THE EFFECTS OF A GARDENING PROGRAM ON THE PROGRESS OF THIRD, FOURTH, AND FIFTH GRADE MATH AND SCIENCE STUDENTS

THESIS

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By

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DEDICATION

To Dad and Mom

Thank you for being there for me along all my steps throughout life.

I love you.

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I would like to begin by thanking my family, especially my parents Keith and Cindy Pigg and my sister Elizabeth Pigg, for encouraging me to strive to achieve my goals and by being there for me through everything. I would also like to thank my roommate, Amanda Ozier, for listening to my hopes and fears; you are truly my best friend. I want to thank my committee. They were a great committee who helped me with every step along this journey. Dr. Tina M. Cade was the most wonderful professor and mentor. Words cannot describe the thanks I have for you encouraging me to move to Texas to pursue this opportunity and helping me through every step. Thank you Dr. Carl Igo for being an excellent professor and for helping me with this research project. Thanks also for being available for all of my questions. Thank you Dr. Deborah Stedman for providing me the knowledge of grant writing, the insight of education in Texas, and for serving on my committee.. I would also like to thank all the teachers and students who participated in my study, for this research could not have been conducted without their cooperation.

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CHAPTER I

INTRODUCTION

Throughout history, technology has played an important role in the lives of most Americans. With technological advances on the rise, an understanding of math and science become tremendously important. In order for the adults of tomorrow to have a competent understanding of math and science, emphasis must be placed on the curriculum being taught to the school aged children of today (Loucks-Horsley et al., 1990).

Basic math and science skills are needed in everyday life, in making day-to-day choices and decisions. Basic math and science skills are sometimes referred to as "math and science literacy". This literacy is defined as "the knowledge and understanding of basic concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Research Council [NRC], 1996, p. 2).

The need for improving the math and science literacy in school-aged children has become a popular topic discussed among educators and politicians of today. Many reform programs have been implemented in the past few years dealing with the improvement of math and science standardized test scores (National Center for Education Statistics [NCES], 2002).

The state of Texas replaced the state's previous assessment testing process formerly called Texas Assessment of Academic Skills (TAAS) with a state-wide standardized test called Texas Assessment of Knowledge and Skills (TAKS) (Texas Education Agency [TEA], 2002). TEA (2002) declared the TAKS tests had been developed to improve instructional practice and more accurately measure student learning.

Science and mathematics were subjects in which an active role must be used by both teacher and student. The programs and curriculum used in these subjects require hands-on activities that will "apply real world problems, collection of data, analyzing data and problems, solving the problem, and applying the information learned to new situations" (DeBuhr, 1996, p. 19). This learning by doing method can be incorporated into the curriculum by providing hands-on gardening activities in order to motivate clear and intelligent thought from the students. Gardening in the school has also been thought to promote creativity, relaxation, independence, and responsibility from students participating in garden programs (Bassett, 1979).

School gardens have been incorporated in the learning process for many years. The first documented school garden in the United States was at Boston's Putnam School in 1891. In the beginning, these school gardens were used to promote morality and patriotism among students (Bassett, 1979). An early educator named Maria Montessori (1912) documented the importance of integrating garden activities into the classroom. In her writings, Montessori noted significant benefits to children working and learning in the garden. The focus of school gardens has progressed to that which improves the curriculum and increase focus on learning. (Shair, 1999). Although school garden programs have been incorporated into school systems in the past and present, they have yet to become a main focus in the curriculum.

In order for garden programs to become a main focus in curricula, research was needed to assess whether garden programs provide success in the curricula of math and science. It was important to research the success of math and science because of their applications to technology and the real world. The problem to be addressed in this research project was whether school garden programs affect science achievement and math TAKS scores of elementary grade students.

Purpose and Objectives

The purpose of this study is to assess the affects of a school garden program on the science achievement and math TAKS scores of elementary students in the third, fourth, and fifth grades. Specific objectives for this study were:

1. Examine the effect of the Junior Master Gardener™ curriculum on the TAKS math scores of participating students.
2. Examine the effect of the Junior Master Gardener™ curriculum on the science achievement of participating students measured using a science cognitive test.
3. Examine the influence of demographic variables to determine if particular groups appear to benefit from the curriculum more than others.

Definition of Terms

For the purpose of this study, the following terms were defined operationally.

Achievement: A measurement of the level of knowledge gained through the school environment through change in scores or grades in school.

Curriculum: The objectives within the courses of study offered in a school program.

Constructivist: Refers to the Constructivist philosophy of learning, which recommends that people actively create new knowledge based on the knowledge they already know. Constructivist classrooms utilize hands-on teaching and learning techniques allowing students to create new knowledge for themselves.

Education Reform: Refers to the reform efforts made in education in order to improve existing programs.

JMG™: The Junior Master Gardener™ program implemented in school curriculum as provided by Texas Cooperative Extension. This program is a youth-based program based on the adult Master Gardener™ program offered by state Extension agencies throughout the United States (Texas Agriculture Extension Service [TAEX], 2001).

TEKS: The State of Texas' idea of the basic skills and knowledge needed for all students (Texas Education Agency, 2002).

TAKS: The standardized test created in the State of Texas, which tests whether the students have learned the basic skills and knowledge (Texas Education Agency, 2002).

Basic Assumptions

It is assumed that, in this study, all the students were typical students not representing unusual cases within the third, fourth, and fifth grades.

It is assumed that, in this study, all the teachers participating in the JMG™ program did so to their full potential.

It is assumed that, in this study, all the third, fourth, and fifth grade students participating completed the science cognitive test to their full potential.

It is assumed that, in this study, all the third, fourth, and fifth grade students participating completed the TAKS to their full potential.

Limitations of the Study

This study was limited by lacking randomization. This study did not include students from all regions of Texas, but only those in a selected school located in McAllen, Texas. Additionally, some teachers have different teaching styles, consequently, all of the students who participated in this study may not have been taught the material in the same manner, or to the same depth. The students participated in the JMG™ program during the 2001-2002 school year, while testing for the study took place in the 2002-2003 school year.

Delimitations of the Study

This study was delimited to a moment in time. This study only focuses on one group of students during the 2002-2003 school year.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, the literature reviewed examines math and science education and the application of school garden programs to learning. This includes a history of math and science education reform, and the most recent reform efforts in the state of Texas. Also included is a review of garden programs used as a teaching tool. The literature is grouped into the following headings and subheadings:

1.) History of math and science education reform
    a. Development of TEKS and TAKS program
    b. Constructivist theories in Math and Science Education
2.) Gardens and school gardening
    a. History of school gardening
    b. Benefits of school gardening
    c. School gardening used for constructivist learning

History of Math and Science Education Reform

Throughout the years, many educators have agreed that there was a need for math and science education reform. Math literacy, or ability, was defined by the National Assessment of Educational Progress (NAEP) in three areas including "conceptual understanding, procedural knowledge, and problem solving" (NRC, 1996, p.22).

The NAEP stated the "understanding of concepts will reflect a student's ability to reason in settings involving the careful application of concept definitions and relations" (NRC, 1996, p.22). The National Science Education Standards define science literacy as the "knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (NRC, 1996, p. 22). Math and science literacy were important topics when discussing education reform.

A number of scholars and politicians have questioned the need for math and science reform. There was evidence presented to indicate math and science education in the United States had become mediocre. Out of thirteen industrialized nations, the United States ranked number thirteen in biological understanding (National Center for Education Statistics, 1996). Fortunately, these statistics were improving. According to a 1999 study from the National Center for Education Statistics, U.S. students ranked higher than the international average of 38 nations in math and science literacy (National Center for Education Statistics, 2002). Approximately one percent of elementary school children received more than two hours of hands-on math and science education during their elementary years. Finally, only five percent of adults in the United States were considered to be scientifically literate (DeBuhr, 1996). These points suggested the mediocrity of math and science education in the United States, and a need for reform.

Educational reform had been evolving throughout history. In the United States, during the 1870's and 1880's many colleges and universities began to move away from traditional education, such as reading, writing, and arithmetic, and integrated natural sciences into the curricula (Mintzes, Wandersee, and Novak, 1998). This was taken further with the Morrill Act of 1862, which established land grant colleges that "came to symbolize the use of scientific knowledge to solve agricultural and technological problems" (Mintzes et al., 1998, p. 31.). Since the establishment of land grant universities, technological advances throughout history have left an important impact on math and science education reform.

On October 4, 1957, when the Soviet Union launched the Sputnik Satellite, Americans saw the need for high quality math and science education (DoBoer, 2000). At that time, criticism of American education and the need for a more rigorous math and science curriculum became important topics. The switch to more intensive math and science programs proved to be a success and gave America the hope it needed in 1969 when Neil Armstrong took the first walk on the moon. This hope was that math and science education was finally developing into a more rigorous program. It was also during this time when the terms of "math and science literacy" were created and taken to be important standards in education (DoBoer, 2000).

In the past, math and science careers were only considered for those children who proved to be exceptional students who showed an inclination toward math and science. Today, however, the goal was math and science literacy for every child (DeBuhr, 1996). This goal, along with others led the country as a whole to develop assessments to measure the curriculum and learning of children across America.

Development of TAKS Program

In Texas, the student testing process began in 1979 when the Texas legislature passed a bill requiring the testing of basic skills in math, reading, and writing for grades three, five, and nine. By 1990, the Texas testing process eventually evolved through time into the development of the Texas Assessment of Academic Skills (TAAS) test (Texas Education Agency [TEA], 2002). As opposed to previous testing instruments, the TAAS tests were created to be more difficult and to follow the state-mandated curricula. As stated by the Texas Education Agency (TEA), the TAAS tests were directed toward assessing the higher-order thinking skills and problem-solving in math, reading and writing for grades 3, 5, 7, 9, and 11. Science and social studies were not added to the TAAS test until 1995 and they were only given in the eighth grade (TEA, 2002).

On September 1, 1998, the entire state of Texas began implementing the Texas Education of Knowledge and Skills (TEKS) into all areas of the curriculum (TEA, 2002). The TEKS curriculum was refined to be aligned with the TAAS test, which was the state testing instrument still in use at that time. However, in 1999, the 76th Texas legislature passed the Senate Bill 103, entitled Texas Education Code Chapter 39 and 28, which called for a more rigorous testing program. This legislature led to the creation of a high-stakes testing program called the Texas Assessment of Knowledge and Skills (TAKS) test, which was formed to coincide with the TEKS, the state-mandated curriculum. In grades three through eleven, the TAKS focus on math and in grades five, ten and eleven, the focus is on science. Under this bill, all students were required to pass the TAKS exams in order to progress to the next grade (TEA, 2002). The spring of 2003 was the first year that the TAKS test was administered. Student assessment has become a very important topic in education reform, as shown previously and assessment was rapidly evolving, especially in Texas.

Constructivist Theories in Math and Science Education

Math and science both required hands-on learning; therefore, it was not surprising that constructivist theories were discussed in math and science education (NRC, 1996). Texas state standards, the TEKS, were heavily influenced by constructivist theories. Although the TEKS were not labeled as a constructivist curriculum, the theory was evident throughout (TEA, 2002). The National Science Education standards as well as the TEKS emphasized student-centered learning using experience-based explorations. This includes cooperative, as well as individual work, and teacher-facilitated, rather than teacher-led investigations (NRC, 1996; TEA, 2002).

