

Developing Middle School Youth's Understanding of Soil Health through Supplementary
Activities and the USDA "Soil Your Undies" Challenge

Meagan Dyer

Project Report to the Faculty of Virginia Polytechnic Institute and State University in
partial fulfillment of the requirements for the degree of

Master of Agriculture and Life Sciences In Education

Dr. Hannah Scherer, Department of Agricultural, Leadership, and Community Education

Dr. Eric Bendfeldt, School of Plant and Environmental Sciences, Virginia Cooperative
Extension

Dr. Brett Milliken, Department of Agricultural, Leadership, and Community Education

11/15/2024

Keywords: Soil Health, Environmental Education, Experiential Learning

Abstract:

Soil is a critical natural resource that impacts life as crops, livestock, water systems, and ecosystems all rely on it. While conducting a gardening program with a group of youth at a middle school 4-H after school program, the USDA Soil Your Undies Challenge was utilized to teach basic soil science concepts. The Soil Your Undies Challenge requires a pair of cotton underwear to be buried for a minimum of eight weeks. Students are unable to observe the experiment during these eight weeks. Because of this, a need for prolonged student engagement was identified and six weekly soil science lessons were developed. The lessons were developed using the Experiential Learning Theory. Students participated in a 40-minute soil science lesson once a week for eight weeks. The participants were youth in sixth, seventh, and eighth grade at a middle school after-school program. Data was collected to evaluate the effectiveness of the weekly soil science lessons created to supplement the USDA's Soil Your Undies Challenge. Students took a pretest before the first activity and a posttest following the final lesson. Short free response exit surveys following each lesson and educator observations helped document the students' learning and engagement. There were nine youth who attended at least 50% of the weekly programs and they on average increased their knowledge of soil science by 80% when comparing pre and post test scores. Based on findings from the data, the lessons have been revised and are ready to be piloted with other 4-H programs.

Table of contents

Abstract:	2
Table of contents.....	3
Chapter 1: Introduction	5
Background and Setting.....	5
Statement of the Problem	8
Significance of the Problem	9
Project Purpose	10
Project Objectives	10
Definition of Terms.....	11
Limitations of the Project.....	12
Chapter 2: Review of Literature	13
Importance of Soil Health.....	13
General Public's Understanding of Soil Science	13
Soil's Impact on Daily Life	14
Learning Needs of Middle School Students.....	16
Scaffolding	16
Out of School STEM Based Learning	16
Theoretical Framework	18
Chapter 3: Methodology	20
Project Overview.....	20
Participants:.....	20
Description of Study:.....	21
Instrumentation	21
Data Collection:.....	22
Chapter 4: Summary of Outcomes, Discussions and Recommendations	24
Project Outcomes and Results.....	24
Data Analysis Overview.....	24
Quantitative Data.....	24
Qualitative Data.....	26
Discussion of Project Outcomes and Results.....	32

Implications, Impacts, and Recommendations	35
Dissemination Plan	37
References	37
Appendices	42
Appendix A- Student Pre- and Post-test.....	42
Appendix B- Lesson Plans	43
Appendix C- Self Evaluation Questions.....	50
Appendix D- SOL Correlation Chart	51
Appendix E: Virginia Tech Human Research Protection Program Letter	51

Chapter 1: Introduction

Background and Setting

4-H is the youth development program of Cooperative Extension. 4-H is provided through over 100 land-grant institutions across the country (National 4-H Council, 2015). Youth who participate in 4-H programs are four times more likely to contribute to their community, twice as likely to participate in science programs during out of school time, and twice as likely to make healthier choices when compared to youth who do not participate in 4-H programs (Lerner & Lerner, 2011). These findings were discovered in a longitudinal study on positive youth development by Tufts University that began in 2002, with more than 7,000 youth from 44 states participating (Lerner & Lerner, 2011).

Virginia 4-H is the youth development education program of Virginia Cooperative Extension. Virginia 4-H provides a wide variety of learning opportunities for youth through programs at local, district, and state levels. Youth can participate in many local programs such as community clubs, project clubs, in-school and afterschool clubs, special interest groups, Cloverbud clubs (Exploratory clubs for youth 5-8 years old), day camps, and overnight camps (Virginia Tech, 2023).

The county 4-H program that this project was held in provides three project clubs, a Cloverbud club, in-school enrichment, after-school clubs at three different schools, day camps and overnight camp. Page County is a rural county in the Shenandoah Valley region, and the fourth largest agricultural commodity producing county in the state of Virginia, therefore, agriculture is a key component of the local 4-H program (Clem et al., 2019). A total of 1,016 youth were enrolled in the local 4-H program for the

2023-24 4-H programming year, with many youth participating in more than one 4-H activity. With a total estimated population of 23,750 people, only 3,467 residents of the county are between the ages of 5-18 (Census, 2020). Given the current number of enrolled 4-Hers in the county compared to the total population of youth 5-18, over twenty nine percent of youth are enrolled in 4-H at the county level.

The local 4-H program currently serves three after-school programs within the county, providing educational programs in the fields of STEM (Science, Technology, Engineering and Math), agricultural science, and nutrition. These topics were identified as needs for the afterschool program through discussions with each site coordinator and program director. To meet the need for reinforcing all three of these topics, a gardening series was held at the local middle school utilizing a small courtyard and pre-existing raised beds. Students began working in the garden and making recipes out of the ingredients they were growing.

While conducting the 4-H gardening series in a local middle school, the need for a soil science-related lesson became evident due to lack of understanding of soil science within the group of students and the importance of soil health to the gardening efforts. The county's Agriculture and Natural Resource Extension Agent shared her experience while working with farmers in North Carolina and how she utilized the USDA's "Soil Your Undies" Challenge to show farmers the impacts of various pasture management practices. The program sparked an interest and was chosen to be incorporated into the gardening lessons at the middle school.

The focus on soil health was initially chosen due to the importance of overall soil health and its impact on the ecosystem that the middle school students were observing,

their school garden. Soil is a critical natural resource that impacts life as crops, livestock, water systems, and ecosystems all rely on it (Virginia Soil Health Coalition, n.d.). Soil health is vital for agricultural success. Head et al. (2020) discussed that many methods of measuring soil health can be costly, creating a barrier to the average person to evaluate soil health. There is a need for increased regulation and cost-effective soil monitoring tools. By increasing easily accessible methods of monitoring soil health, more understanding is fostered. A better understanding of the importance of soil health can inform policy and lead to farmer-led data analysis for educated decision making. By creating accessible, easy to understand tools for people to understand what the status of their soil health is, a greater appreciation is obtained (Head et. al, 2020). The USDA “Soil Your Undies” challenge that this project is based on originated in Oregon to teach people about soil health, specifically about the importance of microbial activity to overall soil health. This experiment allows the average person to qualitatively assess their soil health utilizing a pair of cotton underwear (USDA, n.d.-b).

As the initial “Soil Your Undies” lesson was being prepared, it was noted that from the time the underwear is buried to two months later when they are unearthed, there is no observation of the experiment or supplementary lessons currently available. Having searched for supplementary lessons, it was discovered that there are currently other Extension programs utilizing the “Soil Your Undies” activity to teach youth about soil health, but no supplementary lessons had been developed to increase continuous student engagement while the underwear are buried for several weeks (DeBruyn, n.d.). Because of this waiting period, short lessons were created to utilize once a week at the afterschool program. The mini lessons were created in the spring of 2022 and were

utilized with two different groups of middle school aged youth in spring 2022 and spring 2023. After observing an increase in student engagement, this study was designed to measure the learning outcomes and effectiveness of the supplementary lessons.

