AN INVESTIGATION OF PRESERVICE TEACHERS' UNDERSTANDING OF AND BELIEFS ABOUT TEACHING SCIENCE IN THE EC-6 CLASSROOMS USING PERMACULTURE

by

Sonnur Ozturk, B.S.

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Committee Members:

James P. Van Overschelde, Chair

Gwendolyn Hustvedt

Michelle Forsythe

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LIST OF ABBREVIATIONS

Abbreviation	Description
PST	Preservice Teacher
IPL	In-class Permaculture Lesson

I. INTRODUCTION

Students' learning is more effective in science when the curriculum is conceptually integrated (Nogay, 1994), but much of the science curriculum is taught discretely (Michaels et al., 2008). Permaculture includes the practice of intentionally designing a forest ecosystem of food-producing plants and science teachers can use this conceptual framework to integrate the majority of K-6 science curriculum.

This thesis examined the effectiveness of an integrated curricular design involving permaculture on preservice teachers' (PSTs) understanding of and beliefs about teaching science curriculum in elementary school grades. PSTs were taught about permaculture and the alignment of its many concepts with state science standards. The PSTs' changes in beliefs about permaculture and their ability to incorporate permaculture concepts into science lesson plans were evaluated. Prior research has not been approached through the implementation of permaculture as a holistic method for the science curriculum and the permaculture approach for PSTs.

II. LITERATURE REVIEW

Integrated Science Curriculum and School Gardens

An integrated science curriculum means that multiple concepts can be taught together or taught in a conceptually inter-related fashion (Huntley, 1998). Integrated science emphasizes the unity of scientific concepts and combination of various disciplines (Frey, 1989). For example, to describe the physics of light, teachers can explain how light applies to vision and how our eyes can see an image. Teachers can explain the structure of our eyes that are sensitive to visible light reflecting, in great part, from our surrounding environment. Therefore, integrated science helps teachers to cover both physical and life sciences (Hewitt et al., 2014) and to create a holistic approach of teaching science. The integration of science concepts also helps teachers to focus on the scientific process of ideas and actions rather than just a body of discrete facts.

An integrated science curriculum enables students to develop scientific knowledge and skills through a systematic inquiry, and integration results in better understanding and learning of science concepts (Abosede & Arokoyu, 2012). According to Lipson et al. (1993), there are several positive effects of an integrated curriculum for students. They are: a) giving students the opportunity to apply their learned skills, b) promoting multiple perspectives with higher-order thinking, and c) creating a meaningful learning environment. According to Beane (1996), students benefit from an integrated science curriculum because they can (a) apply knowledge instead of memorizing, (b) learn through patterns and connections rather than discrete elements or concepts, and (c) use this knowledge to focus on world problems using inter-related disciplines instead of a single discipline. In the study of designing an activity-based science course, the integration of chemistry, physics, and earth science concepts helps students to better understand the different science principles (Haan & Jadrich, 1999). Curriculum integration encourages students to have a deeper understanding of their world (Beane, 1997) and research shows that integrated curriculum is helpful for student learning for all grades (Erb, 2005).

In a different study (Nordine et al., 2011), researchers developed an energy unit that is a fundamental unifying science concept for an eighth-grade science course in Texas. The purpose of the energy unit was to emphasize energy systems rather than traditional energy unit that focuses on calculations of energy to meet science standards. Results indicated that students who were taught the new energy unit developed better understanding of energy systems and promoted future energy-related learning than students who were taught using the traditional energy unit.

In another study, a two-year integrated science course was created for groups of ninth graders in Colorado**.** The purpose of this course was to introduce students to life sciences, earth science, and physical science. The students completed a field study on a natural area to examine living organisms and abiotic factors such as water, soil, and climate as a part of this curriculum. The findings of this study showed that the integrated science course helped students to find meaningful relationships in daily life such as between climate and plant types (Crane, 1991).

Another study focused on changing traditional German science education and teaching strategies with an integrated science education and the study focused on the evaluation of the PING project (Practicing Integration in Science Education). In the PING project, a collaborative of teachers, researchers, and in-service trainers developed a basic integrated science curriculum and teaching materials for Grades 5 to 10 to determine whether it would improve students' conceptualized learning. The main theme was nature to explore soil, water, plants, and animals. One hundred and fifty schools in Germany used these materials to provide integrated science education. Teachers, administrators, and researchers had a coordinating network to access materials and revisions. The findings of the study showed that the integrated science curriculum improved students' conceptualized learning of natural science concepts (Riquarts & Hansen, 1998). Therefore, according to Arakoyu and Dike (2009) science teaching should be conceptually unified and interdisciplinary to help students gain scientific literacy.

One way to integrate the science curriculum under a single conceptual framework is designing school gardens and using gardening activities to teach inter-related science concepts (Graham & Zidenberg-Cherr, 2005). Blair (2009) reviewed the U.S. literature on school gardening to examine effects and outcomes on learning. Blair investigated seven qualitative studies about gardening projects in elementary schools and the results of all seven studies showed that teachers provided science, math, and environmental learning experiences in gardens by observing natural processes, experimenting with plants, and gaining knowledge about soil, seeds, and recycling.

Other researchers (Klemmer et al., 2005) collected data from 647 elementary school students from seven different schools in Texas. Students who were in the experimental group attended hands-on gardening activities in addition to their traditional science classrooms to learn science concepts. Students in the control group attended traditional science classroom during the school year. End of the year, both groups took cognitive test to evaluate their science achievement. The result of the study showed that students attending school gardening activities had higher scores on science achievement tests than students in the traditional science classrooms (Klemmer et al., 2005). Thus, designing school gardens supports students’ engagement in science and helps students to better learn scientific concepts (Williams et al., 2018).

Also, gardening is a conceptual framework that can be used to integrate a large number of different science concepts that are required by the national Next Generation Science Standards (NGSS) and the state-specific Texas Essential Knowledge and Skills (TEKS). For instance, gardening activities are well suited for the performance expectation of NGSS in Life Sciences for the kindergarten level: “*Use observations to describe patterns of what plants and animals (including humans) need to survive*.” All animals need food to survive, and they obtain their food from plants or other animals, and plants need water and light to survive (NGSS Lead States, 2013).

Although school gardens help to enhance students’ science learning, teachers have noted that there are some barriers to using school gardens to teach science (Graham & Zidenberg-Cherr, 2005). Graham and Zidenberg-Cherr (2005) conducted a study to assess elementary school teachers’ attitude toward school gardens in California. A majority of teachers (67%) reported that the amount of time the gardens took was the greatest barrier, followed closely by teachers’ lack of interest in gardening (63%). Teachers also reported a lack of experience with gardening activities and a lack of curricular materials that were connected to the academic standards (61% and 60%, respectively). Other studies also found barriers to implementing school gardens that included a lack of teachers’ knowledge and training (Blair, 2009), a lack of funding for gardening supplies (Smith et al., 2019), a lack of staff support to help with maintaining the garden when the teacher is busy with other school activities or on the weekend (Burt et al., 2019), and a lack of space for gardening and to store gardening tools (Burt et al., 2018).

Permaculture as a Conceptual Framework

David Holmgren and Bill Mollison developed permaculture in the 1970s, and the term permaculture comes from a combination of the words "permanent" and "agriculture." The term permaculture was coined to convey the idea of a permanent agricultural system that is automatically regenerative (Holmgren, 2002), as opposed to a traditional agricultural system that must be replanted each year. Permaculture is a holistic design process (Bane & Holmgren, 2012) and it involves a natural growing system to create a self-maintaining ecosystem and habitat. Permaculture involves intentionally designing a food forest ecosystem. A food forest ecosystem consists of different kinds of food-producing plants, animals, and microorganisms, and there is a complex relationship among these species that create a self-sustained and mutually enhancing ecosystem. Designing and creating a food forest requires a lot of work, but this self-regulating ecosystem gets more productive over time while requiring less maintenance.

Designing a food forest requires a conceptual understanding of diverse components including landscape, terrain, elevation, water, soil, sunlight, plants and tree, growing and preparing food, animal, fungi and bacteria, air, structure, energy, and technology (Bane & Holmgren, 2012). Although these components may seem like discrete elements, they are interconnected components of any natural forest ecosystem. The food forest is the core conceptual framework of permaculture design.

Food forest designs incorporate plants that are perennials and annuals, all of which produce fruits, vegetables, herbs, and flowers (Frey & Czolba, 2017). Hart (1996) developed a seven-layered model of a food forest ecosystem and the layers are: 1) a canopy layer of tall fruit and nut trees (e.g., walnut, black cherry), 2) a low-tree layer that consists of dwarf fruit and nut trees (e.g., persimmon, olive tree), 3) a shrub layer that includes fruit bushes (e.g., currants, berries), 4) an herbaceous layer of herbs and perennial vegetables (e.g., parsley, catnip) 5) a ground-cover layer of ground-hugging edible plants (e.g., strawberries), 6) a rhizosphere layer of root crops (e.g., sweet potatoes), and 7) a vertical layer that consists of vines and climbers (e.g., grapes). Although one of the goals of a food forest is food production, a food forest can also produce medicine and provide pollinator habitats.

This natural system helps to create a continuous cycle in the permaculture design. As part of this cycle, the output (i.e., waste) of one component of the food forest can be an input (i.e., food) for another component. For instance, dead plants become food for micro-organisms and the waste becomes compost for growing new plants. Designing a permaculture food forest requires the observation and replication of natural patterns in the environment (Taylor Aiken, 2017). According to Holmgren (2002), working with nature, not against it, helps us to understand natural patterns in permaculture. Therefore, people can have more food production with less effort as a result of intentionally designing a forest ecosystem with permaculture.

By using the concept of a food forest, teachers can teach the many different science concepts from an integrated conceptual framework perspective. As several prior studies have shown, this conceptual integration should result in better student learning of the science concepts.

TEKS (Texas Essential Knowledge and Skills) and Permaculture

Permaculture concepts align closely with the Next Generation Standards (NGSS Lead States, 2013) and with the TEKS science standards for K-12 grade level. Because this study was conducted in Texas, I focus on the alignment of permaculture with the Texas Essential Knowledge and Skills (TEKS). The TEKS are the Texas state standards for public schools for grades K-12. TEKS have been adopted from The State Boards of Education (SBOE) to detail curriculum requirements for each subject (Texas Education Agency, 2017).

Table 1 shows the alignment between permaculture concepts and TEKS science standards. For example, in K-2 grades, the TEKS require students to observe the natural world when doing scientific investigations. When designing a permaculture food forest, students must observe many different aspects of an existing landscape to understand how nature works and patterns in nature to adopt them into a food forest design.

For a specific example, when designing a food forest, the characteristics of the soil must be well understood. Students have to investigate questions such as (a) how hard or soft is the soil, (b) how fast does rain percolates through the soil, (c) what nutrients are available, and (d) how acidic or alkaline is the soil? The answer to each question determines the types of plants that can survive and the types of plants that could thrive in that soil. Understanding soil types in designing food forest aligns with the Grade 4 Science TEKS, *"7(A) examine properties of soils, including (a) color and texture, (b) capacity to retain water, and (c) ability to support the growth of plants."* A teacher can provide students with activities that examine the properties of soil in a food forest. Therefore, finding plants that will grow well in the specific soil type available is another crucial step for designing a food forest. The plants have basic needs such as water, nutrients, and sunlight. Learning about the basic needs of plants and animals are also covered by science TEKS for the elementary grade. For instance, students learn basic needs of living organisms such as food, water, and shelter for animals and air, water, nutrients, sunlight, and space for plants in Kindergarten level science TEKS. Weather condition is another consideration to implement permaculture design because it is one of the basic needs of living organisms. Observing weather and collecting data to record weather information aligns with the science TEKS for Grade 1, *"8 (A) record weather information, including relative temperature such as hot or cold, clear or cloudy, calm or windy, and rainy or icy."*

Observing rainwater and collecting data from the landscape is necessary to design the food forest properly because some plants like more water than others. Designing water resources in the landscape has significance in deciding the whole designing process. Elementary Science TEKS also focus on collecting and analyzing data based on the observations for scientific investigations and reasoning. Observing rainwater aligns with it. Also, the laser level can be used to measure rainwater distribution in the landscape. Using laser level will cover the science TEKS related to using a variety of tools to conduct science inquiry.

Table 1: Relationship Between TEKS and Permaculture Topics for Elementary Schools

Grade Levels	TEKS	Permaculture Concepts
4	7 (A) examine properties of soils, including color and texture, capacity to retain water, and ability to support the growth of plants	Soil: observing soil and examining soil type in the landscape
K	9 (B) examine evidence that living organisms have basic needs such as food, water, and shelter for animals and air, water, nutrients, sunlight, and space for plants.	Plants and Animals: living organisms in the landscape and their basic needs to grow plant in the food forest
1	8 (A) record weather information, including relative temperature such as hot or cold, clear or cloudy, calm or windy, and rainy or icy	Measuring weather: is important to explore living organisms
5	(2) Scientific investigation and reasoning. The student uses scientific practices during laboratory and outdoor investigations.	Rainwater: observing rainwater to design water resources in the landscape
5	(4) Scientific investigation and reasoning. The student knows how to use a variety of tools and methods to conduct science inquiry	Laser level use to measure rainwater distribution.

Teaching Permaculture in the Schools

Nowadays, a few schools around the world have attempted to take the permaculture principles and apply them in their school gardens to implement a permaculture design. For instance, Oak Grove School is a Pre-K through 12th grade school in Ojai, California, and it implemented a permaculture-based school garden so that the garden would have a minimal environmental impact (Praetorius, 2006). The first principle the school followed was working with nature, not against it, and this principle was selected to help students develop environmental awareness. Students at Oak Grove made observations about the weather, sunlight, soil, and plants; observation is one of the keystones of science learning (Praetorius, 2006). Another elementary school that applied permaculture design is Bay Haven School is a K-6th grade in Florida (Morgan, 2017). Bay Haven School used a food forest to create a biodiverse ecosystem. Students learned life science concepts such as life cycles, plants, animals, ecology, and soil in this forest ecosystem (Morgan, 2017). Also, it provided students and staff with fresh fruits, vegetables, and herbs.

Another study investigated whether permaculture could be used to integrate environmental or sustainability education in junior secondary science in New Zealand (Lebo et al., 2013). This study included the design and teaching of permaculture principles during one year in junior secondary science class. The researcher used a mixed-methods, case study approach that included questionnaires, interviews, and observations. Data were collected from the students and the teachers. The findings of this study showed that a permaculture approach on teaching science in junior secondary grade had a positive impact on the students' attitudes toward sustainable thinking, and this positive impact helped to enhance students' learning of science. Most teachers reported in their interviews that permaculture helped them to have contextualized science teaching with real world examples. Also, the teachers responded that they had a better understanding of sustainability and more positive attitudes toward a permaculture approach in the schools as a result of focusing on the environment, the field trips, and in-class activities.