The idea that learners control learning was the heart of the constructivist theory. Likewise, in the same way that students see relevance in their daily activities, which in turn creates an interest in learning, the students must be able to make a connection to the curriculum in order to have an interest in learning (Brooks and Brooks, 1999). In order to create an interest in learning, a hands-on approach to learning can be used. Many previous studies have shown the importance of hands-on learning (Adams and Hamm, 1998; Braun, Kotar, and Irick, 1989; Brooks and Brooks, 1999; Johnson, Wardlow, and Franklin, 1997; Klemmer, 2002; Kyle, Bonnstetter, and Gadsen, 1998; Waliczek, Logan, and Zajicek, 2003). In one study, students who participated in a traditional textbook-oriented science class were compared with students from an experiential, inquiry-oriented science class. The final results of the study showed that the students participating in the experiential science class had very different attitudes toward science as those in the traditional class. More than half of the students in the experiential science class labeled science as "fun and interesting". These students also stated that they could see the relevance of science in their everyday lives. On the other hand, more than half of the students in the traditional science class stated their opinion of science as boring (Kyle et al., 1988). Another study looked at the impact of outdoor activities on the attitudes of elementary students toward math and science. Results from this study showed that the students learned math and science, but also were thinking at higher levels and were also stating that the activities used in the study were fun (Waliczek et al., 2003). It is apparent that the hands-on, constructivist theories could be beneficial in improving math and science curricula.

Public Gardens and School Gardening

Gardening programs have been involved in school programs for many years (Bassett, 1979; Montessori, 1912). However, in recent years, their popularity was growing school garden programs could provide a hands-on approach to learning which follows the experiential method of education. Gardens can be as extravagant as an outdoor natural habitat or as minor as planting seeds in plastic cup in the classroom (Guy, Cromell, and Bradley, 1996). Either way, these gardens have provided a hands-on real life experience for the students in learning about everything from science and math, to nutrition.

History of School Gardening

As stated previously, school garden programs are not a new revelation. Gardens were first introduced for children in 1837 when a German educator named Friedrich Froebel created the term 'kinder garten" which means 'a garden for children' (Shair, 1999). In the United States, the first documentation of a school garden noted the establishment of a garden at Boston's Putnam School in 1891 under the supervision of the Massachusetts Horticultural Society (Green, 1910). The first children's public garden was established in 1914 at the Brooklyn Botanical Garden with the idea of developing important agricultural skills in youth (Maclin and Hyland, 1999). Even during these early times, school gardens were important as teaching tools for providing hands-on learning and experiential learning.

Benefits of School Gardening

It has been suggested that children who have contact with natural settings, such as gardens, will have an altered environmental disposition. Skelly and Zajicek (1998) found that gardening had a positive effect on children's environmental attitudes. This study also found that younger students are more likely to benefit from environmental experiences (Skelly and Zajicek, 1998). School garden programs are said to provide "responsibility, patience, pride, self-confidence, curiosity, critical thinking, and the art of nurturing" (Guy et al., 1996, p. 9). Garden programs are also said to improve environmental attitudes, increase responsibility, and improve self-esteem (Skelly and Zajicek 1998; Waliczek, 1997; Waliczek et al., 2003)

Many public gardens that provide youth gardening programs have been shown to have a positive impact on students as well. The idea of using school gardens as teaching tools increased into the latter half of the twentieth century. The popularity of using gardens to teach subjects such as science, math, nutrition, and environmental education by using hands-on techniques has grown immensely (Shair, 1999). The Midwest Consortium of Botanic Gardens and Arboreta were in the process of conducting an instructional teacher-training project that incorporated national standards for science teaching and professional development. This project has been a guide for other public gardens working with schools on educational development (DeBuhr, 1996). The impacts that public gardens have had on the community have helped school leaders to start implementing gardening programs in their own schools (Klemmer, 2002).

Extension agencies across the country are also playing an important role in school garden programs. Many Extension agencies have created youth gardening programs based on the existing adult Master Gardener™ programs. The Arizona Master Gardeners™ along with the University of Arizona became one example when they published a book to help teachers, administrators and parents learn how to start school gardens (Guy et al., 1996).

Several studies in the past have presented data showing the benefits of school gardening programs. In one study, teachers reported that their students' science scores along with an overall academic achievement improved due to gardening programs (Braun et al., 1989). Another studies found that students who participated in hands-on school gardening programs had a higher science achievement compared to students who did not participate in the school gardening program (Klemmer, 2002; Kyle et al., 1988).

These studies, along with others, show the importance of school garden programs. The importance for school garden programs suggests their ability to enhance overall academic curricula. With the enhancement of the curricula, success in elementary academia, especially in math and science, may be achieved.

School Gardening Used for Constructivist Learning

The idea of hands-on, constructivist learning served as the main idea behind school garden programs. Gardens served as living laboratories, in which students can see what they are learning and then in turn, apply that knowledge to real world situations

(Adams and Hamm, 1998; Klemmer, 2002; Mintzes et al., 1998). A common concept of math and science education is that there are only 'right' and 'wrong' answers, the constructivist styles of school gardens provide alterative answers and that there is never only one-way to complete a task. The role of the teacher as well as the student becomes a changed role. The teacher becomes a facilitator as well as a learning partner with the student rather than just a lecturer of knowledge. The constructivist's theories of learning were also used to create group learning and inquiries (Adams and Hamm, 1998). In a gardening program, if students work in groups to solve math problems or learn scientific techniques in an outdoor garden setting, the learning went beyond the basics taught in a traditional classroom setting. The children learn to work together, learn to take leadership roles, and learn important real world problem solving techniques. This idea of learning through a social process is one of the key components of constructivist learning (Mintzes et al., 1998).

Hands-on learning has become very important to many educators, especially in the areas of math and science education. "The use of hands-on activities makes science vivid, meaningful, and fun for most students" (Johnson et al., 1997, p. 2). It was also found that when middle school students were asked to state their most memorable learning experience, the majority of the students identified hands-on science over all other subjects (Johnson et al., 1997).

The newly implemented state-mandated curricula set in Texas, the TEKS, and the NSES provide a structure for active student learning. This active, constructivist, style of teaching and learning seems to be a significant framework for incorporating school gardening programs into the curriculum. Gardening programs give the teacher numerous possibilities at teaching what the state labels as "important concepts" as well as having the freedom to integrate unique discovery and problem solving techniques. It seems gardening programs have the potential to become beneficial to student learning by providing adequate math and science literacy.

CHAPTER III

METHODOLOGY

The purpose of this study was to assess the effects of a school garden program on the science achievement and math TAKS (Texas Assessment of Knowledge and Skills) scores of elementary students in the third, fourth, and fifth grades. In this chapter, the researcher explains the testing instruments used, and described the school that had students who served as the sample and control population. In addition, the experimental design and the methods of data collection and analysis for the study were described.

Instrumentation

This study utilized existing instruments to gather data. These existing instruments included a demographic survey (Appendix A) for all participants, the math TAKS test for the third, fourth, and fifth grades, and a cognitive science test instrument for each grade (Appendix B, C, and D). These are explained in detail below. The teachers of each student gained parental consent before administering the instruments. The Office of Sponsored Programs at Texas State University-San Marcos reviewed and approved the research. The Internal Review Board (IRB) reference number was 03-0191.

Some students, especially those in the younger grades, were either Spanish-speaking only or enrolled in the English as a Second Language (ESL) program. The tests for this study were written in English only. As a result, those students who could not speak or read English had their tests read orally to them by their teachers. The ESL students in the fifth grade were required to take the tests in English, despite any problems they may have had in understanding English.

Demographic survey

A demographic survey was administered to each participating student in order to obtain information on grade, age, gender, ethnicity, and level of gardening experience. The demographic survey used for this study was adapted from a demographic survey used by Klemmer (2002) in a similar study.

TAKS Math Test

At the time of this study, the state of Texas was in the process of implementing a new standardized testing instrument. The previous statewide assessment, the Texas Assessment of Academic Skills (TAAS) had been revised and republished as the Texas Assessment of Knowledge and Skills (TAKS). The TAKS purports to assess student achievement of the Texas Essential Knowledge and Skills (TEKS), the state's curriculum, and was intended to be more rigorous than the TAAS (TEA, 2002). The spring semester of 2003 was the first semester in which the TAKS tests had been administered. For the purpose of this study, the TAKS math tests of the participating third, fourth, and fifth grade students served as math cognitive testing instrument.

Science Test Instrument

At the time of this study, the state of Texas administered the TAKS tests in science to only the fifth grade. Since TAKS results were not available for third and fourth grades, it was determined that an existing science test instrument for these grade levels be included in the study. The science test instrument used for this study was developed by

Klemmer (2002) for a similar study (Appendix B, C, and D). The development of these tests followed the test development guidelines provided in Gall, Borg, and Gall (1996). Klemmer developed the tests in three phases, including an initial test, an adapted set of piloted test instruments, and a final set of testing instruments. The final set of test instruments was found to have Cronbach's Alpha reliability of 0.8215 (Klemmer, 2002). The cognitive science tests developed by Klemmer (2002) were based on the science TEKS objectives for grades three, four, and five. They were shown to a science curriculum specialist and a science teacher, and finally the tests were reviewed by the Science and Math Curriculum Coordinator for Temple ISD and the Curriculum Coordinator for the JMG™ program in order to establish validity of the science testing instruments. To ensure the validity of the science test instrument for this study, the instruments were shown to teachers from the third, forth, and fifth grade levels in the school where this study took place, before the study began. The teachers who looked at the science test agreed that the content followed the objectives of the TEKS curriculum. The teachers from the schools also agreed upon the effectiveness and appropriateness for testing third, fourth, and fifth grade students in science

Population

The sample used for this study was drawn from a population of third, fourth, and fifth grade students from McAuliffe Elementary School, located in McAllen, TX. McAllen is located ten miles from the Texas-Mexico border, the principal city located in the McAllen-Edinburg-Mission metropolitan area and part of the Rio Grande Valley of South Texas. The population of this metropolitan area was approximately 569,463, of which 88.3 percent of the population was of Hispanic origin (McAllen Economic

Development Corporation [MEDC], 2003). Approximately 100 of the 200 of the students volunteering for this study participated in the Junior Master Gardener™ (JMG™) program (Texas Agriculture Extension Service [TAEX], 2001). A control group was drawn from third, fourth, and fifth grade students at McAuliffe Elementary School who were not participating in the Junior Master Gardener™ program. The students in the control group may or may not have had the same teacher as those students participating in the program. The JMG™ participants of this study participated in the program during the 2001-2002 school year.

Curriculum

The test curriculum used for this study was the Junior Master Gardener™ (JMG™) program. This curriculum was a youth gardening curriculum developed by the Texas Agriculture Extension Service. The overall JMG™ curriculum was intended to educate youth about horticulture, health, nutrition, environmental science, and leadership (TAEX, 2001).

The JMG™ curriculum was divided into a three level program. This study used Level 1 only, entitled, *Health and Nutrition from the Garden*, which targeted the third, fourth, and fifth grades. The level 1 teacher/leader handbook used six teaching concepts along with life-skills and a career exploration activity, and a service learning and leadership project. The six teaching concepts are listed below in Table 1 (TAEX, 2001). A possible limitation of this curriculum could be that this section of the JMG™ curriculum encompassed a nutritional focus and does not cover basic math skills.

Table 1. Teaching concepts and focus of JMG™ Level 1 curriculum, for grades 3-5, which was used in the study of assessing math and science achievement using school gardening.

Teaching Concept	Concept Title	Focus of Concept
Concept 1	Basic Gardening	Participants learn how to garden for optimum plant growth, production, and food quality.
Concept 2	Growing Techniques	Methods used by experienced gardeners and professionals to make our world a better place.
Concept 3	Thrifty Gardens	How to use the garden wisely and make wise choices in purchasing garden items.
Concept 4	Food Safety	Food safety practices when preparing harvested fruits and vegetables.
Concept 5	ABC's of Healthful Eating	Learn about different fruits and vegetables that provide some essential vitamins and minerals.
Concept 6	Healthful Snacks	Learn about and experience healthful snack alternatives to help keep them energized and active.