Statement of the Problem

The “Soil Your Undies” Challenge is a national initiative started in 2018 when Oregon farmers worked with their Soil and Water Conservation Districts and USDA-Natural Resources Conservation Service (NRCS) to promote soil health to the public (USDA, n.d.-b). The experiment was created to increase the general public's understanding of soil health and soil biological activity by burying a pair of cotton underwear in the soil for roughly two months before unearthing them to observe the microbial activity and biological decay that has occurred (USDA, n.d.-b). Microbes needed for good soil health eat the cotton as a food source. This means that the more the underwear is ripped, left thread bare, and ‘soiled’, the healthier the soil is biologically. This experiment allows people an easily accessible tool to qualitatively measure the biological health and activity of their soil with a simple pair of cotton underwear and allows youth to grow a deeper understanding of what soil health really means and why it’s important. Making soil science accessible and easier to understand for all ages and backgrounds is vital for protecting soil health and sustainability (Head et al., 2020). While this experiment introduces the basics of the soil’s biological health, there is currently no curriculum paired with the experiment to increase interest and understanding of the topic while the underwear is buried for eight weeks, and students wait to observe the results of the experiment. Regarding Virginia Standards of Learning

(SOLs), middle school students are only required to know that soil is important for ecosystems (SOL 3.6).

Significance of the Problem

Environmental education is a critical factor in preventing environmental issues (Ozden, 2008). Through environmental education, youth are building connections to their environment and increasing their own understanding of their connection to nature (Cheng & Monroe, 2010).

Agriculture is a vital resource needed for society to function. As climate change, food insecurity, and unemployment impacts society, there is a need for agriculture education. By building youths' interest in agriculture and cultivating meaningful agricultural experiences, youth gain critical skills that prepare them for future career opportunities while initiating interest in agricultural fields to address the growing need for more involvement in agriculture by the next generation (Eissler & Brennan, 2015). Many young people do not have access to agricultural education due to barriers and other access issues (Haruna et al., 2019). By creating an accessible framework for youth to be involved in agriculture regardless of economic, geographic, or other barriers, more youth will be able to have meaningful agricultural experiences (Rice et al., 2016). Youth involved in agriculture education are more aware of their potential impact in their communities and the sustainability of their food systems (Haruna et al., 2019).

While the "Soil Your Undies" Challenge has been utilized by many Extension professionals to teach the public about general soil health, the roughly two months the underwear is buried for changes to the underwear to be visible, limits engagement with the learner. This project aims to address and fulfill the need for prolonged engagement

to the “Soil Your Undies” Challenge. 4-H has supported agriculture education like this from its start, with the very first “Tomato Club” and “Corn Growing Club” in 1902 (National 4-H, 2023). As 4-H continues to offer a wide range of learning opportunities, not only in agriculture but many other topics including earth science, a need for more in-depth science curricula has been identified in order to give youth more opportunities and resources to learn about the interrelationships of our natural resources (Bourdeau, 2002). This project creates an easily accessible and replicable curriculum that teaches youth about soil science.

Project Purpose

The purpose of this project is to implement and evaluate the effectiveness of a 4-H enrichment program that includes six mini-lessons that can be paired with the “Soil Your Undies” Challenge. The stand-alone lessons cover topics regarding gardening and soil health geared towards middle school aged youth. Given the importance of soil health to agriculture, food, and human health, this project’s goal is to increase youths’ understanding and appreciation of soil and soil science by measuring the effectiveness of supplementary lessons I previously developed to increase engagement during the USDA’s “Soil Your Undies” Challenge. In the development of the lessons, I correlated each one with the appropriate SOL’s. These lessons were utilized while youth are unable to view the experiment during the two-month period the underwear are buried.

Project Objectives

The objectives of this project are to 1. Increase student understanding in soil sciences 2. Pilot supplementary lessons to “Soil Your Undies” Challenge and evaluate

their ability to keep youths engaged and increase knowledge while the experiment cannot be observed.

Definition of Terms

Biological Activity - The capacity of a specific molecular entity to achieve a defined biological effect on a target that is measured by the activity or concentration of a molecule required to cause that activity (Jackson et al., 2007).

Soil - A mixture of minerals, dead and living organisms (organic materials), air, and water (About Soils, 2023)

Soil Science - Soil science is the science dealing with soils as a natural resource on the surface of the Earth including soil formation, classification, and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of the soils (Soil facts, n.d.).

Soil Health - Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans (Soil health, n.d.).

Experiential Learning - Experiential learning is an engaged learning process whereby students “learn by doing” and by reflecting on the experience (Boston University, n.d.).

Mixed Methods - A combination of qualitative and quantitative approaches in the study and /or data collection (Mertens and Wilson, 2012, p. 560).

Limitations of the Project

This project was limited to the local population of students attending a middle school (6th-8th grade) after-school program in northwest Virginia. The school calendar and after school schedule could be a limiting factor. A small budget is needed for supplies such as cotton underwear, food items, plastic jars with lids, plastic bags, cotton balls, seeds, and paper plates. Findings from this study are limited to elementary and middle school level educational experiences.

Chapter 2: Review of Literature

Importance of Soil Health

General Public's Understanding of Soil Science

Although soil impacts so many facets of daily life, the general public often does not know its impact. This has been caused largely due to a disconnect between soil scientists and the general public (Koppi et al., 2010). Unlike many scientific disciplines, such as astronomy or geology, soil science has not had any sort of amateur society, where people with a general interest in the topic can learn more about soil science in an informal setting. When analyzing the need for more soil science education for the general public, Koppi et al. (2010) found that, “An important change that we can make to improve the public perception of soil science, thereby possibly attracting more students, is to change soil science teaching and/or academia engaging with the general public through student community projects. In short – getting out there and demonstrating how soil science can enrich local communities and also revealing that there is more to soil than its mere utilization. For such a task, the professional would need to display amateur qualities. The residual impact of these activities may spark interest and enthusiasm which could then be channeled into a Society of Amateur Soil Scientists that is yet to be created.” (Koppi, 2010 p. 33).

One of the most critical issues for soil scientists is the general public's understanding of soil health, how it impacts daily life, and what the average person can do to protect soil quality (Petersen, 2006). Currently, most major decisions regarding

agriculture, the environment, and development are made without consideration of soil science (Pla Sentis, 2006).

The need for education on soil science for the general public has increased over the last twenty years as the recognition of soils impact on life has increased (Sharpley et al., 2017). In an effort to increase soil science education within K-12 learning, the Soil Science Society of America (SSSA) has established websites for youth and teachers to utilize that offers games and activities related to soil (Sharpley et al., 2017). While these websites have resources for single, “one and done” activities, they do not offer longer term interaction with the subject material.

Soil's Impact on Daily Life

Soil health is the foundation of agriculture, food, and overall human health, and yet most people don't understand the importance of soil health to everyday life. Part of this is attributed to a lack of easily accessible, cost-effective soil monitoring methods (Head et al. 2020). Overall, soil health is difficult to measure as it is the culmination of physical, chemical, and biological indicators. When observed, these indicators of soil function can be subjective (USDA, 2015). Determining soil health is still done by examining soil chemical indicators despite the importance of biodiversity due to the lack of functional knowledge and effective methods of analyzing soil biological health (Lehmann et al., 2020).

There are many issues facing society today that are related either directly or indirectly to soil science (Petersen, 2006). Soil is the foundation to plant and animal agriculture (Boggs, 2016). Without healthy soil, we could not produce the quality or yields of products needed to provide for our society. Soil is the foundation of our food

and fiber resources (Boggs, 2016). All life depends upon soil (Boggs, 2016). We not only rely on the soil to cultivate our needed food and fiber, it also is the foundation of our ecosystems and communities (Boggs, 2016).

The rapid increase of population means that now more than ever, there is a high demand for high quality food and water which in turn causes more human influences on soil due to increased agricultural production (Pla Sentis, 2006). Without good soil management practices, the increase in human influences leads to soil degradation that then leads to a decrease in available quality water and biological diversity. This can lead to decreased crop production and water resource depletion (Pla Sentis, 2006).

The key elements to managing soil health are maximizing the presence of living roots, minimizing soil disturbance, maximizing soil cover, and maximizing biodiversity (USDA, 2023). By utilizing the four soil health principles, an increase in microbial activity and organic material will be observed. To increase the general public's awareness of soil health and the practices that increase it, the Soil Your Undies Challenge was created (USDA, n.d.-b). Since its creation Soil Your Undies has been utilized across the United States from Washington to Florida to educate the public on soil health (USDA, n.d.-c). The challenge has also been utilized by states Extension programs, however, there has not been any curriculum developed that specifically pairs with the challenge to create prolonged engagement for youth (DeBruyn, n.d.).

