", not "H₂O".

### Photosynthesis and Respiration

<table>
<thead>
<tr>
<th>Photosynthesis</th>
<th>Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What materials are used?</td>
<td></td>
</tr>
<tr>
<td>2. What substances are formed?</td>
<td></td>
</tr>
<tr>
<td>3. In what part of a plant does the process occur?</td>
<td></td>
</tr>
<tr>
<td>4. What conditions are necessary for the process to occur?</td>
<td></td>
</tr>
<tr>
<td>5. What energy changes occur?</td>
<td></td>
</tr>
</tbody>
</table>

### Questions

1. Use the labeled seed drawing to answer the next two questions:
   1) What does part A turn into?
   2) What is part B used for?

**IMPORTANT ANSWER/ESSAY:** Please answer in complete sentences. Many of the questions have **two parts**. Be sure to **write all parts completely**. If you run out of room, please use your own notebook paper to continue:

Suzy Scientist did an experiment to see if plants need light to grow. She planted bean seeds and placed half the planted seeds in the sunlight and half under a box. The seeds that were under the box came up first, but they were white. How could the seeds have come up when they were not given any light? Why were the plants white and not green?

Describe how water can move from the roots of a tall tree all the way up to its leaves. What kind of forces help the water to move?

Why do leaves of deciduous trees change color and drop off in the fall? Why don't evergreen leaves do the same?

What is a plant? What characteristics make a plant different than other organisms?
APPENDIX D

LESSON PLANS FOR BOTANY UNIT

Day One:
1. Administer pretest.
2. Read a story about a trip to the movie theater. Students brainstorm how plants were used in the story.
3. Brainstorm experimental setups to answer the question, "Do plants need light to grow?"

Day Two:
1. Set up light/dark experiments.
2. Discuss, "What is a seed?"
3. Students observe and cut open bean seeds.
4. Students predict what each part of the seed is for.
5. Students set up experiments with four bean seeds, baggies, and paper towels to see if their hypotheses are correct.

NOTE: From this point on, students will make daily observations of their seeds and their light/dark experiments.

Day Three:
1. Students use reference material to discover the fundamental parts of plants.

Day Four:
1. Students use previous knowledge and reference material to decide what materials are used and made during photosynthesis and respiration.
2. Students role play to simulate the parts of a tree. Students pretend to be xylem, phloem, bark, leaves, or heartwood. Students work together to simulate transport and photosynthesis in the tree.
3. Students use black marker chromatography to infer how the different colors appear on the leaves of deciduous trees in the fall.
Day Five:
1. Students act out the equation for photosynthesis (each student represents a different element).
2. Some of the students work on lab stations. Each lab station has a problem or question for students to discuss. Tropisms, transport, cell structure, and sugar/starch testing in foods are covered. For example, at one station students observe a stalk of celery that has been sitting in blue water. Students try to explain why the leaves are blue.
3. The rest of the students work on other activities which include making concept maps and learning about tree rings.

Day Six:
1. The second group of students now works on lab stations.

Day Seven:
1. The last group of students now works on lab stations.

Day Eight:
1. Students make final observations of seed and light/dark experiments. Each group shares their setup and results.
2. Each group shares their answers to lab stations. If there are disagreements, students will give evidence in support of their answers. (Reference material may also be used to come to a class consensus.)

Day Nine:
1. Students view film strip about roots, stems, and leaves.
2. Students design questions to help the class prepare for the test.
3. Each group shares their questions with the class.

Day Ten:
1. Administer post test.
THEORETICAL-CONCEPTUAL thinking
This is what I already know about the problem.
I need to know more.
I observe, explore, and search the literature.

HYPOTHESIS
I make an educated guess as to the rule of nature that governs the problem.

INSIGHT
Aha! I know what I will do!

VARIABLES
INDEPENDENT
I will vary one thing between the experiment.

CONTROL
...and a control...

DEPENDENT
...that will cause a change...

EXPERIMENTAL DESIGN
I design an experiment to test my hypothesis.

PREDICTION
Based on my hypothesis, I predict a change in the dependent variable...

METHODOLOGY DOING SIDE
What should be my next problem?

NEW KNOWLEDGE
How does the new knowledge fit with what I already know about the world?

KNOWLEDGE
What are the limitations of this new knowledge?

VALUES

CLAIMS

CONCLUSION
What can I conclude?

DATA
...and collect information about the variables that tell me what did happen to the dependent variable.

TRANSFORMATION
I transform the raw data into tables and graphs to make any patterns or regularities more obvious.

...and anticipate a certain result.

EXPERIMENT
I do the experiment.

PREDICTION
Based on my hypothesis, I predict a change in the dependent variable...
REFERENCES