(TAEX, 2001)

Participants in this study were not required to proceed through the program sequentially or to seek certification. However, in order to become certified, the youth must have completed twelve activities (two of which were selected from each teaching concept in the curriculum) complete one Lifeskill/Career Exploration activity, and one Service Learning/Leadership project (TAEX, 2001).

To make certain the JMG™ curriculum supported the Texas curriculum standards, the activities from the Level 1 *Health and Nutrition Teacher/Leader Guide* were correlated to the Texas Essential Knowledge and Skills (TEKS) curriculum. The following math TEKS objectives are covered in the Level 1 *Health and Nutrition Guide*:

third grade objectives 2, 3, 6, 7, 8, and 13-17, fourth grade objectives 1-4 and 11-15, fifth grade objectives 1-3 and 11, 13, 14, and 15 (Junior Master Gardener [JMG], 2003). The following science TEKS objectives are covered in the Level 1 *Health and Nutrition Guide*: third grade objectives 1-5, 8, 9, and 11, fourth grade objectives 2-8, 10, and 11, fifth grade objectives 2-7, 9, and 11 (JMG™, 2003). The specific math TEKS and science TEKS objective are listed in detail in Appendix E (TEA, 2002). The overall JMG™ curriculum standards coincided with the TEKS curriculum in the areas of science, math, language arts, and social studies, making it a suitable curriculum tool in this study (Klemmer, 2002).

Data Collection

The research design used for this study was a quasi-experimental posttest only. The research test implementation for this study was conducted in the spring of 2003. The demographic survey and the science inventory test were given to the teachers of the participating students in this study in February 2003. Those teachers administered the tests to the students in their class in typical format. In order to keep anonymity of the students, no names were added to either the demographic survey or the science inventory tests. The teachers gave the science tests and the TAKS scores a code that indicates each test, the classroom, and the demographic information regarding each child. The researcher collected the demographic surveys, science tests, and the coded TAKS scores in June 2003.

Data Analysis

Each participating students' teacher listed the math TAKS score and the science test score as total correct out of total number of questions on each demographic survey.

From the total number correct out of total number possible, the researcher figured the percentage score for each student. The percentage scores figured were the scores analyzed for this study. The scores were analyzed using the Statistical Package for the Social Sciences Version 11.5 (SPSS, 2003). Mean scores were analyzed using ANOVA methods to compare scores for control versus experimental groups, and demonstrated any demographic differences within the experimental and control groups.

CHAPTER IV

FINDINGS AND DISCUSSION

The purpose of this study was to assess the effects of a school gardening program on the science achievement and math TAKS (Texas Assessment of Knowledge and Skills) scores of elementary students in the third, fourth, and fifth grades. The chapter contains the descriptive statistics and data analysis concerning the math and science achievement of elementary students who participated in the Junior Master Gardener™ (JMG™) gardening program as part of their instruction versus those who did not participate in Junior Master Gardener™ (JMG™) and received traditional (non-gardening related) instruction. Specific objectives for this study were to:

1. Examine the effect of the Junior Master Gardener™ curriculum on the science achievement of participating students;
2. Examine the effect of the Junior Master Gardener™ curriculum on the TEKS math scores of participating students; and
3. Examine the influence of demographic variables to determine if particular groups appeared to benefit from the curriculum more than others.

The results based on these objectives will be discussed within this chapter.

Descriptive Statistics for the Sample

Sample Demographics

The sample population for this study consisted of 196 third, fourth, and fifth grade students located in McAllen, Texas. Students in classes that had participated in a school gardening program using the JMG™ curriculum during the 2001-2002 school year comprised the experimental portion of the sample, while those who had not gardened and had received instruction through traditional methods comprised the control portion of the sample. The SPSS descriptive statistics for the experimental and control groups outlining the number of students within the third, fourth, and fifth grades are included in Table 2.

Table 2. Descriptive statistics: Experimental assignment and grade level of participants in the study of the influence of school gardening on math and science achievement.

Groups	Number in Sample	Percent of Sample
Experimental Group	94	48%
Third Grade	26	14%
Fourth Grade	24	12%
Fifth Grade	44	22%
Control Group	102	52%
Third Grade	34	17%
Fourth Grade	11	6%
Fifth Grade	57	29%
Total Sample Population	196	100%

The experimental group consisted of 48% of the sample, while the control group made up the remaining 52%. The sample in this study was relatively balanced. Each grade had an almost equal counterpart in each of the experimental and control groups.

The SPSS descriptive statistics for experimental and control groups outlining the number of males and females in the third, fourth, and fifth grades are included in Table 3.

Of the 196 students tested for this study, 50% were females and 50% were males. The fourth and fifth grades within the control group and the third grade within the experimental group were all relatively balanced. The control group's third grade had slightly more males (11%) than females (6%) within the sample population. The fourth grade within the experimental group had slightly more females (8%) than males (4%). The fifth grade within the experimental group also had slightly more females (13%) than males (9%).

Table 3. Descriptive statistics: Gender of sample population by grade level and assignment groups in the study of the influence of school gardening on math and science achievement.

Groups	Female	Female %	Male	Male %	Total Number	Total Number %
Experimental Group						
Third Grade	11	6%	15	8%	26	14%
Fourth Grade	16	8%	8	4%	24	12%
Fifth Grade	26	13%	18	9%	44	22%
Sub-total, Experimental	53	27%	41	21%	94	48%
Control Group						
Third Grade	13	6%	21	11%	34	17%
Fourth Grade	5	3%	6	3%	11	6%
Fifth Grade	27	14%	30	15%	57	29%
Sub-total, Control	45	23%	57	29%	102	52%
Totals	98	50%	98	50%	196	100%

Findings Related to Research Question 1

Do the students who participated in the JMG™ program have equal or different science achievement compared to students receiving traditional science instruction?

Descriptive statistics

The science achievement mean score for the experimental group of science students participating in the JMG™ program (22.30) was 1.1 points lower than the control group of science students receiving traditional instructional methods (23.40).

Data analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the mean science achievement scores between the experimental and control group. An a priori alpha level of 0.05 was set. The difference in mean science achievement scores between the experimental group (22.30) and the control group (23.40) was not statistically significant (Table 4).

Table 4. ANOVA comparing mean science achievement scores of experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	df	F	Sig.
Experimental	94	22.30	4.981	1	1.675	.197
Control	102	23.40	6.677			
Total	196			194		

Discussion

Findings suggested that the experimental group participating in the JMG™ program benefited similarly to the control group receiving traditional classroom instruction. The results suggested that school gardening was just as effective at teaching science as the traditional instructional methods. Several previous studies dealing with this subject mentioned in the Review of Literature (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997; Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly and Zajicek, 1998; Waliczek et al., 2003) support these findings and indicate that science achievement can be improved by the use of gardening programs or hands-on experimental activities.

Finding Related to Research Question 2

Do the students who participated in the JMG™ program have equal or different math achievement compared to students receiving traditional math instruction?

Descriptive Statistics

The mean math TAKS scores for the experimental group participating in the JMG™ program (26.01) was 4.13 points lower than the control group math TAKS scores of math students not participating in the JMG™ program (30.14).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the mean TAKS math scores between the experimental and control groups. An a priori alpha of 0.05 was set. The difference in the mean math TAKS scores between the experimental group (26.01) and the control group (30.14) was statistically different (Table 5).

Table 5. ANOVA comparing mean math scores of experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	df	F	Sig.
Experimental	94	26.01	7.606	1	13.285	.000
Control	102	30.14	8.124			
Total	196			193		

Discussion

The differences in these findings exist as a result of the control group having a higher mean math TAKS score (30.14) than the experimental group (26.01). These findings do not support other similar school gardening research (Brooks and Brooks, 1999; Braun et al., 1989; Johnson et al., 1997; Klemmer, 2002; Skelly and Zajicek, 1998; Waliczek et al., 2003). The curriculum used for this study is the Junior Master Gardener™ (JMG™), a youth gardening curriculum developed by the Texas Agriculture Extension Service. The JMG™ curriculum is intended to educate youth about horticulture, health, nutrition, environmental science, and leadership (Texas Agriculture Extension Service [TAEX], 2001). However, the subject of math was not included within the particular JMG™ curriculum Level 1 *Health and Nutrition Guide* used for this study. The portion of the JMG™ curriculum used for this study focused mainly on the subject of nutrition and not math. The mean math TAKS scores of this study suggest that the full JMG™ curriculum, which focuses more on the subject of math as well as other subjects may be needed for improving math scores.

Finding Related to Research Question 3

Are there any demographic differences indicating that particular groups benefit more than others from participation in the JMG™ program compared to receiving traditional science and math instruction?

Comparisons of Ethnicity

The total size of the sample was 196 students. Of the 196 students, 163 were reported as being Hispanic, while the remaining 33 were reported as other ethnicities (Table 6). Because the sample was small, it limited the number within each group and therefore, limited comparisons were made between ethnicities. Comparisons were only made between the Hispanics in the control group versus the Hispanics in the experimental group because the sub samples of Hispanics were large enough to make comparisons.

Table 6. Reported ethnicities in the study of the influence of school gardening on math and science achievement.

Ethnicity	Number Reported	Percent of Sample
Asian	9	5%
African-American	1	0.5%
Hispanic	163	83%
Caucasian	20	10%
Other	3	1.5%
Total	196	100%

Comparisons of Hispanics in Control Versus Experimental Groups

Descriptive Statistics

The science achievement mean score for the Hispanics in the control science group (22.66) was 0.48 points higher than that of the Hispanic students participating in the JMG™ program (22.18).

The mean math TAKS score for the Hispanics in the control math group of students receiving traditional instructional methods (29.19) was 3.79 points higher than the mean math TAKS scores of the Hispanics within the experimental math group of students participating in the JMG™ program (25.40).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the mean science achievement scores between Hispanic students in the experimental and control groups. An a priori alpha level of 0.05 was set. The difference in mean science achievement scores between Hispanics in the experimental group (22.18) and the control group (22.66) was not statistically significant (Table 7).

Table 7. ANOVA comparing mean science achievement scores of Hispanics in experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	df	F	Sig.
Experimental	76	22.18	5.207	1	.287	.593
Control	86	22.66	6.052			
Total	162			163		

A one-way ANOVA was also conducted to test the statistical significance of the difference of the mean TAKS math scores between Hispanics in the experimental and control groups. An a priori alpha of 0.05 was set. The difference in the mean math TAKS scores between the Hispanics in the experimental group (25.40) and the control group (29.19) was statistically different (Table 8).

Table 8. ANOVA comparing mean math TAKS scores of Hispanics in the experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	df	F	Sig.
Experimental	75	25.40	7.330	1	9.762	.002
Control	86	29.19	7.954			
Total	161			160		

Discussion

Findings suggested that the Hispanic students within the experimental group participating in the JMG™ program benefited similarly to the Hispanic students within the control group receiving traditional classroom instruction. The results suggested that the JMG™ curriculum was just as effective at teaching science as the traditional instructional methods. Several previous studies dealing with this subject mentioned in the Review of Literature (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997; Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly and Zajicek, 1998; Waliczek et al., 2003) support these findings and indicate that science achievement can be improved by the use of gardening programs or hands-on experimental activities.

The differences found within the comparisons of Hispanic students and their math TAKS scores exist as a result of the control group having a higher mean math TAKS score (29.19) than the experimental group (25.40). These findings do not support other similar school gardening research (Brooks and Brooks, 1999, Braun et al., 1989; Johnson et al., 1997; Klemmer, 2002; Skelly and Zajicek, 1998; Waliczek et al., 2003). The curriculum used for this study is the Junior Master Gardener™ (JMG™), a youth gardening curriculum developed by the Texas Agriculture Extension Service. The JMG™ curriculum is intended to educate youth about horticulture, health, nutrition, environmental science, and leadership (Texas Agriculture Extension Service [TAEX], 2001). However, the subject of math was not included within the particular JMG™ curriculum used for this study. The portion of the JMG™ curriculum used for this study focused mainly on the subject of nutrition and not math. The mean math TAKS scores of this study suggest that the full JMG™ curriculum, which focuses more on the subject of math, may be needed for improving math scores. These findings are similar to those in research questions one and two due to the Hispanic group making up 83% of the population used for this study.