Lebo and Eames (2015) conducted the study that focused on the sustainable food production aspect of permaculture to improve student's attitudes toward science and sustainability learning. The data were collected from the teachers and secondary science class students. The findings of the study showed that sustainable food production had positive impacts on both the teacher and students. Students reported that learning science was more fun in the garden. Also, the test results revealed that students learned the relativity of science concepts to sustainable learning. Therefore, students identified certain science concepts more effectively, such as seed types and germination, soil, and biological diversity.

A number of studies have shown how schools gardens can be used as a conceptual framework for teaching science, and a limited number of studies have shown how permaculture can also be used as a conceptual framework. However, all of these studies were done with in-service teachers. The present study was done to investigate permaculture with pre-service teachers.

III. THEORETICAL FRAMEWORK

Multidisciplinary curriculum and integrated curriculum are two common approaches to teaching science in schools. The multidisciplinary curriculum begins with separate subjects to identify the theme. For example, the solar system can be a theme for the multidisciplinary curriculum to teach different subjects. To identify this theme, features of the planets can be taught in science while creating solar system model for the art course. Therefore, the theme is a secondary matter for the multidisciplinary curriculum (Beane, 1997) (See Figure 1.1).

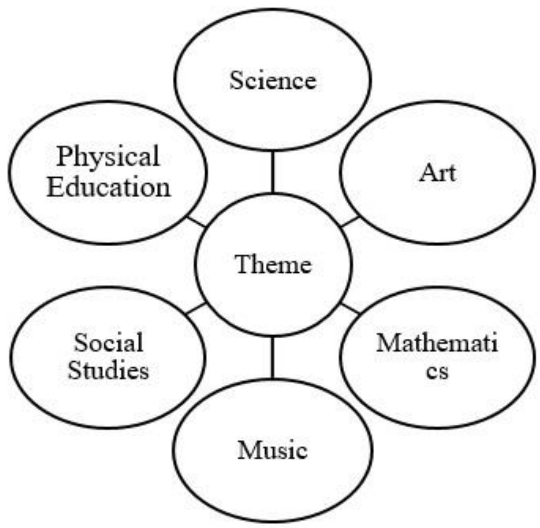


Figure 1: Schematic Web for Multidisciplinary Curriculum

On the other hand, the integrated curriculum begins with a theme and then explores concepts related to the theme with activities (See Figure 1.2). For example, Figure 1.3 shows how permaculture concepts can be used in an integrated curriculum to teach science. Using permaculture as a theme, permaculture concepts such as animals, plants, soil, weather, and water can be explored with the activities to teach elementary school science.

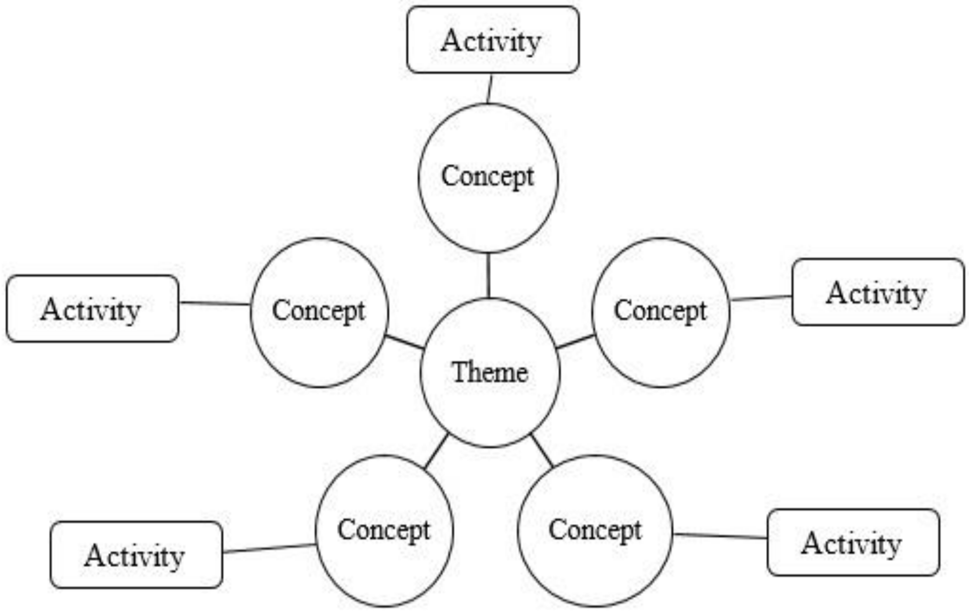


Figure 2: Schematic Web for Integrated Curriculum

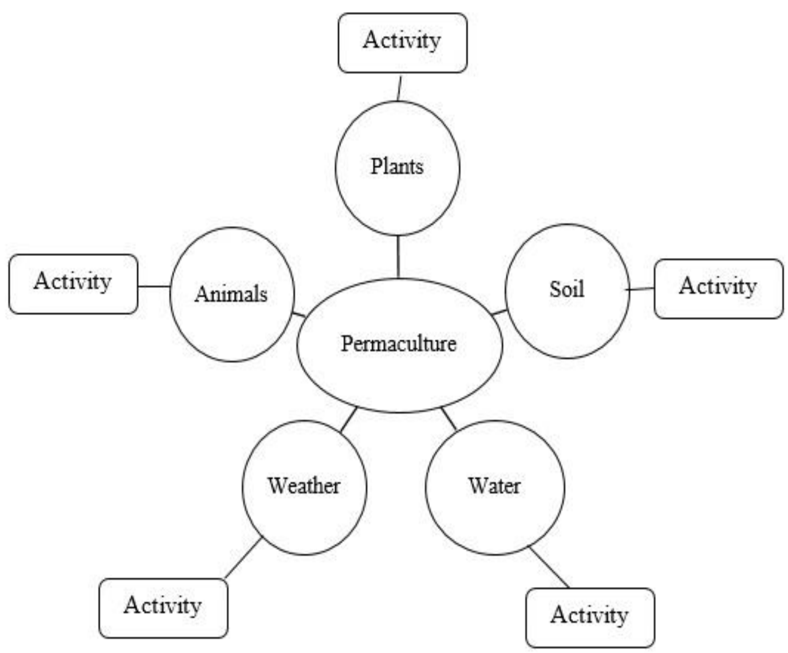


Figure 3: Schematic Web for Permaculture Integrated Curriculum

The theoretical framework I am using for my research is curriculum integration because research shows students can learn science better when taught using an integrated curriculum. Teachers can encourage students to apply their knowledge in a meaningful learning environment by using permaculture to unify science concepts to create an integrated science curriculum. Permaculture, as a theme of the integrated curriculum, can cover science concepts with science activities. Also, permaculture aligns with the most of the science TEKS for K-6. Using permaculture to teach science concepts is a better way to teach an integrated science curriculum for elementary school grades.

IV. METHODOLOGY

The purpose of this study is to assess how understanding and beliefs of PSTs at Texas State University change toward the use of permaculture as a unified conceptual framework for teaching science in elementary schools. To answer my research questions, I used a mixed-methods design that involves both quantitative and qualitative data collection (Creswell & Plano Clark, 2011). The process of data collection started with a pretest the week before an In-class Permaculture Lesson (IPL) was conducted. The IPL included the collection of qualitative data during in-class activities. A posttest was completed the following week.

Research Questions

The aim of this study was to answer the following research questions:

1. How do preservice teachers' understanding and beliefs change toward teaching permaculture as an integrated science framework after 2 hours of training?
2. How do preservice teachers' beliefs about teaching permaculture in their classrooms change after the training?

Study Participants

I collaborated with the Office of Educator Preparation and Department of Curriculum and Instruction, and I recruited PSTs who were enrolled in a Science in Elementary Education class during the fall 2019 semester. The course provides an overview of elementary science standards and contents. It also assists PSTs in developing science literacy and scientific process skills. This course was selected because all participants are PSTs, and they had learned science concepts and standards in this course. Twenty-two PSTs were enrolled in the class and all PSTs in the course agreed to participate in the study. Table 2 shows the demographic characteristics of the participants. All participants were women. Participants were mostly White (92%), with smaller percentages of Black or African American (4%) and Asian (4%). Twenty (91%) of PSTs were in the 18-to-24 year old category, while two (9%) were in the 35-to-44 year old.

Table 2: Frequency Distribution of Participants by Demographic Characteristics

Characteristics	**Frequency**	**Percentage**
Gender		
Male	0	0%
Female	22	100%
Race/Ethnicity		
White	20	92%
Asian	1	4%
Black or African American	1	4%
Age		
18 to 24	20	91%
25 to 34	0	0%
35 to 44	2	9%

In-class Permaculture Lesson (IPL) Design

This research took place during a 90-minute session in the class with 30-minute before class resources. The summary timeline of In-class Permaculture Lesson are shown in Table 3 and it is followed by detailed descriptions of each activity.

Table 3: Timeline for In-class Permaculture Lesson (IPL) Design

30 min.	**Before Class Resources** – Background information about permaculture, its principles, food forest and teaching permaculture with children
20 min.	**Guiding Questions Discussion** - What is a food forest? & What is permaculture?
40 min.	**Small-Group Activity and Presentation** – Designing a Food Forest
30 min.	**Small-Group Activity and Class Discussion** – Assigning Science TEKS to the Permaculture Activity

Before Class Resources. After students completed the pretest in their science class, students were sent links to three videos and one article to study in preparation for the IPL. The videos explained what permaculture is, its core principles, and what a food forest is. The provided reading was about teaching permaculture to children. The purpose of these materials was to help participants gain background information so they could have a better understanding of the activities during the IPL.

Guiding Questions Discussion. During the IPL, we started the class with guiding questions such as "What is a food forest?" and "What is permaculture?" These guiding questions required PSTs' to recall the information learned during the videos and reading and to initiate an in-class discussion. We discussed what they learned about a food forest and permaculture. After finishing the discussion, I asked them *"What kind of plants can a food forests have?"*. After listening to their ideas, I showed them a picture of the seven layers of a food forest (Illustration 1). I explained each of the layers and gave them examples for each layer. This information helped PSTs to better understand the intention of designing a food forest because plants in the food forest are different from each other. Then, I told them "W*e will conduct an activity about the seven layers of food forest. Therefore, it was important to learn biodiversity in a food forest. Now, we can continue with our first activity".*

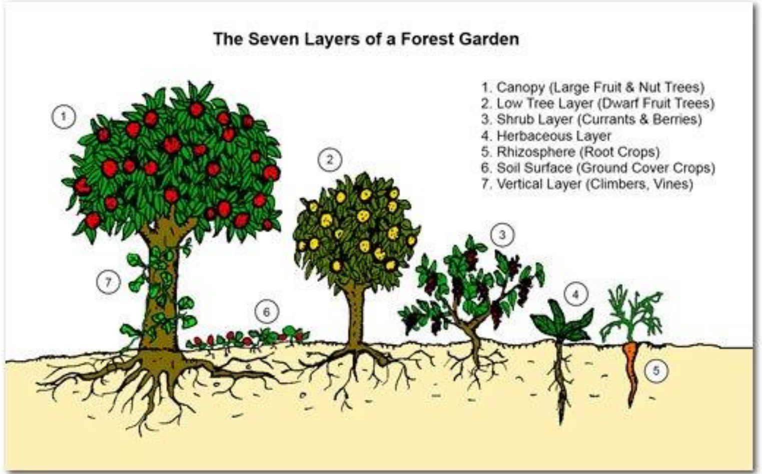


Illustration 1: The Seven Layers of a Forest Garden

First Small-Group Activity and Presentation. "*We will design a food forest for this activity. We learned there are different plants in the seven layers of a food forest and different plants have different needs. Therefore, we need to think about plant needs before designing the food forest".* Then, we discussed the needs of plants such as temperature, soil, water, food, and sunlight. After finishing the discussion, the class divided into teams of 4-5 participants to conduct the activity. Then, I gave them a list of plants and their pictures (see Appendix B). I explained, *"There are 34 different plants from different layers in this list. For example, black cherry is from the canopy layer, persimmon tree from the understory layer, goji berry from the shrub layer, parsley from herbaceous layer, frog fruit from the ground cover layer, and a grape vine from the climber layer. Also, each plant has information about their heights (ft.) and their sun requirements (full/partial). You will use these plants and their pictures to design your food forest on this big paper (Illustration 2). You can see the curved movement of the sun during the day and the cardinal directions on this paper. You should consider about it while thinking about sun requirements of the plants. Now you can discuss about plants' heights and their places on the paper by considering their sun requirements. Then, you* *can develop your own food forest as a group."* After each group finished their food forest design, they explained why they chose the plants they did and why they located the plants were they did. Then, they explained their designs to the class (See Appendix C for pictures of designed food forests). After we talked about all of the food forest designs, I told them "*There are some science standards related to this activity. Now, we will continue with our second activity to talk more about these science standards"*.

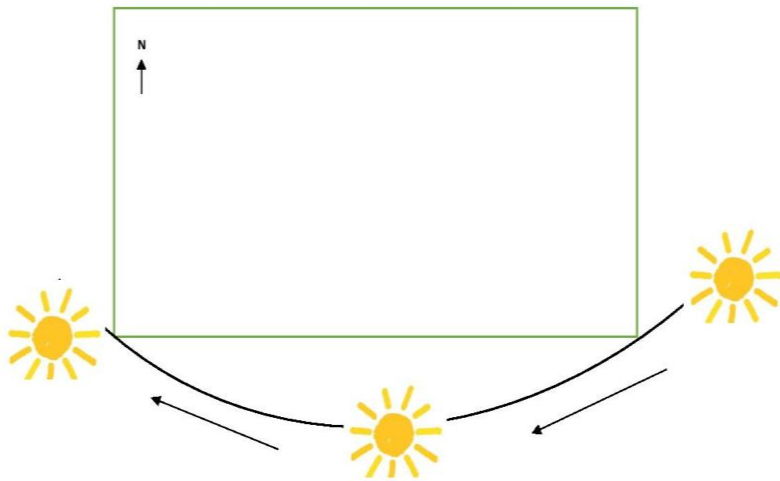


Illustration 2: The Paper for a Food Forest Design

Second Small-Group Activity and Class Discussion. There are some science TEKS related to plant needs for elementary grades. For example, for Grade K, the TEKS 9 (B) examine evidence that living organisms have basic needs such as food, water, and shelter for animals and air, water, nutrients, sunlight, and space for plants. After this information, we discussed how the first activity aligns with science TEKS and found other TEKS related to this activity. For instance, 2.9. (A) Identify the basic needs of plants; 3.9. (A) Observe and describe the physical characteristics of environments and how they support populations and communities of plants within an ecosystem; and 4.10.

