Soil Exploration Station to Engage Children in Nature and Play-Based Learning at Turn Back Time

An Interactive Qualifying Project
submitted to the Faculty of
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degree of Bachelor of Science

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Acknowledgments

We would like to thank our sponsor, Lisa Burris, and Turn Back Time (TBT) for providing us with this opportunity to learn about the benefits of nature and play based education, and for allowing us to create educational activities which will be used at TBT. Burris and TBT's team were very supportive of our efforts throughout the entire project. Our team would also like to thank Professor Elisabeth Stoddard for allowing us to work on this project, and advising our team throughout its entirety. Additionally, we would like to give a special thanks to Professor Robert Traver for guiding our team throughout the planning of this project. Professor Traver also assisted our team in creating the educational activities and structures that have been implemented at TBT. We would also like to thank Katie Baker, assistant director for Turn Back Time, for her contributions in creating and assessing the educational activities that will be implemented at TBT.

Authorship

Each team member contributed to the writing and revisions of the entirety of this report. We have all reviewed the paper and contributed equally to its various sections.

Executive Summary

Introduction and Project Goals

Turn Back Time (TBT) is a non-profit, nature-based education center that focuses on using nature as a healer and equalizer (Turn Back Time, n.d). The faculty at TBT believe that a connection to nature is essential to live a balanced life. Through nature exploration and education, they hope to give individuals a way to connect back to nature. Many schools including TBT lack education on soil. To further their mission TBT wants to continue to engage students with the environment, hence the need for a soil science curriculum.

Turn Back Time focuses on equality through nature and play based learning. This offers a unique non-traditional learning experience. Non-traditional learning offers the flexibility needed to accommodate varying learning styles. This is important in order to accommodate children of various learning differences and disabilities

The purpose of our project for Turn Back Time is twofold; the first is to design and construct a small self-contained soil exploration station. The second is to design a nature and play-based soil curriculum for the children at TBT. To accomplish this goal our team developed the objectives of determining the appropriate soil tests and structures to utilize, and determining play-based and nature-based soil curriculums for the children at Turn Back Time.

Methods

To accomplish our first objective of determining the appropriate soil test and structures we first consulted with our sponsor Lisa Burris and farmer Dawn (Dawn handles the garden produce for the Community Share Association (CSA)). After an informal conversation it was understood that the initial plans for the soil exploration station would need to change. We concluded that a home soil-testing kit would suffice.While determining the appropriate structures for the soil exploration station we had to take into consideration the need for maintenance from possible weathering. This led us to believe a roof structure would be the most appropriate to combat weathering.

Before carrying out our second objective we needed to familiarize ourselves with nature and play-based education. We first interviewed Katie Baker, the head curriculum writer at TBT and assistant director, on the nature of TBT play-based learning. This created a need to understand how curriculums accommodating different learning styles are built. We learned about the difference in playstyles across age groups from the assistant director of TBT, Katie Baker. Mrs. Baker explained the use of Massachusetts curriculum standards as a backbone for non-traditional learning, which we used to structure our own curriculum. TBT also uses nature-based education to promote learning. To better understand the differences between nature/play education and the traditional classroom setting, we reviewed a conducted interview with Rachel Larimore. Rachel Larimore is an educator focused on the integration of nature in early childhood education. The Massachusetts Audubon society was also referred to for activity ideas. The activities offered by their nature and play modules aided in our activity design. These activities were redesigned to incorporate opportunities of nature and play learning into the curriculum taught at TBT.

Results and Analysis

Based on our preliminary designs we constructed a set of tables that function as an interactive space for children. The table top has interactive activities designed to promote inquiry based learning. We considered insights from Katie Baker, the lead curriculum developer for TBT, regarding the design and placement of the tabletop activities based on age groups. We created a tiered learning progression that accounted for differences in learning development. To ensure our activities and kits were protected from the weather we decided to design and build a roof structure. We found that using fencing with a mesh screen and tarp as roofing to be a cost effective option.

To complete objective two (Determine nature and play based soil curriculums for children at TBT) our team explored various curriculum requirements. The activities and kits were designed with nature and play-based learning, Massachusetts curriculum standards, and accessibility in mind. These activities came from two different sources; Mass Audubon, Massachusetts and from soils4kids. Before we assembled our kits, the activities were paired to the Massachusetts standards that we alphanumerically coded. The activity kits are lightweight, portable and include a list of material and guiding questions needed for each activity. We also included a maintenance plan (see Appendix F) for the soil exploration station and kits for the farm to follow for weathering purposes.

Recommendations

The following section discusses the team's recommendations to the sponsor. These are based directly on the objectives of the project and the research we conducted.

1. **Using the Coded Curriculum and activity kits for future activities**
2. **Regular Soil Testing**

The following recommendations are our suggestions to the various problems that were discussed during informal conversations with the staff.

1. **Installing a Water Irrigation system**
2. **Regular Maintenance (follow maintenance guide)**

Abstract

Nature and play-based learning is a form of non-traditional learning that allows children with learning differences to develop skills that are not taught in a traditional classroom. Turn Back Time—a non-profit, nature and play-based education center and farm— was seeking to include soil science as a part of their curriculum, and looking for recommendations on soil testing for their garden. By conducting semi-structured interviews and background research, we created soil science activities and kits. Our team also designed and built a roof structure and tables to house the various activities. Additionally, recommendations on soil testing were provided based on the farm's production levels.

1.0 Introduction

In a traditional school setting, there exists a structured and routine-oriented curriculum (Punkoney, 2020). A structured environment does not work for all children and can often result in them falling behind academically (LDRFA, 2010). One cause of this is the difference in each child's approach to learning. The various learning differences that exist affect the way information is processed and recalled (Hudson et al., 2007). These learning differences must be considered when forming an effective and inclusive curriculum. Another possibility is that the child has a learning disability. A learning disability (LD) is a neurological disorder that affects the brain's ability to receive, process, store, and respond to information (Clauss-Ehlers, 2010). It is important to consider the needs of each individual student and their learning style in order to establish a curriculum that best suits them. This is very important in achieving academic success for all children. For this reason, alternative learning techniques are becoming more prevalent.

One such example of a non-traditional education is nature and play-based learning. The inclusion of nature and play-based learning at an early age can often facilitate the formation of necessary skills (American Camp Association, 2015). Nature and play-based learning is often inquiry based and unstructure. Unstructured learning provides children with educational freedom and creates a sense of fun in learning for those who have problems in typically structured classrooms. Nature and play-based learning also serve in helping foster curiosity and initiative in children (Dupree, 2019).

Turn Back Time (TBT) is a non-profit nature-based education center that focuses on using nature as a healer and equalizer (Turn Back Time, n.d). The faculty at TBT believes that a connection to nature is an essential aspect to a balanced life. Through nature exploration and education, they aim to give individuals a way to connect back to nature. One of their objectives is to "form a community of environmental stewards and advocates, during this time when we need it most" (Turn Back Time, n.d). In addition, TBT has emphasized inclusivity, with qualified staff for children with disabilities to provide for a safe and enjoyable learning experience for all.

Turn Back Time offers many educational programs such as 'Critter Catchers'—a fun play-based activity that allows children to examine and inspect critters—that focuses on outdoor exploration (Turn Back Time, n.d). However, there is a lack of education modules, testing materials, and physical structures to teach children about soil.

The purpose of our project for Turn Back Time is twofold; the first is to design and construct a small self-contained soil exploration station. The second is to design a nature and play-based soil curriculum for the children at TBT. To accomplish this goal our team developed the objectives of determining the appropriate soil tests and structures to utilize, and determining play-based and nature-based soil curriculums for the children at Turn Back Time.

2.0 Background

2.1 Introduction

The following sections provide background information relevant to this project. First, information regarding the town of Paxton, where the project center resides, is provided. Then, the mission of Turn Back Time and the project liaison, Lisa Burris, are discussed. These sections are followed by discussion of learning differences and non-traditional learning through nature and play for children of all abilities. Research was also done on the Massachusetts curriculum standards for pre-k through fourth grade. Soil science activities based on nature and play from the Mass Audubon society were also studied. Turn Back Time had a need to implement soil science education as it is an invaluable component of nature education. Learning more about soil will help the children at TBT develop a better understanding of their environment.

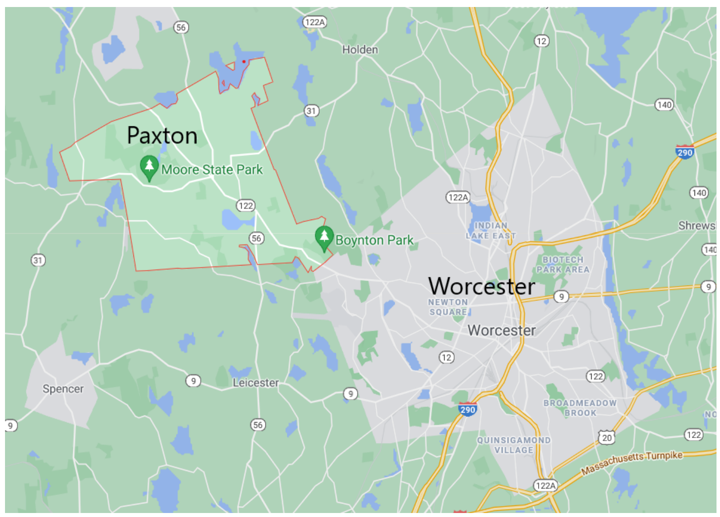
2.2 Paxton

Paxton is a small town in Worcester County, Massachusetts and the location of Turn Back Time. According to the United States Census Bureau, Paxton's population in 2019 was estimated to be 4900. Additionally, the racial makeup of this town is primarily white (89%), Black or African American (8.6%), and Asian (2.1%) (US Census Bureau, 2019). The median household income was $120,469 with a median age of 37.5 years (Cupbit, n.d).

The town has a total area of 15.4 square miles, of which 4.78% is water (US Census Bureau, 2019). The estimated elevation level is approximately 1,132 feet above sea level (US Census Bureau, 2019). Additionally, as shown in Figure 2.1, Paxton is adjacent to Worcester—the second most populated city in New England (United States Census, 2010).

Figure 1

Portion of a map of Worcester County (Google Maps, 2021)



In terms of soil, Paxton has some of the most fertile and productive soils in New England. The soil is defined as coarse loamy soil with good drainage. Loam is fertile soil containing sand and clay and organic matter. The base rock that Paxton soil sits on was first deposited from the movement of glaciers, lending to a diverse soil mineral content. The clay content of Paxton soil contributes to its structure providing an enhanced ability to hold nutrients and barriers for soil acidification (Pabedinskas, n.d.). The soil is primarily used for crops such as apples and corn as well as hay (United States Department of Agriculture, 2015). Generally, the growing season lasts for 167 days with the first frost in early October (Farmer's Almanac, n.d.).

2.3 Turn Back Time

While Paxton is known to be the home of prized agriculture soil, it is also home to Turn Back Time. Turn Back Time is a non-profit nature-based education center located on 58 acres in Paxton, Massachusetts. The property includes an active beaver pond, forested trail system, and a large commercial garden (Turn Back Time, n.d). They focus on building relationships between the learner and the natural world. Additionally, they seek to "provide opportunities to take supported risks appropriate to the environment and to ourselves," in order to give individuals of all ages and capacities to learn and grow in confidence (Turn Back Time, n.d). They offer a variety of programs such as preschool, homeschool and summer camps. Their official mission statement is as follows: "Turn Back Time's mission is to help people recognize nature's ability to teach and heal with a commitment to offering programs to underserved populations."