Comparisons of General Gardening Experience

Due to the small sample size, comparisons could not be made between students who reported having general gardening experience and students who reported having no general gardening experience. Of the 196 students participating in the study, 168 reported having other general gardening experience, including gardening at home, at a relative's house, or gardening at a friend's house, while the remaining 28 reported having no other general gardening experience (Table 9).

Table 9. Reported level of general gardening experience in the study of the influence of school gardening on math and science achievement.

General Gardening Experience	Number Reported	Percent of Sample
Yes-general gardening experience	168	85.7%
No-general gardening experience	28	14.3%
Total	196	100%

Comparisons of Grade Level and Science Achievement

Comparisons of Control Versus Experimental for 3rd Grade Science Achievement Scores

Descriptive Statistics

The mean science achievement test scores for the students in the third grade control group (21.09) was 0.17 points higher than the science achievement test scores mean for the students in the third grade experimental group (20.92).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the means between the control and experimental groups within the third grade. An a priori alpha of 0.05 was set. The difference in the mean scores between the third grade control group (21.09) and the third grade experimental group (20.92) was not statistically significant (Table 10).

Table 10. ANOVA comparing mean science achievement scores of experimental and control groups within the third grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	df	F	Sig.
Experimental	26	20.92	1	0.018	.894
Control	34	21.09			
Total	60		59		

Discussion

Findings suggested that third graders who participated in the JMG™ program benefited similarly in studying science using the gardening program to the third graders who received traditional classroom science instruction. These results suggest that school gardening was just as effective at teaching science to third graders as the traditional science instructional methods. Several previous studies dealing with this subject support these findings and also indicate that science achievement can be improved by the use of gardening programs or other hands-on experimental activities (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999; Skelly and Zajicek, 1998).

Comparisons of Control Versus Experimental for 3rd Grade Math TAKS Scores

Descriptive Statistics

The mean math TAKS scores for the students in the third grade in the control group (30.58) was 2.66 points higher than the mean math TAKS score for the students in the third grade in the experimental group (27.92).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the math TAKS scores mean between the control and experimental groups within the third grade. An a priori alpha of 0.05 was set. The difference in the mean math TAKS scores between the third grade control group (30.58) and the third grade experimental group (27.92) was not statistically significant (Table 11).

Table 11. ANOVA comparing mean math TAKS scores of experimental and control groups within the third grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Df	F	Sig.
Experimental	26	30.58	1	1.764	.189
Control	34	27.92			
Total	60		58		

Discussion

Findings suggested that third graders who participated in the JMG™ program benefited similarly to the third graders who received traditional classroom math instruction. Several previous studies dealing with this subject support these findings and also indicate that science and math achievement can be improved by a gardening program or other hands-on activities (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999).

Comparisons of Control Versus Experimental for 4th Grade Science Achievement Scores

Descriptive Statistics

The mean science achievement test scores for the students in the fourth grade control group (19.27) was 4.94 points lower than the mean science scores for the students in the fourth grade experimental group (24.21).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the differences of the science achievement test score means between the control and experimental groups within the fourth grade. An a priori alpha of 0.05 was set. The difference in science achievement mean scores between the fourth grade control group (19.27) and the fourth grade experimental group (24.21) was statistically significant (Table 12).

Table 12. ANOVA comparing mean science achievement scores of experimental and control groups within the fourth grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	df	F	Sig.
Experimental	24	24.21	1	6.985	.012
Control	11	19.27			
Total	35		34		

Discussion

Findings suggest that when learning science, fourth grade students who participated in the JMG™ program benefited more from the program than the fourth grade students who participated in the traditional science lessons. These results suggest that the JMG™ program was more effective at teaching science to fourth grade students than traditional science instructional methods. Similar research supports the idea that school gardening is more effective at teaching science than traditional science teaching methods (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999). Skelly and Zajicek (1998) found, when examining environmental attitude of children participating in a gardening program, that younger children had more positive environmental attitude scores when compared to older students. However, in that study, knowledge was not tested (Skelly and Zajicek, 1998).

Comparisons of Control Versus Experimental for 4th Grade Math TAKS Scores

Descriptive Statistics

The mean math TAKS score for the students in the fourth grade in the control group (27.64) was 0.53 points lower than the mean math TAKS scores for the students in the fourth grade in the experimental group (28.17).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the differences of the mean math TAKS scores between the control and experimental groups within the fourth grade. An a priori alpha of 0.05 was set. The difference in mean scores between the fourth grade control (27.64) and the fourth grade experimental group (28.17) was not statistically significant (Table 13).

Table 13. ANOVA comparing mean math TAKS scores of experimental and control groups within the fourth grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Df	F	Sig.
Experimental	23	28.17	1	.025	.875
Control	11	27.64			
Total	34		33		

Discussion

Findings suggested that fourth graders who participated in the JMG™ program benefited similarly to the fourth graders who received traditional classroom math instruction. Several previous studies dealing with this subject support these findings and also indicate that science and math achievement can be improved by a gardening program or other hands-on activities (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999).

Comparisons of control versus experimental for 5th grade science achievement scores

Descriptive statistics

The mean science achievement test scores for the students in the fifth grade control group (25.61) was 3.54 points higher than the mean science scores for the students in the fifth grade experimental group (22.07).

Data analysis

A one-way ANOVA was conducted to test the statistical significance of the differences of the means between the control and experimental groups within the fifth grade. An a priori alpha of 0.05 was set. The difference in mean scores between the fifth grade control group (25.61) and the fifth grade experimental group (22.07) was statistically significant (Table 14).

Table 14. ANOVA comparing mean science achievement scores of experimental and control groups within the fifth grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	df	F	Sig.
Experimental	44	22.07	1	7.942	.006
Control	56	25.61			
Total	100		99		

Discussion

Findings suggested that when learning science, fifth grade students benefited more from traditional science lessons than the fifth grade students who participated in the JMG™ program. These findings do not support the idea that school gardening is more effective at teaching science than traditional science teaching methods (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999).

Comparisons of Control Versus Experimental for 5th Grade Math TAKS Scores

Descriptive Statistics

The mean math TAKS scores for the students in the fifth grade control group (30.37) was 6.62 points higher than the mean math TAKS scores for the students in the fifth grade experimental group (23.75).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the differences of the mean math TAKS scores between the control and experimental groups within the fifth grade. An a priori alpha of 0.05 was set. The difference in mean math TAKS scores between the fifth grade control group (30.37) and the fifth grade experimental group (23.75) was statistically significant (Table 15).

Table 15. ANOVA comparing mean math TAKS scores of experimental and control groups within the fifth grade in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	df	F	Sig.
Experimental	44	23.75	1	19.973	.000
Control	57	30.37			
Total	101		100		

Discussion

The results from this analysis show that within the fifth grade, the students in the control group achieved higher mean math TAKS scores than the students in the experimental group. These findings do not support other similar research which showed that students participating in a gardening program had higher achievement in either math or science than those students not participating in a gardening program (Braun et al., 1989; Guy et al., 1996; Klemmer, 2002; Shair 1999).

Gender Comparisons and Science

Descriptive Statistics

The mean science achievement test score for the females (23.41) in the experimental group was higher than the males (22.15) in the experimental group by 1.26 points. The mean science achievement scores for the female control group (22.44) was 0.92 points lower than the mean scores within the control group for the males (23.36).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the mean science achievement scores between the experimental and control groups for both genders. An a priori alpha level of 0.05 was set. The results are shown in Tables 7 and 8. The difference in the mean scores between the females in the experimental group (23.41) and the females in the control group (22.44) was not statistically significant (Table 16).

Table 16. ANOVA comparing the mean science achievement scores of females in experimental and control groups in the study of the influence of school gardening on math and science achievement

Group	Number	Mean Score	Standard Deviation	Df	F	Sig.
Experimental	52	23.41	5.993	1	.766	.384
Control	44	22.44	4.828			
Total	96			95		

The difference in the mean science achievement scores in the comparison between the males in the experimental group (22.15) and the males in the control group (23.36) was not statistically significant (Table 17).

Table 17. ANOVA comparing the mean science achievement scores of males in experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	Df	F	Sig.
Experimental	41	22.15	5.280	1	.819	.368
Control	57	23.36	7.275			
Total	98			96		

A one-way ANOVA was also conducted to test the statistical significance of the difference of the mean science achievement scores between the genders in the experimental groups. An a priori alpha level of 0.05 was set. The difference in the mean scores between the females (22.89) and the males (22.85) in the comparison of science achievement mean scores was not statistically significant (Table 18).

Table 18. ANOVA comparing the mean science scores of females and males in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	Df	F	Sig.
Females	96	22.89	5.386	2	.002	.998
Males	98	22.85	6.504			
Total	194			194		

Discussion

These findings suggest that males and females benefited similarly from the Junior Master Gardener™ program. The JMG™ curriculum seems to be just as effective in teaching science to males and females. The findings suggest that females benefited similarly from the JMG™ program on science achievement when compared to females in the traditional science program. These findings also suggest that males benefited similarly from the JMG™ program when compared to the males in the traditional science program. These findings support other similar research, which concluded that females benefit similarly and sometimes better than males when using a gardening program as part of the science curriculum (Klemmer, 2002; Skelly and Zajicek, 1998, Waliczek, 1997).

Gender Comparisons and Math

Descriptive Statistics

The math TAKS scores mean for the females (25.58) in the experimental group was 0.72 points lower than the males' (26.30) math TAKS scores mean for the experimental group. The math TAKS mean score within the control group for the females (30.51) was 0.79 points higher than the math TAKS mean scores for the males (29.72) within the control group (Table 19 and 20).

Data Analysis

A one-way ANOVA was conducted to test the statistical significance of the difference of the math TAKS mean scores between the experimental and control groups for both genders. An a priori alpha level of 0.05 was set. The difference in the math TAKS mean scores between the females in the experimental group (25.58) and the females in the control group (30.51) was statistically significant (Table 19).

Table 19. ANOVA comparing the mean math TAKS scores of females in experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	Df	F	Sig.
Experimental	52	25.58	7.925	1	9.616	.003
Control	43	30.51	7.465			
Total	95			94		

The difference in the mean math TAKS scores between the males in the experimental group (26.30) and the males in the control group (29.72) was statistically significant (Table 20).

Table 20. ANOVA comparing the mean math TAKS scores of males in experimental and control groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	df	F	Sig.
Experimental	40	26.30	7.137	1	4.233	.042
Control	57	29.72	8.641			
Total	97			96		

A one-way ANOVA was also conducted to test the statistical significance of the difference of the means of the math TAKS scores between the genders in the experimental groups. An a priori alpha level of 0.05 was set. The results are shown in Table 22. The difference in the mean scores between the females (27.81) and the males (28.31) was not statistically significant (Table 21).

Table 21. ANOVA comparing the mean math TAKS scores of females and males in the experimental groups in the study of the influence of school gardening on math and science achievement.

Group	Number	Mean Score	Standard Deviation	Df	F	Sig.
Females	95	27.81	8.067	2	1.431	.242
Males	97	28.31	8.192			
Total	192			193		

Discussion

These findings show that the males and females in the control group achieved higher math TAKS scores with the traditional math curriculum compared to the math TAKS scores achieved by the males and females in the experimental group participating in the Junior Master Gardener™ program. The reason for this difference was probably due to the focus of the particular portion of the JMG™ program for this study being on nutrition instead of math. These findings do not support other similar research which showed that students participating in a gardening program had higher achievement in either math or science than those students not participating in a gardening program (Klemmer, 2002; Skelly and Zajicek, 1998, Waliczek, 1997).