(A) Explore how structures and functions enable organisms to survive in their environment can be covered with this activity. Then, I told them *"We will focus on the following activity to have more experience on the relationship between permaculture concepts and science TEKS. We will justify science TEKS to activities related to food forest and permaculture for elementary school grades. There are six different activities labeled as A, B, C, D, E, and F (see Appendix B) and these activities focus on planting from seeds, soil and soil textures, garden ecosystem for animals and plants, interaction of living organisms with their environment, composting in the garden, seasonality of plants in connection to their climate, plant lifecycles, microorganisms in the soil, and observation of patterns in nature. Small groups will continue to work together for the activity. Two different activities will be assigned to each group randomly. Also, I will provide the activity sheet to each group (see Appendix B). The activity sheet includes the label of the lesson plan, grade level, science TEKS, justifying section, and the question (Would you use this activity in the classroom? Why/Why not?) about PSTs' opinion on this activity"*. After giving all activity materials to the groups, they read the activities, justified the appropriate science TEKS to the activities, and recorded their ideas to justify how the activity aligned with TEKS. Also, the PSTs gave feedback about the activity and whether or not to use it in the classroom. The PSTs focused on both the scientific process TEKS and science concepts TEKS to discover relationships between permaculture concepts and the Texas Science Standards. At the end of the activity, each group explained their activity and related TEKS to their classmates during the class report out.

Data Sources

I utilized data sources that included a) a pretest/posttest, b) food forest activity, c) alignment of TEKS and permaculture activity, and d) personal classroom reflections by PSTs. While the pretest/posttest was a quantitative data source, the lesson plans and classroom reflections were qualitative data sources.

To answers RQ_1, the sources are:

a) Permaculture pretest/posttest: I created a questionnaire to understand PSTs' prior knowledge and interest in gardening, permaculture, and permaculture concepts. The pretest included 25 multiple choice and Likert Scale questions to determine understanding and beliefs of PSTs on teaching science and permaculture, and the posttest included 26. The Likert scale ranged from strongly disagree to strongly agree and I used an 11-point Likert scale that ranged from 0 to 10. There were two sets of questions. One set was related to nine different permaculture related science concepts (biodiversity, food forest, microorganisms, soil, pattern in nature, interaction of living organisms, plants and their needs, animals and their needs, and climate). The other set was related to integrated science curriculum and science standards.

b) Food forest activity: I conducted two in-class activities as a part of the In-class Permaculture Lesson (IPL). For the first activity, PSTs designed their food forest on the big paper, and also, they provided written feedback about their food forest designs and plants that were used in the design process.

To answers RQ_2, the sources are:

a) Permaculture pretest/posttest: Pretest and posttest also had questions about school gardens and science curriculum to answer the second research question, which is to measure PSTs beliefs about teaching permaculture in the classrooms.

b) Personal classroom reflections: PSTs wrote feedback every week as a part of their science class to reflect on the topic they had learned and if they would adopt it in their science classrooms to teach students. Participants had half of the day's lesson for permaculture section in their science course and they reflected permaculture thoughts on their personal classroom reflections on the day. Thus, IPL provided qualitative findings for my study.

c) Alignment of TEKS and permaculture activity: The second activity in the classroom was designed to measure how permaculture concepts align with TEKS and to understand if PSTs would use activities related to permaculture in their classrooms. Therefore, their lesson plans were examined as a part of the qualitative findings of the study.

Data Collection and Analysis

The pretest was completed one week before the IPL and the posttest was completed one week following the IPL. Both tests were administered during the course, and during the pretest, a consent form provided the option for the PSTs to participate or not participate in this study.

The pretest and posttest took about 10 minutes to complete, and each participant completed them individually. Before analyzing the data, I converted the numerical values from the 0 to 10 Likert-scale to a new scale from -5 to 5. This means that the neutral mid-point was coded as 0. Assigning these new numerical values makes interpreting scores more intuitive. Negative values mean the response was on the disagree side of the scale, and positive values mean the response was on the agree side. Mean differences between the posttest and pretest were analyzed in SPSS using a paired t-test.

In the second part of data collection, I examined PSTs' science lesson plans and personal class reflections for further explanation and interpretation of the qualitative results. During the IPL, we conducted two in-class activities with PSTs, and I examined these lesson plans as a part of my qualitative findings. For food forest design results, I counted how many times participants used plants height, sun requirements, general location, and the impact of the plants to each other correctly and incorrectly on their food forest designs. I also compared their notes against their food forest design to determine whether they used these descriptions correctly or incorrectly.

For alignment of TEKS and permaculture activity, I created codes to evaluate the pattern of justifying TEKS to the activities. These codes also helped me to identify advantages and disadvantages of permaculture activities. Coding was used to evaluate classroom reflections to find a pattern of PSTs' beliefs about the use of permaculture in their future classrooms. After coding each qualitative data set separately, the number of times codes appeared was recorded. These data were descriptively analyzed to evaluate frequency of use in classroom reflections and lesson plans.

V. RESULTS

The quantitative results associated with Research Question 1 (RQ1) are presented first, then the qualitative results. This same order is used with Research Question 2.

RQ1: Teachers' understanding of and beliefs about teaching permaculture as an integrated science framework

Pretest/Posttest Results. A paired t-test was conducted to examine mean change scores for test questions about science concepts and PSTs' beliefs about the use of an integrated science curriculum with permaculture (See Table 4 & 5). The results are presented in order from the strongest change to the weakest.

There is a statistically significant change in the scores for the food forest question ($M = 4.68$, SD = 2.77); $t(21) = 7.94$, $p < 0.001$. The mean score for this item on the pretest was -2.59 and the mean score on the posttest was 2.09. There is a statistically significant change in the scores for biodiversity ($M = 2.68$, SD = 2.57) on teachers' beliefs about teaching permaculture as an integrated science framework; t (21) = 4.89, $p < 0.001$. While the mean score for this item was -1.41 on the pretest, the mean score was 1.27 on the posttest. This score means that PSTs' knowledge of biodiversity moved almost three points higher on the Likert scale as a result of the training. There is also a statistically significant change in the scores for microorganisms question ($M = 2.32$, SD = 1.81) after the pretest/posttest; $t(21) = 6.01$, $p < 0.001$. The mean score for this item on the pretest was -1.14 and the mean score on the posttest was 1.18. There is a statistically significant change in the scores for soil ($M = 1.91$, SD = 2.60); $t(21) = 3.45$, $p = 0.002$ and there is a marginally significant change in pattern in nature ($M = 0.95$, SD = 2.46); $t(21) = 1.82$, $p = 0.083$ between pretest and posttest. There is not a statistically significant change for plants and their needs (*M* = 0.91, SD = 2.58); *t*(21) = 1.65, p = 0.113. Moreover, there is a marginally significant mean change for the interaction of living organisms (*M* = 0.87, SD = 2.14); *t*(21) =1.89, p = 0.073. The understanding of permaculture and its description has a statistically significant change after the pretest/posttest (*M* = 0.41, SD = 0.67); *t*(21) = 2.88, p = 0.009. There is also not a significant change in animals and their needs (*M* = 0.09, SD = 1.85); *t*(21) = 0.23, p = 0.820 and there is not a statistically significant mean change for PSTs' beliefs on climate (*M* = 0.09, SD = 1.74); *t*(21) = 0.24, p = 0.809.

Table 4: Paired Sample t Test of Self-evaluation of Expertise in Science Concepts

Science Concepts	**Mean Diff**	**Std. Deviation**	***t***	**N**	***p***
Food Forest	4.68	2.77	7.94	22	< 0.001
Biodiversity	2.68	2.57	4.89	22	< 0.001
Microorganisms	2.32	1.81	6.01	22	< 0.001
Soil	1.91	2.60	3.45	22	0.002
Pattern in nature	0.95	2.46	1.82	22	0.083
Plants and their needs	0.91	2.58	1.65	22	0.113
Interaction of living organisms	0.87	2.14	1.89	22	0.073
Permaculture	0.41	0.67	2.88	22	0.009
Animals and their needs	0.09	1.85	0.23	22	0.820
Climate	0.09	1.74	0.24	22	0.809

Table 5: Average Responses for Each Question in Pretest & Posttest

Science Concepts	Mean-Pre	Mean-Post
Food Forest	-2.59	2.09
Biodiversity	-1.41	1.27
Microorganisms	-1.14	1.18
Soil	0.09	2.00
Pattern in nature	0.41	1.36
Plants and their needs	1.64	2.55
Interaction of living organisms	1.68	2.55
Permaculture	0.41	0.82
Animals and their needs	2.64	2.73
Climate	1.55	1.64

Food Forest Design Lesson Plans Results. Table 6 shows the number of selected plants by PSTs to describe on their food forest designs and other plants' height, sun requirement, general location, and the impact of each other applied correctly and incorrectly by PSTs on their food forest designs. The number of descriptions applied correctly is greater than the number of descriptions applied incorrectly. The sun requirement of the selected plant was applied correctly 18 times without any incorrect applications. Participants mentioned the full or partial sun requirements of their plants. For instance, one group said that we put the persimmon tree in the location where it will get full sun.

For the general location of the selected plants and their relative location to other plants, PSTs mentioned this 18 times and it was applied correctly 16 times. For instance, one of the correct locations was for grapes, and the group said, "Grapes climb on trees where it has access to full sunlight." Another of the most frequent descriptions used was the height of the selected plant with it being mentioned 14 times. Also, the height of the selected plant was applied correctly 13 times while it was applied incorrectly 1 time. The incorrect answer was, “The sweet potatoes plant is in a good spot because it is lower to the ground and does not have to worry about the other plant or trees covering it with their shadows.” A similar number of participants talked correctly about the impact of other plants on the selected plant. For example, one group explained how the location of peach and apple trees have a positive impact on an avocado tree to get partial sun. Although the impact of other plants on the selected plant was mentioned 10 times, only one group mentioned the reason for this impact. The one mention was “The Ginkgo tree is behind the red mulberry which has a height of 35-50 feet, so the Ginkgo gets partial sunlight because it is shorter than red mulberry.” On the other hand, only a few PSTs mentioned the impact of the selected plant on other plants. There were five answers given, and four were correct. Although it was mentioned five times, only two of them mentioned the reason of this impact. Only one group mentioned the impact of sun movement on the plants’ sun requirement. The group focused on the sun requirement of black cherry by considering sun movement.

Table 6: Example Descriptions from PSTs' Food Forest Designs

Description	Applied Correctly	Example	Applied Incorrectly	Example
The sun requirement of the selected plant	18	We put the persimmon tree in the location where it will get full sun.	0	
General location of the selected plant or relative location to other plants	16	Grapes climb on trees where it has access to full sunlight.	2	Peachtree is at a good location because it is 15 ft. in height and is direct in sunlight.
The height of the selected plant	13	Peachtree is at a good location because the peach tree is 15 ft in height and is direct in sunlight.	1	The sweet potatoes plant is in a good spot because it is lower to the ground and does not have to worry about the other plant or trees covering it with their shadows.
The impact of other plants on the selected plant	10	Avocado tree is placed so it receives mainly full sun, but sometimes partial sun behind the peach and apple trees, as it needs.	1	the red mulberry is at a good place because it is one of the bigger trees, so it will receive full sun while providing shade for other plants
The reason for the impact on the selected plant	1	The Ginkgo tree is behind the red mulberry which has a height of 35-50 feet, so the Ginkgo gets partial sunlight because it is shorter than red mulberry.	0	
The impact of the selected plant on other plants	4	I placed frog fruits here because it is a ground cover and only grows 0.5 feet. It will help keep the soil moisturized for the sweet potatoes.	1	Ginkgo covers other trees and plants from the harsh sun.
The reason for the impact on other plants	2	We placed red mulberry here without blocking the plants that also need full sun and provides shade for plants that need full/partial sun.	0	
Sun moving	1	Black cherry needs full/partial sun. As the sun moves, it will always be receiving sunlight, whether it is full or partial.	0	

RQ2: Pre-service teachers' beliefs about teaching permaculture in the classrooms:

Pretest/Posttest Results. A paired t-test was conducted to compare mean change scores for test questions about and PSTs' beliefs about applying permaculture in the classrooms (See Table 7 & 8). The results are presented in order from the strongest change to the weakest.

There is a statistically significant change in the scores for teaching science concepts effectively question (*M* = 2.09, SD = 1.85; *t* (21) = 5.30, $p < 0.001$. The mean score for this item on the pretest was -0.23 and the mean score on the posttest was 1.86. This change score means that PSTs' beliefs about teaching science effectively moved two points higher on the Likert scale. There is a statistically significant change in the scores for understanding the NGSS for science curriculum (*M* = 1.82, SD = 1.56); *t*(21) = 5.46, $p < 0.001$. The mean score for this item on the pretest was -0.91 and the mean score on the posttest was 0.91. There is a statistically significant change in the scores for understanding the science TEKS question (*M* = 1.64, SD = 1.87); *t*(21) = 4.11, $p < 0.001$. There is also a statistical significance in finding better ways to teach elementary science than traditionally taught (*M* = 1.64, SD = 1.89); *t*(21) = 4.06, p = 0.001. On the other hand, there is not a statistically significant change in the scores for liking gardening activities (i.e., growing vegetables, fruits, and herbs, mowing, or digging) (*M* = 0.91, SD = 2.63); *t*(21) = 1.62, p = 0.121. Although there is no statistically significant change in using school garden to implement science curriculum (*M* = 0.05, SD = 0.21); *t*(21) = 1.00, p = 0.329, all PSTs reported on the posttest that they would like to use school garden to implement science curriculum because they a) have interest work in gardening with students, b) have enough time to spend in the garden with students, c) know how gardening aligns with science curriculum or science standards, d) have the resources, and e) have enough knowledge to do gardening activities. Also, 17 of PSTs reported that they would use hands-on permaculture lesson plans connected to science curricula if they had them and there were 5 answers as “maybe.”

Table 7: Paired Sample t Test of PSTs’ Beliefs about Permaculture

School Gardens & Science Curriculum	**Mean Diff**	**Std. Deviation**	***t***	**N**	***p***
I can teach science concepts effectively	2.09	1.85	5.30	22	< 0.001
I know and understand the NGSS for science curriculum	1.82	1.56	5.46	22	< 0.001
I know and understand TEKS for science curriculum	1.64	1.87	4.11	22	< 0.001
I can find better ways to teach elementary science than traditionally taught	1.64	1.89	4.06	22	0.001
I like gardening activities	0.91	2.63	1.62	22	0.121
If you knew how, would you like to use school garden to implement science curriculum	0.05	0.21	1.00	22	0.329

Table 8: Average Responses for Each Question in Pretest & Posttest

School Gardens & Science Curriculum	**M-pre**	**M-post**
I can teach science concepts effectively	-0.23	1.86
I know and understand the NGSS for science curriculum	-0.91	0.91
I know and understand TEKS for science curriculum	1.36	3.00
I can find better ways to teach elementary science than traditionally taught	0.86	2.50
I like gardening activities	1.18	2.09
If you knew how, would you like to use school garden to implement science curriculum	0.95	1.00

Personal Classroom Reflections Results. Fourteen of the 22 participants mentioned permaculture and school gardens in their class reflections. Twelve PSTs reflected on only permaculture in their personal classroom reflections. Five of them mentioned permaculture in their class reflection with general ideas of permaculture. For instance, "Permaculture can be used in schools" was one of the reflections. On the other hand, seven participants focused on more specific concepts related to permaculture such as the impact of permaculture on the environment and applying permaculture with students. For example, one of the PSTs said that "Educating students about permaculture is important for the future of our environment and sustainability." Also, other participant mentioned "Permaculture can be a positive topic to introduce to students, allowing them to have hands-on activity." Five PSTs focused on school gardens and outdoor learning in their classroom reflections. For instance, one participant is planning to incorporate the outdoors (garden, habitats) into learning to help students gain knowledge and respect for the environment.