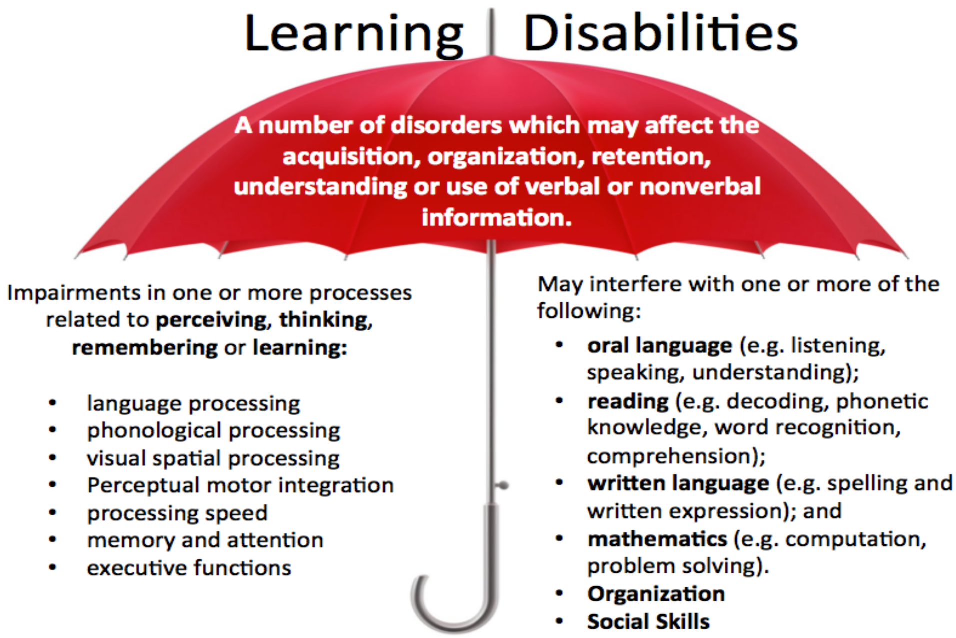
Lisa Burris is the Executive Director of Turn Back Time, and the liaison for this project. She holds a master's degree for Nature Based Education and Forest Kindergarten from Antioch University located in Keene, New Hampshire (TurnBackTime, "Our Team"). Additionally, she is a trained foster parent in the state of Massachusetts and has worked with kids as an Applied Behavior Therapist (TurnBackTime, "Our Team").

2.4 Learning Differences

Learning differences must be considered when forming an effective and inclusive curriculum. This is a major focus at Turn Back Time because the majority of the children which they work with have learning differences making it challenging for them to learn in a traditional classroom setting. A learning disability (LD) is a neurological disorder that affects the brain's ability to receive, process, store, and respond to information (Elleseff, 2018). There exists various forms of learning disorders. As shown in Figure 2, there are several impairments and interferences that can arise as a result (Hudson et al., 2007). It can be daunting for children with a learning disability to be given the same assignments and expectations as their peers. For children with learning disabilities, it becomes increasingly more difficult to build interpersonal skills and keep up in learning with an extremely structured school curriculum (Pandy, 2012). This becomes an even bigger issue when they are expected to learn at the same pace as other children. This concept is not feasible and can result in a decrease in the confidence and self-esteem of the child (Pandy, 2012). Research has shown that individuals with learning disabilities develop a negative self-perception of themselves when comparing themselves to peers who do not have a learning disability (LaBarbera, 2008). As a result, it is crucial to demonstrate to children with learning disabilities that they are also able to effectively learn.

Figure 2

The Effects of Learning Disabilities (Elleseff, 2018)



Effective learning depends on having the ideal learning environment, pace, and curriculum. Some children with learning disabilities learn best when they are not given too much information to process all at once (LDRFA, 2010). A technique known as chunking can be helpful in breaking down large quantities of information and presenting it in a manageable form for the child (LDRFA, 2010). Short-cuts such as the use of mnemonics can also be helpful with a child's learning process. Extra attention outside of a classroom is also necessary; this is because oftentimes their learning occurs at a different pace. It becomes easy to fall behind in academics and because of this an individualized approach and extra time spent on the curriculum can help the student excel.

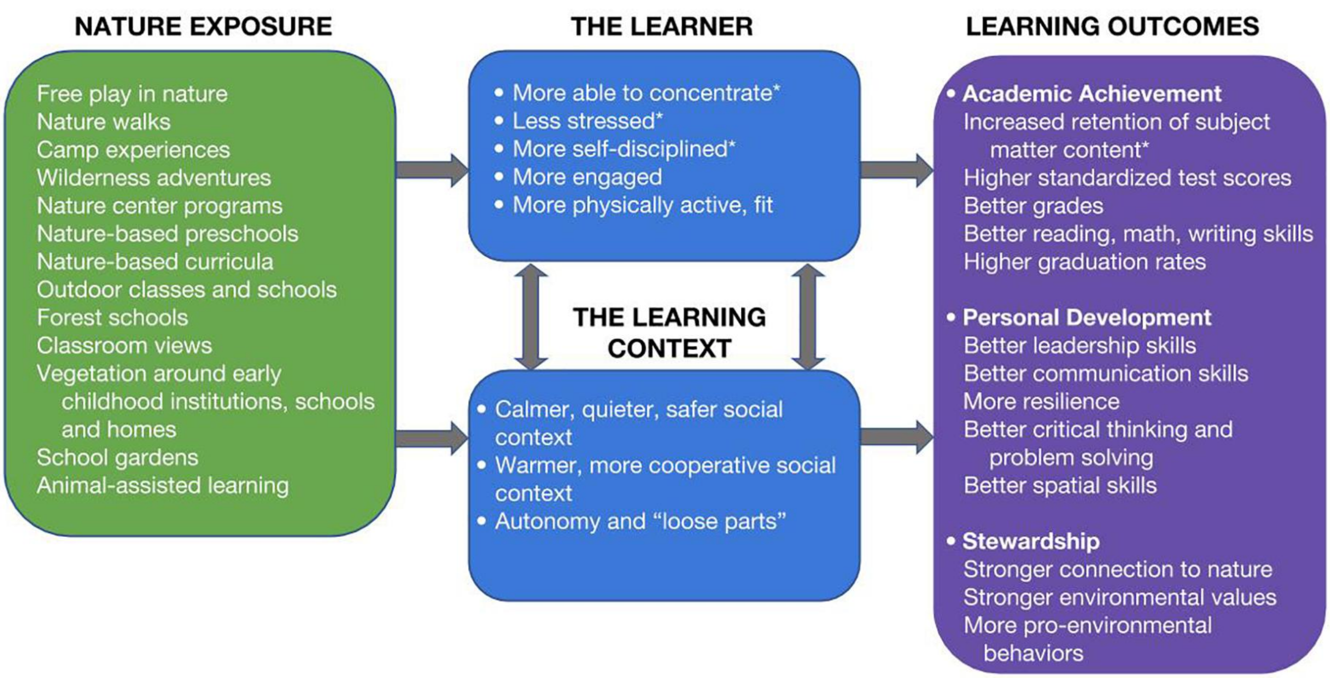
2.5 Nature and Play Based Learning

Turn Back Time provides children with disabilities and learning differences, opportunities through non-traditional settings. Their focus is on structuring their curriculum around nature and play based learning. Nature based learning consists of learning through exposure to nature based activities in an outdoor setting (Jordan and Chawla, 2019). Play based learning is a form of early education which focuses on learning through open-ended play (Vogel, 2021). Nature and play based learning are important in a child's educational career. They can be effective in aiding a range of age groups and in providing the opportunity to build skills that are not practiced in a classroom setting. Nature and play based learning are alternative methods of learning, rather than a structured school curriculum that is in place at standard schools. An unstructured and unguided learning curriculum allows for students who tend to have issues learning in a structured educational setting to become exposed to alternative learning styles (Reid, 2005). With the way curriculum is structured there is not much consideration for alternative learners. It is important to consider that children have different styles of learning and as a result will not be able to optimize their education if they are not given the considerations they require (Reid, 2005).

Nature-based learning is where learning occurs in the context of nature (Samara Early Education, 2021). Nature-based learning is significant in allowing for educational immersion through exploration and development of curiosity and intrapersonal skills. In terms of acquiring environmental awareness, learning about the environment as early as ages three to ten can be crucial in the formation of a child's outlook on environmental sustainability. Early environmental education creates a lasting effect on sustainable living and development (Ogelman, 2012). There are many scientific studies to prove that nature-based learning helps students perform significantly better in academics (Jankovich, 2017). As shown in Figure 3, nature exposure presents students with multiple positive learning outcomes including the following: an increase in academic achievement, personal development, and stewardship, among many others (Kuo et al., 2019).

Figure 3

Nature-based Learning and its Benefits (Kuo et al., 2019)



There currently exists a lack of environmental literacy among the population, this literacy gap is increasing rather than decreasing (Driessnack, 2009). As a result, the No Child Left Inside

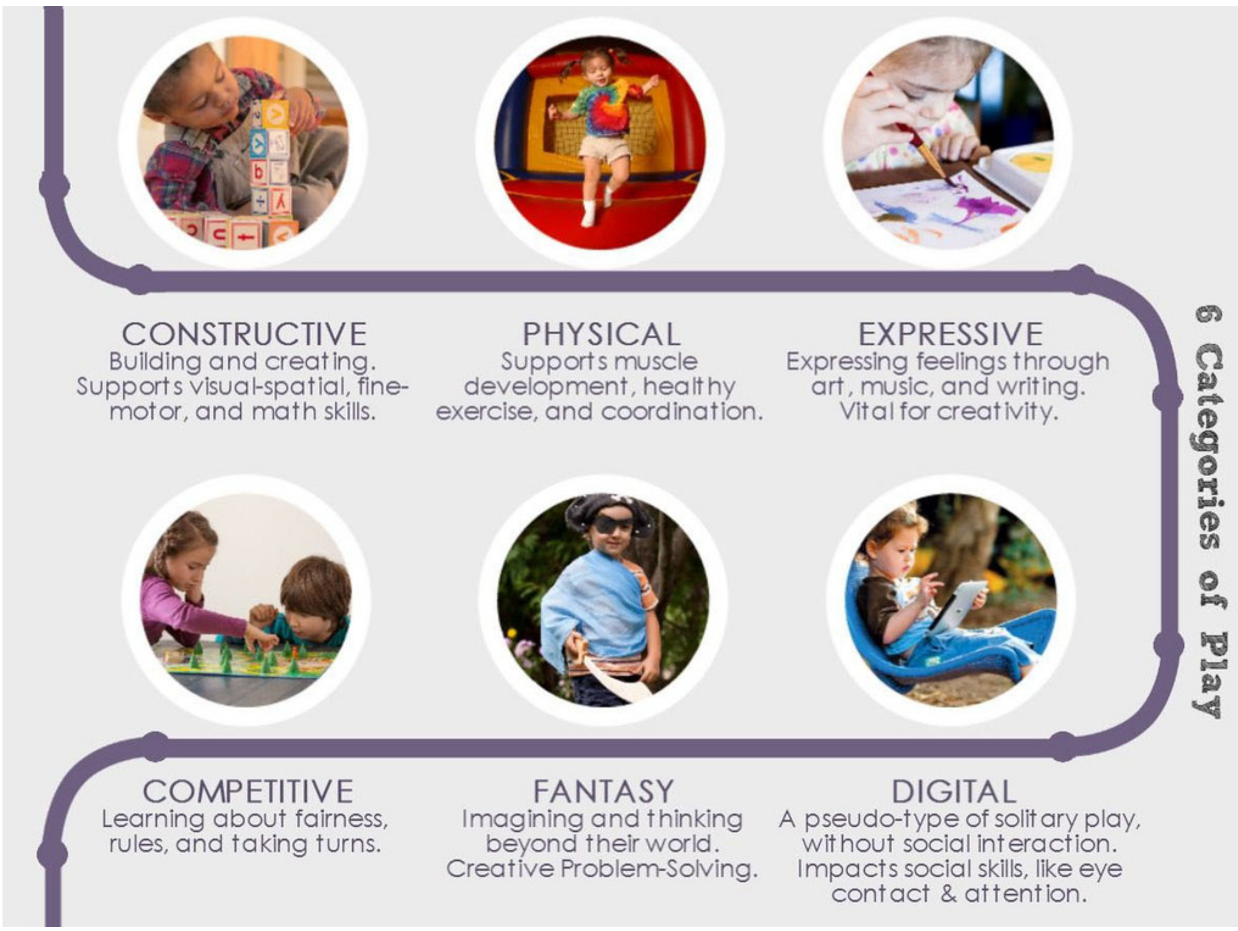
Act signed into law by Obama in 2015 as a provision to Every Student Succeeds Act set out to make nature-based learning a core part of curriculum (American Camp Association, 2015). The No Child Left Inside Act has required that states develop environmental literacy plans, approved by the Secretary of Education, for kindergarten through grade twelve that include environmental education standards and teacher training (American Camp Association, 2015). Studies done by environmental education programs have found improvements in "understanding science concepts, cooperation, conflict resolution skills, self-esteem, positive environmental behavior, problem solving, motivation to learn, and classroom behavior" (American Institutes for Research, 2005, pg. vi). Many of these positive qualities practiced in nature-based education can transfer to a school setting, allowing for greater academic achievement (American Camp Association, 2015).