Learning Needs of Middle School Students

Scaffolding

The scaffolding teaching strategy allows the learner to build upon their preexisting knowledge. As stated in Cognitive Characteristics, “The zone of proximal development is the distance between what children can do by themselves and the next learning that they can be helped to achieve with competent assistance” (Raymond, 2000). A primary principle of scaffolding is that the role of the educator supporting learners’ development provides supporting structures to get to the next level, building upon what has been learned previously (Raymond, 2000). Scaffolding engages the learner through the utilization of their prior knowledge to build new understanding. In a 2007 study, it was determined that, “elementary and middle school-aged children, most of whom are under 14 years of age, may have difficulty connecting claims with evidence during the course of a PBL [Project Based Learning] unit without the help of scaffolding” (Belland et al., 2007, p. 406).

Out of School STEM Based Learning

Learning doesn’t just take place within the classroom. The Committee on Successful Out-of-School STEM Learning with the Board of Science Education identifies three long-term goals of STEM education. The goals are:

1. Increasing advanced training and careers in STEM fields,
2. Expanding the STEM-capable workforce who serve as STEM educators, science communicators, medical assistants, computer technicians, and other STEM-related careers,

3. Increasing scientific literacy among all young people, supporting life-long interest and engagement with STEM (National Research Council, 2015)

Although there is limited evidence regarding out of school programs effect, a number of studies claim that out of school programs can contribute to learners' understanding and interest in STEM (National Research Council, 2015, p. 10). Several criteria have been identified to create productive out-of-school STEM programs. Programs must engage youth, respond to their interests, experiences, and cultural practices, and connect learning experiences across different settings (National Research Council, 2015, p. 15). High quality out of school programs support student learning and encourage the pursuit of STEM careers (Barker et al., 2013). This is because out of school learning environments can help make STEM concepts more real and applicable through providing engaging and interesting STEM activities (Hoachlander & Yanofsky 2011). The concern with out-of-school STEM programs is that there is little documentation on the fidelity of the programs and they are implemented in different settings (Sheridan et al. 2009). By ensuring the fidelity of an out of school program, the quality of the program stays consistent, which is needed for greater student impact (Barker et al., 2013).

Through STEM experiences students can gain knowledge in scientific concepts. These concepts are described in the Next Generation Science Standards (NGSS) practices. The eight practices that the Next Generation Science Standards identifies as essential for students to learn are:

1. Asking questions,

2. Developing and using models,
3. Planning and carrying out investigations,
4. Analyzing and interpreting data,
5. Using mathematics and computational thinking,
6. Constructing explanations (for science) and designing solutions (for engineering),
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information.

By providing students with opportunities to master these skills they are able to engage in the scientific process (NGSS, 2013).

Theoretical Framework

The Experiential Learning Theory theoretical framework was utilized for this study (Kolb, 1984). The 4-H Youth Development program as a whole relies heavily on experiential learning in order to teach skills. The 4-H slogan, “learn by doing,” showcases this (Carver, 1998). The Experiential Learning Model highlights a cycle of steps that include experiencing, sharing, processing, generalizing, and applying. Each step of this model can be simplified as the following.

- **Experiencing:** Performing the activity
- **Sharing:** Describing the experience and sharing thoughts with others
- **Processing:** Understanding what was learned from the experience
- **Generalizing:** Generalizing what was learned so that it is applicable in different settings and situations.

- **Applying:** Applying those generalizations and what was learned to the learners life.

The Experiential Learning Model highlights action, reflection, and application so that learners gain life skills and knowledge through their engagement in all phases of the activity (Woffinden & Packman, 2001). This experiment and supplementary lessons are designed based on the experiential learning model. The learners will start engaging in the experimental process on week one as they make a hypothesis and begin their experiment by burying a pair of cotton briefs and planting seeds in the soil above them. Over the course of six weeks they will participate in six mini lessons that will follow the experiential learning model of experiencing, sharing, processing, generalizing and applying. In the eighth week, students will unearth their previously buried cotton underwear and observe the biological activity, utilizing what they have learned from the lessons to make observations and recommendations for the experiment and what they would change if they were to replicate it. Lastly, students will apply their knowledge of soil science to new situations such as making suggestions for their school's garden that is being reestablished.

The Experiential Learning Model highlights Kolb's belief that learning is a process that fosters knowledge through experiences (Kolb, 1984). By utilizing this model, learners can experience and process the activities in a way that fosters understanding and application to other parts of their lives. Experiential Learning Theory has been consistently utilized by Virginia 4-H as a tool to ensure that youth are obtaining life skills through their participation in 4-H programs.

Chapter 3: Methodology

Project Overview

This project pairs short lessons with the Soil Your Undies Challenge to create an eight-week program. Participants completed the Soil Your Undies Experiment and six lessons that were developed and implemented with a group of middle school youth in an afterschool program. All lessons are SOL correlated (Appendix D). Utilizing educator observation and feedback, pre and post student surveys, and exit slips for each activity, the effectiveness of this program was observed and documented. The Virginia Tech Human Research Protection Program determined that this study is not research involving human subjects as defined by Health and Human Services and Food and Drug Administration regulations (see letter in Appendix E).

Participants:

The participants were sixth, seventh, and eighth graders that participated in the local middle school's afterschool program in the Spring semester of 2024. The local 4-H Agent led instruction for this study once a week for eight weeks with students with the afterschool program coordinator providing additional supervision. The total number of students participating in the afterschool program was originally 59, however due to a new rule that required students who had below a certain grade in any class to attend after school tutoring the number of participants decreased rapidly. While each lesson had an average of twelve attendees, nine students participated in at least 50% of the total lessons.

Description of Study:

Activities were held at the afterschool program once a week for eight weeks. Each activity lasted approximately 40 minutes, with some activities being shorter to account for cleanup time. See Appendix B for lesson plans with exit slip questions.

Instrumentation

For this project, several instruments were used to collect data to measure changes to students' understanding in soil sciences. All exit slip and pre/post test questions were piloted by a small group of middle school aged youth not involved in the program prior to use in the study to ensure that the questions and their wording was easily understood. Feedback from the pilot indicated that no changes needed to be made. All questions were developed utilizing the lesson objectives and Bloom's taxonomy (Armstrong, 2010). Bloom's Taxonomy identifies six levels of the cognitive domain from simplest to most complex. This taxonomy includes knowledge, comprehension, application, analysis, synthesis, and evaluation. This is utilized to classify learning objectives (Gogus, 2012).

The same test was used for the pretest and posttest. The test consisted of ten multiple choice questions that evaluate the learners' understanding of the content covered throughout the activities. See appendix A for the pre- and posttest. The table below indicates which questions within the pre- and post-test address which lesson within the curriculum.

Table 1: Pre- and Post-test questions and the lesson they correspond with.

Pre- and Posttest Question	Associated Lesson(s)
What does the soil do? Select all that apply.	Week 1, Week 5,
Is all soil the same?	Week 2, Week 3
List the soil particles from smallest to biggest.	Week 2, Week 3
Which is soil made of?	Week 1, Week 2, Week 3
Which item can NOT be composted?	Week 4
Composting breaks down waste, but doesn't make anything useful. True or False.	Week 4
Why is soil important to plants?	Week 1, Week 5
When planning a garden what are things you should consider? Select all that apply.	Week 6
What is erosion?	Week 6, Week 7
What causes erosion? Select all that apply.	Week 7

Exit slips are two or three questions in length and can be found in Appendix B as part of each weekly lesson plan.

A standard set of observation reflection questions were developed to track any observable changes, issues, and comments youth participants have on the material as well as to capture any observations other educators assisting may have. Lesson evaluation questions can be found in Appendix C.