Thirteen participants reflected that they started to think or feel differently towards permaculture after the IPL. For instance, one PST said that "I learned what permaculture is and how to incorporate in the classroom," and other PSTs mentioned, "I learned about permaculture and why students should learn about it." Moreover, four PSTs said they plan to do activities differently with permaculture in their schools. For example, one of the participants said "I will give emphasis to teaching kids about gardening and permaculture."

Lesson Plans about How Permaculture Aligns with TEKS Results. Groups justified science standards to the activities from 1^{st} grade to 5^{th} grade covering the topic of Earth and Space and Organisms and Environment. Seven themes were identified through the coding process. Although four of them were advantages (hands-on, real-life experiences, developmentally appropriate, and environmental consciousness) of the activities, three of them were disadvantages (available resources, budget, time-consuming) about the assigned activities. Table 9 shows the advantages and disadvantages of assigned lesson plans and their science TEKS with science themes. The advantages are:

Hands-on learning. The most mentioned advantage of using permaculture to teach science was the ability to incorporate hands-on learning into the classroom. This theme was mentioned eight times by PSTs. While Lesson plan A, B, D, and E were selected as hands-on activity by all assigned groups, only one group accepted Lesson plan F as a hands-on activity. The discussion about hands-on learning centered on how it leads to more engagement and active learning for students. For instance, Lesson plan D was selected as a hands-on lesson by both groups because it provides students the opportunity to explore the garden habitat by working in the garden.

Real-life experiences. After hands-on learning, the most frequently mentioned advantage was real life experiences. Groups mentioned real-life experiences five times for lesson plans B, C, D, and F. This theme was chosen because the lesson plans provided interactive real-world experiences to the participants. For example, Lesson plan B encourages students to plant summer crops to understand differences in lifecycles between cool and warm-season crops.

Developmentally appropriate. Two groups focused on developmentally appropriate activities, and both of them were analyzing Lesson plan A, which is about a forest floor and the investigation of a variety of organisms on the forest floor. This lesson plan was perceived as developmentally appropriate by PSTs because it could be used for K-2 grades.

***Environmental consciousness*.** Environmental consciousness was mentioned only once in the results for Lesson plan C. This lesson plan was about composting, and participants specified that this lesson plan is important to teach kids about environmental conservation, and it is a way to teach students about healthier and cleaner ways of living. There are several disadvantages of permaculture activities:

Available resources. Available resources was cited two times as a disadvantage. This concern includes the conducting of permaculture lesson plans when it might be hard to find space to grow different plants at the school. Also, some activities need specific environments to do the activity, and those might not be available at the school. Therefore, this disadvantage was found in Lesson plan A and B that need specific environments and space.

***Budget*.** Having funds in the budget to apply permaculture design in the school gardens was cited as another disadvantage. PSTs mentioned that the inability to find budget funds might make it difficult to buy different plants to grow in the food forest.

Time. The fact that permaculture can be time consuming was cited as the last disadvantage because some parts of the activities take an large amount of time, and it affects the activity process. For example, the beginning part of Lesson Plan E was described as time-consuming because students needed to wait for the dirt to settle before continuing to other parts of the activity. On the other hand, one group mentioned the positive effect of time on the permaculture lesson plan. The group said that "Lesson plan

B provides students chance to grow a garden and observe it throughout the year. It allows students to be more engaged in the activity process."

Table 9: Permaculture Lesson Plans of PSTs

Groups	Lesson Plans	Science TEKS	Themes	Advantages				Disadvantages		
				Hands on	Real life experiences	Developmentally appropriate	Environmental consciousness	Available resources	Budget	Time
Group 1	A	1.7A	Earth&Space	X		X		X		
Group 2	A	5.9A	Organisms&Env.	X		X				
Group 1	B	5.9A	Organisms&Env.	X	X			X	X	
Group 2	B	3.10B	Organisms&Env.	X						
Group 1	C	5.9B	Organisms&Env.		X		X			
Group 1	D	1.9B	Organisms&Env.	X	X					
Group 2	D	5.9B	Organisms&Env.	X	X					
Group 1	E	4.7A	Earth&Space	X						X
Group 1	F	2.9A	Organisms&Env.		X					
Group 2	F	2.9B	Organisms&Env.	X						

VI. DISCUSSION

Discussion

In answer to my first research question about whether PSTs change in their understandings of and beliefs about teaching permaculture as an integrated science framework after the In-class Permaculture Lesson (IPL), I found that PSTs' responses changed significantly. The findings suggest that PSTs experienced increases in their knowledge about permaculture as a self-sustained design system and about components in the food forest such as soil, plants, animals, and microorganisms. PSTs' self-evaluation about their knowledge changed significantly on four permaculture-related science concepts *(biodiversity, food forest, microorganisms, and soil).* Of the remaining five permaculture-related science concepts, self-evaluations of knowledge changed marginally significantly on two *(interaction of living organisms and pattern in nature)* and did not change significantly on three *(plants and their needs, animals and their needs, and climate*).

Some prior studies reported that teachers used school gardens to unify science concepts for elementary grades (Graham et al., 2004). For example, form and function of plants can be taught in the school gardens through observation of plants and their life cycles (Rye, et al., 2012). The current findings add to this literature because most science concepts can be unified by permaculture teaching including biodiversity, microorganisms, soil, interaction of living organisms, and patterns in nature.

Furthermore, the findings of this study demonstrate that designing a food forest in a school gardens could be an effective way to unify science concepts in elementary schools. This is because the findings demonstrate that learning about permaculture increased PSTs knowledge about identifying a new way about teaching in science and science concepts effectively. This result is consistent with previous research on school gardens and implementing gardening activities for integration of science concepts (Graham & Zidenberg-Cherr, 2005) because the results of the current study show that permaculture activities can be applied to teach science with hands-on learning, real life experiences, and developmentally appropriate for all elementary grades. It is also consistent with teaching life science concepts such as life cycles, ecology, soil, animals, and plants in the edible garden (Morgan, 2017). The findings of the current study suggest that permaculture concepts align with science TEKS to teach science. The current findings also extend these prior results because the response of PSTs from the activity justifying TEKS to the lesson plans demonstrated that most of the science TEKS for elementary grade levels can be unified with permaculture activities.

While responses of PSTs did not change significantly on plants and their needs, the results from PSTs' lesson plans showed that PSTs focused on plants and their sun requirements in a different way than traditional taught. PSTs experienced how plants' heights and locations affect to meet their sun requirements with hands-on experiences. They focused on the impacts on plants to each other on their food forest designs. In this way, the IPL helped PSTs to have new ways to use their prior knowledge on plants and their needs by designing food forest.

In answer to my second research question about whether PSTs differ in their beliefs of teaching permaculture in their classrooms, I found that PSTs' responses changed significantly on understanding national and state science standards for science curriculum after the IPL. Furthermore, PSTs' responses changed significantly on teaching science concepts effectively and finding better ways to teach science than traditionally taught after the IPL. These findings are consistent with a prior study that focused on designing school gardens to help students learn science concepts better (Williams et al., 2018). As prior studies focused on school gardens to teach science with observation, experimentation, and gaining knowledge about natural process (Blair, 2009), the current study adds to this literature by unifying science concepts with hands-on activities and real life experiences in the food forest. Also, the current study shows that how permaculture can easily be applied to different science standards. For example, we identified for grade K, the TEKS 9 (B) *examine evidence that living organisms have basic needs such as food, water, and shelter for animals and air, water, nutrients, sunlight, and space for plants* during the in class alignment of TEKS and permaculture activity. Permaculture can also be applied to other states science standards because they have similar science standards. For instance, Colorado academic science standard for preschool is *recognizing that living things have unique characteristics and basic needs that can be observed and studied* to indicate observing and describing how natural habitats provide for the basic needs of plants and animals with respect to shelter, food, water, air and light. Another example is Illinois learning standards in science for kindergarten for Earth and Human activity. Students are expected to develop understanding of what plants and animals (including humans) need to survive and the relationship between their needs and where they live. Permaculture can be applied to other states science standards.

The results of the current study suggests that there are several advantages of applying permaculture to teaching science in elementary school grades. First, PSTs found that permaculture activities were developmentally appropriate to conduct K-5 grade variation. It seems reasonable that PSTs can make changes to permaculture activities to adapt them to different grade levels. The second advantage was that permaculture activities provide hands-on learning. This finding is consistent with a prior study that showed sustainable food production in the garden helps students to be more engaged with the natural environment and learn science concepts better (Lebo & Eames, 2015). My findings also extend this prior study's result with the advantage of real life experiences provided by permaculture activities. Engagement of students in the gardens provides them with interactive real-world experiences. The last advantage was that permaculture activities encouraged the teaching of environmental consciousness to students. Similarly, a prior study indicated that a permaculture approach to teaching science encourages students' understanding of sustainable thinking (Nelson, 2013).

Some previous research suggest that there are some barriers to conducting gardening activities to enhance science learning such as time, curricular materials connected to academic standards, lack of teachers' interest and experience (Graham & Zidenberg-Cherr, 2005), funding (Smith et al., 2019), and space (Burt et al., 2018). I found similar results with the previous study that PSTs' responses showed several disadvantages of permaculture activities. They are space, budget, and time. In contrast to the research that indicates lack of teachers' interest and knowledge as other barriers (Graham & Zidenberg-Cherr, 2005), the current study demonstrated that all PSTs reported that they would like to use school gardens to implement science curriculum because they a) have interest in gardening activities with students, b) have enough time to spend in the garden with students, c) know how gardening aligns with science curriculum or science standards, d) have the resources, and e) have enough knowledge to do gardening activities. Moreover, PSTs responded positively to finding curricular materials connected to academic standards to apply permaculture in schools to teach science although teachers found this as a barrier in previous studies.

Implications

This study was conducted to investigate preservice teachers' understanding of and beliefs about applying permaculture design to unify science concepts in the schools. The results of the current study suggest that permaculture could increase understanding and beliefs of preservice teachers to teach unified science concepts in elementary schools in the following ways.

First, teacher preparation programs could emphasize the importance of a permaculture curriculum to unify science concepts to teach science in a way that results in better science achievements in elementary grade levels. Because preservice teachers might not know about permaculture activities, a program can provide workshops and information sessions that introduce permaculture concepts and explain teaching science in school gardens. Also, preservice teachers can be provided hands-on practices for food forest gardens. It can help them to initiate permaculture activities in their schools.

Second, because the results of this study showed that finding space and budget is a concern for teachers to design school gardens, administrators and policy makers would consider about new policy to find a space and budget for food forest gardens in the schools. Also, schools can get some help from their communities and parents to design and sustain food forest gardens.

Additionally, published permaculture curriculum for elementary school grade levels can be a guide for teachers to conduct permaculture activities. The results of the current study showed that understanding of PSTs increased on how permaculture can unify science state science standards and PSTs would use permaculture curriculum if it were available for them. Thus, a published permaculture curriculum would help to enhance students' conceptual understanding of science as Nogay (1994) mentioned that conceptually integrated science curriculum improves students' science learning.

Finally, this current study models how other integrated concepts from sustainability such as carbon foot print or food miles could be evaluated for use with PSTs as a means to improve science learning and provide hands on activities. By incorporating into the lesson plan intervention an activity about the relationship of sustainability concepts to state standards such as TEKS the method outlined the current study not only improves PSTs' understanding of integrated science teaching but also provides them the rationale for incorporating sustainability in their teaching. In a teaching landscape governed by "teaching to the test" one way to increase sustainability concepts in the curricula is to connect teaching sustainability with improved learning outcomes.

Limitations and Further Research

While the study contributes to the literature to unify science concepts with permaculture teaching, there are some limitations to consider. First, the small sample population can be a limitation to generalize the results because there were only 22 participants. Generalization of the study should be done with caution. The second limitation is that all participants were studying at the same university, the understanding and beliefs of PSTs can be restricted to science and permaculture concepts. Therefore, the results should be generalized with caution because different results could emerge from PSTs who are studying at different universities. Third, the data was collected in Texas and this study focused on Texas Essentials Knowledge and Skills for science standards. Generalization of the results beyond Texas should be made with great caution as there are differences in the science education standards across the U.S. Fourth limitation is the PSTs' knowledge about TEKS and NGSS. PSTs had completed two class periods before and after the IPL. During these classes, they learned more about NGSS and TEKS in their science method course. Their knowledge and understanding the NGSS and TEKS for science curriculum can be affected by their continued instruction in the science course.

As the current study found that PSTs' beliefs about teaching permaculture to unify science concepts and teaching permaculture in their classrooms, future research can explore the same research with in-service elementary teachers. Implementing permaculture curriculum to unify science concepts in the classrooms and student learning outcomes would help to extend this research. Adding a new research question (how students will respond to permaculture learning in the schools?) to the current research questions can help to conduct the future research with elementary school teachers. A goal of a future study would be for elementary teachers to apply permaculture curriculum to unify science concepts in their schools.

APPENDIX SECTION

APPENDIX A

Consent Form

Sonnur Ozturk, a graduate student at Texas State University, is conducting a research study to evaluate the effectiveness of an integrated curricular design involving permaculture on pre-service teacher attitudes and beliefs about teaching science curriculum in elementary school grades. You are being asked to complete this pretest because you are a preservice teacher and studying at Texas State University.

Participation is voluntary. If you agree to take part in this research you are providing us permission to use your data collected from the pretest, workshop, and post test administered as part of your class. The pretest and post tests will take approximately 10 minutes or less to complete. . The workshop training will take place during a Science in Elementary Education course and this session will be approximately 75 minutes long. I will examine the lesson plans as a part of my qualitative findings. After the training, The posttest will be conducted one week after the training. You must be at least 18 years old.

This study involves no foreseeable risks. We ask that you try to answer all questions; however, if there are any items that make you uncomfortable or that you would prefer to skip, please leave the answer blank. Your responses will be kept confidential.

Possible benefits from this study are:

- Learning more about what permaculture is.
- How permaculture can be integrated with elementary science curriculum.
- How permaculture concepts can align with Texas Essential Knowledge and Skills (TEKS).

The findings of this study may help in-service teachers to choose permaculture design to teach science curriculum in their schools. It also may help educator preparation programs to teach science curriculum to elementary pre-service teachers.

Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. Dr. Forsythe will not have access to the preservice teacher consent forms or analyze study data that has not been de-identified until after final course grades have been submitted. The members of the research team and the Texas State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is completed and then destroyed.

If you have any questions or concerns feel free to contact Sonnur Ozturk or her faculty advisor Dr. Jim Van Overschelde.