Unstructured play is the basis for most nature-based learning; however, educators can guide and encourage learning to take place. It is important for educators to be informed on questions students may have in a natural setting. By teaching children material, they are genuinely curious about and asking about on their own, they are more likely to remember the information they are given. When children are given answers based on their own questions, they are likely to maintain curiosity and initiative in their own learning (Dupree, 2019). Nature-based learning can be adapted to all age groups. Due to its flexibility in teaching to all ages and its benefits, it is an asset that should be incorporated into the education of all children (Kuo, 2019).

Another crucial form of learning is through play. There exist different forms of play that can contribute to learning as shown in Figure 4. Each method of play presented in this figure has its own benefits, including but not limited to increased creativity, problem-solving, improved social skills, etc. (E-learning infographics, 2017).

Figure 4

Categories of Play-based Learning (E-learning infographics, 2017)



Play-based learning is important in the development of healthy social and emotional skills. Skills that are acquired or improved upon including the following: communication, cooperation, critical thinking, and motor skills (Granada Preparatory School, 2018). Learning through play has been shown to keep children actively engaged while also remaining motivated at their tasks. Play-based learning establishes the best conditions for children to learn in an unstructured environment (Pui-Wah and Stimpson, 2004).

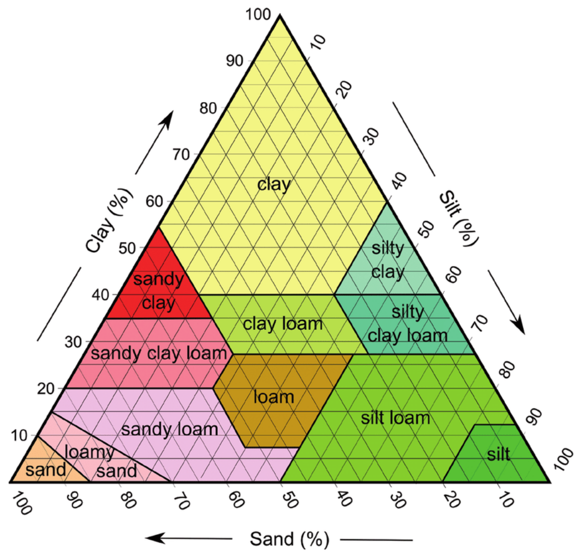
2.6 Soil

Soil, which is a component of nature and a major indicator of the health of the environment is understudied in schools. The study of soil science is ripe with opportunities to introduce physicality and fun, a characteristic of nature and play-based learning. Soil as a medium for play, allows teachers to continue use of nature and play based curriculum while successfully introducing soil education to children.

Fertile soil is a balance between the elements that support plant growth and soil structure. All soils can be broken down into their base components of sand, clay, and silt. Based on the differing quantities of each primary soil particle, soil takes on different structural and physical attributes (Stirling et al, 2016). Fertile soil such as loam is an equal mixture of sand, silt, and clay. The predominance of one particle can distinguish it as sandy loam or clay loam as seen in Figure 5 where loam is in the middle and its varieties are around it and defined by their particle (Ngowari, n.d.). Loam is good for farming due to its ability to hold water and nutrients with good drainage. Outside of the primary particles soil also consists of air, water, and organic particles in varying quantities.

Figure 5

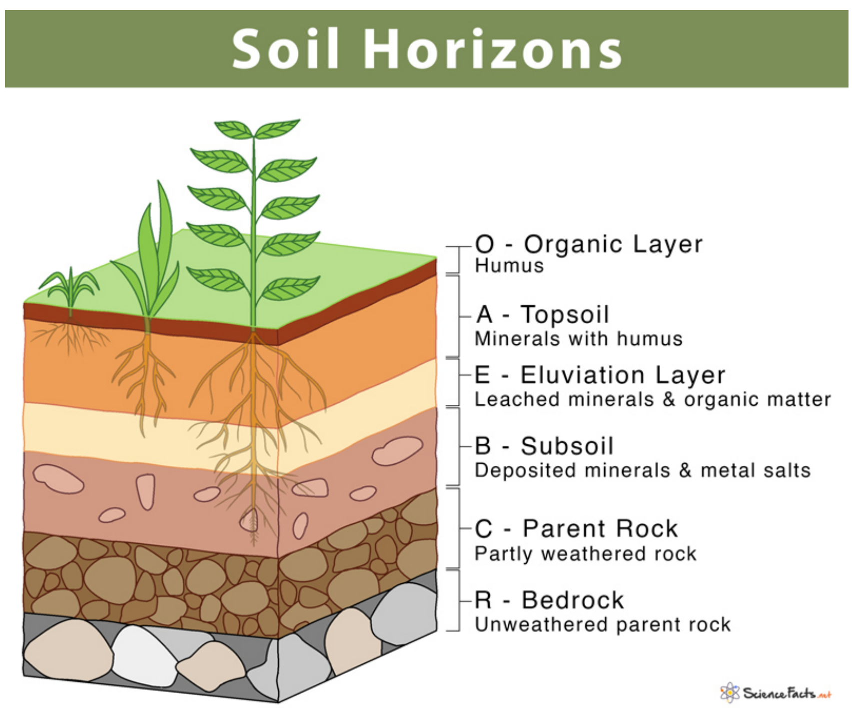
Soil Texture Diagram



Soil composition is vital for holding nutrients most of which comes from the organic matter of soil. The soil can be divided into different layers or horizons which can be easily differentiated and used to understand the best use of a soil. Soils principally have an A, B and C horizons corresponding to the surface horizon, the subsoil, and substratum respectively. Seen in Figure 6 the A horizon corresponds to the topsoil, which represents a mixture of organic material and minerals. The B horizon or subsoil contains mainly minerals and less organic matter, and it has a blocky texture due to the higher concentration of clay. The subsoil catches the minerals that are leached or physically transported by the soil organisms and microorganisms. from the topsoil. The C horizon is the closest to the bedrock and is not affected by changes in the soil due to agriculture or the soil formation process. The O horizon is the topmost layer and feeds into the topsoil (United States Department of Agriculture, n.d.). The O horizon contains organic material like humus (United States Department of Agriculture, n.d.). Humus is the part of the soil that affects crop growth the most. Humus is important for nutrient recycling, cation exchange capacity, water holding, and structure stability (Zhu, 2018, pg. 285). At TBT the raised beds only contain a top soil layer while the surrounding forest retains its humus. Most agricultural soils do not retain their humus due to tilling. While TBT uses no-till agriculture their raised beds feature a cultivated topsoil designed to best support their crops.

Figure 6

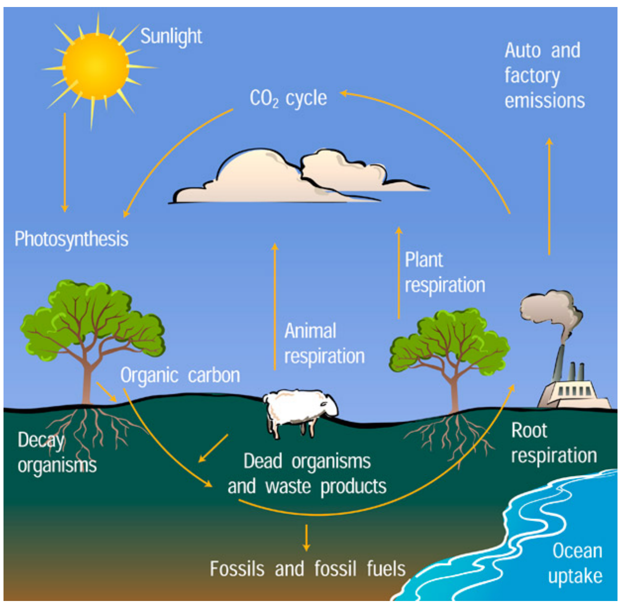
Soil Horizons



Agricultural topsoils have many health factors but two of the biggest elemental factors are carbon and nitrogen. Carbon and nitrogen are the most integral nutrients that humus helps store and cycle. Seen in Figure 6 and Figure 7, carbon and nitrogen cycle through organic and inorganic forms before being able to be accessed by plants. Humus acts as an integral carbon source, which participates in regulating the biological and geological balance of the carbon cycle in the soil and environment. Its breakdown returns carbon to the soil in an organic form stabilizing the soil (Garcia, 2019). The organic matter that makes up soil and humus contains a substantial amount of available nitrogen, sulfur, and phosphorus. The dead organic matter is mainly plant residue such as leaf litter and roots, as well as animal feces, and the remains of decomposing fauna (Stirling et al, 2016).

Figure 7

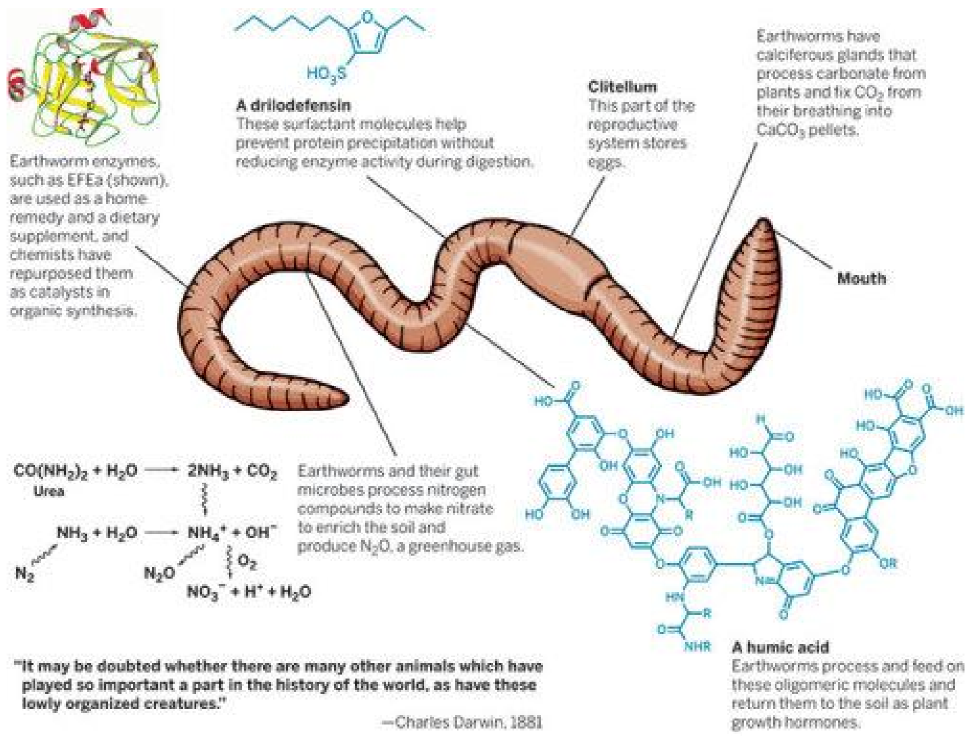
Carbon Cycle



The biotic or living portion of the soil is a major source in regulating soil nutrients. There are many microorganisms in the soil that principally regulate its balance of carbon and nitrogen. If there is too much of either element in the soil it will cause a deficit of the other element in the soil. This is due to the organisms over consuming the element in abundance first and then completely depleting the less available element afterward (USDA, 2011). The biotic part of the soil is also host to a varied amount of insects. Many of these insects can go on to influence the health of crops. Aphids for example are a very common garden insect that act as a pest and cause plants to wither. Aphids suck out plant sap out while damaging the plant flesh. Aphid population is regulated by predators such as the ground beetle. The ground beetle not only hunts their eggs but destroys weed seeds in the soil (Roubinet, 2016). This is one example of the ecosystem that soil can host. One of the most important living players of the soil are worms. Worms are a major decomposer. Worm castings, the material left after worms eat dead matter, is full of available nutrients. Outside of recycling nutrients back into the soil, worms also help the soil structure. The tunnels that worms build promote water drainage and infiltration. This process also turns the soil their burrowing provides a natural tillage. (Garg, 2019) The action of worms is directly linked to the health of the soil structure.