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Purpose of the Study

The purpose of this study was to assess the effects of a school garden program on the science achievement and math TAKS scores of elementary students in the third, fourth, and fifth grades. Specific objectives for this study were to 1) examine the effect of the Junior Master Gardener™ curriculum on the TAKS math scores of participating students, 2) examine the effect of the Junior Master Gardener™ curriculum on the science achievement of participating students and 3) examine the influence of demographic variables to determine if particular groups appear to benefit from the curriculum more than others.

Summary of the Review of Literature

Improving math and science literacy has become a major topic in educational reform. Math literacy is defined by the National Assessment of Educational Progress (NAEP) in three areas of "conceptual understanding, procedural knowledge, and problem solving" (NRC, 1996, p.22). The National Science Education Standards define science literacy as the "knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity" (NRC, 1996, p.22).

Evidence has been presented that indicates that math and science education in the United States has become very poor. Approximately one percent of elementary school children are exposed to more than two hours of hands-on math and science education during their elementary years (DeBuhr, 1996). This suggests the mediocrity in math and science education and the need for education reform.

Educational reform has evolved throughout history. The development of the Morrill Act in 1862 had a large impact on educational reform by establishing land grant colleges that "came to symbolize the use of scientific knowledge to solve agricultural and technological problems" (Mintzes et al. 1998, p.31). Since the establishment of land grant universities, technological advances throughout history have left an important influence on math and science education reform. In 1969, Americans were given hope of more successful math and science programs when Neil Armstrong took the first walk on the moon. At that time, the terms "math and science literacy" were created and taken to be important standards in education (DoBoer, 2000).

In the past, math and science careers were only considered for those children who proved to be exceptional students showing an inclination toward math and science. Today, however, the goal has become a motto of 'math and science literacy for every child' (DeBuhr, 1996, p. 19). This goal has led the country as a whole to develop assessments to measure the curriculum and learning of children across America.

The Texas state standards, the TEKS, are heavily influenced by constructivist theories. The National Science Education standards as well as the TEKS emphasize student-centered learning, experience-based explorations, cooperative as well as individual work, and teacher-facilitated rather than teacher-led investigations (National Research Council, 1996). The idea that learners control learning rather than teachers controlling learning is the heart of the constructivist theory. Likewise, in the same way that students see relevance in their daily activities, which in turn creates an interest in learning, the students must be able to provide relevance to the curriculum in order to have an interest in learning (Brooks and Brooks, 1999). In order to create an interest in learning, a hands-on approach to learning can be used.

Many previous studies have shown the importance of hands-on learning. In one study, students who participated in a traditional, textbook-oriented science class were compared with students from an experiential, inquiry-oriented science class. The results of the study showed that the students participating in the experiential class had more positive attitudes toward science than those participating in the traditional class. More than half of the students in the experiential class labeled science as "fun and interesting" while more than half of the students participating in the traditional science class labeled science as "boring" (Kyle et al., 1988). Results of another study showed that the students learned math and science, but also were thinking at higher levels and stating that the activities used in the study were "fun"(Waliczek et al., 2003).

Gardening programs could be a form of a hands-on, constructivist method of teaching and learning. Gardening programs have been involved in school programs for many years (Bassett, 1979). However, in recent years, gardening programs have grown in popularity. School gardens are said to provide "responsibility, patience, pride, self-confidence, curiosity, critical thinking, and the art of nurturing" (Guy et al., 1996, p. 9).

The first children's public garden was established in 1914 at the Brooklyn Botanical Garden with the idea of developing important agricultural skills for youth (Maclin and Hyland, 1999). Even during these early times, school gardens were important teaching tools for providing hands-on learning and experiential learning (Bassett, 1979). It has also been suggested that children who have contact with natural settings, such as gardens, will have an altered environmental disposition (Waliczek, 1997). Skelly and Zajicek (1998) found that gardening has a positive effect on children's environmental attitudes. This study also found that the younger students are more likely to benefit positively from environmental experiences (Skelly and Zajicek, 1998). In another study, teachers reported that students' science scores, along with an overall academic achievement improved due to gardening programs (Braun et al., 1989). Similar research found that students who participated in hands-on school gardening programs had a higher science achievement compared to students who did not participate in a school gardening program (Klemmer, 2002).

The idea of hands-on, constructivist learning serves as the main idea behind school garden programs. Gardens can serve as living laboratories, in which students can see what they are learning and in turn, apply that knowledge to real world situations. The constructivist theories of learning also believe in creating group learning and inquiries (Adams and Hamm, 1998). In a gardening program, if students work in groups to solve math problems or learn scientific techniques in an outdoor garden setting, the learning goes beyond the basics taught in a traditional classroom setting. The children learn to work together, learn to take leadership roles, and learn important real world problem-solving techniques. This idea of learning through a social process is one of the key components of constructivist learning (Mintzes et al., 1998).

School gardening programs have recently increased in popularity around the United States. Several different types of curricula focusing on gardening, nature, and plants have been published in the past few years (Guy et al., 1996; TAEX, 2001). However only a few studies have been conducted using gardening curricula as a focus to demonstrate the positive affects these curricula (Bassett, 1979; Braun et al., 1989; Guy et al., 1996; Klemmer, 2002). The purpose of this study was to assess the effects of a school gardening program on the math and science achievement of elementary students in the third, fourth, and fifth grades.

Methodology

Sample Group

The sample used for this study was drawn from a population of third, fourth, and fifth grade students at McAuliffe Elementary School, located in McAllen, TX. Approximately 200 of the students volunteering for this study participated in the Junior Master Gardener™ program. A control group was drawn from third, fourth, and fifth grade students at McAuliffe Elementary School who were not participating in the JMG™ program but were similar otherwise demographically. The final sample population consisted of 196 students. The experimental group consisted of 94 students, while the control group consisted of 102 students.

Instrumentation

This study utilized existing instruments to gather data. These existing instruments included a demographic survey (Appendix A) for all participants, adapted from Klemmer (2002), the math TAKS tests for third, fourth, and fifth grades, and a cognitive science test instrument developed by Klemmer (2002) for each grade level used in this study (Appendix B, C, and D).

Conclusions

The following conclusions were based on the research and results presented in the previous chapters. A summary of the results were as follows:

Research Question 1

Do the students who participate in the JMG™ program have equal or different science achievement compared to students receiving traditional science instruction?

Results indicated no statistically significant differences in science achievement scores when comparing students receiving traditional science teaching methods to those students participating in the JMG™ curriculum. The difference in mean science achievement scores between the experimental group (22.30) and the control group (23.40) was not statistically significant. No difference in mean scores indicated that students who participated in the JMG™ program learned as much about science as those who participated in traditional science lessons. These findings suggest that students who participate in JMG™ program can learn science similarly to students participating in traditional science lessons. Several previous studies dealing with this subject (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997, Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly and Zajicek, 1998) indicate that science achievement can be improved by the use of gardening programs or hands-on experiential activities.

Research Question 2

Do the students who participate in the JMG™ program have equal or different math achievement compared to students receiving traditional math instruction?

Results indicated that traditional math lessons appeared to be better teaching methods in comparison to the JMG™ program used in this study. The difference in the mean scores between the experimental group (26.01) and the control group (30.14) was statistically different. The results suggest that students learn math more effectively using traditional math lessons than those students participating in this particular JMG™ program used for this study. One limitation to this study is the area of focus of the particular JMG™ curriculum that was used in this study. This particular part of the JMG™ was only one section of multi-level program (Table 1). This particular JMG™ curriculum is intended to educate youth about nutrition and few activities stressed math within each lesson (Texas Agriculture Extension Service [TAEX], 2001). The mean scores of this study suggest that a JMG™ curriculum integrating more math lessons may be needed for improving math scores using a gardening program.

Research Question 3

Are there any demographic differences indicating that particular groups benefit more than others from participation in the JMG™ program compared to receiving traditional science and math instruction?

Comparisons of Hispanics in Control Versus Experimental Groups

Results indicated no statistically significant differences in science achievement scores when comparing Hispanic students receiving traditional science teaching methods to those Hispanic students participating in the JMG™ curriculum. No difference in mean scores indicated that Hispanic students who participated in the JMG™ program learned as much about science as those Hispanic students who participated in traditional science lessons. These findings suggest that students who participate in JMG™ program can learn science the same as students participating in traditional science lessons. Several previous studies dealing with this subject (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997, Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly and Zajicek, 1998) indicate that science achievement can be improved by the use of gardening programs or hands-on experiential activities.

Results indicated that traditional math lessons appeared to be better teaching methods for Hispanic students in comparison to the JMG™ program used in this study. The researcher concluded that Hispanic students learn math more effectively using traditional math lessons than those Hispanic students participating in this particular JMG™ program used for this study. One limitation to this study is the area of focus of the particular JMG™ curriculum that was used in this study. This particular part of the JMG™ was only one section of multi-level program (Table 1). This particular JMG™ curriculum is intended to educate youth about nutrition and few activities stressed math within each lesson (Texas Agriculture Extension Service [TAEX], 2001). The mean scores of this study suggest that a JMG™ curriculum integrating more math lessons may be needed for improving math scores using a gardening program.

Comparisons of Grade Level and Science Achievement

There were no differences between grade level and science achievement. These results indicate that the JMG™ was just as effective as a traditional science curriculum. This suggests that third grade students benefit the same from the JMG™ curriculum and traditional science lessons. This supports similar research, which states a gardening curriculum may benefit science achievement (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997, Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly and Zajicek, 1998).

Comparisons of Grade Level and Math TAKS Scores

The results indicated that third and fourth grade students within the experimental group benefited similarly in learning math from exposure to the JMG™ curriculum when compared to those third and fourth grade students in the control group participating in traditional math lessons. In both the third and fourth grade levels, where math TAKS scores were measured, the results were not statistically significantly. This suggests that the particular JMG™ curriculum used for this study can benefit math students in the third and fourth grades similarly to students learning from traditional math lessons. This supports similar research, which states a gardening curriculum may benefit math and science achievement (Braun et al., 1989; Guy et al., 1996; Johnson et al., 1997, Klemmer, 2002; Kyle et al., 1988; Maclin and Hyland, 1999; Mintzes et al., 1998; Shair, 1999; Skelly, 1997).

Comparisons of Gender and Science Achievement

The results indicated that females and males within the experimental group benefited similarly in learning science from exposure to the JMG™ curriculum when compared to those females and males in the control group participating in traditional science lessons. The difference in mean scores between the females in the experimental group (23.41) and the females in the control group (22.44) was not statistically significant. The difference in the mean scores between the males in the experimental group (22.15) and the males in the control group (23.36) was also not statistically significant. These findings suggest the Junior Master Gardener™ curriculum used for this study does not affect science achievement scores within gender. The finding from across gender tests also show there is no difference between the science scores of males and females participating in this study. The difference in the mean scores between the females (22.89) and the males compared within the experimental group (22.85) was not significantly different. This suggests that the JMG™ curriculum used for this study is not favorable to girls or boys, but benefits both genders equally. This supports similar research that states that a school gardening program benefits girls and boys equally (Klemmer, 2002; Skelly and Zajicek, 1998, Waliczek, 1997).