Sonnur Ozturk, Graduate Student
Professor Sustainability Studies
512-618-5628
s_o160@txstate.edu

Jim Van Overschelde, Assoc.
Curriculum & Instruction
512-245-9112
jimvano@txstate.edu

This project 6571 was approved by the Texas State IRB on September 24, 2019. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Denise Gobert 512-716-2652 – (dgobert@txstate.edu) or to Monica Gonzales, IRB Regulatory Manager 512-245-2334 - (meg201@txstate.edu).

Contact the researcher by email if **you choose not to participate**. Otherwise your deidentified class work will be used for analysis.

RESPECT FOR PERSONS ★ BENEFICENCE ★ JUSTICE
TEXAS STATE
Exempt Review
9/24/2019
INSTITUTIONAL REVIEW BOARD

Pretest

Master's Thesis Questionnaire: Permaculture to teach science in EC-6 classrooms

My name is Sonnur Ozturk and I am currently a student for a Master in Sustainability Studies at Texas State University. I am conducting research into preservice teachers' attitudes toward permaculture to teach science in EC-6 classrooms. This survey consists of 16 questions and it will take no longer than 10 minutes to complete. Demographic information and your identification code are requested only for comparative study and all answers you provide will be kept anonymous.

Thank you for agreeing to take part in this study.

1. **Please type your identification code.**

• Your first name initial (if none, write X)
• Your last name initial (if none, write X)
• Last 4 digits of your phone number (if none, write X)
• (e.g., SO5628)

2. **What is your gender identity?**

- Woman
- Man
- Genderqueer or non-binary
- Agender
- Not specified above, please specify

4. **Please describe your race/ethnicity.**

- 1) American Indian or Alaska Native
- 2) Asian
- 3) Black or African American
- 4) Native Hawaiian or Other Pacific Islander
- 5) White

5. **What is your age?**

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 or older

6. **I know and understand the NGSS for science curriculum**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

7. **I know and understand TEKS for science curriculum**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

8. **I can teach science concepts effectively**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

9. **I can find better ways to teach elementary science than traditionally taught**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly agree

10. **I like gardening activities? (i.e. growing vegetables, fruits, and herbs, mowing, or digging)**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

11. **Do you have access to a garden for these activities?**

- Yes
- No

12. **If you knew how, would you like to use school garden to implement science curriculum?**

- Yes
- No

13. **If you selected "No", then please select the following reason or reasons**

- don't have enough time to spend in the garden with students
- don't have enough knowledge to do gardening activities
- don't have interest work in gardening with students
- don't see how gardening aligns with science curriculum or science standards
- don't have the resources

14. **If you selected "Yes", then please select the following reason or reasons**

- have interest work in gardening with students
- have enough time to spend in the garden with students
- know how gardening aligns with science curriculum or science standards
- have the resources
- have enough knowledge to do gardening activities

15. **Have you had any garden-based training in recent years? (Check all that apply.)**

- Onsite, school sponsored garden training
- Offsite,in-person workshop, conference, or seminar
- Webinars or online courses
- No formal garden-based training
- Other

16. **Biodiversity**

	0	1	2	3	4	5	6	7	8	9	10	
None												Expert

17. **Food Forest**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

18. **Microorganisms**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

19. **Soil**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

20. **Pattern in nature**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

21. **Interaction of living organisms**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

22. **Plants and their needs**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

23. **Animals and their needs**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

24. **Climate**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

25. **Permaculture is**

- ⬭ is the study of insects, including related arthropods.
- ⬭ the art and science of cultivating the soil, growing crops and raising livestock.
- ⬭ consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber, and energy for provision of local needs.
- ⬭ the art and science of growing and handling fruits, nuts, vegetables, herbs, flowers, foliage plants, woody ornamentals, and turf.

Posttest

Master's Thesis Questionnaire: Permaculture to teach science in EC-6 classrooms

My name is Sonnur Ozturk and I am currently a student for a Master in Sustainability Studies at Texas State University. I am conducting research into preservice teachers' attitudes toward permaculture to teach science in EC-6 classrooms. This survey consists of 16 questions and it will take no longer than 10 minutes to complete. Demographic information and your identification code are requested only for comparative study and all answers you provide will be kept anonymous.

Thank you for agreeing to take part in this study.

1. **Please type your identification code.**

• Your first name initial (if none, write X)
• Your last name initial (if none, write X)
• Last 4 digits of your phone number (if none, write X)
• (e.g., SO5628)

____

2. **What is your gender identity?**

- ◯ Woman
- ◯ Man
- ◯ Genderqueer or non-binary
- ◯ Agender
- ◯ Not specified above, please specify

4. **Please describe your race/ethnicity.**

- ◯ 1) American Indian or Alaska Native
- ◯ 2) Asian
- ◯ 3) Black or African American
- ◯ 4) Native Hawaiian or Other Pacific Islander
- ◯ 5) White

5. **What is your age?**

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 or older

6. **I know and understand the NGSS for science curriculum**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

7. **I know and understand TEKS for science curriculum**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

8. **I can teach science concepts effectively**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

9. **I can find better ways to teach elementary science than traditionally taught**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly agree

10. **I like gardening activities? (i.e. growing vegetables, fruits, and herbs, mowing, or digging)**

	0	1	2	3	4	5	6	7	8	9	10	
Strongly Disagree												Strongly Agree

11. **Do you have access to a garden for these activities?**

- Yes
- No

12. **If you knew how, would you like to use school garden to implement science curriculum?**

- Yes
- No

13. **If you selected "No", then please select the following reason or reasons**

- don't have enough time to spend in the garden with students
- don't have enough knowledge to do gardening activities
- don't have interest work in gardening with students
- don't see how gardening aligns with science curriculum or science standards
- don't have the resources

14. **If you selected "Yes", then please select the following reason or reasons**

- have interest work in gardening with students
- have enough time to spend in the garden with students
- know how gardening aligns with science curriculum or science standards
- have the resources
- have enough knowledge to do gardening activities

15. **Have you had any garden-based training in recent years? (Check all that apply.)**

- Onsite, school sponsored garden training
- Offsite,in-person workshop, conference, or seminar
- Webinars or online courses
- No formal garden-based training
- Other

16. **Biodiversity**

	0	1	2	3	4	5	6	7	8	9	10	
None												Expert

17. **Food Forest**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

18. **Microorganisms**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

19. **Soil**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

20. **Pattern in nature**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

21. **Interaction of living organisms**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

22. **Plants and their needs**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

23. **Animals and their needs**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

24. **Climate**

	0	1	2	3	4	5	6	7	8	9	10	
None	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Expert

25. **Permaculture is**

- ⬭ is the study of insects, including related arthropods.
- ⬭ the art and science of cultivating the soil, growing crops and raising livestock.
- ⬭ consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber, and energy for provision of local needs.
- ⬭ the art and science of growing and handling fruits, nuts, vegetables, herbs, flowers, foliage plants, woody ornamentals, and turf.

26. **If you have hands-on permaculture lesson plans connected to science curricula, would you use them?**

- ⬭ Yes
- ⬭ No
- ⬭ Maybe

APPENDIX B

IPL Handout

PERMACULTURE TO TEACH SCIENCE IN THE EC-6 CLASSROOMS

Outline

- Discussion about Permaculture
- 1st activity
  - Food Forest Design
- 2nd activity
  - Assigning Science TEKS to the Permaculture Activities

What is a Food Forest?

- The forest ecosystem consists of different kinds of plants, animals, and microorganisms, and there is a complex relationship between all these species to create a self-sustained ecosystem.
- A food forest mimics a forest edge that is planted with edible plants.
- Understand how nature design forest systems. They are self-maintaining
- We can model this system with productive species.

What is Permaculture?

- Bill Mollison and David Holmgren -1970s
- Combination of the words "permanent" and "agriculture
- Maintaining itself and does not require annual inputs
- a continuous cycle : one output can be an input for another in nature
  - For instance, dead plants become composted for soil and new growing plants.
- Focus on the observation and replication of natural patterns in the environment
- By using natural patterns, we are consciously designing and maintaining productive systems

TEKS Worksheet

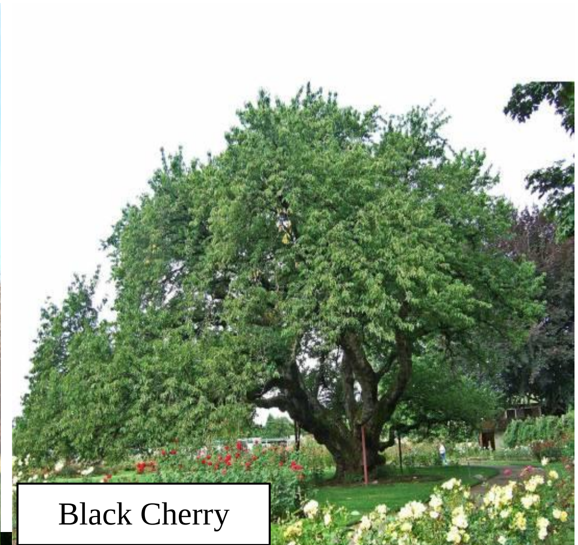
Lesson Plan (A-B-C-D-E-F)	**Grade**	**Science TEKS**	**Justify** (Why did you choose these science TEKS?)	**Would you use this activity in the classroom? Why/Why not?** **0** ⟷ **5**

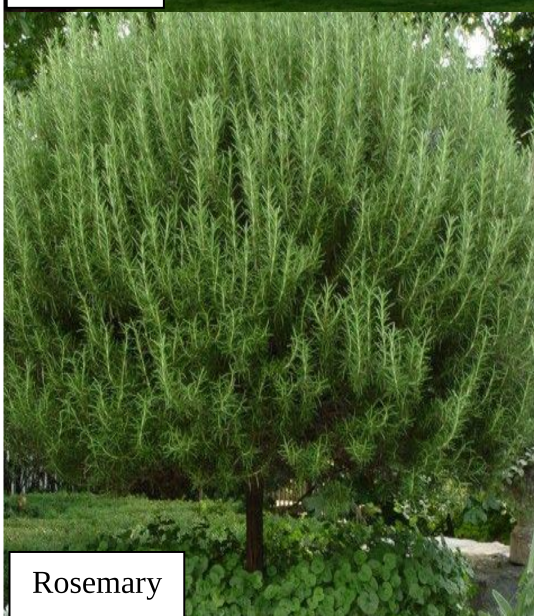
List of the Plants and Their Needs

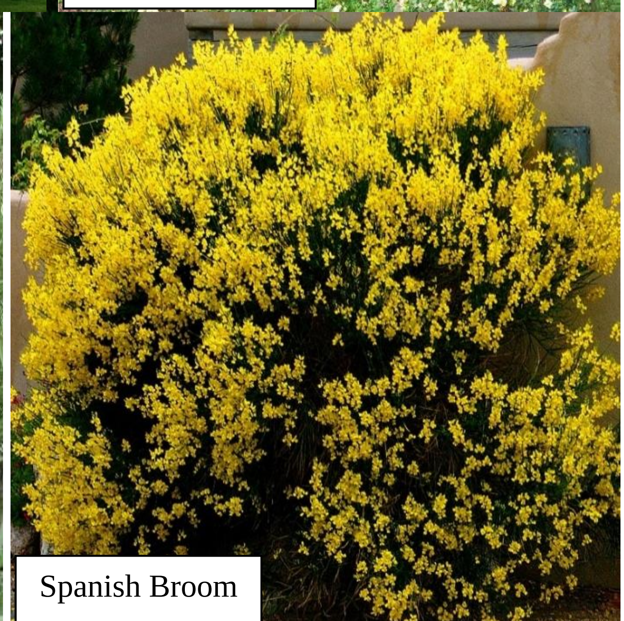
Name	Layer	Height (ft)	Sun
Black Cherry	Canopy	45-50	Full, Partial
Ginkgo	Canopy	25–50	Full, Partial
Red Mulberry	Canopy	35-50	Full, Partial
Japanese pagoda tree	Canopy	50-75	Full, Partial
Loquat 'Japanese Plum'	Understory	10-20	Full
Persimmon	Understory	15 - 20	Full
Peach Tree	Understory	15	Full
Cherry Tree	Understory	15-20	Full
Olive Tree	Understory	20	Full
Red Pomegranate	Understory	8-10	Full
Avocado	Understory	15-20	Full-Partial
Apple	Understory	10-20	Full
Italian Alder	Understory	30-50	Full-Partial
Golden Chain Tree	Understory	20	Full-Partial
Blackberry	Shrub	8-10	Full-Partial
Goji Berry	Shrub	8-10	Full-Partial
Mulberry	Shrub	30-35	Full-Partial
Rosemary	Shrub	2-3	Full
Lavender	Shrub	2-3	Full
Indigo	Shrub	4	Full-Partial
Spanish Broom	Shrub	6-10	Full
Comfrey	Herbaceous	36-60	Full, Partial
Parsley	Herbaceous	24-36 "	Full, Partial
Partridge Pea	Herbaceous	12-36 "	Full, Partial
Narrow Leaf Coneflower	Herbaceous	18-24 "	Full, Partial
Lemon Balm	Herbaceous	12-18 "	Full
Catnip	Herbaceous	36-48 "	Full, Partial
Frog Fruit	Ground Cover	0.5	Full, Partial
Peanuts	Ground Cover	1-3	Full, Partial
Sugar Beet	Underground	18 "	Full
Sweet Potatoes	Underground	15 "	Full, Partial
Grape	Vertical	4-6	Full
Passionflower	Vertical	20	Full
Chinese Knotweed	Vertical	10-15	Partial