Figure 8

Worms cycle nutrients through the soil



Soil structure is needed for water retention, soil aeration and thermal conductivity. Soil structure is also generally used to indicate quality and fertility (Pereira, 2019). Soil organic matter improves water retention and binds soil particles strengthening to soil structure. The top organic layer in soil is the first to be degraded in processes such as erosion. This can lead to the destruction of the microbiome and the loss of the soil's ability to process and hold nutrients needed for plant growth (Bot and, Benites, 2005, pg. 5).

Reintroduction of nutrients and repair of the humus/soil organic matter is a common practice for restoring degraded soil. Composting helps alleviate soil destruction such as erosion and compaction, and different kinds of compost can be applied to different soil types. The reintroduction of organic matter into degraded topsoil can start to provide the structure and water retention lost to erosion (Environmental Protection Agency, 1997). Critical variables for successful composting include the ratio of carbon to nitrogen, the nature of the cellulosic component, particle size, bed size and format, moisture, pH, aeration, temperature, and time (Hubbe et al., 2010). Fertilizer specifically natural fertilizers help to also add carbon and nitrogen back into the soil. Intensive agriculture practices tend to use inorganic fertilizer due to its quick acting effects. Organic fertilizer takes time to act and with variable success (Jun, 2016). However, synthetic fertilizers have been shown to increase the acidity of the soil. The overuse of nitrogen fertilizers has been linked to the degradation of soil organic matter and water pollution (Jun, 2016). Manure has long lasting positive effects. The application of manure strongly and positively affects crop yields by increasing soil organic carbon storage, soil nutrients, and soil pH (Cai et al., 2019).

2.6.1 Soil Testing

Soil health (used interchangeably with soil quality), is the capacity of soil to function as a living ecosystem that can sustain plants, animals, and humans (USDA, n.d). This definition outlines the importance of managing the sustainability of soil. According to Doran and Parkin (1994), “[similar to air or water,] the quality of soil has a profound effect on the health and productivity of a given ecosystem” (pg. 5). However, unlike air or water, defining and quantifying soil has been difficult (Doran and Parkin, 1994, pg. 6). This is mainly due to the variable nature of 'good' soil. As outlined by Doran and Parkin (1994), different individuals determine soil quality based on their personal utilization of soil and perceived importance of soil's functionality (5-6). Soil health cannot be measured solely based on crop yield, and individual indicators must be tested for an overall assessment (USDA, n.d).

The result of soil tests may offer valuable insights into soil health, which in turn can be used to determine the amount of fertilizer and lime to use. Furthermore, soil testing aids in the diagnosis of plant culture problems, provides information on improving nutritional balance and may lower expenditure on fertilizers (UMass Amherst Soil and Plant Testing Laboratory, n.d).

While there are many aspects of soil that can be tested, a basic and important indicator of soil health is pH. Soil pH refers to the degree of soil alkalinity or acidity and it affects the soil's physical, chemical and biological properties (soilquality.org, n.d). Soil pH changes the solubility of minerals and nutrients, which directly determines the nutritional content of a soil sample (SUNY Environmental Science and Forestry, n.d). Since different plants require different soil pH levels to grow well in, lime may be added as needed to increase and control the pH of a soil.

Similarly, plants require different nutrients in different concentrations to grow well. The three main elements for plants are: Nitrogen (N), Phosphorous (P) and Potassium (K) (NSW, n.d) (See Figure 8 for their usage in plants). Measurement of the levels of these elements can give insight into what type of fertilizer to use, and what crops may grow well in the soil.

Figure 8

Nitrogen, Phosphorus and Potassium usage in plants

In summary, testing soil produces information that can be used to make informed decisions while purchasing fertilizers and pH balancers. Hence, it can reduce expenditure on maintaining soil fertility and health.

2.7 Massachusetts Curriculum Standards

The present framework behind the curriculum taught to children is oftentimes too advanced for their age group and overly structured in nature for grade schoolers (Darling-Hammond, 2019). As a result, students tend to fall behind on the curriculum being taught and this results in a lack of motivation and initiative to learn in fear of failure (Darling-Hammond, 2019). It is important to maintain a setting in which all children can learn effectively and improve upon basic social and emotional patterns. Social-emotional learning includes the development of interpersonal skills (Shafer, 2018). Many of these skills taught to children are vital for future success in life; academically, professionally, and socially (Denham et al, 2010). Play-based learning can be structured appropriately to suit the needs of each individual child. Play and nature based curriculum focus on unstructured learning through interacting with the environment and outdoors. Unstructured learning however may still be guided to an extent to optimize learning conditions. However, characteristics of nature and play curriculum have a number of similarities to curriculum standards taught in traditional classroom settings.

The purpose of curriculum standards is to set expectations and guidelines for what students are expected to learn at each grade level. The curriculum standards researched for this project are from preschool to fourth grade. The curriculum framework topics consist of the following: language, number sense, patterns and relations, etc. (refer to appendix E for the entire list of standards). These standards have been selected for three to ten year olds. It is also important to take into account that individual students have different rates at which they learn best.

Both curriculum standards and effective learning conditions must be taken into account when establishing the most effective interactive activities for early education. Our main curriculum focus is on soil science and soil health.

2.8 Mass Audubon Society

The Massachusetts Audubon Society was founded in 1896 by Harriet Hemenway and Minna B. Hall, headquartered in Lincoln, Massachusetts. It is a nonprofit organization (Mass Audubon, 2021), that focuses on conservation, “by acting directly to protect the nature of Massachusetts and by stimulating individual and institutional action through conservation, education, and advocacy” (Mass Audubon, 2021). Mass Audubon has various nature centers with a goal of developing and sustaining nature-based early childhood education in all settings. A resource which contains a set of nature and play activities that are focused on soil education is a particular article taken from the Mass Audubon Society. There exists various functional activities which serve to incorporate soil science into early education through nature and play.

3.0 Methodology

3.1 Introduction

The goal of our project was to provide recommendations to Turn Back Time regarding soil testing and its required structures. Additionally, there was a need for a soil science curriculum, while maintaining the nature and play-based teaching principles of Turn Back Time. With the goals of our project in mind, the following are the project's objectives:

1. Determine the appropriate soil tests and structures to utilize for the improvement of crop production and soil education at Turn Back Time
2. Determine nature and play based soil curriculums for children at Turn Back Time

This section will cover how we planned to use semi-structured interviews to gather information. Information taken from these interviews have been used to accomplish our team objectives. First, to determine necessary structures for soil education at Turn Back Time. Second, forming a set of nature and play soil education activities aligned to Massachusetts science standards. Our objectives also included determining soil testing recommendations for crop maintenance and production of Turn Back Time's garden. The interviews have also served to provide us with further knowledge on soil health and testing.

3.2 Objective 1

Determine the appropriate soil tests and structures to utilize for the improvement of crop production at Turn Back Time

In order to fulfill part of our project's purpose, the team utilized Semi-structured interviews to gain more information on soil testing. Furthermore, the informal conversations the team had with the faculty of TurnBackTime and the workers at Home Depot provided insight into the required structures.

3.2.1 Soil Testing

To address objective 1, the team required extensive knowledge on soil testing. We were aware that there were two different soil testing methods: first, a home testing kit and second, a professional soil lab test. Additionally, our team needed a way to assess the overall soil health at Turn Back Time. This was particularly important given that the garden at TBT utilized raised beds. Furthermore, the team required information on what soil health indicators to test for (Example: pH, Nitrogen).

When considering information on soil testing and what could be done to improve crop production on the farm we found that it would be helpful to interview a soil testing expert. In depth knowledge on soil health and garden management were needed. We had planned on getting this information through an interview with Nathan Hunt, an Environmental Protection Agency (EPA) project manager.

From the semi-structured interview with the EPA project manager, we received information on different types of soil sampling (such as: random discrete sampling, grid sampling, etc.) which were used in determining what would be most effective for Turn Back Time's garden. We also wanted to know how we could improve soil in each individual garden bed, to do this we needed to know the nutrient levels optimal for each crop that the farm intended to grow. Mr. Hunt recommended that we use Cornell University's gardening database (http://www.gardening.cornell.edu/homegardening/scene0391.html). This database consists of growing guides for both flowers and vegetables. Mr. Hunt also discussed the various soil health indicators that he suggested we consider for the farm. According to him, the main indicators were: pH, Nitrogen, Phosphorus, and Potassium.

Additionally, we were also given information on soil mapping. For TBT, that would imply discrete random soil samples from each garden bed. This would be tested and put together in a map of the garden. According to Mr. Hunt, this map can be used to streamline the process of identifying and resolving issues with soil health. It is also suitable for identifying which soil bed would be optimal for a particular crop. Crop rotation and optimal planting conditions were also suggested as a way of organically improving soil health.

We had two viable options for soil testing, a home testing kit or professional soil testing (Example: Umass, Soil and Plant Nutrient Testing Laboratory, https://ag.umass.edu/services/soil-plant-nutrient-testing-laboratory). After discussing the soil testing needs with Lisa Burris and farmer Dawn (Burris and Dawn, Informal Conversation), along with analyzing the community-supported agriculture (CSA) records, we concluded that TBT's crop production level was small-scale.

With the information we gathered, our team gained valuable insight into the process of soil testing. Additionally, given that the farm was producing at a small scale, the team could choose a suitable soil testing method. The team also gathered information regarding which soil health indicators to utilize.

While the interview with Nathan Hunt, the EPA project manager, was informative and valuable, his job mainly revolved around contaminated soil. That is to say, his work focused on testing and replacing soil that was contaminated by radiation, factory wastes, etc. It may have been better to interview a farmer with experience in soil testing. However, due to Mr. Hunt's extensive background knowledge in soil testing, we were able to gather data relevant to our project.

3.2.2 Additional Structures

Given that the farm did not require on-site soil testing, the soil exploration station would be utilized solely for educational purposes. The construction of these structures required basic carpentry skills. Furthermore, the team required information regarding suitable table dimensions. Specifically, the height of the table, since children would be using them. The team also wanted to know the optimal way to ensure maximum longevity of the soil exploration station.