Data Collection:

Data was collected through student written responses to exit slips, pre- and posttest were collected on paper. Observations and student's verbal feedback were recorded used the Lesson evaluation questions found in Appendix C. Students took the

pretest before being introduced to the initial lesson or burying the underwear. Students completed exit slip questions immediately after each lesson. The last lesson of the series when the underwear is dug up did not have an exit slip. Youth instead completed their post-test immediately following the last lesson. During each lesson, I noted any comments of interest made by students and any observations I made. Immediately after youth left, I completed the self-evaluation.

Chapter 4: Summary of Outcomes, Discussions and Recommendations

Project Outcomes and Results

Data Analysis Overview

Once concluding all lessons, each student's posttest was compared to their pretest to determine any change in knowledge and understanding. Post-tests of youth who were present for less than 50% of lessons were not utilized in the data, however all exit slips for each lesson were included when interpreting the qualitative data. Due to the small number of students participating, data from their exit slips were summarized.

Quantitative Data

Students who attended 50% or more lessons ($n=9$) scored an average of 3.33 out of 10 on their pretest. The average post test score ($n=9$) was 7.78. The average score increased by +4.44 from pre-test to post test. When examining each individual question and the percentage at which it was answered correctly, every question was answered correctly at a higher rate during the posttest than it was during the pretest.

Table 2 below shows the change in the number of students answering each question correctly. Comparing the rate at which each question is answered correctly from pre- to posttest allows the effectiveness of each lesson that the questions correspond with to be analyzed.

Table 2: Number of Students Who Answered Pre- and Posttest Questions Correctly

Question	Number of Students Who Answered the Question Correctly on the Pretest (n=9)	Number of Students Who Answered the Question Correctly on the Posttest (n=9)	Percent increase in correct response
1	0	7	-
2	6	9	49%
3	0	7	-
4	5	7	39%
5	1	8	709%
6	7	9	28%
7	3	3	0%
8	3	8	170%
9	2	7	255%
10	2	5	155%

Each student (n=9) increased their test score from pretest to post test. The table below shows each student's pretest score, post test score, and the percentage increase between test scores.

Table 3: Individual Students Pre- and Post Test Score Differences

Student	Pretest Score Out of Ten	Posttest Score Out of Ten	Percentage Increase in Test Scores
1	2	3	50%
2	3	7	133%
3	4	9	125%
4	6	10	67%
5	7	9	29%
6	2	10	400%
7	1	7	600%
8	4	9	125%
9	1	6	500%
Average	33%	78%	225%

Qualitative Data

Qualitative data was collected each week through exit slips and educator observation.

During the first week students took the pretest, did an activity on what the different soil services are, buried underwear and were asked to make a prediction of what would happen to the underwear while they were buried (Week 1 Lesson, Appendix B).

Predictions included they would get dirty, they would disappear, and they will decompose. Students were asked to name two soil services which were identified in the activity. Students answers to this question included biodiversity, stability, moisture retention, decomposing, holding roots and nutrients, filters contaminants. Most students

stated two accurate soil services while two answers could not be deciphered. During the first week, I as the instructor observed the students getting excited to bury the underwear. They thought the activity was funny and couldn't wait to get outside. The first activity covered soil services and how they compare to human services. I observed that students had a hard time pairing the two together. We reviewed what each word meant and filled in one box per row in the graph and students were then able to fill in the gaps correctly.

The activity in Week 2 (Appendix B) focused on identifying the differences between soil mediums by taking samples of soil from various locations, adding them to a jar with water, shaking them and letting the soil settle. Students observed how the difference sized particles fell at different rates. The second week's exit slips asked students to identify the three types of soil and if there were any differences between the soil samples they took and why they thought they were different. All students were able to identify the sand, silt, and clay. When asked if there were any differences between the samples taken from different locations students identified that the soil had been separated into three distinct layers and that those layers were different in color and texture. Six out of the ten students present identified that while we added the same amount of soil into each jar from various locations they ended up at different amounts. Two students did not complete the entire exit slip. While observing I identified that two students were disengaged and did not participate or sit with the rest of the group during the activity. The exit slip reflected this.

Youth were excited to choose where to take their samples and quickly chose two locations. Two samples were provided from off school grounds in addition to the two

samples the students collected. When asked why they thought the samples were so different they shared much more verbally than they did on their exit slips. Multiple students discussed the different particle sizes and how they fell at different rates as well as why they thought the samples were different. Students agreed as a group that the sample from the boat dock was mainly silt due to the river, that the nature trail sample was the best sample because it was rich topsoil that plants were thriving in, and that the courtyard was mostly clay because the top soil had been removed when the court yard was graded to build the school in the 1960's and stated that it takes a long time for quality soil to return. One student stated that this is why the courtyard was mostly weeds and moss. Students identified that there was less clay in all the samples than there was silt or sand. The fourth sample was from a bag of topsoil purchased from a store. Students observed that this sample was mainly mulch and that the contents floated when water was added.

The third week's activity (Appendix B) covered the parts of soil. Students created their own soil trail mix while recording the amounts of each ingredient and what part of soil the specific food items stood for. Exit slips asked, "How would you describe the type of 'soil' you made?" and "Where would you be most likely to find the kind of soil you made? (In a garden, the beach, the forest?)" Students' answers were based on the individual mix they had made. Students who included a large amount of "air" said their soil may be found in a garden. Students who used a large amount of "sand" said they would be near water or a coastline. A student whose mix was mainly "living things" and "organic matter" stated that their soil would be found in a garden since it had compost added to it. Overall, the students were engaged and on task. Two exit slips couldn't be

utilized as they were illegible and could not be assigned to a student. Students had difficulty adding their fractions together.

Composting was the topic covered in week four. During this lesson (Appendix B) students made their own mini compost container utilizing plastic jars, and I reviewed the importance of compost and what could and couldn't be composted. Before students built their compost jars they worked together to sort pictures of items into two categories, "can be composted" and "cannot be composted" the students had a general idea of what could and couldn't go into compost but were surprised about some items. Students were engaged as they added to their compost jars. Some students did not want to touch certain items, so gloves were provided. When it was time for students to add water to their jars, many of them overwatered. After cleaning up the activity, students labelled their jars and sat them together so that they could observe them over the next few weeks to see their changes. At the end of the lesson student exit slips asked, "What is a benefit to composting?" and "What does composted materials add to soil?" Students identified the benefits of compost as adding nutrients to the soil, healthier plants, healthy soil, and helping the environment by not wasting things that can be composted and used. All students identified that compost added nutrients to the soil. When I returned the next week students pointed out their compost jars and wanted to show me the changes that had occurred in them. One student was still surprised that the jars didn't have a bad smell.

During week five's lesson (Appendix B), the group learned about what plants need to survive. Students created a "greenhouse in a bag" and explored what was needed for a plant to grow and survive. I observed that some students struggled with some tasks,

specifically cutting things out with scissors. Participants enjoyed the activity, but most could not successfully cut out their greenhouse paper without assistance. When students completed their exit slips that asked them, “What do plants need to grow?” and “Why is soil important to plants?” their responses were accurate but limited. Students only wrote on average three things plants needed and only one reason why soil was important to plants. We talked about the questions as a group after the exit slips were turned in and the group agreed that the soil does a multitude of things including providing stability, nutrients, space to grow, and a healthy environment. I observed that participants were much more responsive in a conversation than in their writing. Written responses were extremely limited.

The topic of week six’s lesson (Appendix B) was garden design. Students were tasked with using various food items to create a garden on a plate that would provide their plants with everything they need. Students were extremely engaged with this activity and put detail into their garden plates. The exit slip questions were, “Explain why and how you made your garden the way you did” and “What issues could you see happening if your garden on a plate was used to design a real garden? What would you change?” Of the students who answered the second question, all but one stated that they saw no issues. One student indicated that they would change the soil they had on the ground. Since it didn’t have anything covering the soil there would be mud and runoff when it rained. Most students did not explain what they did and why in their writing, however, when going around the room and having each participant show their plate and explain it they went into great detail about what the items stood for and why they were important to have in a garden space. Students were so engaged with the

activity that the group went over the allotted time we had for the program. Three students indicated that they also tried a new food they hadn't tried before.