Pictures of the Plants


Ginkgo

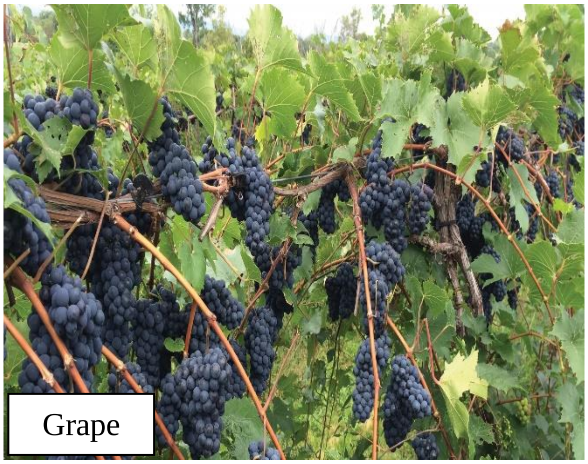

Black Cherry


Rosemary


Spanish Broom

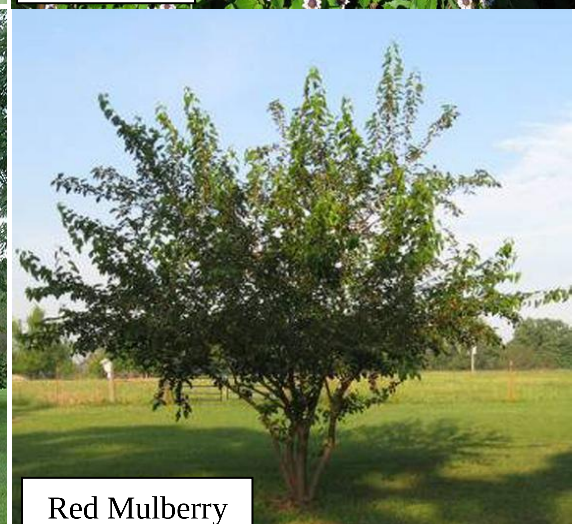

Parsley


Catnip

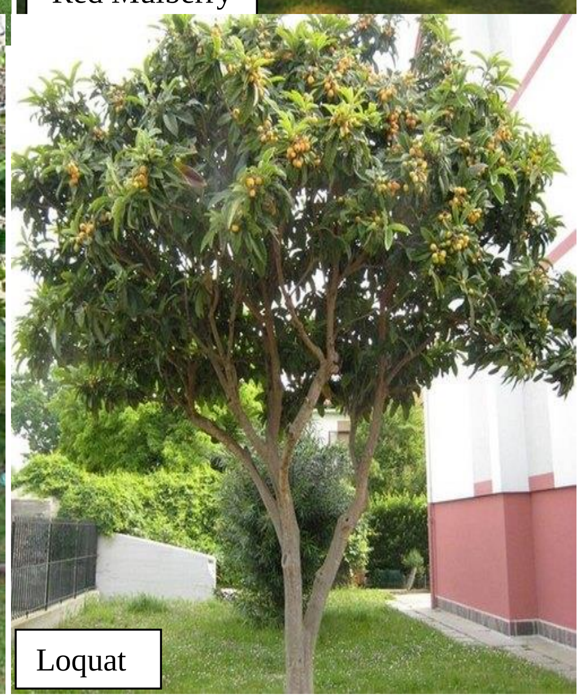

Grape


Frog Fruit


Japanese pagoda tree


Red Mulberry


Persimmo


Loquat

Published Lesson Plans

Lesson Plan - A

Forest Floor Investigation

ALABAMA OUTDOOR CLASSROOM ACTIVITY

Grade Levels
3-7

Overview
While exploring the forest floor, the students will learn about the various organisms that live in and under the leaf litter, including a variety of decomposers.

Subject Areas
Biology, Mathematics and Environmental Sciences

Duration
1 period of 45 minutes

Learning Objectives
1) Students will discover a variety of organisms that live on the forest floor while conducting an investigation. 2) Students will identify and draw sketches of organisms that they find during this activity. 3) The students will learn about the role that decomposers play in the environment.

Alabama Course of Study Objectives (on page 2)

Vocabulary:
Fungi, fungi strands, decomposers, organic, compost

Materials
- One hula-hoop per group of students (4 students per group works well)
- One clipboard per student or team of students
- Copies of Worksheets (two different worksheets attached)
- One magnifying glass or loupe per person
- Trowels or other digging tools
- Clear containers for holding moving organisms until activity is finished

Page 1 of 2

Background Info

Leaves, sticks, logs and other organic materials are constantly being added to the forest floor. With this constant flow of organic material being added to the forest floor, it would be impossible within a short period of time to even walk around under the forest canopy. Thanks to a host of small organisms (decomposers), this layer of organic material is constantly being broken down (composted) into soil. If we look closely at the forest floor, we will discover that there are a lot of organisms living right under our feet. This activity will have the students examine the forest floor for signs of life through a "hands-on" investigation. At the end of this activity, the students will discover that there is an abundance of biodiversity inside an area the size of a hula-hoop and that this biodiversity is vital to the health of a forest.

Preparation

Before doing this activity, find a place that has a tree canopy and room under the trees to spread out several hula hoops. It will be even better if there is a nice layer of leaves as well as rotting wood in the form of sticks, or logs scattered about. If an area of trees is not available, then this activity may be done anywhere on the school-grounds or surrounding area. You will also want to make copies of the attached Nature Journal Work Page.

Grade Level Variations

Grades K-2: This activity can be easily adapted for this age group. Have them focus on the decomposition of leaves and how this helps enrich the soil by moving nutrients from the leaves back into the soil where they are used by the tree again. Stress cycles such as the life cycle and seasonal cycle with this age group.

Grades 3-5: This activity can be used *as written* with this age group. Stress cycles such as the nutrient cycle, life cycle, and water cycle.

Grades 6-7: This activity can be used *as written* with this age group. Stress cycles such as the nutrient cycle, life cycle, carbon-oxygen cycle, nitrogen cycle, and water cycle.

Procedure

1. Introduce cycles to the class such as the Life Cycle, Carbon-Oxygen Cycle, Nitrogen Cycle, Water Cycle, Seasonal Cycle, etc. What are some constant cycles that take place in the forest environment? List these cycles on a chart for further study if possible.

2. Today, we want to focus on the nutrient cycle. Begin this discussion by asking the students what happens each fall to the trees in a forest or their front yard? Why isn't there a huge pile of leaves and other forest material under the trees? What happens to all of this organic material? What kinds of organisms do you think live in the forest that reduce this layer of organic material? What happens to the nutrients that were used to produce this material?

3. Place the students into groups of approximately four students. Give each group a hula-hoop, clipboard, and pencil. Give each student a magnifying glass to use for a closer look at the living organisms they discover.

Forest Floor Investigation

ALABAMA OUTDOOR CLASSROOM ACTIVITY

Alabama Course of Study Objectives
Science:
Kindergarten: 6, 7, 8
First: 1, 4, 7, 10
Second: 5, 6, 7
Third: 2, 7, 8,10, 13
Fourth: 5, 6
Fifth: 9
Sixth: 3, 7
Seventh: 1, 4, 5, 7

Literature Connections:
Cooper, Sharon Katz, **Rotten Logs and Forest Floors**
ISBN-978-1-4109-3501-4

Pascoe, Elaine, **Nature Close-Up Juniors: Forest Floor,**
ISBN-10:1410303144

Outdoor Classroom Connection
Students will learn about the forest floor and the various organisms that can be found living there, including decomposers.

Other Related Conservation Education Activities

Project Learning Tree
⇒ *The Forest of S.T. Shrew*
⇒ *The Fallen Log*
⇒ *Nature's Recyclers*

Access Nature
⇒ *Compost Crazy*

Project WILD
⇒ *Eco Enrichers*

Procedure continued...

4. Instruct the students that their job today is to help count the types and numbers of organisms that live in an area the size of their hula-hoop.

5. Have the students place the hula-hoop on the forest floor. Once they have placed the hoop and have started the activity, do not let them move the hoop to a new location as this is their survey area.

6. (Observation #1) Begin the activity by having the students take the observation worksheet and begin observing the area inside the hoop. They are to record all of the organisms (living and not living anymore) that they see inside the hoop on the worksheet. While doing the first step of the activity, do not let them touch or move anything inside the hoop. This step will take between 5 and 10 minutes. If they find any moving organisms, they may place then in the plastic collection containers.

7. (Observation #2) Once they have observed the surface, have the students carefully remove the leaves and sticks without digging in the soil and tell them to watch for living things. **Caution the students not to harm any of the living organisms and do not step inside the hoop.** Have them lay the items around the outside of the circle. When they see an organism, they need to record its presences on the worksheet. If it is something they have already seen they will need to make a tally mark beside the organism so that they can record a population total. They also need to list at least three adjectives about each of the organisms they find. They also need to observe how the structure of the leaves changes as they move from the top layer to the bottom layer.

8. (Observation #3) Once the leaves have been removed, they may use the digging tools to carefully excavate the soil to a depth of about 4-6 inches. As they do the digging, have the students record any organisms that they see in the soil.

9. Once all three observations are completed, have the students return the soil, organisms and leaves to the area.

10. Have the students describe what they see and have them share their observations. For example, they should have noticed that the leaves are being broken down as you move from the top layer to the soil surface. They should also notice that the color of the soil may change as you dig downward into the soil. They will also notice that digging in the forest is very hard due to the roots that are located in the soil.

11. Have the students construct graphs to show what and how many organisms they found in their area.

Extensions

1. Have the students repeat this activity in other areas that have a different use. For example, repeat the activity in a grassy yard or on a bare ground playground.

2. Have each student write a descriptive paragraph about one of the organisms (they could do research about that organisms) that they discovered, using the adjectives that they recorded earlier.

ALABAMA OUTDOOR CLASSROOM

Date: ____________________________ Name of Naturalist: __________________________________

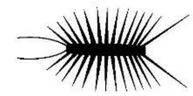
Forest Floor Investigation Activity Page

Please complete the sections marked with a millipede first, before completing the rest of the page. Please include sketches of what you observe and use tally marks beside you drawings if you find more than one member of each specimen.

What do you think you will find on the surface (don't disturb the area) of your sample area?
List what you observe in your sample area without disturbing the surface area.
What do you think you will find under the leaf litter in your sample area?
List what you observe while carefully removing the leaf litter, but don't disturb the soil.
What do you think you will find in the soil once you start digging in your sample area?
List what you observe while digging below the surface.

Date: ____________   **Name:** ______________________________

Getting Down and Dirty With Nature



Forest Floor Investigation

ALABAMA OUTDOOR CLASSROOM

While examining the forest floor, complete a specimen data square for each specimen that you discover during your investigation. There are more spaces on the back of the work page.

Description: **Drawing:**	**Description:** **Drawing**
Description: **Drawing:**	**Description:** **Drawing:**
Description: **Drawing:**	**Description:** **Drawing:**

Description: **Drawing:**	**Description:** **Drawing**
Description: **Drawing:**	**Description:** **Drawing:**
Description: **Drawing:**	**Description:** **Drawing:**
Description: **Drawing:**	**Description:** **Drawing:**

The Alabama Outdoor Classroom Program is a partnership between:

Lesson Plan - B

Year 1

Spring 5: Planting the Summer Garden

Objectives

Students will be able to:

- Describe the difference in lifecycles between cool season and warm season crops and how they relate to climate
- Identify certain plants which cannot survive year round in their local climate
- Communicate specific plant needs and garden accordingly

NGSS Primary Standard:

3LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction and death.

Disciplinary Core Ideas:

LS1.B: Growth and Development of Organisms Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)

Cross-cutting Concepts:

Patterns Patterns of change can be used to make predictions. (3-LS1-1)

Lesson Length
45-60 minutes

Vocabulary
climate, diversity, life cycle, reproduction, season

Summary

During this lesson students will learn about the seasonality of plants in connection to their climate. Students will mimic diverse plant lifecycles through a game, plant summer crops and survey the garden for different plant lifecycle stages.

Background

In temperate climates weather patterns shift yearly along with sun exposure, temperature, precipitation and humidity. These environmental changes directly affect crops by altering their resources. For instance, in the summer there is an abundance of sun which plants use to photosynthesize (creating food), however in winter, the sun becomes far less available and thus plants must either be adapted to cope with the lack of this resource (by storing food in roots, having thicker leaves or needles or slowing growth down to minimum to preserve food) or otherwise reproduce and perish. As the season and climate changes, so does the diversity of life within the garden. Bees and butterflies get to work again as the sun makes its return, and plants gain more opportunities to create food and grow. This growth helps them to produce flowers, become pollinated and create fruits and go to seed. This seasonal ebb and flow drastically affects the types of crops which can be planted and grown at different times throughout the year.

By observing the seasonality of crops, students can plan and plant gardens with appropriate species. Too much sun is not always the best for tender greens such as spinach and lettuce, however, without the blasting summer heat, corn and tomatoes would not be possible. By gaining an understanding of cool season vs. warm season crops, students can expand their knowledge of plants and their lifecycles, taste a greater diversity of foods, and improve soil health and habitat within their garden.

Materials
- Harvest trading cards for game
- Seeds and starts for summer crops
- Plant lifecycle sheets
- Blank garden maps (optional)
- Pencils/ colored pencils for drawing

Preparation

Garden Tasks
- This is the last chance to harvest things for the kids to take home.
- Plant the last of the warm crops- tomatoes, pepper, squash, corn, melons.
- Get the summer watering system set up
- Do end of the year weeding to set the garden up for success through the summer

Procedure

Classroom Introduction

Begin the lesson by showing students pictures of different fruits and vegetables one at a time. Students will be using a thumbs up/thumbs down approach to share whether they believe that the food shown can grow locally. Be sure to include tropical foods such as bananas, citrus and coconut. Once students have a peeked interest, ask them to explain why, for instance, a coconut cannot grow in your local climate.
The answers are all directly related to plant needs and habitat. Plants need food, water, sunlight, air, soil and nutrients, but not all plant species require the same amount of these resources. Just as different animals such as wolves and lions eat and live very differently, plants too have unique needs, which vary among species, and enable survival. Students recognize that a polar bear could not survive in the jungle so it becomes easy to accept that a mango would not survive in Antarctica.

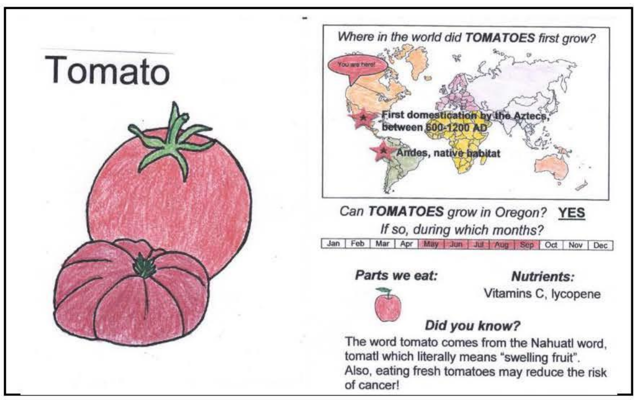
Tomatoes are a great example of diverse plant lifecycles, especially in more temperate climates. Ask students if they have ever seen a tomato growing locally- many will say yes. Now ask students to describe the season when they have seen tomatoes grow. Tomatoes are an annual plant in temperate climates, meaning that they cannot survive year round (in their native habitat, tomatoes are perennial plants but are grown as tender annuals in temperate climates). If tomatoes can only live for four to five months in a particular climate, how long is their lifecycle? Have students revisit plant lifecycles briefly and describe the steps from seed to seed which a plant takes throughout its life.

Does the changing of season have an effect on what we can grow in our garden? The answer is yes. As days become longer, warmer and less rainy, different plants will grow well, while others may begin to grow less, or even complete their lifecycle by going to seed. This means that the types of crops we can plant will change along with the season. Explain to students that in the garden, they will be learning more about different crops which can grow locally and when. They will then have the opportunity to use that knowledge to plan and plant a summer garden with plants which cannot normally grow during the colder months of the school year.

Supporting Activities

Planting the Summer Garden

During this activity, students will be working to plant summer specific crops based on what they have learned in the classroom. This is a great time to seed beans and corn, or transplant squash and tomatoes into the garden. Have students compare the difference between the plants they put into the garden during the fall vs what they are planting presently. Some good questions to ask students include: did any fall plants complete their lifecycles already? Are any plants still thriving now? What do they notice about these plants? If there is time after planting, have students do any necessary weeding or garden clean up.