Research was done using instructional videos on Youtube in order to gain better insight in designing and building a functional station for children. Various designs were considered based on simplicity and availability of materials. Additionally, a conversation with one of the lead teachers of TBT led to the conclusion that the table needed to be at a height of two feet, and a maximum of two and a half feet (Amber, Informal Conversation). This was based on the height ranges of the children at TBT.

In order to ensure the longevity of the exploration station, we had to take into consideration the possible weathering of the tables and activities. A simple tarp was first considered. However, our project Advisor, Professor Traver, suggested building a semi-permanent structure such as a roof. This was primarily due to concerns of heavy snow and rain. Our team now required information on various roofing materials, and possible roof designs including dimensions.

The dimensions of the roof were primarily based on the size of the area that TBT allowed us to work with. Our site had dimensions of fifteen feet by eight and a half feet (15' x 8'6"). This provided the team with the information regarding the maximum possible dimensions of the roof. The team visited Home Depot in an attempt to receive information regarding the required materials. While the workers at Home Depot were unable to suggest a design for the frame of the roof, they suggested two roofing materials that were weatherproof. The first was a polycarbonate roofing that is both durable and long lasting (see Figure 9). The second was a simple tarp that is weather resistant and rot resistant.

Figure 9

Polycarbonate Roofing from Home Depot

Image source: Home Depot

With the information gained from the various informal conversations, the team had enough information to begin designing the table and roof frame. The informal conversations provided valuable insight into the required dimensions and materials to utilize. However, an interview with a carpenter, or someone with experience with roofing, particularly someone dealing with snow load and various weather conditions, would have been beneficial.

3.3 Objective 2

Determine nature and play based soil curriculums for children at Turn Back Time

While Turn Back Time is focused on nature and play learning, they did not have any specific curriculum coverage on soil science. This is a common problem that currently exists in early education curriculums and among the general population. This was the team's main objective when working on creating a more well rounded coverage of curriculum frameworks for Turn Back Time. By introducing soil science activities to Turn Back Time's lesson plans we hope to reduce this prevalent issue.

Our team required further knowledge on how nature and play function together and the specific curriculum needs of Turn Back Time. We also wanted to know more on how specific age groups learn differently and information on how to improve effective learning among students with learning differences. Along with these considerations we wanted to know more on how nature and play settings can improve learning for children of all abilities to maximize the effectiveness of our activities.

We planned to get this information by conducting semi-structured interviews. Our first resource was Rachel Larimore, a professional on nature and play in early childhood education. Our second resource was an interview with Katie Baker, lead curriculum developer for Turn Back Time. We choose to conduct these interviews to acquire enough information in order to create a comprehensive list of activities that cover soil science for early education.

Nature and play-based education is necessary to an extent for proper child development. To further understand the benefits that derive from nature/play education we seeked professional input. This was done by reviewing information from an interview with an educator focused on the integration of nature into early childhood education, Rachel Larimore. From this research, it was reinforced that nature education benefits include: cognitive, physical, emotional, spiritual and social development. How children interact and learn with nature is important when formulating an outdoor curriculum. Ms. Larimore stated that being outdoors is not enough and that there must be active engagement such as through play-based learning. Also stating that nature provides a level playing field for all children to learn at their own pace. An important consideration when handling various age groups and children with a range of abilities.

Furthermore, our group also needed information on Turn Back Time's specific educational needs. For this we interviewed with the lead curriculum developer and assistant director for Turn Back Time, Katie Baker. Mrs. Baker was interviewed for further information on forming lesson plans for students with moderate to severe disabilities. From this interview we yielded various insights into the expectations and requirements for designing curriculums for the children at TBT.

Firstly, we received information on differences in learning standards per age group. Younger children (ages three to six years) preferred isolated play and learning whereas older children (ages six to nine years) preferred a collaborative experience. According to Mrs. Baker both these age groups required a teacher to prompt them. However, the oldest age group at Turn Back Time (ages nine to thirteen years) preferred a self-prompted and collaborative play and learning experience. Secondly, we discussed the viability of creating a soil science based curriculum for TBT. Mrs. Baker suggested creating activities that aligned with the current Massachusetts curriculum standards rather than creating our own curriculum.

When considering the need for a soil exploration station, it is also important to note how a human made structure can facilitate nature based learning. Information from Ms. Larimore will be considered when creating both functional and versatile outdoor activity kits and table top activities. Our structures will ultimately provide children of all ages with different opportunities to partake in activities regarding soil science. The data we gathered from the interview with the executive director of TBT led to a shift in our project objective. Rather than creating a play and nature-based soil curriculum, the team now shifted focus to creating play and nature-based activities that aligned with the Massachusetts standards.

4.0 Results and Analysis

4.1 Introduction

In this section we will go over the final results of our project. The results have been divided according to the project's three major milestones. We will first discuss the design of the activities and kits, which addresses objective two. Then, we will move on to the design of the table and the roof, which address objective one.

4.2 Designed activities and kits

The activities and kits were designed with nature and play curriculum, Massachusetts curriculum standards and accessibility in mind. This sub-section discusses the process through which our team developed these activities and kits that align with the various requirements for Turn Back Time.

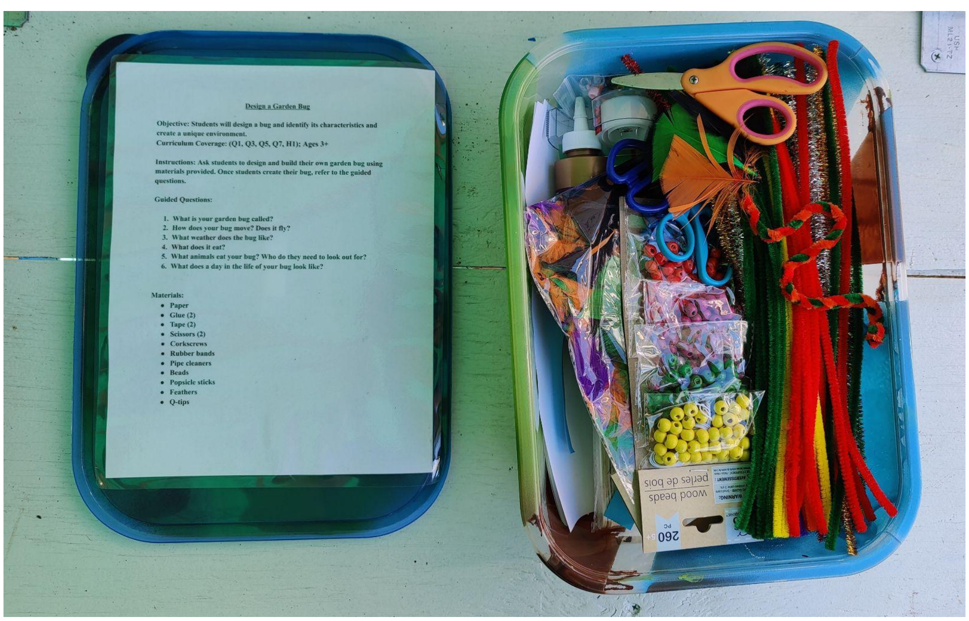
In order to complete objective two (Determine nature and play based soil curriculums for children at TurnBackTime) our team explored various curriculum requirements. The original plan was to create a nature and play-based curriculum. However, Katie Baker—the head curriculum developer and assistant director for Turn Back Time— suggested utilizing Massachusetts' existing curriculum standards to develop activities instead.

We received a simplified version of the Massachusetts curriculum standards from the assistant director which was being used in Turn Back Time. We alphanumerically coded the simplified standards for easy future reference. This system could also be utilized to streamline and simplify the creation of new activities.

We found various soil science based activities from the education section of Mass Audubon—Massachusetts' largest nature conservation nonprofit [https://www.massaudubon.org/about-us]. Another source for activities was soil4kids (https://www.soils4kids.org/), which had activities for a larger age range. Our team adopted these activities to be better fitting for Turn Back Time. This was achieved by simplifying instructions and adding guiding questions to aid both teachers and students. In doing so, we prepared thirteen activities that align with the state standards and covered important topics in soil science. Each activity fulfills multiple requirements of the curriculum standards. Additionally, some of these activities are accompanied with their respective kits.

Figure 10

Example of an activity kit (Design a garden bug activity)



According to another conversation with the assistant director, teachers struggled bringing materials to perform activities in nature and play settings (K. Baker, informal conversation). In an effort to resolve this, our team decided on using activity kits. Initially, we considered using metal boxes due to their durable nature. However, after considering our budget and the portability factor, we concluded the use of plastic boxes would be better.

The activity kits we prepared are medium-sized plastic boxes that hold the items required for a particular activity (See figure 10 for an example of the kits). The kits are lightweight and stackable; teachers can easily carry them in various nature and play based settings. While grouping similar items would have been cost effective rather than separating by activity, the kits provide modularity and convenience. The kits also include general instructions to carry out the activity. New teachers can simply grab an activity kit to start a class. This kit can also be modified to match the different physical and mental needs of the children present.

4.3 Designed and built soil exploration table

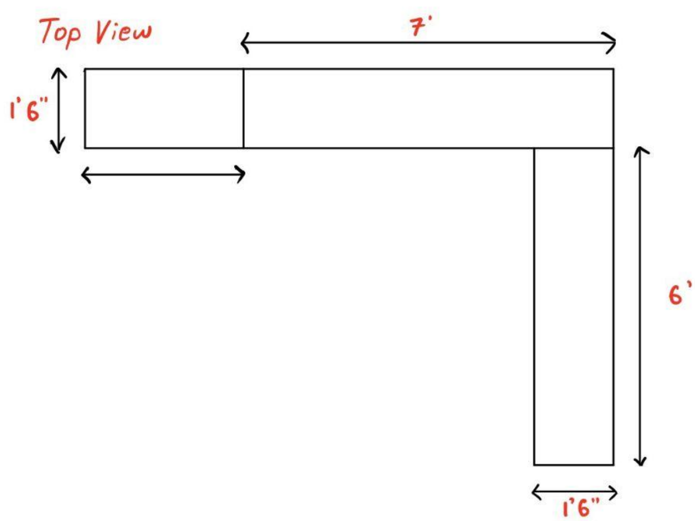
The soil exploration table was initially planned to incorporate an educational aspect, but focused mainly on soil testing for the farm. This subsection discusses the scaling down of our project from a lab to an exploration space for the children.

Initially, our team thought that the soil exploration station would be used for both educational purposes and soil testing. However, after a discussion with Lisa Burris and farmer Dawn (Dawn handles the garden produce for the Community Share Association (CSA)), we concluded a home soil-testing kit would suffice. The soil exploration station now serves the singular purpose of being an educational and play space.

The project utilized pro-bono and waste material whenever possible. This decreased costs. Designs were made based on basic carpentry skills and the sizes of the available lumber. For example, the availability of large plywood made our team change the dimensions of the table. The final design of the soil exploration table consisted of two tables arranged in an 'L' shape (See Figure 11 for the final design and dimensions of the tables). The dimensions of the tables were 7x1.5 feet and the other being 6x1.5 feet.

Figure 11

Final dimension for the tables



The exploration table also consists of an old repurposed metal sink. It serves as the dedicated space for a Soil Bed and Archeological Dig space, which are one of many soil activities we prepared.

The tables are to house both the kits and tabletop interactive activities. The table houses various activities such as a soil sifter activity that separates the soil into its particles. The table also houses an activity called “Drain race”, an activity designed to get children to question the properties of soil such as water retention. Additionally, the table houses a matching game based on helpful and harmful garden insects (See Appendix D for a full list of activities).