Comparisons of Gender and Math TAKS Scores

The overall results indicated that females and males in the control group benefited more from traditional math instruction when compared to those students studying the JMG™ curriculum for learning math. The differences in mean scores between the females in the experimental group (25.58) and the females in the control group (30.51) was statistically significant. Females within the control group appeared to benefit more from traditional math lessons when compared to those who participated in the JMG™ curriculum. The differences in the mean scores between the males in the experimental group (26.30) and the males in the control group (29.72) was statistically significant. Males within the control group appeared to benefit more from traditional math lessons when compared to those males who participated in the JMG™ curriculum. This particular portion of the JMG™ curriculum is intended to educate youth about nutrition (Texas Agriculture Extension Service [TAEX], 2001). The subject of math was not included within the curriculum, which suggests that using a gardening curriculum that focuses more on the subject of math may be needed for improving math scores when implementing this gardening program.

Programmatic Implications

The following implications for the program are based on the findings and conclusions of this study:

1. The overall results of this study indicated that the JMG™ curriculum used for this study was just as effective as traditional science lessons. Previous studies have shown hands-on methods of teaching to have positive effects on science students. Based on the results from this study, if teachers would like to use a constructivist, hands-on activity to increase interest in science, the JMG™ curriculum would be an effective tool.

2. The results from this study indicated that traditional math lessons were more effective at teaching math than this particular portion of the JMG™ curriculum. It is recommended that a more extensive JMG™ curriculum combining math skills with gardening and science be used to improve math achievement. It is also recommended that the particular JMG™ curriculum that was used for this study be more aligned with the math TEKS in order to improve math achievement from a gardening program.

3. The results from this study indicated that younger students, including those students in the third and fourth grades, benefited more from the JMG™ curriculum in the areas of both science and math.

4. The results from this study indicated that the JMG™ curriculum used for this study was just as effective at teaching science to males as it was for females. However, while the scores were not statistically significant, the mean scores of the females were higher than the mean science scores of the males. It is recommended females continue to be encouraged to engage in science activities, including gardening programs.

5. The results from this study indicated that males and females benefited more from the traditional math lessons. This suggests that more math concepts should be

emphasized in the particular JMG™ curriculum used for this study. It is recommended that more of the overall curriculum, which would emphasize more math-based activities, be included within the JMG™ curriculum in order to improve math achievement from a hands-on gardening program.

Recommendations for Additional Research

The following recommendations are made based on the findings of this research:

1. It is recommended that a follow-up study be conducted using a balanced experimental design within each grade level to confirm or refute the findings shown in this research study.
2. It is recommended that additional studies looking at gender and math and science achievement as a result of the JMG™ be conducted to further explore the results indicated from this research.
3. It is recommended that a study similar to this one be done using the math and science scores of the same school year in which the JMG™ program took place.
4. It is recommended that a study lasting over several years be considered, including students being tested each consecutive year for math and science achievement, to track the changes in achievement that may occur after a prolonged exposure to gardening activities.
5. It is recommended that a new study with more of the overall JMG™ curriculum be integrated into the program besides the Level 1 *Health and Nutrition from the Garden.*

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APPENDIX A

DEMOGRAPHIC SURVEY

Math and Science Achievement Study
Student Information

Age: ___________

Teacher: ______________________________

School: ______________________________

Choose the answer that best describes you.

1. **I am a**
   a. Girl
   b. Boy
2. **I am**
   a. Asian
   b. Black
   c. Hispanic
   d. White
   e. Other
3. **What grade are you in?**
   a. Third
   b. Fourth
   c. Fifth
4. **Have you ever worked in a garden before?**
   a. Yes   b. No
5. **If you have worked in a garden before, where was the garden?**
   a. Home
   b. School
   c. A relative's house (grandparent, aunt, etc.)
   d. A friend's house
6. **Where do you learn the most about plants?**
   a. At home, from my family
   b. At school
   c. From TV
   d. From books and/or magazines

APPENDIX B

THIRD GRADE SCIENCE TEST

Science Achievement Test
Grade 3

Please fill in the circle next to the response that you think best answers the question.

1) Plants are important to all life because they take in ________ and give off ________.

- O A) oxygen, carbon dioxide
- O B) carbon dioxide, oxygen
- O C) ozone, carbon dioxide
- O D) water, carbon dioxide

2) All of the food that we eat can be traced back to ______

- O A) animals.
- O B) people.
- O C) plants.
- O D) minerals.

3)Just like all other living organisms, plants need all of the following things to live **EXCEPT** _________

- O A) water.
- O B) light.
- O C) air
- O D) darkness.

4) A monocot is a plant with _____ cotyledons.

- O A) one
- O B) two
- O C) three
- O D) four

5) For a plant to survive and reproduce, it must produce ______

- O A) spores.
- O B) sprouts.
- O C) spuds.
- O D) seeds.

6) A plant that lives for more than one year is called a(n)_______

- ○ A) annual.
- ○ B) perennial.
- ○ C) stomate.
- ○ D) phloem.

7) The purpose of a flower is ______

- ○ A) to smell good.
- ○ B) to be pretty.
- ○ C) to make seeds.
- ○ D) to be colorful.

8) What part of the plant does the fruit come from?

- ○ A) root
- ○ B) stem
- ○ C) leaves
- ○ D) flower

9) To collect information on the growth of a plant in your garden, you could use a ______

- ○ A) meter stick.
- ○ B) microscope.
- ○ C) balance.
- ○ D) metroscope.

10) The color of a plant's flower is determined by ______

- ○ A) scientists.
- ○ B) the parent plants.
- ○ C) nature.
- ○ D) the environment.

11) Soil is made up of rock particles, minerals, and decayed __________ and animal material.

- A) rock
- B) dirt
- C) mud
- D) plant

12) Another word for rain is _________

- A) precipitation.
- B) transpiration.
- C) evaporation.
- D) respiration.

13) A soil with a lot of clay in it will feel _______

- A) gritty.
- B) slick.
- C) crumbly.
- D) soggy.

14) Which of these soils will drain the quickest?

- A) a sandy soil
- B) a loamy soil
- C) a clay soil
- D) a soil with both loam and clay

15) Dead plants can be broken down into organic matter through a process called *composting*. This means that they are a __________

- A) combustible resource.
- B) non-combustible resource.
- C) renewable resource.
- D) non-renewable resource.

16) Organisms that are adapted to break down plant material are called ______

- A) decomposers.
- B) beneficials.
- C) pests.
- D) insects.

17) Which of the following organisms should you add to your garden to improve the soil?

- A) crickets
- B) grub worms
- C) earth worms
- D) lady bugs

18) The best location for a vegetable garden is a place that ____________

- A) receives at least 6-8 hours of sun each day.
- B) receives 6-8 inches of water each day.
- C) has 6-8 inches of rocky soil.
- D) receives at least 6-8 hours of shade each day.

19) Depending on its temperature, water can have the physical properties of a ______

- A) solid, liquid, or gas.
- B) solid, liquid, or vapor.
- C) solid, steam, or ice.
- D) solid, vapor, or ice.

20) Without ______, there would be no soil.

- A) sand
- B) coal
- C) oil
- D) rocks

21) The place where a plant or animal lives is called it's ______

- A) house.
- B) food chain.
- C) habitat.
- D) environment.

22) What are the three R's of recycling?

- A) Readin', 'Ritin, and 'Rithmetic
- B) Reduce, Reuse, and Recycle
- C) Respond, Reproduce, and Regulate
- D) Repeat, Renew, and Rotate

23) Choose the answer that best completes the food chain below:
worm beetle ______ rattlesnake hawk

- A) turtle
- B) cat
- C) ant
- D) mouse

24) A squirrel, a bird, and the tree they live in are parts of a ______

- A) environment.
- B) ecotype.
- C) habitat.
- D) home.

25) Which of the following is **NOT** needed by plants to live?

- A) energy from the sun
- B) nutrients
- C) water
- D) darkness

26) A good way to use your grass clippings after mowing the lawn is to _______

- A) put them in a trash bag for the garbage man to pick up.
- B) pile them up and burn them.
- C) add them to a compost pile.
- D) spread them across the sidewalk to make it look greener.

27) Out of the choices below, predict which watering schedule will help to conserve water when watering your garden?

- A) You should not water your garden at all.
- B) You should water just a little every day.
- C) You should water deeply once a week.
- D) It does not matter how often you water.

28) Which of the following organisms share the same habitat and compete with each other for food?

- A) a hawk and a mouse
- B) a frog and a turtle
- C) a deer and a squirrel
- D) a fish and a dragonfly

29) To make a model of an oil spill, it would be a good choice to use ______

- A) a stream, some rocks, and a can of oil.
- B) a river and a boat carrying oil.
- C) an aquarium, some sand, and a can of oil.
- D) a lake and a barrel of oil.

30) In a drought, some plants might ______

- A) die.
- B) grow.
- C) shrink.
- D) expand.

31) All insects have three body parts called _______, ________, and ________

- ○ A) head, wings, tail.
- ○ B) head, cephalothorax, abdomen.
- ○ C) head, thorax, abdomen.
- ○ D) head, abdomen, spinnerets.

32) Butterflies go through complete metamorphosis, which has four stages, which are: 1) _______, 2) _______, 3) _______, and 4) _______.

- ○ A) adult, larva, pupa, egg.
- ○ B) egg, larva, pupa, adult.
- ○ C) larva, egg, pupa, adult.
- ○ D) egg, pupa, larva, adult.

33) What color would you use to color a picture of an insect so that it would be camouflaged on a green leaf?

- ○ A) red
- ○ B) green
- ○ C) yellow
- ○ D) blue

34) All insects have ______

- ○ A) 8 legs.
- ○ B) 6 legs.
- ○ C) 8 wings.
- ○ D) 6 wings.

35) A spider can modify its environment by ______

- ○ A) eating other insects.
- ○ B) catching its food.
- ○ C) stealing another spider's web.
- ○ D) spinning a web.

36) A _______ is an insect that causes harm to a plant.

- ○ A) beneficial insect
- ○ B) pest insect
- ○ C) organic insect
- ○ D) common insect

37) Which of the following insects is **NOT** a beneficial?

- ○ A) a ladybug that eats aphids
- ○ B) a dragonfly that eats mosquitoes
- ○ C) an aphid that eats plants
- ○ D) a praying mantis that eats insects

38) A good way to control insect pests in your garden without harming the environment is to ______

- ○ A) spray it with pesticides once a month to keep pests from building up.
- ○ B) spray it with pesticides two times a year, once in spring and once in fall.
- ○ C) monitor your garden weekly to keep aware of pest populations.
- ○ D) spray your garden with water once a day to knock off all the insects.

39) You have discovered a new insect called the School Bug. You are trying to describe its life cycle. How many School Bugs will you need to look at to know that you have described it correctly?

- ○ A) None, you can read about it in a book.
- ○ B) One School Bug insect, because they are all alike.
- ○ C) Two School Bug insects, so you can look at both males and females.
- ○ D) As many School Bug insects as possible, in case the individuals vary.

40) To look at a beetle on trunk of a tree without moving it, you could use a ______

- ○ A) compass.
- ○ B) hand lens.
- ○ C) microscope.
- ○ D) telescope.

APPENDIX C

FOURTH GRADE SCIENCE TEST

Science Achievement Test
Grade 4

Please fill in the circle next to the response that you think best answers the question.

1) Plants are important to all life because they take in ________ and give off ________

- ○ A) oxygen, carbon dioxide.
- ○ B) carbon dioxide, oxygen.
- ○ C) ozone, carbon dioxide.
- ○ D) water, carbon dioxide.

2) All of the food that we eat can be traced back, either directly or indirectly, to ______

- ○ A) animals.
- ○ B) people.
- ○ C) plants.
- ○ D) minerals.

3) Seeds are distributed, or dispersed, in many different ways. Some of these include blowing in the wind, floating on water, passing through the digestive tract of animals such as birds, and sticking to the fur of animals. Which of the seeds listed below is more likely to be carried on the wind?

