Nature-Play Design and Construction for Learning Disabled Children and Enhanced Handicap Access: Creating an Inclusive Outdoor Play Space and Bridge at Turn Back Time

An Interactive Qualifying Project

In partial fulfillment of the requirements of the degree:

Bachelor of Science

Submitted to:

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and

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Abstract

Turn Back Time (TBT) is a nature-based outdoor education center in Paxton, MA. We worked with TBT to develop more accessibility and learning space for their classes. To accomplish this, we conducted interviews with experts in 2 areas; nature-play education and local wildlife. Additionally, our team researched inclusive trail guidelines and nature-play space principles and design. For construction; we utilized stonework and carpentry skills. To ensure the effectiveness of our design, we also studied how children in different ages and classes played within the space. This gave us a better understanding of how to purposefully create a space for inclusive and outdoor education- especially with regards to TBT. The result is a bridge that spans a difficult area to walk, alongside an outdoor classroom/playground with educational resources.

Acknowledgements

Throughout the process of executing our project, we have received a great amount of support, advice and effort from the following parties. We want to express our gratitude towards these individuals for their help and time.

We extend our thanks to Lisa Burris and The Burris Family, who were very active participants in our project and were always willing to assist and offer guidance.

The staff at TBT always offered encouragement and expressed excitement towards our project, and were ready to answer our questions and provide feedback. We would like to offer thanks to them.

Additionally, Professor Stoddard has allowed us to undertake this project, and was always checking in on us. She helped us to ground our projects and gave us a better understanding of previous projects and TBT as a whole.

Katie Baker was our gateway into the world of nature-play, and often provided firsthand accounts and book recommendations on our topics of interest. She was ripe with insight and has a clear passion for this field. We want to thank Katie for her expertise, attentiveness, and care.

Finally, Professor Traver was an exemplary advisor throughout the course of this IQP. He aided us in construction and nature knowledge, and was eager to toss ideas back-and-forth in order to bring out the best in our capabilities and skill sets.

Executive Summary

Project Goal

Turn Back Time Inc. (TBT) is a nature-based education center founded by our sponsor, Lisa Burris. Sitting on 58 acres, TBT is a hybrid of woodland and garden learning spaces. They are guided by the mission to "help people recognize nature's ability to teach and heal with a commitment to offering programs to underserved populations" (Turn Back Time Inc. – Let Nature Be Your Teacher, 2021). Therefore, the purpose of our IQP is twofold: (1) to provide structures that would span hard-to-cross areas of woodland footpaths and (2) to develop nature and play based curriculums tailored to 3-to-10-year-old children walking woodland nature trails.

To achieve this, we established 3 objectives. The first, to determine the appropriate structures and materials to utilize on the paths to allow children and adults to cross muddied areas in a safe manner, and without impacting the ecosystem. The second and third objectives are to develop play-based and nature-based learning activities for 3–10-year-old children that focus on the woodland environment.

Results

Team members developed various iterative designs to fit the budget and needs of TBT, incorporating feedback from the staff and children in attendance. There was also a great influence from our interviewees that was taken into consideration while designing our spaces. The final design created an outdoor classroom, a playground with educational curriculum mixed throughout, and a 16ft bridge that offers a mud-free path to the rest of the trails.

There are multiple distinct modules that encourage the children to engage with nature and become active participants, which sit adjacent to a natural obstacle course/playground and fort. This clearing gives way to a bog-bridge telephone pole walkway that crosses over an area of water runoff. Hikers would traditionally have to walk through mud and unbalanced stone, or cross into untamed forest, however they are now given an alternate route that offers ease and inclusivity.

Authorship

Each team member -Victoria Heffern and Shu Guo- have contributed in order to produce this report. Both parties have reviewed, written, and revised this document.