Figure 12

A photo of the final table with activities

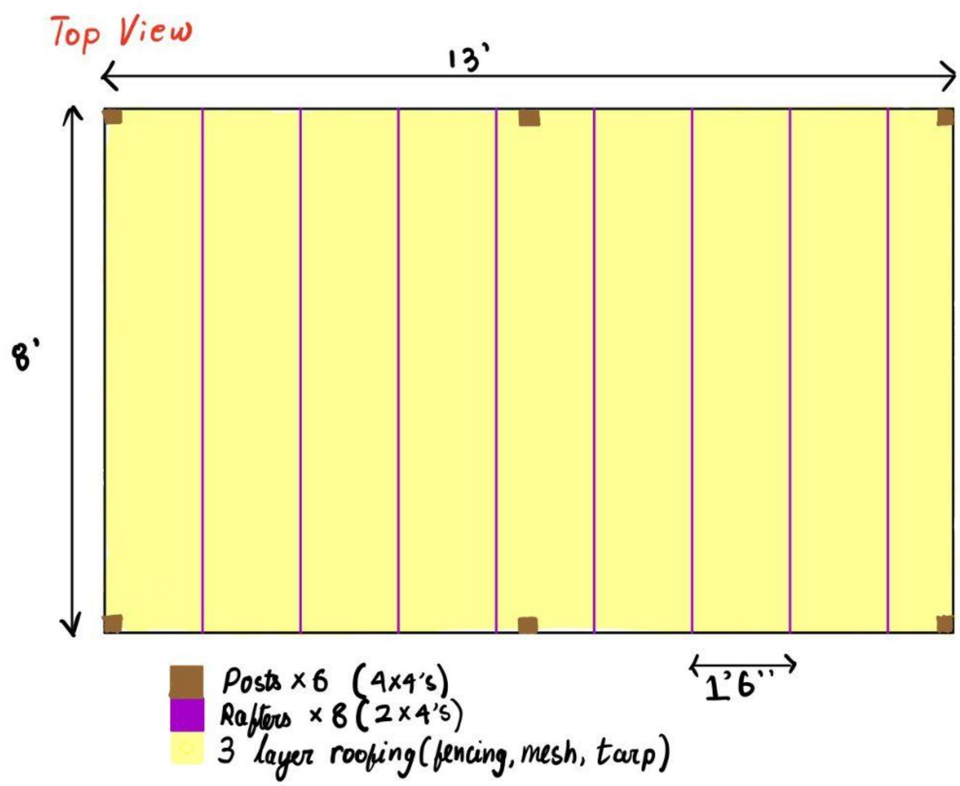
4.4 Designed and built roofing over soil exploration station

This subsection discusses the process through which the roofing was designed given various factors needing to be considered such as the budget, maintainability and weather.

At the start of the project, our team was under the assumption that a simple tarp covering our station would suffice to deal with the various weather conditions. However, the lack of feasibility of covering the table daily and concerns about the longevity of the tables and kits under heavy rain and snow, led us to believe a roof-like structure would be the most appropriate.

Figure 13

Diagram of roof structure



Our roof design was heavily influenced by the budget and our skillset. We decided on using a simple design using fencing overlayed with mesh and a waterproof tarp (As shown in Figure x). The dimension of the roof is 13'x8', which is big enough to protect the soil exploration station from the wind, snow, and rain. Snow weight was a major concern, and it is why we changed our initial flat roof design to be slanted, which helps lessen water and snow build-up on the roof.

Unlike the table, most materials needed to be purchased. Additionally, the purchased lumber was untreated and so we used sealants to make them weatherproof. (See Figure 14 for the final roof structure)

Figure 14

Photo of final roof structure

4.5 Maintenance

In order to ensure the maximum longevity of our project, we have come up with a maintenance plan that consists of three sections: the roof, the table, and the activity kits. Each section will describe the maintenance protocol that we recommend the sponsors to carry out. The maintenance plans can be found in Appendix F.

5.0 Recommendations

5.1 Introduction

The following section discusses the team's recommendations to the sponsor. These are based directly on the objectives of the project and the research we conducted. In regards to objective one, we will be reviewing the need for further structure regarding lesson planning based on coded curriculum standards. In accordance with objective two, our team recommends the need for at home soil testing done on a consistent basis for the garden at Turn Back Time.

Further recommendations include future installation of a water irrigation system for Turn Back Time's garden and following a maintenance guide that we created to maintain our educational activities and structures.

5.2 Recommendations based on Objective 1

1. **Using the Coded Curriculum and activity kits for future activities:** The team recommends Turn Back Time to use the coded curriculum developed by the team to label various activities. This data can be compiled in order to get better insights on what requirements are being met, and if any are missing or lacking coverage.

   Furthermore, the team recommends having activity kits similar to the ones we produced. Having activity kits that are portable, weather-resistant and modular can help teachers easily choose multiple set activities and make carrying around educational materials around the various nature and play based settings easier.

5.3 Recommendations based on Objective 2

1. **Regular Soil Testing:** The team recommends investing in soil testing kits that are readily found in home improvement stores such as Home Depot. These test kits can be used to gain valuable insight into the health of the soil by testing basic indicators such as Nitrogen, Phosphorus, Potassium, and pH. This is especially applicable to Turn Back Time, as they have a raised bed garden, implying different results for each bed.

   Optimally the results of the tests should be stored in a map of the garden, which can then be analyzed to strategically plant certain crops. Alongside this, the team recommends using online resources such as the University of Vermont extension service (http://pss.uvm.edu/ppp/pubs/oh34.htm) or Cornell University's gardening database (http://www.gardening.cornell.edu/homegardening/scene0391.html), in order to plant crops based on their needs.

   Example 1: Blueberries require acidic soil (4.5-5.5 pH), any bed that meets that criterion is optimal for planting blueberries. If not, the pH can be adjusted to the correct value.

   Example 2: Certain plants require certain NPK ratios (Nitrogen:Phosphorus:Potassium) for a more productive harvest. The maps and/or soil tests can inform the farmer what fertilizer and compost to use in order to increase production.

5.4 Additional Recommendations

The following recommendations are our suggestions to the various problems that were discussed during informal conversations with the staff.

1. **Installing a Water Irrigation system:** The team recommends Turn Back Time to install a water irrigation system. This recommendation is based on a conversation the team had with Farmer Dawn, who stated that watering the beds with the watering cans takes too long (Dawn, informal conversation). Installing a semi-automatic or automatic watering system would be optimal, additional modifications such as direct fertilizer input may also be beneficial. This is a possible future IQP venture.
2. **Regular Maintenance (follow maintenance guide):** The team recommends Turn Back Time to follow the maintenance guide that the team created. There were many concerns raised about the long-term longevity of the projects made by WPI students. However, with the maintenance sheet, our team hopes that the team's various structures and activities will remain in good shape and face minimal weathering.

References

American Camp Association. (2015, December 12). No Child Left Inside Act - Reintroduced. https://www.acacamps.org/news-publications/hot-topic/no-child-left-inside-act-reintroduced

American Institutes for Research. (2005, January 31). *Effects of Outdoor Education Programs for Children in California* (Rep.). Sacramento, CA: American Institutes for Research. http://www.seer.org/pages/research/AIROutdoorSchool2005.pdf

Cai, A., Xu, M., Wang, B., Zhang, W., Liang, G., Hou, E., & Luo, Y. (2019). Soil and Tillage Research,Volume 189, Pages 168-175, ISSN 0167-1987, https://doi.org/10.1016/j.still.2018.12.022 (https://www.sciencedirect.com/science/article/pii/S0167198718300722)

Autism society: What is autism? (2020, March 26). Autism Society. https://www.autism-society.org/what-is/

Barron, Cook, Darling-Hammond, Flook, Osher. (2019, February 17). *Implications for educational practice of the science of learning and development*. Taylor & Francis. https://www.tandfonline.com/doi/abs/10.1080/10888691.2018.1537791

Batey, T. (2009). Soil compaction and soil management a review. *Soil Use and Management*, *25*(4), 335–345. https://doi.org/10.1111/j.1475-2743.2009.00236.x

Bot, A.,and Benites José. (2005). The importance of soil organic matter: key to drought-resistant soil and sustained food production. Food and Agriculture Organization of the United Nations. Food and Drug organization of the United Nations.

Bureau, U. S. C. (2016, November 1). *Demographic Profile with Geos Summary File Dataset*. The United States Census Bureau. https://www.census.gov/data/datasets/2010/dec/demographic-profile-with-geos.html.

Cai, A., Xu, M., Wang, B., Zhang, W., Liang, G., Hou, E., & Luo, Y. (2019). Manure acts as a better fertilizer for increasing crop yields than synthetic fertilizer does by improving soil fertility. *Soil and Tillage Research*, *189*, 168–175. https://doi.org/10.1016/j.still.2018.12.022

Cherry. (n.d.). *Understanding Erikson's stages of psychosocial development*. Verywell Mind. https://www.verywellmind.com/erik-eriksons-stages-of-psychosocial-development-2795740

Cherry. (n.d.). *What are Piaget's four stages of development?* Verywell Mind. https://www.verywellmind.com/piagets-stages-of-cognitive-development-2795457

State University of New York. (n.d.). *Soil pH: What it Means*. https://www.esf.edu/pubprog/brochure/soilph/soilph.htm.

Darling-Hammond, L. (2019, February 17). Implications for educational practice of the science of learning and development. https://www.tandfonline.com/doi/full/10.1080/10888691.2018.1537791

Denham, S. A., Brown, C., & Domitrovich, C. (2010, October). (PDF) "Plays Nice With Others": Social–Emotional Learning and Academic Success. Retrieved from https://www.researchgate.net/publication/225280386_Plays_Nice_With_Others_Social-Emotional_Learning_and_Academic_Success

Doran, J. W., & Parkin, T. B. (1994). Defining and Assessing soil quality. In *Defining soil quality for a sustainable environment*. essay, Soil Science Society of America.

Driessnack, M. (2009, January 12). Children and Nature‐Deficit Disorder. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1111/j.1744-6155.2009.00180.x

Dupree, R. (2019, Jan. & Feb.). Explore the Benefits of Nature-Based Education. https://www.motherearthliving.com/health-and-wellness/explore-the-benefits-of-nature-based-education-zm0z19jfzpop

Elleseff, T. (2018, September 26). Is it Language Disorder or Learning Disability? A Tutorial for Parents and Professionals: Smart Speech Therapy.

https://www.smartspeechtherapy.com/is-it-language-disorder-or-learning-disability-a-tutorial-for-parents-and-professionals/

García, A. C., van Tol de Castro, T. A., Santos, L. A., Tavares, O. C., Castro, R. N., Berbara, R. L., & García-Mina, J. M. (2019). Structure-Property-Function Relationship of Humic Substances in Modulating the Root Growth of Plants: A Review. *Journal of Environmental Quality*, *48*(6), 1622–1632. https://doi.org/10.2134/jeq2019.01.0027

George Zalidis, Stamatis Stamatiadis, Vasilios Takavakoglou, Kent Eskridge, Nikolaos Misopolinos, Impacts of agricultural practices on soil and water quality in the Mediterranean region and proposed assessment methodology, Agriculture, Ecosystems & Environment, Volume 88, Issue 2,2002,Pages 137-146,ISSN 0167-8809,https://doi.org/10.1016/S0167-8809(01)00249-3. (https://www.sciencedirect.com/science/article/pii/S0167880901002493)

Hudson, R., High, L., & Al Otaiba, S. (2007, February 28). Dyslexia and the Brain: What Does Current Research Tell Us?. https://eric.ed.gov/?id=EJ756492

Huenneke, L. F. (2016). Desertification. In M. S. Hill (Ed.), *Biology* (2nd ed., Vol. 1, pp. 285-287). Macmillan Reference USA. https://link.gale.com/apps/doc/CX3629800119/SCIC?u=mlin_c_worpoly&sid=SCIC&xid=dadf391d

Hubbe, M., Nazhad, M., & Sanchez, C. (2010). Composting as a way to convert cellulosic biomass and organic waste into high-value soil amendments: A review. *BioResources*, *5*(4), 2808–2854. https://doi.org/10.15376/biores.5.4.2808-2854

Is Paxton the Best MASSACHUSETTS city for your business? (n.d.). https://www.massachusetts-demographics.com/paxton-demographics.