Seasonal Plants Game

During this activity students will be using the Harvest Trading Cards *(found in the materials section)* to act out the varying lifecycles of plants. To begin the game, give each student a different food card from the harvest trading cards set. On the front of each card is a picture of a fruit or vegetable which can grow in a temperate climate. The back of the card has a chart which includes the months during which the plant can grow (specifically for Oregon). Not all plants can grow year round although some can.

To play the game, have all students gather at a cone or marked area. Explain to students that they are currently in the "seed bank" (*they may be seeds in the soil which have spread on their own or seeds being stored by humans for use*). In the seed bank, students must wait to germinate until the month when they can begin their lifecycle. Depending on which plant you are, you may get to begin germinating immediately or wait, sometimes for a long time, before you begin to grow.

You will be going through the months of the year, beginning with January. If your plant can germinate in January (the month is colored in) you get to take a hop forward and shout out the name of your food. If you cannot germinate then you have to stay put in the seed bank.

As the adult, go through the different months seasonally (using 3 month increments) being sure to pause and have students share cards after March, June, September and December. Whenever a plant can grow during a month they get to take a hop forward. (For groups who can handle a bit of silliness, you can have crops, such as radishes, with very short lifecycles, die dramatically when there is a break or end to their growing season).

At the end of the "year" have students look around at the different crops. Warm season varieties such as corn, squash and tomatoes will be close together while brassicas and many "greens" will be farther away. This distance corresponds with the varying lifecycle lengths of the different plant varieties which is affected by the seasons when they can grow. Have your group gather back together at

Plant Lifecycles in my garden during: *(month)*	
Seeds and Sprouts	Growing Leaves
Flowering	Creating Fruit
Creating Seeds	Dead

the end of the game to share whether they can grow during the summer or not and whether their lifecycle was long or short.

Plant Lifecycle Hunt
During this activity, students will survey the garden to identify the different stages of life varying plants are in. Begin by handing each student a plant lifecycle sheet (as seen below). Students will be drawing a picture of the different lifecycles they see and if possible, recording the names of plants which are in the different stages of life. Give students 5-8 minutes to draw and identify what they see within their garden. Once students have found all of the different life stages,

gather back together as a group to share what they have discovered. Ask students to make a hypothesis as to why different types of plants are behaving differently in the garden. This hypothesis should be based on plant needs. Give time at the end to allow students to pair share their hypotheses with one another.

Wrap-up
At the end of the lesson, gather back together as a whole group. Ask students the question "why do different plants grow in winter compared to summer?" Be sure that students identify varying plant needs and lifecycles during this time.

Adaptations

To simplify
Keep the same introduction in the classroom then begin outdoors as a whole group playing the seasonal plants game. Then, have students break into small groups and rotate through any needed garden work including weeding, planting, and watering.

To add complexity
Have students create a yearly planting chart which maps out and communicates which local crops can grow when. Students can either create a yearly calendar or a seasonal wheel. Be sure to assign students or table groups no more than 10 plants with varying seasons to work with.

Rainy Day
Use the simplified lesson, seen above, but play the game as a whole group in a gym or covered area. Have students create a list of seasonal crops as a whole group indoors, based on what they learned during the game. End the lesson by giving students time to create a planting schedule for their local region/garden. You can have students use a map of their own garden and draw/label summer vs. fall crops or create a simple monthly planting chart which can be used to plan gardens in the future.

Lesson Plan - C

Whole Kids Foundation and American Heart Association

SCHOOL GARDENS LESSON PLANS

Composting: Healthy In + Healthy Out = Garden Goodness

Recommended Grade Level:
K-5

Season:
Year Round

Outdoor

Description:

Students create a class compost bin for the garden. Students collect food scraps from their breakfasts and/or lunches. Only certain types of healthier foods are collected (like inedible uncooked fresh fruit and vegetable peels, scraps and cores). Students will learn that leftovers of certain healthy foods they eat can also contribute to the health of their garden. Students will learn about the carbon/nitrogen cycle in compost (layering of brown and green material) to create a chemical reaction.

Background:

By creating compost, the students will learn the parts that make up the compost cycle. Many designs can be used to make a compost bin. This lesson uses a basic design for smaller scale composting. You can choose other designs or purchase one at a garden center. A compost pile needs: **nitrogen** that comes from fresh food scraps; **carbon** that comes from the brown layer from carbon rich brown items such as dried leaves or straw; **water** that helps the microbes and beneficial bugs convert the wastes to compost; and **air**. The students will learn that only certain healthy things can be put into the compost and how foods healthy for their bodies also create healthy benefits for the garden. This lesson may encourage students to increase their fruit and vegetable consumption and to care for the earth by reducing their waste and turning food waste into rich organic soil.

Materials:

- Plastic trash can with the bottom cut out
- Composting 101 Sheet
- Investigating Soil Worksheet (optional)
- Hand lens (optional)
- Compost thermometer to measure temperature (optional)

Preparation:

1. Remove the bottom of the trash can by cutting it off. Dig a hole about 10-12 inches into the ground and place the trash can in it. This will allow worms and microbes to interact with the compost and provide adequate drainage.
2. Collect dried leaves, newspaper, straw or other items that contain carbon to layer over food waste to create the brown layer. Reference the brown items in the Composting 101 Sheet for the items that contain carbon.

3. Determine what items will be allowed in the compost bin and how the items will be collected. Apple cores, orange and banana peels and melon rinds are examples of common food scraps from a school cafeteria. Produce with butter, salt or salad dressing should not be added; only fresh fruit and vegetable scraps.
4. As the compost pile builds, see the Compost Trouble Shooting Chart to make adjustments to the process.

Activity:

1. Gather the class and start a discussion on things they can do to help the environment, like recycling, picking up trash, not littering, conserving water, etc.
2. Explain composting to the students and tell them it's a way to reduce our trash while helping the garden at the same time.
3. Take them outside to the compost bin and explain how they will be contributing to the compost. Share with them things that can be composted and those that can't. Remind students that it's important for them to eat their healthy food before collecting items to add the compost bin.
4. Students come back to the classroom and create posters or flyers to show what items can be added to the compost bin. This can be placed in the cafeteria or classroom as a reminder. They can also write letters to their parents about composting and the importance of fruits and vegetables for their bodies and the garden.
5. Each day students will add the approved food scraps to the compost bin from their breakfasts and/or lunches. After the daily collection is deposited, add a small amount of the brown carbon layer. Once a week, the temperature of the compost will need to be monitored and then turned with a shovel or fork to add air. The ideal temperature is 120-160° Fahrenheit.

Tying it Together:

1. How are we helping the earth by composting?
   Less trash goes to the landfills and compost creates healthy soil.
2. How do healthy food scraps contribute to healthy soil?
   They contain nutrients and vitamins. They help plants grow just like they help our bodies grow and be healthy.
3. How are we helping our bodies by eating foods that can be composted?
   Only certain healthy foods should be composted. Healthy foods have vitamins and nutrients that we need to be healthy. If it is easy to break down in the compost, it is easier for our bodies to digest.

Digging Deeper:

Make a worm composting bin using vermicomposting worms. Vermicomposting is the process of using worms and micro-organisms to turn food scraps into a nutrient-rich compost. To create a worm bin, use a large tub with a lid (at least 10-gallon sized). Drill several holes in the bottom for drainage and several along the top for air. Fill half of the tub with soil and add vermicomposting worms, which can be purchased at a local bait shop or by inquiring at a local plant nursery. Place a 3-inch layer of shredded newspaper on top of the worms. Pour water on top of the newspaper to moisten. Lift the moistened newspaper and place small amounts of the food scraps collected for the compost below the newspaper to feed your worms. The food scraps should be placed in different locations in the bins to help you monitor the amount of food they're eating. The shredded newspaper should be replaced when there is a less than 3-inch layer covering your soil and worm.

Helpful Tips:

- Worms need moisture to breathe. Since worms don't have lungs, their skin has to stay damp for the exchange of oxygen coming into their bodies and carbon dioxide going out of their bodies. Continue to add water to the worm bin to keep the newspaper moist and damp.
- They are vegetarians. Do not add meat, cheese or dairy products. Only fruit and vegetable scraps with no additives should be added. If you have 1 pound of worms, you should feed them approximately 3 pounds of food scraps each week.
- Bury the food scraps in a new place every day. This will show the quantity of food that your worms are eating. If you add too much food, it will rot and start to smell. If you add too little, your worms will be hungry. Adding the right amount will make the worms happy and create rich amendments for your garden soil. This should be monitored weekly to see if the worms are eating the food.
- The worm bin can be located inside or outside. If your worm bin is kept inside, keep a tray or liner under it since there are holes in the bottom. If your worm bin is outside, find a shady and cool area to keep them. Worms do not like extreme temperatures. The worm bin should be kept in an area that is 50-80° Fahrenheit to keep them healthy.

Problem	Cause	Solution
Worms are dying	Too wet Too dry Not enough air	Add more shredded newspaper Moisten shredded newspaper Drill more holes
Bin stinks	Too much food Too wet	Do not feed for 2-3 weeks Add more shredded newspaper
Fruit Flies	Exposed food	Bury food in shredded newspaper

National Standards:

NGSS

- Interdependent relationships in ecosystems: Animals, plants, and their environment.
- Structure, function and information processing.
- Energy.
- Matter and energy in organisms and ecosystems.

Lesson Extensions:

Language Arts: Write a narrative on the steps of making a compost and what it takes to turn food waste into garden magic.

Write a description of the process of the compost cycle and describe what happens at each step.

Explain why we only use certain food scraps in our compost.

Math: Track and record the number of students who composted each day.

Measure the compost temperature and record. The ideal temperature is 120-160°Fahrenheit.

Track the length of time it takes for the compost to be ready. The compost pile is ready when the ingredients are dark brown and has a slight earthy smell. This can take 3-6 months.

Science: Grow the same plants in soil with compost and soil without compost. Study and collect data on their growth. Make predictions and conclusions on what healthy compost does to help grow healthier plants.

After six weeks of building compost, take a look at different soil samples (sand, compost, garden soil). Have students use the Soil Investigation Worksheet to make observations about what is found in different soil types.

Literature Connections:

Compost Stew by Mary McKenna and Ashley Wolf
Composting: Nature's Recyclers by Robin Michal Koontz
What's Sprouting in My Trash? A Book About Composting by Esther Porter

Investigating Soil

Look at sand, garden soil and compost with a hand lens or magnifying glass. List and sketch what you observed.

Sand	Garden Soil
Compost	**Benefits of Compost**

Composting 101

Greens – Nitrogen Rich

- Fruits and vegetable scraps
- Bread and grains
- Coffee grounds
- Coffee filters
- Green garden waste
- Paper tea bags with the staple removed

Browns – Carbon Rich

- Nut shells
- Sawdust from untreated wood
- Hay and straw
- Yard trimmings (e.g., leaves, branches, twigs)
- Wood chips
- Leaves
- Shredded newspaper

What not to add to the compost pile:

- Aluminum, tin or other metal
- Glass
- Dairy products (e.g., butter, milk, sour cream, yogurt) & eggs
- Fats, grease, lard, or oils
- Greasy or oily foods
- Meat or seafood scraps
- Pet wastes
- Plastic
- Stickers from fruits or vegetables (to prevent litter)
- Black walnut tree leaves or twigs
- Yard trimmings treated with chemical pesticides
- Roots of perennial weeds
- Coal or charcoal ash
- Treated or painted wood

Troubleshooting Your Pile

Problem	Cause	Solution
Bad Odor- Rotten Smell	Not enough air or too much moisture	Turn pile and incorporate coarse browns (sawdust, leaves)
Bad Odor- Ammonia Smell	Too much nitrogen	Incorporate coarse browns (sawdust, leaves)
Pile does not heat up or decomposes slowly	Pile too small	Add more organic matter
	Insufficient moisture	Turn pile and add water
	Lack of nitrogen	Incorporate food waste or grass clippings
	Not enough air	Turn pile
	Cold weather	Increase pile size or insulate with straw or a tarp

Adapted from EPA Composting Fact Sheet and How to Guide. http://www.epa.gov/waste/conserve/tools/greenscapes/pubs/compost-guide.pdf

Lesson Plan - D

Garden Habitat

Objectives
Students will be able to:
- Define the word habitat
- Identify resources in healthy habitats for plants and animals
- Identify and explain the connections between parts of a garden ecosystem
- Work cooperatively to implement a design solution for improving the health of their garden habitat for plants and animals.

NGSS Primary Standard:

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all

Disciplinary Core Ideas:

LS4.C: Adaptation For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

Cross-cutting Concept:

Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

NGSS Supporting Standards:

K-2 ETS1 Ask questions, make observations and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool

Background

During this lesson students will explore the garden habitat through game based learning, garden exploration and working in the garden to improve their own schoolyard habitat. Students will learn the importance of food, water and shelter, and begin to understand the different needs of organisms throughout the world.

Background

An **ecosystem** is a broad term for a community of interacting organisms and their environment. A **habitat** is the same concept on a smaller scale, referring to the natural home or environment of a particular animal, plant, or other organism. Habitats can be found everywhere. The habitat for a particular organism might be in a forest, a swamp, a small meadow, a particular city or even a building. Gardens provide habitats for many organisms, both plants and animals. Especially in cities, where green space can be hard to come by, gardens are a very important habitat for many small creatures.

A habitat must be able to meet four important needs for the organisms that call it home. They need to be able to find **water**, **food**, **shelter** and have enough **space** to thrive. If there is a lot of food, water, shelter and space to go around, the populations of organisms will rise, leading to overcrowding. Organisms within the habitat will then die or leave to find another space. Once the population goes back down, there will once again be an overabundance of habitat, leading to population climbs. The cyclical nature of populations of organisms within a habitat is naturally balanced by the amount of habitat.

K-2 ETS1 Develop a simple sketch, drawing or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

2ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

5PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion and to maintain body warmth) was once energy from the sun.

5PS3-1 Develop a model to describe the movement of matter among plants, animals, decomposers and the environment.

Lesson Length
45-60 minutes

Vocabulary
Habitat, ecosystem

Materials
- web of life cards and rope or yarn
- materials needed to make critter habitats
- Seeds and starts which improve habitat
- Paper, pencils and clipboards for four-corners activity if needed

Preparation
Set up the playing field with boundaries. If building critter shelters, make sure to gather all the needed materials ahead of time.

Gardens are a great source of habitat because they hold plenty of food. But they are sometimes lacking in a good water source or shelter for larger animals like amphibians and birds. Adding shelter and a year-round water source will encourage more animals to make their home in the garden. Utilizing the school garden, students have the opportunity to get hands-on with the concept of habitat, make changes to promote habitat and ultimately make observations and draw conclusions relating to cause and effect relationships which exist right outside of the classroom door.