- ○ A) an apple seed
- ○ B) a dandelion seed
- ○ C) an acorn
- ○ D) a coconut

4) A cotyledon is the part of the seed that stores food for use by the baby plant, or embryo. A monocot is a plant with _____ cotyledons.

- ○ A) one
- ○ B) two
- ○ C) three
- ○ D) four

5) If all of the leaves are taken off of a plant, what do you predict will happen?

- ○ A) The plant will grow more quickly because it does not have to support leaves.
- ○ B) The plant will die because it has no leaves to make food for itself.
- ○ C) The plant will die because all the sap will run out.
- ○ D) None of the above statements are correct.

6) To look at a plant cell from a diseased plant, you would use a ______

- ○ A) telescope.
- ○ B) microscope.
- ○ C) thermometer.
- ○ D) magnascope.

7) Which of the following is **NOT** a fruit?

- ○ A) cucumber.
- ○ B) tomato.
- ○ C) spinach.
- ○ D) apple.

8) Every part of a plant has a function and a purpose. For example, the purpose of a flower is to ______

- A) smell good.
- B) be pretty.
- C) make seeds.
- D) be colorful.

9) A model representing all the parts of a plant would need to include __________

- A) roots, stems, leaves, flowers, fruits, and seeds.
- B) roots, stems, leaves, tubers, fruits, and seeds.
- C) roots, petioles, leaves, flowers, fruits, and seeds.
- D) roots, stems, leaves, flowers, nodules, and seeds.

10) An ecosystem is made up of many organisms that interact with each other in the same environment. What do you think would happen to an ecosystem if all the plants in it were killed?

- A) The ecosystem would stay the same.
- B) The ecosystem could not survive.
- C) The ecosystem would survive.
- D) None of the above things would happen.

11) Soil is made up of rock particles, minerals, and decayed __________ and animal material.

- A) rock
- B) dirt
- C) mud
- D) plant

12) Another word for rain is _________

- A) precipitation.
- B) transpiration.
- C) evaporation.
- D) respiration.

13) What are the properties that can be used to describe soil?

- A) texture, composition, mineral content
- B) bedrock, subsoil, topsoil
- C) nitrogen, phosphorous, potassium
- D) oxygen, nitrogen, and hydrogen

14) Garden plants get __________ from the soil and also from _________ that we give them.

- A) nutrients, fertilizer
- B) fertilizer, nutrients
- C) nutrients, light
- D) fertilizer, water

15) Plants prevent soil erosion because their roots _______

- A) channel rainwater away from the plant.
- B) hold the soil in place.
- C) create a trench for the rainwater.
- D) dry the soil around the plant.

16) Years ago, Native Americans planted a dead fish beside each corn seed that they planted. As the plants sprouted and grew, what did the decaying fish provide for the growing plant?

- A) oxygen
- B) nutrients
- C) water
- D) carbon dioxide

17) Over time, plants adapt to increase their chances for survival. In other words, a successful plant adaptation will alter a plant so that it can grow better than other plants that don't have the adaptation. There are many ways that plants can adapt. One example of a successful adaptation would be for a plant to _______

- A) increase the number of seeds it produces.
- B) decrease the number of seeds it produces.
- C) grow at a slower rate.
- D) change the shape of its leaves.

18) Some organisms play an important role in the life cycle of plants by breaking them down and recycling them into organic matter after the plants die. These recycling organisms are called _______

- A) decomposers.
- B) beneficials.
- C) pests.
- D) insects.

19) A soil with a large percentage of clay in it will feel ______

- A) gritty.
- B) slick.
- C) crumbly.
- D) soggy.

20) To make food through photosynthesis, plants use water, oxygen, nutrients, and ______

- A) compost applied to the soil surface.
- B) soil from around the roots.
- C) energy from the moon.
- D) energy from the sun.

21) The place where a plant or animal lives is called it's ________

- A) house.
- B) food chain.
- C) habitat.
- D) environment.

22) Recycling is an important way to help the environment. A good recycling program has three components, called the "Three R's of Recycling." What are they?

- A) Readin', Ritin', and Rithmetic
- B) Reduce, Reuse, and Recycle
- C) Respond, Reproduce, and Regulate
- D) Repeat, Renew, and Rotate

23) Reducing the amount of water needed in your garden, called conserving water, is a also a good way to help the environment. What is a good way to conserve water in your garden?

- A) Water every day during the hottest part of the day.
- B) Leave the garden hose running.
- C) Choose plants that live in the water.
- D) Choose plants that do not need much water to grow well.

24) All living organisms must eat. Animals, which are living organisms, either eat plants or they eat other animals. Plants, which are also living organisms, make their own food through a process called ______

- A) oxidation.
- B) transpiration.
- C) photosynthesis.
- D) electrosynthesis.

25) Which of the following traits of a plant is **NOT** inherited?

- A) flower color
- B) fruit type
- C) leaf shape
- D) insect damage

26) If you want to increase the health of your garden soil, which of the following organisms could you add?

- A) grub worms
- B) earth worms
- C) crickets
- D) lady bugs

27) Imagine that you are a gardener and that you live in an area that is dry, with frequent droughts. Based on what you know, which watering schedule below makes the most sense if you want to conserve water?

- A) every day, watering for at least an hour
- B) twice a week, watering for six hours
- C) twice a week, watering for a half hour
- D) once a month, watering for a day

28) What would be the best way to use your grass clippings after mowing the lawn?

- A) Put them in a trash bag for the garbage man to pick up.
- B) Pile them up and burn them.
- C) Add them to a compost pile.
- D) Spread them across the sidewalk to make it look greener.

29) Which of the following organisms share the same habitat and compete with each other for food?

- A) a hawk and a mouse
- B) a frog and a turtle
- C) a deer and a bird
- D) a fish and a mouse

30) To examine an insect on a tree, what instrument would you use?

- A) telescope
- B) hand lens
- C) thermometer
- D) magnascope

31) The three body parts of all insects are _______, ________, and ________

- A) head, thorax, abdomen.
- B) head, cephalothorax, abdomen.
- C) head, wings, tail.
- D) head, abdomen, spinnerets.

32) Butterflies go through complete metamorphosis, which has four stages, which are: 1) _______, 2) _______, 3) _______, and 4) _______.

- A) adult, larva, pupa, egg.
- B) larva, egg, pupa, adult.
- C) egg, pupa, larva, adult.
- D) egg, larva, pupa, adult.

33) Suppose that everyone in your county decides to work together to completely eliminate fire ants. To make sure that all of the fire ants are killed, the group decides to use twice as much of the chemical as the bottle recommends. What could be the effect of this?

- A) The fire ants would all die.
- B) Birds that eat fire ants would not have enough to eat.
- C) The local water supply might not be safe to drink because of extra chemical running off into streams and rivers.
- D) All of the above answers are correct.

34) A beneficial insect is one that provides some benefit to people as part of its normal life cycle. Which of the following insects is **NOT** a beneficial insect?

- A) a ladybug that eats aphids
- B) a dragonfly that eats mosquitoes
- C) an aphid that eats plants
- D) a praying mantis that eats insects

35) If you draw a line down the middle of an insect, both sides will be exactly the same. This is called a ______

- A) symmetrical arrangement.
- B) asymmetrical arrangement.
- C) bisymmetrical arrangement.
- D) nonsymmetrical arrangement.

36) Aphids have infested the roses in your garden. You know that aphids are a pest insect that can damage your roses, and there are lots of them. Which of the following methods of control would be the **SAFEST** for the environment?

- ○ A) Spray them with a pesticide to kill them.
- ○ B) Spray them with oil to suffocate them.
- ○ C) Spray them with water to try to knock them off the roses.
- ○ D) Spray them with alcohol to kill them.

37) A good way to control insect pests in your garden without harming the environment is to ______

- ○ A) spray it with pesticides once a month to keep pests from building up.
- ○ B) spray it with pesticides two times a year, once in spring and once in fall.
- ○ C) monitor your garden weekly to keep aware of pest populations.
- ○ D) spray your garden with water once a day to knock off all the insects.

38) An example of an organism that can modify its environment is a ______

- ○ A) frog.
- ○ B) daisy.
- ○ C) slug.
- ○ D) spider.

39) If there is a change in the food chain, the result can affect people as well as the plants and animals lower in the chain. For example, if you live on a farm, and there is a decrease in the population of birds that feed on an insect that eats your crops, what might be the effect on your crops?

- ○ A) There would be an increase in insects, and you would lose income.
- ○ B) There would be a decrease in insects, and you would lose income.
- ○ C) There would be an increase in insects, and you would increase your income.
- ○ D) There would be an decrease in insects, and you would increase your income.

40) You have discovered a new insect called the School Bug. You are trying to describe its life cycle. How many School Bugs will you need to look at to know that you have described it correctly?

- ○ A) None, because you can read about it in a book.
- ○ B) One School Bug insect, because they are all alike.
- ○ C) Two School Bug insects, so you can look at both males and females.
- ○ D) As many School Bug insects as possible, in case the individuals vary.

APPENDIX D

FIFTH GRADE SCIENCE TEST

Science Achievement Test

Grade 5

Please fill in the circle next to the response that you think best answers the question.

1) Plants are important to all life because they take in ________ and give off ________

- ○ A) oxygen, carbon dioxide.
- ○ B) carbon dioxide, oxygen.
- ○ C) ozone, carbon dioxide
- ○ D) water, carbon dioxide.

2) All of the food that we eat can be traced back, either directly or indirectly, to ______

- ○ A) animals.
- ○ B) people.
- ○ C) plants.
- ○ D) minerals.

3) A fruit is one of the parts of a plant. From which part of the plant is the fruit generated?

- ○ A) petals
- ○ B) flower
- ○ C) root
- ○ D) stem

4) A cotyledon is the part of the seed that stores food for use by the baby plant, or embryo. What do you predict would happen if you removed the cotyledons from a bean seed and then planted it?

- ○ A) The embryo would keep on growing because it's still alive.
- ○ B) The seed coat would hold the embryo so it could keep growing.
- ○ C) The embryo would not grow because the stored food was removed.
- ○ D) The cotyledons would grow back.

5) If all of the leaves are removed from a plant, what do you predict will happen?

- A) The plant will grow more quickly because it does not have to support leaves.
- B) The plant will die because it has no leaves to make food for itself.
- C) The plant will die because all the sap will run out.
- D) None of the above statements are correct.

6) Plants use solar energy from the sun to do what?

- A) Make their own water through photosynthesis.
- B) Make their own water through respiration.
- C) Make their own food through photosynthesis.
- D) Make their own food through respiration.

7) All of the following foods can technically be considered fruits **EXCEPT** _______

- A) cucumber.
- B) tomato.
- C) spinach.
- D) apple.

8) Every part of a plant has a function and a purpose. For example, the purpose of a flower is to ______

- A) to smell good.
- B) to be pretty.
- C) to make seeds.
- D) to be colorful.

9) A model representing all the parts of a plant would need to include __________

- A) roots, stems, leaves, flowers, fruits, and seeds.
- B) roots, stems, leaves, tubers, fruits, and seeds.
- C) roots, petioles, leaves, flowers, fruits, and seeds.
- D) roots, stems, leaves, flowers, nodules, and seeds.

10) An aquarium is a created habitat, with each component playing a role. How are the fish in an aquarium helped by adding plants?

- A) The plants release carbon dioxide into the water.
- B) The plants release oxygen into the water.
- C) The plants release algae into the water.
- D) The plants make the aquarium look pretty.

11) Soil is made up of rock particles, minerals, and decayed __________ and animal material.

- A) rock
- B) dirt
- C) mud
- D) plant

12) Another word for *rain* is ______

- A) precipitation.
- B) transpiration.
- C) evaporation.
- D) respiration

13) What causes water vapor to condense?

- A) decrease in temperature
- B) increase in temperature
- C) precipitation from the clouds
- D) rise in air pressure

14) Garden plants get __________ from the soil and from _________ that we give them.