During week seven's activity (Appendix B), students explored the topic of erosion. The local Soil and Water Conservation District office assisted with the activity and discussed the impact erosion has on our land and specifically on our soil. Students were engaged and gave thoughtful answers to questions. Students were asked in their exit slip to predict what would stop erosion more, plain soil, straw covered soil, or soil with established grasses. One of the participants guessed the dirt alone would stop erosion, two of students guessed that the straw would stop the erosion, and three guessed that the grass would stop erosion the best. Once water was poured over the bins and students observed the water's effects on the different bins, they answered the second question of their exit slip which asked what stopped the erosion the most. All students agreed that established grasses stopped erosion the best. When asked why they thought this happened the group stated that the roots held the soil in place. When asked what the second-best option was, the group stated that the straw stopped erosion better than the uncovered soil. The group determined that this was because the straw covered the soil, and the water wasn't hitting soil directly and slowed down the water's impact. One student stated that was why we put straw down when we are growing new grass after building something. By using clear bins, students were able to observe how deep the grass roots went into the soil and were surprised to see how deep roots really grow.

In the final week, students were excited that it was finally time to dig up the underwear and see what had happened to them. Before the underwear were unearthed,

students were asked what they thought the underwear would look like. Some students thought the underwear would be gone all together, while some stated that the underwear would still be there and just dirty especially since it hadn't rained much and the area was in a current drought. When students unearthed the underwear, they all indicated that they were shocked at just how much of the underwear had seemingly disappeared. The only part of the underwear left was the elastic waistband and elastic stitching. When asked why they thought this could have happened students discussed weather changes, microbial activity, and decomposition. Students continued to discuss where they would like to try burying new underwear and redo the experiment. When the fall semester of this program started several months later, students again asked if they could do this program again because they enjoyed it and wanted to repeat it.

Discussion of Project Outcomes and Results

This project aimed to increase soil science knowledge in a group of middle school youth participating in an afterschool program. As Peterson (2006) states, "One of the most critical issues for soil scientists is the general public's understandings of soil health, how it impacts daily life, and what the average person can do to protect soil quality". Students who participated in this program increased their soil science knowledge as shown by the qualitative and quantitative data.

When reviewing the quantitative data, each student that attended at least 50% of the sessions increased their test score. The average pretest score for the nine students who attended 50% or more of sessions was 33% and the average posttest score was 78%, a more than two-fold in knowledge gained. This shows an increase in the participants' understanding of soil health. When reviewing each pre and posttest

question individually the percentage of students who answered the question correctly significantly increased for all questions except for one. Question seven, "Why is soil important to plants?" had the same number of students answer it correctly in the pre-test as in the post-test. The answer options were A. It provides nutrients and water, B. It keeps plant's roots in place, C. It protects plants from temperature changes, D. Just A and B, and E. All of the above. All students who selected the wrong answer in the posttest selected answer choice D. Just A and B. Looking at the lesson plans, the lessons did not address how soil protects roots from temperature changes in detail. It was mentioned very briefly.

When reviewing the results of each lesson and the project as a whole and comparing them to the goals and learning objectives, the project was successful. However, a need for edits and changes to some of the lessons was revealed.

The objective of week one was for students to create a hypothesis and to be able to describe the soil as a living system. They were able to accomplish this, however, there was a lack of previous knowledge and vocabulary observed. Once students reviewed what the words meant, they were able to complete the tasks.

Week two's lesson objectives were for students to be able to describe all the different particles that make up soil and identify the difference between soil mediums. The lesson as outlined was successful in this, however, students did not understand how to measure the samples and a review on how to measure with a ruler was needed.

Week three's lesson objectives were for students to demonstrate knowledge of soil ingredients by creating edible models and to be able to demonstrate their knowledge of fractions as they created their own soil trail mix. Students demonstrated

their knowledge of soil ingredients and discussed the differences of soils found in various locations as they created their mixes. Students struggled to add their different measurements together.

Based on the qualitative and quantitative data collected, the lesson objectives for week's five and six were met. Students were able to define what composting is and why it is beneficial. Students properly identified items that could and could not be composted. In week five, students were able to investigate what plants need for survival and how soil plays a role in that survival.

The lesson in week six was one of the students' favorite activities. Students were extremely engaged in their gardens on a plate. It was observed that students didn't record what the different food items stood for but could express it verbally.

Week seven's erosion lesson met the lesson objectives by allowing students to investigate the impacts of erosion on ecosystems, how it occurs and humans' involvement in it through observing the results of the demonstration and asking students how removal of native plants with established root systems could impact various places as well as how humans contribute to erosion and what people could do to mitigate erosion.

Students' increase in soil science knowledge can likely be attributed to the Experiential Learning Theory, in which the lessons are rooted. The theory can be simplified into five main steps: experiencing, sharing, processing, generalizing, and applying. Students experienced weekly lessons in soil science by performing various activities. They shared by describing the experience and their thoughts through discussion and exit slips. Pre- and post-test data indicate that students processed and

understood what was learned through the experience. After the weekly lessons students were able to go on nature walks around the school. During this time, it was observed that students began to generalize what was learned in the lessons. During a nature walk, two students discussed the differences of soil quality along the path and what was or wasn't growing based on what they determined was the soil quality. Students began applying lessons into their lives. One student indicated that she and her grandmother had started composting since she learned how in this program. A second student reported that he repeated the Soil Your Undies experiment at home in his grandfather's garden so that he could test the soil quality there as well. Experiential learning opportunities, like this project, is a critical tool to teach and encourage interest in life sciences and STEM-related topics and connects them to everyday life experiences. By utilizing everyday items that students are familiar with and utilizing them in the curriculum provided and built scaffolding for the students in various ways. Using edible models, familiar foods, and even the underwear themselves to teach youth about an unfamiliar topic allowed them to build upon their previous knowledge to learn new things.

Implications, Impacts, and Recommendations

Overall, the lessons were well received by students, however, if this research were to be recreated a different method of collecting data should be utilized. Students took the multiple choice pre- and post- test without complaints; however, the exit slips did not showcase the participants understanding of each lesson. As this was done in an after-school program setting, youth were reluctant to write their responses down. When

asked the same exit slip questions verbally, the group of students answered with much greater detail than what they were willing to write.

Week one's lesson primarily introduced participants to soil science and what the soil can do. Based on the qualitative data, there should be an additional piece added to this lesson to cover vocabulary words. Since students did not understand the vocabulary used in the lesson, they struggled to complete it. Once the vocabulary was explained to them students could complete the tasks. Another option to increase understanding of the vocabulary is to add definitions to the cards with the soil service or human system labeled on them. The lack of change in correct answers to the pre-test post question "Why is soil important to plants?" shows a need to further explain how soil protects plants from temperature changes. An addition to the Soil Services table in lesson one that covers temperature regulation is needed. Changing the phrase "Soil Services" to the more fitting phrase "Soil Functions" is needed.

Week two, we discussed the difference between sand, silt, and clay. As students observed their samples in the lesson, they struggled to properly measure the samples. Creating a simple table such as the one below in addition to reviewing how to measure with a ruler would be beneficial to the students.

Table 4: Suggested addition to lesson two's lesson plan

Sample Location	Sand	Silt	Clay
Location 1:			
Location 2:			
Location 3:			

Week three's soil trail mix lesson allowed students to create their own soil mixes and discuss where various soil could be found, meeting the lesson objective that they

could demonstrate knowledge of soil ingredients through creating edible models. Students had difficulty adding various fractions together and needed significant support in doing so. Adding a third column to the chart given to student would help students track their measurements easier. For some students, fraction models of 1/4, 1/3, and 1/2 cup should be provided to aid them in adding fractions.

Week six's lesson on garden design needs to be altered to provide students a way to record what food item represents what item you would find in the garden. Students verbally stated what the items represented but struggled to record. A simple graph with the food items already listed could assist students.