Procedure

Classroom Introduction

Begin the lesson in the classroom by writing the word "Habitat" on the board. Ask students to raise their hands if they recognize the word. Next, explain that there are hundreds of different habitats on our planet. Ask students to name an example of a habitat. Encourage students to think of the ocean, arctic circles, jungles, forests, etc. Now ask, "Can a polar bear live in the rain forest?" Students will answer "no." Now ask students to raise their hands and explain why (you can also have them pair and share for this part of the introduction). Polar bears would not have the right type of food, water or shelter in the rain forest, they may get too hot, and they wouldn't be able to hide. Polar bears, like all living creatures, have adapted to live in a very specific habitat. Now ask students to brainstorm the three things that every habitat needs to support the creatures who live there. Food, water, and shelter are common amongst all habitats worldwide. Next ask students if they think that a school can be a habitat; how about a garden at our school?

Explain to students that today in their garden they will be looking at the food, water and shelter available, and doing work to improve the habitat around their school.

Supporting Activities

Below are a series of activities which can be used to help support the overarching concept for the day.

Web of Life

The web of life activity aims at getting students to think more deeply about the interdependence of plants and animals within a habitat. For instance, plants need to be pollinated to survive, and

Garden Tasks

- Seed flowers to attract beneficial insects
- Plant early spring greens, cover plants with cloches as needed
- Build pea trellis' and plant peas if needed
- Turn compost and look for decomposers

flowering plants provide nectar for bees who in turn distribute pollen amongst plants. Without one another, neither species would be able to survive. Begin by passing out a habitat card to each student (cards can be found in the materials extension or created with your own local habitat in mind). Have each student hold their cards so that everyone can see what they have. In this game the students will be trying to make as many connections between the cards as they can. Begin with the student holding the sun card- remind students that the sun is the original source of energy for all living things. The sun will hold onto one end of the yarn and pick one other person (based on the card they're holding) who needs them and explain why. From there the yarn is unrolled and passed to that person who in turn makes a connection to another card and the yarn continues around the circle, making connections between creatures until everyone in the group is holding onto the string. If one organism or part of a habitat in the circle has a problem then everything is affected. You can simulate this by having one person tug gently on the yarn. Anyone who feels the tug also tugs until everyone feels the effects. Have students observe the shifting web they have created.

With older students, you can use sturdy rope or webbing for this activity. In a field or safe area, have all students lean back, relying on the web you have created for support. Next, identify a species who can no longer survive in the habitat, and have them drop the rope/webbing in their hands. All of the other students will have to take a step back, losing their balance as the web (ecosystem) is impacted by species loss.

Improving Habitat in the Garden

There are numerous ways to increase habitat within your garden for both plants and animals. Below are some gardening tasks which can help to support a thriving habitat within your garden space.

- *Plants*: Work on tending the garden and making sure that plants have all of their needs being met: air, soil, space, sunlight, and water. This is a good time to thin seedlings, add compost or fertilizer, and potentially build a miniature greenhouse to provide more warmth during the cool season.

- *Animals*: Work on creating spaces for small animals like the mason bee house listed in extensions or the frog/toad houses, plant pollinator attractors, leave bits of materials for bird nests.

- *Pollinators:* This is a wonderful day to plant pollinator attracting flowers such as marigold, bachelor button and calendula. By providing vital food sources for pollinators, students will also be ensuring the health of their plants and the ability to make fruits and seeds.

- *Decomposers:* The garden is teeming with life beneath the soil. Worms, springtails, centipedes and roly-poly bugs are just a few examples of beneficial decomposers who help to recycle nutrients from dead and decaying materials back into vital food for our plants! To care for decomposers, have a group work on turning the compost pile, add leaf mulch to garden beds for worms, or check beneath logs, rocks and compost layers to observe the diversity of life which is often unseen!

Lesson Plan - E

Purpose

Students will learn about soil texture and determine the texture of several soil samples.

Materials

Activity 1: Dirt Shake

- Soil samples brought in by students from home, cleaned of rocks, roots, etc. (about 1 cup)
- Quart jars
- Rulers
- Alum (optional)

Activity 2: Soil Textures By Feel

- Soil samples of sand, silt, clay, and local soil
  - A Soil Sample Kit is available for purchase from agclassroomstore.com if local samples are not available.
- *Dirt Shake* handout
- *Soil Texture Triangle* handout
- Small bowls
- Spoons
- Water
- Bucket
- Newspaper

Essential Files (maps, charts, pictures, or documents)

- Soil-Themed Activity Sheets
- Dirt Shake Handout
- Soil Texture Triangle Handout

Vocabulary

sand: soil particle that measures between 2.00 and 0.05 mm.

clay: soil particle less than 0.002 mm.

loam: a mixture of sand, silt, and clay

silt: soil particle that is between 0.05 and 0.002 mm.

Did you know? (Ag Facts)

- Almost all the food you eat, the fiber used to make your clothing, and lumber to build homes is produced by soil.[1]

- One shovelful of soil can contain more species of living things than live in the Amazon rain forest above the ground.[1]
- 6 billion bacteria species can be found living in a cup of soil.[1]
- Farmers use conservation techniques and practices to help maintain fertile soil for planting crops.[1]

Background Agricultural Connections

Soil is the foundation of agriculture. Farmers know that different soils are suitable for different crops, but how do they recognize what type of soil they have? Texture is an easily recognizable property that informs farmers about how to manage their soils. Soil texture cannot be changed, and it affects the movement of water and nutrients in the root zone of plants. Clayey soils hold water and nutrients, while sandy soils drain and dry out quickly. Farmers will make different decisions about irrigation, tillage, and what type of crop to plant based on the texture of their soil. With some practice anyone can learn to recognize different soil textures by feel.

more ...

Interest Approach – Engagement

1. Start a conversation about soil with your students. Ask the following questions to build interest.
   - "What forms of life does soil support?" *(plants, bacteria, insects, earthworms, crops)*
   - "Name a function of soil that plants depend upon?" *(medium for plant growth, transports nutrients & water, anchors roots)*
   - "Do all soils look the same, feel the same, and contain the same nutrients?" *(no)*
   - "How do farmers find out what nutrients are missing in the soil before planting their crops?" *(take soil samples and have them analyzed in a laboratory)*
   - "What environmental factors play a role in determining soil types?" *(mineral material, time of formation, climate, landscape position, organisms)*

Procedures

Activity 1: Dirt Shake

1. Divide the students into groups of three or four. Provide each group with a soil sample or instruct each group to use one of the samples brought from home. *Two notes:*
   - *This activity will not work with most potting soil. Soil texture is an evaluation of the mineral component of soil; potting soil is mostly organic matter.*
   - *Remove rocks, roots, and anything else that is clearly not soil from samples and break up any large clumps before beginning.*
2. Provide each group with a quart jar. Instruct the students to place 2" to 4" of soil into the jar, measure the level of soil, and record the measurement as "total soil." It's important to measure and record the depth you start with so that you can accurately estimate the sand, silt, and clay fractions.
3. Add water until the jar is two-thirds to three-fourths full. Add one teaspoon of alum (found on the spice aisle of most grocery stores; it does help the soil settle faster, but is not necessary). Be sure the lid is tight.
4. Shake the jar vigorously until all the particles have been separated by the water, about two minutes. Set the jar down, and allow the soil to settle.
5. After 1 minute, measure the amount of soil on the bottom of the jar. Record this measurement and label it as the "sand fraction." Share the *Dirt Shake* and *Soil Texture Triangle* handouts with the students.

6. Allow the sample to settle for 3 to 4 hours, then measure again and record the level. This second layer indicates the silt fraction of your soil.
7. The remaining clay particles may take as long as a week to settle depending on the composition of the sample. However, you can use the measurements you already have to determine the amount of clay in the soil. Simply subtract the combined sand and silt measurements from the total soil measurement as shown below. Organic matter will float on the surface of the water. Generally it is a small component that won't affect your measurements, but if there is a floating organic layer large enough to measure, subtract its measurement from the total soil before calculating the clay fraction and before moving on to calculate percentages.
   - Total soil = 2"
   - Sand fraction (first layer) = 1"
   - Silt fraction (second layer) = 1/2"
   - Clay fraction (total soil - sand + silt)= 1/2"
8. Now convert the measurements into percentages as shown here:
   - Sand percentage (sand/total soil x 100) = (1 ÷ 2) x 100 = 50%
   - Silt percentage (silt/total soil x 100) = (1/2 ÷ 2) x 100 = 25%
   - Clay percentage (clay/total soil x 100) = (1/2 ÷ 2) x 100 = 25%

9. Once you know these percentages, use the *Soil Texture Triangle* handout to determine the name of the soil type.
10. Discuss the following questions:
    - *Why do the larger particles settle out first?*
    - *What is the stuff floating in the jar?*
    - *How does each person's sample compare?*

Activity 2: Soil Textures By Feel

1. Place four soil samples of at least three different textural types (sand, silt, clay, and loamy) into four separate bowls. Samples of sand, silt, and clay can be obtained from agclassroomstore.com (see Materials).
   - *Note: Samples can be reused if allowed to dry after each use. In each subsequent use, the samples can be moistened to a paste and textured as explained. To show students what the soils look like dry, use a mortar and pestle (a wooden dowel or carriage bolt and plastic bowl will work) to pulverize the sample to its original loose state.*
2. Share the *Soil Texture Triangle* handout with students. Show them that there are different names for different types of soil. It will be the task of your students to determine the texture of the supplied soil samples.

Lesson Plan - F

Recommended Grade Level:
2-5
Season: All
Indoor/Outdoor

Seed Packets — Things to Know Before You Grow

Description:

Students will research a plant or one that's growing in the garden, gathering information from seed packets and displaying the information using a rubric.

Background:

Learning about seeds and the steps that you need to take when planting is a great lesson in sequencing. Seed packets contain a wealth of information about the plant that grows from them. It's important that the directions on the seed packet are followed so that they grow and produce a large harvest. Review the directions with students. Like seeds, people who live healthy (healthy diet, exercise, sleep) can grow healthy and strong.

Materials:

- Several varieties of seed packets
- Things to Know Before You Grow Worksheet

Preparation:

Determine if students will complete the activity individually, with a partner or in a small group. Make copies of the Things to Know Before You Grow Worksheet for each student, partner or group.

Activity:

1. Explain to students that they'll be researching plants using seed packets as a reference. Seed packets have important information that helps gardeners know how to take care of their plants and help them grow in to healthy plants. Most seed packets have the following information:
   - Picture: A picture of the plant when it's full grown and ready for harvest.
   - Plant description: The common and scientific name of the plant, the plant height and days to harvest.
   - Planting directions: Directions normally include planting depth, spacing, sunlight requirements, indoor or outdoor planting, and basic care instructions.

2. Pass out seed packets and allow students to read the information on them. Have students share what they find on the seed packets. Ask students:
   - Why is it important to follow directions and how can that impact the success of their harvest?
     If plants don't get what they need, they won't grow into healthy plants.
   - What directions should you follow as you grow to be healthy?
     Eating healthy, exercising, sleep well, drinking water
3. Allow students to choose a plant that they would like to research from the seed packets. If you don't have enough seed packets for the number of students who want to research it, make copies of the front and back of the seed packet.
4. Pass out and review the Things to Know Before You Grow Worksheet.
5. Give students time to gather information and complete the Things to Know Before You Grow Worksheet. Have students share their worksheet with the class.

Tying it Together:

1. Why is it important to read the instructions on seed packets?
   The seed packets tell you the important steps for planting and will help you get the best harvest.
2. What happens if we plant seeds too close to each other?
   They become crowded and won't grow properly.
3. What happens if we plant them at the wrong time of the year?
   They won't produce a plant or the best harvest.
4. Will our plants grow properly if we don't follow the directions?
   No. Plants have things they need to grow properly just like humans do.
5. What do we need to help us grow healthy?
   Healthy foods, exercise, sleep, drinking water.

Special Care:

The font of seed packets can be small. If you need larger font size for students, you can make an enlarged copy of the front and back or you could buy some larger seed packets with bigger lettering.

If you want to eliminate some of the information on the seed packets, highlight the information you want to include on a black and white copy of the seed packet to reduce the visual clutter and allow the student to focus on the information that they'll be researching.

Digging Deeper:

Using the app Aurasma, or another similar free app, students choose a plant growing in the garden. They research and gather information about the plant. Have them create a marker for the plant that the QR reader can scan. Then, have students create a video that links to the QR scan for their plant.

National Standards:

CCSS.ELA

- Reading: Informational text: Key ideas and details.
- Writing: Production and distribution of writing.
- Writing: Research to build and present knowledge.

ISTE

- Creativity and innovation: Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
- Communication and collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
- Research and information fluency: Students apply digital tools to gather, evaluate, and use information.

NGSS

- Interdependent relationships in ecosystems.
- Inheritance and variation of traits.
- Structure, function and information processing.
- Matter and energy in organisms and ecosystems.

Lesson Extensions:

Health: Students create or share a healthy recipe that uses the plant as an ingredient.

History: Students can extend their research to include the origin, history and uses of their plants and make Produce Fact Sheets with the information.

Language Arts: Students take the information from their Things to Know Before You Grow Worksheet and write the information in a narrative form. Create a class book using all the worksheets.

Math: Make word problems using the information from the seed packets. Students can also make word problems that can be assigned to the class. Here are some examples:

- If the planting space is 1 inch apart, how long would your row be if you planted all the seeds in one row?
- If the seeds take 75 days until harvest and you planted today, when would your produce be ready?
- How many more days do carrots take to sprout than lettuce?

Science: Seed packets could be sorted into a variety of groups:

- Fruits/Vegetables/Flowers/Herbs
- Fall/Winter/Spring/Summer Crops
- Color

If it's planting time, have students plant their seeds in the garden or in indoor container gardens.

Literature Connections:

From Seed To Plant by Gail Gibbons
Oh Say Can You Seed? All About Flowering Plants by Bonnie Worth

Things to Know Before You Grow

PLANT NAME	
DAYS TO GERMINATION *(plant sprouts out of the soil)*	
DAYS TO HARVEST *(fruit or vegetable is ready to pick)*	
PLANTING DEPTH *(how deep to plant seeds)*	
PLANT SPACING *(how far apart to plant the seeds)*	
PLANT HEIGHT *(how tall the plant grows)*	
OTHER PLANTING TIPS	

APPENDIX C

Food Forest Designs


Black Cherry
N
Black Cherry
Japanese pagoda tree
TOMATOES
Ginkgo
CARROTS
Parsley
Red Mulberry
Catnip
Frog Fruit
Loquat
Grape
Spanish Broom


4
N
Ginkgo
Black Cherry
ground cover
Japanese pagoda tree
Apple
Peach
Pomegranate
Loquat
Avocado
Persimmon
lavender
Spanish Broom
Rosemary
Catnip
Parsley
Frog Fruit
Sweet Potatoes


N
Pomegranate
Red Mulberry
Ginkgo
Black Cherry
Olive
Persimmon
Loquat
Rosemary
Spanish Broom
Sweet Potatoes
Frog Fruit
Parsley
Catnip
sunrise

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