- A) nutrients, fertilizer
- B) fertilizer, nutrients
- C) nutrients, light
- D) fertilizer, water

15) Plants play an important role in preventing soil erosion because their roots ______

- A) channel rainwater away from the plant.
- B) hold the soil in place.
- C) create a trench for the rainwater.
- D) dry the soil around the plant.

16) Soil can be improved for use in a garden by adding _________

- A) organic material.
- B) inorganic material.
- C) seeds.
- D) more rocks.

17) If you want to examine the tiny particles that make up your garden soil, which of the following tools would you use?

- A) telescope
- B) compass
- C) meter stick
- D) microscope

18) Some organisms play an important role in the life cycle of plants by breaking them down and recycling them into organic matter after the plants die. These recycling organisms are called _______

- A) decomposers.
- B) beneficials.
- C) pests.
- D) insects.

19) A soil with a large percentage of clay in it will feel ______

- A) gritty.
- B) slick.
- C) crumbly.
- D) soggy.

20) Water is taken into a plant through its roots, and is released from the plant through its ______

- A) leaves.
- B) fruit.
- C) seeds.
- D) roots.

21) The place where a plant or animal lives is called it's ______

- A) house.
- B) food chain.
- C) habitat.
- D) environment.

22) Recycling is an important way to help the environment. A good recycling program has three components, called the "Three R's of Recycling." What are they?

- A) Readin', 'Riting, and 'Rithmetic
- B) Reduce, Reuse, and Recycle
- C) Respond, Reproduce, and Regulate
- D) Repeat, Renew, and Rotate

23) A plant is a living organism that needs to take in ______ in order to live.

- A) oxygen
- B) carbon dioxide
- C) carbon monoxide
- D) oxygen monoxide

24) All living organisms must eat. Animals, which are living organisms, either eat plants or they eat other animals. Plants, which are also living organisms, make their own food through a process called ______

- A) oxidation.
- B) transpiration.
- C) photosynthesis.
- D) electrosynthesis.

25) An ecosystem is made up of many organisms that interact with each other in the same environment. What do you think would happen to an ecosystem if all the plants in it were killed?

- A) The ecosystem would stay the same.
- B) The ecosystem could not survive.
- C) The ecosystem would survive.
- D) None of the above things would happen.

26) Which of the following components of a garden system could be called a living system in itself?

- A) soil
- B) water
- C) plants
- D) nutrients

27) Imagine that you are a gardener and that you live in an area that is dry, with frequent droughts. Based on what you know, which watering schedule below makes the most sense if you want to conserve water?

- A) every day, watering for at least an hour
- B) twice a week, watering for six hours
- C) twice a week, watering for a half hour
- D) once a month, watering for a day

28) As plant material is decomposed through composting, it gives off energy in the form of ______

- A) light energy.
- B) heat energy.
- C) food energy.
- D) solar energy.

29) To measure the rate of growth of the plants that you plant in your garden, which of the following instruments could you use?

- A) meter stick
- B) thermometer
- C) stop watch
- D) calculator

30) Which of the following plant traits is **NOT** inherited?

- A) flower color
- B) fruit type
- C) leaf shape
- D) insect damage

31) The three body parts of all insects are _______, ________, and ________

- A) head, thorax, abdomen.
- B) head, cephalothorax, abdomen.
- C) head, wings, tail.
- D) head, abdomen, spinnerets.

32) Butterflies go through complete metamorphosis, which has four stages, which are: 1) _______, 2) _______, 3) _______, and 4) _______

- A) adult, larva, pupa, egg.
- B) larva, egg, pupa, adult.
- C) egg, pupa, larva, adult.
- D) egg, larva, pupa, adult.

33) Carpenter Bees are actually flies that have adapted to look like bumble bees so that birds do not try to eat them. They cannot sting, but they look as if they could! This type of adaptation is called ______

- A) symmetry.
- B) cheating.
- C) hiding.
- D) mimicry.

34) You find a pill bug, or doodle bug, in your garden. It has ten body segments and twenty legs. You know for sure that it is **NOT** _______

- A) an insect.
- B) an isopod.
- C) an arthropod.
- D) a crustacean.

35) If you draw a line down the middle of an insect, both sides will be exactly the same. This type of body arrangement is called ________

- A) symmetrical arrangement.
- B) asymmetrical arrangement.
- C) unimmetrical arrangement.
- D) polysymmetrical arrangement.

36) Aphids have infested the roses in your garden. You know that aphids are a pest insect that can damage your roses, and there are lots of them. Which of the following methods of control would be the **SAFEST** for the environment?

- ○ A) Spray them with a pesticide to kill them.
- ○ B) Spray them with oil to suffocate them.
- ○ C) Spray them with water to try to knock them off the roses.
- ○ D) Spray them with alcohol to kill them.

37) You and your classmates are going to conduct a survey of a nearby park to see what types of insects you can find there. Before going, you need to make a list of safety rules that you will all agree to follow. Which of the following would **NOT** be a good rule to include in your list?

- ○ A) Wear a long-sleeved shirt and pants so that you do not get scratched or bitten.
- ○ B) Spray yourself with insect repellent to avoid being bitten or stung.
- ○ C) Feel under logs with your hands to check for insects that might live there.
- ○ D) Stay with a partner at all times, so that one of you can go for help if needed.

38) Although we often think of insects as pests, most insects are actually beneficial. Which of the following is **NOT** a benefit provided by insects?

- ○ A) Many insects are pollinators.
- ○ B) Insects are food for organisms higher up in the food chain.
- ○ C) Many insects are beneficial organisms that feed on pest insects.
- ○ D) All of the above are correct.

39) If there is a change in the food chain, the result can affect people as well as the plants and animals lower in the chain. For example, if you live on a farm, and there is a decrease in the population of birds that feed on an insect that eats your crops, what might be the effect on your crops?

- ○ A) There would be an increase in insects, and you would lose income.
- ○ B) There would be a decrease in insects, and you would lose income.
- ○ C) There would be an increase in insects, and you would increase your income.
- ○ D) There would be an decrease in insects, and you would increase your income.

40) You have discovered a new insect called the School Bug. You are trying to describe its life cycle. How many School Bugs will you need to look at to know that you have described it correctly?

- ○ A) None, you can read about it in a book.
- ○ B) One School Bug insect, because they are all alike.
- ○ C) Two School Bug insects, so you can look at both males and females.
- ○ D) As many School Bug insects as possible, in case the individuals vary.

APPENDIX E

MATH AND SCIENCE TEKS OBJECTIVES

Third Grade Math TEKS

Objective 2: Number, operation, and quantitative reasoning. The student uses fraction names and symbols to describe fractional parts of whole objects or sets of objects.

Objective 3: Number, operation, and quantitative reasoning. The student adds and subtracts to solve meaningful problems involving whole numbers

Objective 6: Patterns, relationships, and algebraic thinking. The student uses patterns to solve problems

Objective 7: Patterns, relationships, and algebraic thinking. The student uses lists, tables, and charts to express patterns and relationships

Objective 8: Geometry and spatial reasoning. The student uses formal geometric vocabulary. The student is expected to name, describe, and compare shapes and solids using formal geometric vocabulary.

Objective 13: Measurement. The student applies measurement concepts. The student is expected to measure to solve problems involving length, area, temperature, and time.

Objective 14: Probability and statistics. The student solves problems by collecting, organizing, displaying, and interpreting sets of data

Objective 15: Underlying processes and mathematical tools. The student applies Grade 3 mathematics to solve problems connected to everyday experiences and activities in and outside of school

Objective 16: Underlying processes and mathematical tools. The student communicates about Grade 3 mathematics using informal language.

Objective 17: Underlying processes and mathematical tools. The student uses logical reasoning to make sense of his or her world

Fourth Grade Math TEKS

Objective 1: Number, operation, and quantitative reasoning. The student uses place value to represent whole numbers and decimals.

Objective 2: Number, operation, and quantitative reasoning. The student describes and compares fractional parts of whole objects or sets of objects

Objective 3: Number, operation, and quantitative reasoning. The student adds and subtracts to solve meaningful problems involving whole numbers and decimals

Objective 4: Number, operation, and quantitative reasoning. The student multiplies and divides to solve meaningful problems involving whole numbers

Objective 11: Measurement. The student selects and uses appropriate units and procedures to measure weight and capacity

Objective 12· Measurement. The student applies measurement concepts. The student is expected to measure to solve problems involving length, including perimeter, time, temperature, and area

Objective 13: Probability and statistics. The student solves problems by collecting, organizing, displaying, and interpreting sets of data.

Objective 14: Underlying processes and mathematical tools. The student applies Grade 4 mathematics to solve problems connected to everyday experiences and activities in and outside of school.

Objective 15: Underlying processes and mathematical tools. The student communicates about Grade 4 mathematics using informal language.

Fifth Grade Math TEKS

Objective 1: Number, operation, and quantitative reasoning. The student uses place value to represent whole numbers and decimals.

Objective 2: Number, operation, and quantitative reasoning. The student uses fractions in problem-solving situations

Objective 3: Number, operation, and quantitative reasoning. The student adds, subtracts, multiplies, and divides to solve meaningful problems.

Objective 11: Measurement. The student applies measurement concepts.

Objective 13: Probability and statistics. The student solves problems by collecting, organizing, displaying, and interpreting sets of data

Objective 14: Underlying processes and mathematical tools. The student applies Grade 5 mathematics to solve problems connected to everyday experiences and activities in and outside of school.

Objective 15: Underlying processes and mathematical tools. The student communicates about Grade 5 mathematics using informal language

Third Grade Science TEKS

Objective 1: Scientific processes. The student conducts field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices

Objective 2: Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.

Objective 3: Scientific processes. The student knows that information, critical thinking, and scientific problem solving are used in making decisions

Objective 4: Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry

Objective 5: Science concepts. The student knows that systems exist in the world.

Objective 8: Science concepts. The student knows that living organisms need food, water, light, air, a way to dispose of waste, and an environment in which to live.

Objective 9: Science concepts. The student knows that species have different adaptations that help them survive and reproduce in their environment

Objective 11: Science concepts. The student knows that the natural world includes earth materials and objects in the sky

Fourth Grade Science TEKS

Objective 2: Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations

Objective 3: Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions.

Objective 4: Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry

Objective 5: Science concepts. The student knows that complex systems may not work if some parts are removed.

Objective 6: Science concepts. The student knows that change can create recognizable patterns

Objective 7: Science concepts. The student knows that matter has physical properties

Objective 8: Science concepts. The student knows that adaptations may increase the survival of members of a species

Objective 10: Science concepts. The student knows that certain past events affect present and future events.

Objective 11: Science concepts. The student knows that the natural world includes earth materials and objects in the sky.

Fifth Grade Science TEKS

Objective 2: Scientific processes. The student uses scientific methods during field and laboratory investigations

Objective 3: Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions

Objective 4: Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry.

Objective 5: Science concepts. The student knows that a system is a collection of cycles, structures, and processes that interact.

Objective 6: Science concepts. The student knows that some change occurs in cycles.

Objective 7: Science concepts. The student knows that matter has physical properties

Objective 9: Science concepts. The student knows that adaptations may increase the survival of members of a species.

Objective 11: Science concepts. The student knows that certain past events affect present and future events

VITA

Adelaide Ellen Pigg was born in Urbana, Illinois, on September 9, 1978, the daughter of Keith Mitchell Pigg and Cynthia Ellen Pigg. In August of 1997, she entered Illinois State University in Normal, Illinois. She received the degree of Bachelor of Science from Illinois State University in May, 2001. During the following six months she was employed by Disney World in Orlando, Florida, as an Epcot Science Intern. In August 2002, she entered the Graduate College of Texas State University-San Marcos, Texas.

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