Dissemination Plan

Results of this study will be presented as part of the Virginia Cooperative Extension Poster Contest in February 2025. Once the recommended updates to the lesson plans have been made, the lessons will be piloted in other localities and programming settings. Lesson plans will be piloted with interested 4-H Agents and agriculture teachers to receive feedback to utilize in the Virginia Cooperative Extension publication process. Other potential audiences for this curriculum include Virginia Association of Soil and Water Conservation Districts, Virginia USDA-NRCS, Virginia Soil Health Coalition, and the Soil Health Institute.

References

Abrahams, P. W. (2002). Soils: Their implications to human health. *Science of The Total Environment*, 291(1–3), 1–32. [https://doi.org/10.1016/s0048-9697\(01\)01102-0](https://doi.org/10.1016/s0048-9697(01)01102-0)

Armstrong, P. (2010). *Bloom's taxonomy*. Vanderbilt University Center for Teaching. <https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>.

Barker, B. S., Nugent, G., & Grandgenett, N. F. (2013). Examining fidelity of program implementation in a STEM-oriented out-of-school setting. *International Journal of Technology and Design Education*, 24(1), 39–52. <https://doi.org/10.1007/s10798-013-9245-9>

Belland, B. R., Glazewski, K. D., & Richardson, J. C. (2007). A scaffolding framework to support the construction of evidence-based arguments among middle school students. *Educational Technology Research and Development*, 56(4), 401–422. <https://doi.org/10.1007/s11423-007-9074-1>

Boggs, J. (2016, June 8). *Soil basics*. Ohio State University Department of Entomology. https://www.canr.msu.edu/uploads/234/74792/Boggs_-_Soils_General_Ver_6-8-16.pdf

Boston University. (n.d.). *Experiential learning*. Center for Teaching & Learning. <https://www.bu.edu/ctl/guides/experiential-learning/#:~:text=Experiential%20learning%20is%20an%20engaged%20learning%20process%20whereby,exercises%2C%20study%20abroad%2C%20undergraduate%20research%20and%20studio%20performances>.

Bourdeau, V. D. (2002). Improving science education in the 4-H geology project. *The Journal of Extension*, 40(1), Article 19. <https://tigerprints.clemson.edu/joe/vol40/iss1/19>

Carver, R. L. (1998). Experiential education for youth development. *Focus; A Monograph of the 4-H Center for Youth Development, University of California, Davis*, 4(4).

Cheng, J.C., & Monroe, M.C. (2012). Connection to nature. *Environment and Behavior*, 44, 31 - 49.

Clem, N., Beardslee, M., Shenk, L., & Mays, A. (2019, September 3). *Situation analysis report: Page County*. VCE Publications. https://www.pubs.ext.vt.edu/content/pubs_ext_vt_edu/en/VCE/VCE-596/VCE-596-74/VCE-596-74.html

DeBruyn, J. (n.d.). *Soil your undies! How healthy is your soil?*. UT Extension Institute of Agriculture. <https://utia.tennessee.edu/publications/wp-content/uploads/sites/269/2023/10/W1047.pdf>

Department of Commerce and Labor. (n.d.-a). *U.S. Census Bureau quick facts: Page County, Virginia*. U.S. Census Bureau.

<https://www.census.gov/quickfacts/fact/table/pagecountyvirginia/PST045222>

Eissler, S., & Brennan, M. (2015). Review of research and practice for youth engagement in agricultural education and training systems. INNOVATE Innovation for Agriculture Training and Education. https://pdf.usaid.gov/pdf_docs/PBAAF352.pdf.

Gogus, A. (2012). Bloom's taxonomy of learning objectives. *Encyclopedia of the Sciences of Learning*, 469–473. https://doi.org/10.1007/978-1-4419-1428-6_141

Haruna, O. I., Asogwa, V. C., and Ezhim, I. A. (2019). Challenges and enhancement of youth participation in agricultural education for sustainable food security. *African Educational Research Journal*, 7(4): 174-182.

Head, J., Crockatt, M., Didarali, Z., Woodward, M.-J., & Emmett, B. (2020). The role of citizen science in meeting SDG targets around soil health. *Sustainability*, 12(24).

<https://doi.org/https://doi.org/10.3390/su122410254>

Hoachlander, G., & Yanofsky, D. (2011). Making STEM real. *Educational Leadership*, 68(6), 60–65.

Jackson, C.M., Esnouf, M.P., Winzor, D.J. *et al.* (2007). Defining and measuring biological activity: applying the principles of metrology. *Accreditation and Quality Assurance* 12, 283–294. <https://doi.org/10.1007/s00769-006-0254-1>

Knox, O., Dickenson, S., & Jenson, M. (2018). Soil your...what! *Spotlight*, p. 29. [/https://www.crdc.com.au/sites/default/files/pdf/Spotlight%20Winter%202018.pdf](https://www.crdc.com.au/sites/default/files/pdf/Spotlight%20Winter%202018.pdf)

Koppi, T., Field, D., McBratney, A., & Hartemink, A. (2010). The need for soil science amateurs. *19th World Congress of Soil Science, Soil Solutions for a Changing World*, 32–33.

Lehmann, J., Bossio, D. A., Kögel-Knabner, I., & Rillig, M. C. (2020). The concept and future prospects of soil health. *Nature Reviews Earth & Environment*, 1(10), 544–553. <https://doi.org/10.1038/s43017-020-0080-8>

Lerner, R. M., & Lerner, J. V. (2011). *The positive development of youth: Comprehensive findings from the 4-H study of positive youth development*. Tufts University, Institute for Applied Research in Youth Development, Medford, MA.

Mertens, D. M., & Wilson, A. T. (2012). *Program evaluation theory and practice: A comprehensive guide*. New York: Guilford Press.

National Research Council. (2015). *Identifying and supporting productive STEM programs in out-of-school settings*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/21740>.

National 4-H Council. (2015). *4-H positive youth development*. Retrieved from <http://www.4-h.org/about>

Next Generation Science Standards. (2013, April). *Appendix F: Science and engineering practices in the NGSS*. [https://www.nextgenscience.org/sites/default/files/Appendix F Science and Engineering Practices in the NGSS - FINAL 060513.pdf](https://www.nextgenscience.org/sites/default/files/Appendix%20F%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf)

Ozden, Mustafa. (2008). Environmental awareness and the attitudes of student teachers: An empirical research. *International Research in Geographical & Environmental Education*, 17(1), 40-55.

Petersen, G. (2006). Soil science: multiple scales and multiple opportunities. In A. Hartemink (Eds), *The Future of Soil Science* (p. 108). IUSS.

Pla Sentis, I. (2006). Future of soil science. In A. Hartemink (Eds), *The Future of Soil Science* (pp. 110-112). IUSS.

Raymond, E. (2000). Cognitive characteristics. In *Learners with mild disabilities* (pp. 169-201). Needham Heights, MA: Allyn & Bacon, A Pearson Education Company.

Rice, J. E., Rugg, B., & Davis, S. (2016). Minnesota 4-H science of agriculture challenge: Infusing agricultural science and engineering concepts into 4-H youth development. *The Journal of Extension*, 54(3), Article 15. <https://doi.org/10.34068/joe.54.03.15>

Sharpley, A., van Es, H., Dick, R., Bergfeld, E., Anderson, K., Fisk, S., & Chapman, S. (2017). Education and policy in soil science: The U.S. Experience. *Geophysical Research Abstracts*, 19.

Soil Science Society of America. (2023) *About Soils: What is soil science?*. (2023). <https://www.soils.org/about-soils/>

U.S. Department of Agriculture. (n.d.). *Soil facts*. Natural Resources Conservation Service. <https://www.nrcs.usda.gov/resources/education-and-teaching-materials/soil-facts>

USDA. (2015, January). *Soil quality indicators: Physical, chemical, and biological indicators for soil quality assessment and management*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/sites/default/files/2022-10/indicator_sheet_guide_sheet.pdf

USDA. (n.d.-b). *Soil your undies challenge*. Natural Resources Conservation Service. <https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/oregon/soil-your-undies-challenge>

USDA. (n.d.-c). *Soil your undies challenge tracker*. Natural Resources Conservation Service. <https://nrcs.maps.arcgis.com/apps/Shortlist/index.html?appid=df53302953484fa5b523aec263c86631>

USDA. (2023, December 28). *Soil health*. Natural Resources Conservation Service. <https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health>

USDA. (2023, February 10). *4-H history*. National 4-H Council. <https://4-h.org/about/history/>

Virginia Soil Health Coalition. (n.d.). *4theSoil*. 4 The Soil. <https://www.4thesoil.org/>

Virginia Tech. (2023, December 18). *4-H youth*. Virginia Cooperative Extension. <https://ext.vt.edu/4h-youth.html>

Woffinden, S., & Packham, J. (2001). Experiential learning, just do it! *The Agricultural education magazine*, 73, 8.