Jankovich, T. (2017, November 12). Benefits of Learning in Nature. https://encenter.org/blog/benefits-of-learning-in-nature/

Jordan, C., & Chawla, L. (2019, April 22). *A coordinated research agenda for Nature-Based Learning*. Frontiers in psychology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6487259/.

Kuo, M. (2019, June 7). Six Ways Nature Helps Children Learn. https://greatergood.berkeley.edu/article/item/six_ways_nature_helps_children_learn

Kuo, M., Barnes, M., & Jordan, C. (2019, January 31). Do Experiences With Nature Promote Learning? Converging Evidence of a Cause-and-Effect Relationship. https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00305/full

LaBarbera, R. (2008). *Perceived Social Support and Self-Esteem in Adolescents with Learning Disabilities at a Private School*. https://www.researchgate.net/publication/234726645_Perceived_Social_Support_and_Self-Esteem_in_Adolescents_with_Learning_Disabilities_at_a_Private_School

LDRFA. (2010, November 04). Learning Disability, Dyslexia & ADHD Facts. https://www.ldrfa.org/learning-disability-adhd-facts/

Manolis, L. (2016, March 15). *Program Guidance: Autism* (Publication). Teach for America. https://schoolwires.henry.k12.ga.us/cms/lib/GA01000549/Centricity/Domain/50/AUT%20ESE%20Program%20Guide%20Website%20Edit.pdf

Mission & Values. Mass Audubon. (n.d.). https://www.massaudubon.org/about-us/mission-values.

Natural Resources Conservation Service. A Soil Profile | NRCS Soils. (n.d.). https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054308.

Ngowari, J.,n.d., Understanding the Texture of your Soil for Agricultural Productivity, Publication CSES-162P, Virginia Cooperative Extension, https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/CSES/CSES-162/CSES-162-PDF.pdf

NRCS East National Technology Support Center, NRCS National Soil Survey Center, ARS National Laboratory for Agriculture and the Environment, NCERA-59 Scientists, and Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign. (n.d.). *Soil pH*. Soil Quality: Indicators: Soil pH. http://soilquality.org/indicators/soil_ph.html.

NSW. *Plant nutrients in the soil*. Department of Primary Industries. https://www.dpi.nsw.gov.au/agriculture/soils/improvement/plant-nutrients#:~:text=Soil%20is%20a%20major%20source,are%20calcium%2C%20magnesium%20and%20sulfur.

García, A. C., van Tol de Castro, T. A., Santos, L. A., Tavares, O. C., Castro, R. N., Berbara, R. L., & García-Mina, J. M. (2019). Structure-Property-Function Relationship of Humic Substances in Modulating the Root Growth of Plants: A Review. *Journal of Environmental Quality*, *48*(6), 1622–1632. https://doi.org/10.2134/jeq2019.01.0027

Garg P, Kaushik G , Nagar J.K , Singhal P,(2019) *Role of Earthworms in Managing Soil Contamination,* Handbook of Environmental Materials Management.Springer, Cham. 1859-1877. https://doi-org.ezpv7-web-p-u01.wpi.edu/10.1007/978-3-319-73645-7_162

Granada Preparatory School. (2018, February 26). *Top 5 benefits of learning through play*. Chatsworth Hills Academy. https://chaschool.org/top-5-benefits-learning-play/

Ogelman, H. G. (2012, January 18). Comparison of environmental attitudes and experiences of five-year-old children receiving preschool education in the village and city centre. https://www.tandfonline.com/doi/abs/10.1080/03004430.2015.1092963?journalCode=gecd20

Old Farmer's Almanac. (2021). *Frost Dates for Worcester, MA*. Old Farmer's Almanac. https://www.almanac.com/gardening/frostdates/MA/Worcester.

Pandy, Renee I., "Learning Disabilities and Self-Esteem" (2012). All Capstone Projects. 133. http://opus.govst.edu/capstones/133

Parikh, S. J. & James, B. R. (2012) Soil: The Foundation of Agriculture. *Nature Education Knowledge* 3(10):2

Pabedinskas, V. (n.d.). *Paxton Massachusetts State Soil.* https://www.soils4teachers.org/files/s4t/k12outreach/ma-state-soil-booklet.pdf.

PAXTON SERIES. Official Series Description - PAXTON Series. (2015, April). https://soilseries.sc.egov.usda.gov/OSD_Docs/P/PAXTON.html.

Pearce-Moses, R. (n.d.). Dictionary of Archives Terminology. SAA Dictionary. https://dictionary.archivists.org/index.html.

Psychology Notes HQ. (2021, April 11). Erik Erikson's Stages of Psychosocial Development. Retrieved from https://www.psychologynoteshq.com/erikson-stages/

Psychology Notes HQ. (2020, November 18). The Jean Piaget Stages of Cognitive Development. Retrieved from https://www.psychologynoteshq.com/piagetstheory/

Polluck. (2019, June 13). *The difference between structured, unstructured & semi-structured interviews — Oliver parks consulting LLC*. Oliver Parks Consulting LLC - Technology Sector Recruitment Experts. https://www.oliverparks.com/blog-news/the-difference-between-structured-unstructured-amp-semi-structured-interviews

Pui-Wah, D.C., & Stimpson, P. (2004). Articulating contrasts in kindergarten teachers¿ implicit knowledge on play-based learning. *International Journal of Educational Research, 41*, 339-352.

Reid, K. (2005, February 09). The Implications of Every Child Matters and the Children Act for Schools. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.0264-3944.2005.00317.x

Roubinet, E. (March, 2016). *Food webs in agroecosystems implications for biological control of insect pest*. Acta Universitatis Agriculturae Sueciae. http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-e-3295

Samara early learning. (n.d.). *What is nature-based early childhood education?* https://www.samarael.com/what-is-nbece

Shafer. (n.d.). *Summertime, playtime*. Harvard Graduate School of Education. https://www.gse.harvard.edu/news/uk/18/06/summertime-playtime

Pereira P (2019). *Soil Degradation, Restoration and Management in a Global Change Context*, Elsevier Science & Technology, *ProQuest Ebook Central*, http://ebookcentral.proquest.com/lib/wpi/detail.action?docID=5968259.Created from wpi on 2021-04-20 19:55:34.

Center for Agriculture, Food and the Environment (n.d.). *Soil and Plant Nutrient Testing Laboratory*. https://ag.umass.edu/services/soil-plant-nutrient-testing-laboratory.

SSM - Ch. 3. Examination and Description of Soil Profiles | NRCS Soils. (n.d.). United States Department of Agriculture (n.d.) https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054253

TBT. (n.d.). *Critter Catchers – Turn Back Time Inc.* Turn Back Time Inc. https://tbtinc.org/critter-catchers/.

Turn Back Time (n.d.). *Our Team – Turn Back Time Inc.* Turn Back Time Inc. https://tbtinc.org/our-team/.

Turn Back Time (n.d.). *Who We Are – Turn Back Time Inc.* Turn Back Time Inc. https://tbtinc.org/mission/.

United States Census Bureau. (n.d.). *ACS Demographic and Housing Estimates*. US Census Bureau. https://data.census.gov/cedsci/table?q=paxton&tid=ACSDP5Y2019.DP05

United States Department of Agriculture(January 2011). *Carbon to Nitrogen Ratios in Cropping Systems*. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd331820.pdf

United States Department of Agriculture (n.d.). *Natural Resources Conservation Service*. Soil Health | NRCS Soils. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/.

United States Department of Agriculture (n.d.). *Natural Resources Conservation Service*. Soil Health Assessment | NRCS Soils. https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/assessment/.

United States Department of Agriculture. (1997). *Innovative Uses of Compost Erosion Control, Turf Remediation, and Landscaping*. https://www.epa.gov/sites/production/files/2015-08/documents/erosion.pdf.

Vogel, M. (2021, September 11). *What is play-based learning?* Wonderschool Resources Hub. https://www.wonderschool.com/p/parent-resources/what-is-play-based-learning/.

What is Autism? (2021). Autism Science Foundation. https://autismsciencefoundation.org/what-is-autism/

Zhao J., Ni T., Li J., Lu Q., Fang Z., Huang Q., Zhang R., Li R., Shen B., Shen Q. (2016), Effects of organic–inorganic compound fertilizer with reduced chemical fertilizer application on crop yields, soil biological activity and bacterial community structure in a rice–wheat cropping system, Applied Soil Ecology,Volume 99, Pages 1-12, ISSN 0929-1393, https://doi.org/10.1016/j.apsoil.2015.11.006.

Zhu, H., & Li, D. (2018). Using Humus on Golf Course Fairways to Alleviate Soil Salinity Problems, *HortTechnology hortte*, *28*(3), 284-288. Retrieved Apr 20, 2021, from https://journals.ashs.org/horttech/view/journals/horttech/28/3/article-p284.xml

Appendix A: Informed Consent Agreement for Participation in a Research Study for Teacher of Students with Moderate Disabilities and Severe Disabilities

Investigators: Cleo Caldwell, Siddhartha Pradhan, Jacqueline Simon

Contact Information: Cleo Caldwell: cgcaldwell@wpi.edu, Siddhartha Pradhan: sppradhan@wpi.edu, Jacqueline Simon: jdsimonvillacis@wpi.edu

Professor and Project Advisor: J Dudle: jddudle@wpi.edu

Title of Research Study: Designing a Soil Exploration Station to Engage Children in Nature and Play-Based Learning at Turn Back Time

Sponsor: Lisa Burris

Introduction

Our team are going to be working with Turn Back Time, a non-profit nature-based education center based in Paxton, Massachusetts, who focus on inclusivity for children in a play and nature-based environment. We seek to design a soil science-based curriculum for children of ages three to ten and of various mental and physical capabilities. The curriculum will have to incorporate an unstructured learning environment to give children a chance to explore and connect with nature. We hope to gain insight into the various details regarding soil testing, nature and play based curriculums, as well as inclusivity for children to achieve our purpose. Additionally, as Turn Back Time has a fully functional farm, our team seeks to provide recommendations on soil tests.

Purpose of the study:

The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

Procedures to be followed:

There will be an approximately 45-minute interview session conducted either in person, via phone call, or via zoom.

Risks to study participants:

None

Benefits to research participants and others:

None

Alternative procedures or treatments available to potential research participants:

None

Record keeping and confidentiality:

Verbal permission will be received from interviewees before any auditory session is recorded. No video recording will be conducted. Any auditory recording will be kept on a flash drive. Any written document will be kept in a notebook. All recorded and written records will be kept in the researchers' private residence. All recorded information, both auditory and written, will be deleted, or destroyed upon completion of the project.

Compensation or treatment in the event of injury:

None.

Cost/Payment:

None.

For more information about this research or about the rights of research participants, or in case of research-related injury, please contact our team using the information provided at the top of the first page. In addition, you may contact the IRB Manager (Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu) and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu))

Interview Begins

Hello and thank you for your time. Before we begin, we would like to ask your permission to record this session for transcription? You will remain anonymous, this recording will be kept confidential, and your anonymity protected, and we will ask you for permission if we wish to use a quote that identifies you. May we record this session? Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you. You may decide to stop participating in the interview or the research at any time. This entire consent form is available to you in written form if you desire.