Appendices

Instrumentation- lesson plans, instructional aids and evaluation tools

Supporting documents- tables, program agenda, program evaluation data

Appendix A- Student Pre- and Post-test

1. What does the soil do? Select all that apply.
 - a. Decomposes things
 - b. Holds water
 - c. Protects plants from diseases
 - d. Provides stability
 - e. Filters waste
2. Is all soil the same?
 - a. Yes
 - b. No
3. List the soil particles from smallest to biggest.
 - a. Sand, Silt, Clay
 - b. Clay, Sand, Silt
 - c. Clay, Silt, Sand
 - d. Sand, Clay, Silt
4. Which is soil made of?
 - a. Living organisms
 - b. Rocks
 - c. Minerals
 - d. All of the above
5. Which item can NOT be composted?
 - a. Fruit and Vegetable Scraps
 - b. Meat
 - c. Newspaper
 - d. Coffee Grounds
6. Composting breaks down waste, but doesn't make anything useful.
 - a. True
 - b. False
7. Why is soil important to plants?
 - a. It provides nutrients and water
 - b. It keeps plant's roots in place
 - c. It protects plants from temperature changes
 - d. Just A and B
 - e. All of the above.

8. When planning a garden what are things you should consider? Select all that apply.
- Sunlight
 - Rainfall
 - Drainage
 - Location
 - Types of plants
9. What is erosion?
- Wearing away of land
 - Movement of soil
 - Rocks cracking
 - All of the above
10. What causes erosion? Select all that apply.
- People
 - Water
 - Wind
 - Animals
 - Temperature

Appendix B- Lesson Plans

Week 1: Introduction to “Soil your Undies” (40 minutes)

Objectives: Students will create their own hypothesis. Students will be able to describe the soil as a living system.

SOLS: Science- K.1, 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, BIO.1, 3.6, 4.8

Materials Needed: Two pair of white 100% cotton underwear, shovel for digging, landscape markers, seeds for planting, watering can, jar or dirt, place to bury the underwear, white board

Introduction to Activity: Hold up a jar of soil and ask students what it is. Many will say “dirt.” Explain that soil is much more than just dirt, but that it is an ecosystem with lots of activity going on! Soil provides many services. Discuss the different services soil provides, when kids are stumped, ask “what kind of systems in your own body help you?” Utilize this chart for students to see and fill in comparisons, if they are stumped, you can fill in some sections to guide them.

Soil Service	...Is like our... (Human	...because it provides...
--------------	--------------------------	---------------------------

	System)	(What does it do/provide?)
Decomposition	Digestive System	Nutrients for plants
Moisture Retention	Circulatory System	Holds water
Biodiversity	Immune System	Provides resilience in difficult conditions (fights pathogens)
Stability	Skeletal System	Structure
Biodegradation (filtration)	Liver	Breaks down waste, filters out wastes

Soil Service	...Is like our.... (Human System)	...because it provides... (What does it do/provide?)

One way we can give our soil a checkup and test how healthy it is is to see how much biological activity our soil has. Specifically, how well those little organisms can decompose organic matter. Would you expect healthy soil to be able to break down a little bit or a lot of organic matter? How can we test this?

Activity:

- Choose two undisturbed locations to conduct your test (garden, yard, woods)
- Dig Holes around 6 inches deep and bury the underwear.
- Mark with landscaping flag

(If you don't have access to landscaping flags, you can cut a small hole in the waistband of the underwear before burying it and tying any sort of non-cotton string or rope to it, leaving a section visible after burying)

- Cover the underwear back up with dirt!
- If planting in a garden space, plant seeds over the underwear and have students make observations of what they see in the experiment site

Exit Slip Questions

- What do you think will happen to the underwear?
 - What are two 'soil services'?
-

Week 2: Soil Particles (40 minutes)

Objectives: Students will describe all of the different parts that make up soil. Students will be able to identify the difference between soil mediums.

SOL'S:

Science SOL's: 1.5, 3.2, 3.5, 3.6, 4.3, LS.6, BIO.8, PH.3

Math SOL: 3.7

Materials Needed: Soil from different locations in jars, water, paper, pencils

Introduction to Activity: Ask students what soil looks like. Ask if it depends on where you are, whether you are in the garden, the forest, or near the beach. Discuss how soil is made up of different particles all with their own different characteristics, and not all soil is the same.

Activity: Take a walk around the school with students and have them collect samples from different locations, placing the samples in jars and labeling them. (For the sake of time or weather, you can take samples ahead of time from different locations.) Once students have collected their samples, add water to the jars, reseal them, and have students shake them. Then sit the jars on a table and have students observe what happens. Explain that because soil is made up of different particles, all being a different size and weight, they fall at different rates. As the particles setting students will observe the different levels of sand, silt, and clay. Have students measure how much of each type is in each jar and discuss the differences in soil composition based on the location the sample was collected.

(Bonus: If the jars stay sealed in a sunny window, these jars can be turned into mini terrariums and youth will slowly begin to see the biological activity the soil produces over time)

Exit Slip Questions

- What are the three types of soil?

- Were there any differences between the soil samples? If so why do you think they were different?

Week 3: Parts of the Soil (40 Minutes)

Objectives: Students will demonstrate knowledge of soil ingredients through creating edible models. Students will be able to demonstrate knowledge of fractions as they create their own soil trail mix.

SOL's: Science 3.6, Math 6.2

Materials Needed: Pencils, Paper, Measuring Cups, Large Bowls, Small Bowls, Trail mix ingredients of your choosing

Introduction to Activity: Last week we talked about the different types of soil and how the ratio of silt, sand, and clay can impact the soil and change its characteristics. But sand, silt, and clay aren't the only things that make up soil. Can anyone tell us what is something else that helps make up soil? Have students brainstorm all of the different things that make up our soil.

Today we are going to be making our own soil trail mix. So what we are going to do is decide what kind of soil we want as we create our soil trail mix using our ingredients: Minerals (clay, silt, and sand), organic matter, living organisms, gas, and water. Now if we really made a trail mix out of those items they wouldn't taste very good so we have labeled our ingredients to represent the different parts of the soil, and its your job to create your own mix and write down how much of each item you put into your mix.

Activity: Have students make their own trail mix in their own bowls using the ingredients you supply, make sure they are righting down how much of each item they put in. You can choose any ingredients you like to represent the different parts of soil but here is what was used:

Soil Ingredient	Food Ingredient
Living Plants and Animals	Gold Fish
Organic Matter	Chocolate Chips
Air	Popcorn
Water	Freeze Dried Blueberries or Shaved Coconut

Sand (Largest Particle Size)	Chex Cereal
Silt	Rice Cereal
Clay (Smallest Particle Size)	Sprinkles

After Students Have completed their soil trail mix, have them look at the amounts of each item they used and find the total amount of soil trail mix they made.

As students are figuring out their soil trail mix fractions, they can eat their treat. Have students share what type of “soil” they made.

Exit Slip Questions:

- How would you describe the type of ‘soil’ you made?
- Where would you be most likely to find the kind of soil you made? (In a garden, the beach, the forest?)

Week 4: Composting! (40 minutes)

Objectives: Students will define composting and why it is beneficial. Students will describe what items can and cannot be composted

SOL’s: Science 3.6, LS.6

Materials Needed: Plastic jars with lids, compostable items such as egg shells, coffee grounds, and newspaper, spray bottle of water

Introduction to Activity: Discuss what composting is and why it is beneficial, review what can and cannot be composted by printing various pictures of compostable and non compostable items, have youth sort them and review.

Activity: Mini-Compost Jars

Depending on the age group, you can have students poke holes in the lids of their jar using a screwdriver, or premake them. Have students add roughly one cup of topsoil to their jar and then using what they just learned to fill their compost jar with items such as newspaper, coffee grounds, and veggie scraps. Have students water their compost jar with a spray bottle until damp. Students can either take their jars home to continue to observe or leave them at school where they can observe the changes together.

Exit Slip Questions:

- What is a benefit to composting?
- What does composted materials add to soil?

Week 5: What Plants Need to Survive and Thrive (40 minutes)

Objectives: Students will investigate what plants need to survive and how soil plays a role in plants survival.

SOL's: Science 1.4, 2.4, 3.6, LS.6

Materials Needed: Plastic sandwich bags, fast sprouting seeds, soil medium (soil or cotton balls), spray bottle of water, sunny window, construction paper, markers, scissors
Introduction to Activity: Discuss what living things need, specifically plants. Have students staple their plastic bag to a piece of construction paper and allow students to design their own greenhouse on the paper.

Activity: Once students have decorated their mini-greenhouse, and identified what plants need to survive, have them create their own greenhouse using the soil medium, seeds, and water. Ask them, "What does the soil do for the plant?" and discuss how it offers stability, nutrients, etc. Students can hang their greenhouses on a sunny window and watch their seeds sprout over the next several days. As seeds begin to sprout, students can transfer them to the garden or a pot to continue to watch them grow.

Exit Slip Questions:

- What do plants need to grow?
- Why is soil important to plants?

Week 6: Garden Design (30 minutes)

Objectives: Students will explore garden design and how different factors can impact a garden.

SOL's: Science 2.5, 2.8, 3.6, 3.8, 4.3, LS.6

Materials Needed: Selected food items, paper plates, hand washing station, spoons, forks, knives

Introduction to Activity: Explain to students that when creating a garden, we only have one chance to really set it up correctly, so we are going to proactive by creating a mock garden on a plate. Ask students what are some things they would normally find in a garden. Ask students to wash their hands and give each student a paper plate. Explain that this will be their garden space for today and that they will use the various food items to represent different items in their garden.

Activity: Give students 15 minutes to design their garden on a plate using the various food items you provide. Suggested items can include: pretzels (logs), hummus (soil), corn kernels or sunflower seeds (seeds), shredded cheese (mulch), Broccoli (growing plants) and various other vegetables or fruits to choose from. After fifteen minutes have students go around and explain their garden design and what each item represents on their plate. Students can then eat their garden on a plate and clean up!

Exit Slip Questions:

- Explain why and how you made your garden the way you did.
- What issues could you see happening if your garden on a plate was used to design a real garden? What would you change?

Week 7: Erosion (40 minutes)

Objectives: Students will investigate the impact of erosion on ecosystems. Students will discuss how erosion occurs and humans involvement in erosion.

SOL's: Science 2.8, 3.6, 3.8 6.8, ES.8

Materials Needed: Three clear empty basins/plastic totes, three totes or boxes with drainage: One with just soil, one with soil covered in straw, one with plants with established root systems, a table, watering can, water source, pencils, paper

Introduction to Activity: This is a great lesson to partner with your local soil and water district! Discuss erosion and what can happen if there aren't enough roots to hold soil in place. Ask students which of the three tubs will hold the most water and which one will produce the cleanest water run-off.

Activity: Utilizing three **tilted** tubs on a table, one with shallow rooted grasses, one with dirt, and one with soil and deep-rooted grass, and three empty tubs on the ground below. Have youth guess what will happen when water is poured at the top of the containers. Have youth pour the water and observe the differences in water clarity, discussion on the importance of root systems and quality soil for things to grow to prevent erosion. Discussion on what erosion can cause and how we prevent it.

Exit Slip Questions:

- Which tub did you think would stop the erosion the best?
- Which tub stopped the erosion the best?

Week 8: Unearth the Underwear! (30 minutes)

Objectives: Students will observe the biological activity of the soil and discuss why they think the underwear is in the condition they are in.

SOL's: Science K.1, 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, BIO.1

Materials Needed: Camera

Introduction to Activity: Recap previous lessons and ask students what they think will happen when the underwear is unburied.

Activity: Head to the locations you initially buried the underwear, have students make observations of the locations and dig up the underwear! Allow students to observe the underwear and discuss how the conditions over the last two months could have impacted the changes. Ask students what they would do differently if we ran the experiment again. Take pictures of the underwear and submit them to <https://nracs.maps.arcgis.com/apps/Shortlist/index.html?appid=df53302953484fa5b523aec263c86631> ([Soil Your Undies Challenge Tracker \(arcgis.com\)](https://nracs.maps.arcgis.com/apps/Shortlist/index.html?appid=df53302953484fa5b523aec263c86631)) so that others can see the results of the experiment!

Exit Slip Questions

- Instead of exit slip questions, have students complete the post-test

Appendix C- Self Evaluation Questions

1. What worked well? What didn't?

2. What did I notice?
3. What did the students take away from the lesson/activity?
4. Insights from other facilitators, if any.

Appendix D- SOL Correlation Chart

Lessons at a Glance

Week 1	Science SOL's K.1, 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, BIO.1, 3.6, 3.8
Week 2	Science SOL's 1.5, 3.2, 3.5, 3.6, 4.3, LS.6, BIO.8, PH.3 Math SOL 3.7
Week 3	Science SOL 3.6 Math SOL 6.2
Week 4	Science SOL's 3.6, LS.6
Week 5	Science SOL's 1.4, 2.4, 3.6, LS.6
Week 6	Science SOL's 2.5, 2.8, 3.6, 3.8, 4.3, LS.6
Week 7	Science SOL's 2.8, 3.6, 3.8, 6.8, ES.8
Week 8	Science SOL's K.1, 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, BIO.1, 3.6

Appendix E: Virginia Tech Human Research Protection Program Letter



Division of Scholarly Integrity and
Research Compliance
Institutional Review Board
North End Center, Suite 4120 (MC 0497)
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732
ib@vt.edu
<http://www.research.vt.edu/irb/pp>

MEMORANDUM

DATE: February 22, 2024
TO: Hannah H Scherer, Meagan Lee Dyer
FROM: Virginia Tech Institutional Review Board (FWA00000572)
PROTOCOL TITLE: Developing Youth's Understanding of Soil Health through Supplementary Activities and the USDA "Soil Your Undies" Challenge
IRB NUMBER: 24-188

Based on the submitted project description and items listed in the Special Instructions section found on Page 2, the Virginia Tech Human Research Protection Program (HRPP) has determined that the proposed activity is not research involving human subjects as defined by HHS and FDA regulations.

Further review and approval by the Virginia Tech Human Research Protection Program (HRPP) is not required because this is not human research. This determination applies only to the activities described in the submitted project description and does not apply should any changes be made. If changes are made you must immediately submit an Amendment to the HRPP for a new determination. Your amendment must include a description of the changes and you must upload all revised documents. At that time, the HRPP will review the submission activities to confirm the original "Not Research" decision or to advise if a new application must be made.

If there are additional undisclosed components that you feel merit a change in this initial determination, please contact our office for a consultation.

Please be aware that receiving a "Not Research" Determination is not the same as IRB review and approval of the activity. You are NOT to use IRB consent forms or templates for these activities. If you have any questions, please contact the Virginia Tech HRPP office at 540-231-3732 or irb@vt.edu.

PROTOCOL INFORMATION:

Determined As: **Not Research**
 Protocol Determination Date: **February 22, 2024**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

Invent the Future

SPECIAL INSTRUCTIONS:

This activity does not meet the federal definition of research. The purpose of this activity is to implement and evaluate the effectiveness of a 4-H enrichment program that includes six mini-lessons that can be paired with the "Soil Your Undies" Challenge. The results will be used for curriculum development and will not be generalizable, therefore this is not considered research.

***Please note, this determination only covers the activities described in this determination submission. Any future plans to further analyze or compare will need to be submitted and approved by the HRPP off

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu) immediately.