The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

We are going to be working in an outdoor, non-classroom, small group setting on a small farm with children ranging in age from three to ten. The estimated class size will be 1 educator with 4-7 children for a period of 30 minutes to 45 minutes. Classes will be taught in nature by looking at animals, birds, plants, water, and frogs. Naturally, there will be many distractions for children. Our job is to teach them about the animals or plants in front of them at that moment. For example, if the children see a fascinating plant or insect, we need to have the ability to teach them about that on the spot. Due to this special need, all curriculum developments need to be highly flexible that can adapt to a wide range of circumstances. We as educators need to be very familiar with the basic knowledge about a diverse group of topics. With that very general description in mind, we appreciate your guidance on a few things, your experience, and your wisdom.

1. What are three to five most effective teaching, communication, methods we need to learn if we are to be effective with this age group and their special needs? What is the attention span of children this age? Navigate? Techniques?
2. What are the challenges of teaching this age group with special needs that we need to be most aware of and how can we prepare ourselves to meet those challenges? For example, books or articles you recommend we read this A-Term?
3. What are typical behaviors exhibited by children this age? How do we best navigate through multiple behaviors exhibited all at once?

4. What are the typical moods exhibited by children this age and the ‘movement’ of these moods when in a group setting? How do we best navigate through these moods being exhibited?
5. We are responsible for the safety of the children as we work with them with tools or walk in the woods. How do we establish a sense of importance of safety and following rules and guidelines with children? Also, in line with this, what safety measures with children this age MUST we put into practice?
6. When considering communication styles, what are the most effective styles of communication we need to learn and practice to be effective with these children?
7. What are strategies for inclusive group teaching?
8. What are some examples of students with learning disabilities behaving differently than students without learning disabilities that we need to be aware of to be inclusive, safe, and effective instructors?

Appendix B: Informed Consent Agreement for Participation in a Research Study for Individual with an advanced degree or license in Nature/Play Learning

Investigators: Cleo Caldwell, Siddhartha Pradhan, Jacqueline Simon

Contact Information: Cleo Caldwell: cgcaldwell@wpi.edu, Siddhartha Pradhan: sppradhan@wpi.edu, Jacqueline Simon: jdsimonvillacis@wpi.edu

Professor and Project Advisor: J Dudle: jddudle@wpi.edu

Title of Research Study: Designing a Soil Exploration Station to Engage Children in Nature and Play-Based Learning at Turn Back Time

Sponsor: Lisa Burris

Introduction

Our team are going to be working with Turn Back Time, a non-profit nature-based education center based in Paxton, Massachusetts, who focus on inclusivity for children in a play and nature-based environment. We seek to design a soil science-based curriculum for children of ages three to ten and of various mental and physical capabilities. The curriculum will have to incorporate an unstructured learning environment to give children a chance to explore and connect with nature. We hope to gain insight into the various details regarding soil testing, nature and play based curriculums, as well as inclusivity for children to achieve our purpose. Additionally, as Turn Back Time has a fully functional farm, our team seeks to provide recommendations on soil tests.

Purpose of the study:

The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

Procedures to be followed:

There will be an approximately 45-minute interview session conducted either in person, via phone call, or via zoom.

Risks to study participants:

None

Benefits to research participants and others:

None

Alternative procedures or treatments available to potential research participants:

None

Record keeping and confidentiality:

Verbal permission will be received from interviewees before any auditory session is recorded. No video recording will be conducted. Any auditory recording will be kept on a flash drive. Any written document will be kept in a notebook. All recorded and written records will be kept in the researchers' private residence. All recorded information, both auditory and written, will be deleted, or destroyed upon completion of the project.

Compensation or treatment in the event of injury:

None.

Cost/Payment:

None.

For more information about this research or about the rights of research participants, or in case of research-related injury, please contact our team using the information provided at the top of the first page. In addition, you may contact the IRB Manager (Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu) and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu))

Interview Begins

Hello and thank you for your time. Before we begin, we would like to ask your permission to record this session for transcription? You will remain anonymous, this recording will be kept confidential, and your anonymity protected, and we will ask you for permission if we wish to use a quote that identifies you. May we record this session? Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you. You may decide to stop participating in the interview or the research at any time. This entire consent form is available to you in written form if you desire.

The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

We are going to be working in an outdoor, non-classroom, small group setting on a small farm with children ranging in age from three to ten. The estimated class size will be 1 educator with 4-7 children for a period of 30 minutes to 45 minutes. Classes will be taught in nature by looking at animals, birds, plants, water, and frogs. Naturally, there will be many distractions for children. Our job is to teach them about the animals or plants in front of them at that moment. For example, if the children see a fascinating plant or insect, we need to have the ability to teach them about that on the spot. Due to this special need, all curriculum developments need to be highly flexible that can adapt to a wide range of circumstances. We as educators need to be very familiar with the basic knowledge about a diverse group of topics. With that very general description in mind, we appreciate your guidance on a few things, your experience, and your wisdom.

1. How does nature/play learning help children learn? What is the root psychology or developmental psychology involved? Specifically, how does nature/play education benefit those who need accommodations or who have special needs?
2. Please share two to four examples of using nature learning/play learning to help children learn, maybe even as compared to a normal classroom setting.
3. How do you successfully implement/teach nature & play learning? Examples?
4. What is the fundamental philosophical difference between classroom education and nature/play education?

5. When considering communication styles, what are the most effective styles of communication we need to learn and practice to be effective with these children?

Appendix C: Informed Consent Agreement for Participation in a Research Study for Farmers with experience in Soil Testing

Investigators: Cleo Caldwell, Siddhartha Pradhan, Jacqueline Simon

Contact Information: Cleo Caldwell: cgcaldwell@wpi.edu, Siddhartha Pradhan: sppradhan@wpi.edu, Jacqueline Simon: jdsimonvillacis@wpi.edu

Professor and Project Advisor: J Dudle: jddudle@wpi.edu

Title of Research Study: Designing a Soil Exploration Station to Engage Children in Nature and Play-Based Learning at Turn Back Time

Sponsor: Lisa Burris

Introduction

Our team are going to be working with Turn Back Time, a non-profit nature-based education center based in Paxton, Massachusetts, who focus on inclusivity for children in a play and nature-based environment. We seek to design a soil science-based curriculum for children of ages three to ten and of various mental and physical capabilities. The curriculum will have to incorporate an unstructured learning environment to give children a chance to explore and connect with nature. We hope to gain insight into the various details regarding soil testing, nature, and play-based curriculums, as well as inclusivity for children in order to achieve our purpose. Additionally, as Turn Back Time has a fully functional farm, our team seeks to provide recommendations on soil tests.

Purpose of the study:

The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

Procedures to be followed:

There will be an approximately 45-minute interview session conducted either in person, via phone call, or via zoom.

Risks to study participants:

None

Benefits to research participants and others:

None

Alternative procedures or treatments available to potential research participants:

None

Record keeping and confidentiality:

Verbal permission will be received from interviewees before any auditory session is recorded. No video recording will be conducted. Any auditory recording will be kept on a flash drive. Any written document will be kept in a notebook. All recorded and written records will be kept in the researchers' private residence. All recorded information, both auditory and written, will be deleted, or destroyed upon completion of the project.

Compensation or treatment in the event of injury:

None.

Cost/Payment:

None.

For more information about this research or about the rights of research participants, or in case of research-related injury, please contact our team using the information provided at the top of the first page. In addition, you may contact the IRB Manager (Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu) and the Human Protection Administrator (Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu)) J Dudle: jddudle@wpi.edu)

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The purpose of our project for Turn Back Time is twofold; the first is to provide a recommendation for the construction of a small self-contained soil exploration station structure and second to provide recommendations for nature and play based soil curriculums for 3-to-10-year-old children working and playing in the garden area.

We are going to be working in an outdoor, non-classroom, small group setting on a small farm with children ranging in age from three to ten. The estimated class size will be 1 educator with 4-7 children for a period of 30 minutes to 45 minutes. Classes will be taught in nature by looking at animals, birds, plants, water, and frogs. Naturally, there will be many distractions for children. Our job is to teach them about the animals or plants in front of them at that moment. For example, if the children see a fascinating plant or insect, we need to have the ability to teach them about that on the spot. Due to this special need, all curriculum developments need to be highly flexible that can adapt to a wide range of circumstances. We as educators need to be very familiar with the basic knowledge about a diverse group of topics. With that very general description in mind, we appreciate your guidance on a few things, your experience, and your wisdom.

1. What are the baseline elements of the soil that you are measuring at the start of planting season? How often do you recheck the health of your soil?
2. Based on our research the recommended basic soil tests measured pH, N (Nitrogen), P (Phosphorus) and K (Potassium). What are some of the tests that you perform in your farm?
3. What do you use to maintain your soil health in terms of soil structure and organic matter? What are some (three or four) supplements you use in order to maintain soil health and how do you determine when these supplements are necessary?
4. There are many factors that affect soil health such as the climate, and soil or air pests and pathogens. How do you adapt to these changing factors in order to maintain proper soil health?
5. Please tell us about how you take care of the soil after the harvest?

6. Please share some thoughts and examples of how you prepare the soil for planting season.

Appendix D: List of Activities by Age Group

Activities by Age (3-13)

Ages 3-4

- Make mud: combine soil and water (A2, A8, G2, G5, Q1,Q3,Q5, I1, J1)

Ages 5-6

- Worm sculptures with art materials (Q1, Q2, Q5, Q6, Q7)
- Make mud: combine soil and water (A2, A8, G2, G5, Q1,Q3,Q5, I1, J1)

Ages 7-9

- Comparison of Soils (A1, A8, B1, B2, C1, D1, E1, F1, G1, K1)
- Measuring worms: create chart to track results of class (A1, A2, A8, D1, E1, E2, F1, G1, G3, G4, I1)

Ages 10-13

- Composting (N11, A1, A4, A8, B3,F1,G1,G2,G5)
- Comparison of Soils (A1, A8, B1, B2, C1, D1, E1, F1, G1, K1)
- Measuring worms: create chart to track results of class (A1, A2, A8, D1, E1, E2, F1, G1, G3, G4, I1)

All Ages

- Worm Expedition (A1, A2, A3, A4, A8, C1, D2, F1, G1, G5, I1, I2, M2, M4)
- Mud painting (A2, A8, C2, G3, K1,Q1, Q2, Q3, Q4, Q5, Q6, Q7)
- Soil concept map (A1, A2, A3, A7, A8, C1, F1, G4, H1, I1)
- Worm concept map (A1, A2, A3, A7, A8, C1, F1, G4, H1, I1)
- Design your own garden bug (include habitat and predators/prey) (Q1, Q3, Q5, Q7, H1)
- Archeological dig (Tweezers, sift, spoons/popsicle sticks, magnifying glass look for treasures in soil) (A4, D1, G3)

Appendix E: Shortened List of Massachusetts Curriculum Framework

- Language
- Number sense
- Patterns and relations
- Measurement
- Inquiry skills
- Life sciences
- Living things and their environments
- Physical sciences
- Technology and engineering
- History and social sciences
- Health
- Social and emotional health
- Movement and dance
- Theater Arts
- Visual Arts

Appendix F: Maintenance Guide

Maintenance Guide

Kits

1. Replenish materials in all kits once a month.

2. Check plastic kits for outside wear. If necessary apply a new layer of clear coat sealant spray.

Table

1. Check the tables for any wear such as paint or wood chipping. Should the table start to weather sand down any splintered or rough edges. Repaint the damaged area and then apply a layer of clear coat.
2. Check and replace the velcro on the pest or guest game if it starts to wear.

Roof

1. Check tarp after heavy snow or rain. Look for any signs of tears or leaks.

2. Should the tarp become damaged it can be easily replaced by removing the screws. Once a new tarp is purchased add new grommets for fastening to the roof.
3. Replace the duct tape covering the edges of the roof if they start to wear. The duct tape protects the tarp from getting rips from wire roofing.