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1.0 Introduction

Turn Back Time Inc. (TBT) is a 58-acre forest school in Paxton, Massachusetts. The mission statement of TBT is to “let nature be your teacher”, and recognizing this fact for a better quality of life (Turn Back Time Inc. - Let Nature Be Your Teacher, 2021). Their place-based education and play allows for structured and unstructured class time. TBT focuses on mental, physical and emotional connection and health. There are a variety of classes, from preschool to adult, that allow individuals, families, and volunteers alike to participate. Examples of groups that also attend the farm facilities include both public and private schools, boy scouts, college interns, and even birthday events. As strong advocates towards unserved, at-risk children, the farm provides equal opportunities for all its visitors. TBT’s educational programs are therefore inclusive for all children.

However, there is a lack of space for place-based learning. Currently, the barn, yurt, interactive garden, and the loose-parts playground are the only educational spaces at TBT. The expansive trail system lacks modules for engagement. Given the focus on nature-education, there are missed opportunities for better interactivity with the environment. Additionally, it is difficult to cross certain areas of the trails due to the terrain.

TBT wants to construct a bridge/walkway structure that can allow visitors to safely cross a muddy section of pathway. They have requested that it be environmentally friendly, both in material choice and impact. Adjacent to the bridge is an outdoor classroom space. This was developed using play space design principles. The bridge functions as an extension of the play space, promoting engagement with the outdoors.

2.0 Background

Nature-play learning promotes social, emotional and physical development. An outdoor play-space was constructed to create more of these spaces on the property. Additionally, a bridge was constructed to allow more access to the rest of the paths. In order to implement these two components, we researched information on hands-on play and nature-play. This helped to contextualize how these styles work, and their benefits. For the design of the space and bridge, we reviewed nature space design, inclusive trails, and typical bridge structures/materials.

2.1 Hands On/Play-Based Learning

Play-based learning is deeply rooted in early childhood education. Play-based is a teaching method that offers interactivity and customization. In order to assess its effectiveness, we first look into its framework and implementation.

Typically, play is broken into two factors, adult guided and free (or child directed). When we refer to play-based learning, we are referring to the latter. Incorporating freedom in learning provides more benefits. Students experience more effective learning when lessons are mixed into play (Pyle & Danniels, 2017). Thus, the teacher should offer further assistance as the child sees fit, rather than leading them to begin with. This is crucial, as play alone does not automatically correlate to beneficial results. The educator's role is distant, but not entirely removed. In order to properly facilitate an insightful mindset, they must "be actively observing, assessing, and acting on opportunities to extend students' learning. The teacher can be viewed as a guide to prompt students' play, open their perspectives, and further the learning opportunities." (Taylor & Boyer, 2020). Children are the catalysts for their learning, but still require some instruction. From a research standpoint, "play-based learning alone was [found] insufficient for supporting children's acquisition of content knowledge; there was an increasing acceptance that the teacher needed to perform some type of role in the play experiences provided to children to enable learning." (Edwards, 2017).

Children learn better in such environments because play is a natural part of their sociology. Concepts are simplified and broken down, creating an easy-to-grasp learning system. In one study, children were exposed to different learning styles of the same concepts, and the "development of cognitive flexibility or attention shifting readily occurred when there were fictive characters … but changing perspective toward a nonfictive environment … was a more difficult and time-consuming process" (Vidal Carulla et al., 2021). Consider for a moment the traditional toys and modules that are often provided. Sand, water, toy construction materials, houses for roleplay activities - all of these mimic elements found within our society, simply shrunken down to a smaller scale to be understandable by children. One has to consider that it is not these materials themselves, but how they are implemented. Such play is overlooked and taken for granted, and we forget that "the young child, alone, with adults and with peers, can direct their play and expand their understandings of how the world works and of how they can have influence within and upon that world." (Broadhead, 2004). Creating such a balance however, is the most difficult part of the process. Many teachers find themselves eager, and yet lacking information on how to best execute the process. With the introduction of technology, children's imagination has become far too limited and grounded. One teacher cites how "back before then we were outside, we did a lot more imaginative play; there was a lot of using natural materials in [our] play, not so much the plastics and consumables. And I think the children were more focused and had a lot more opportunities to build on that and we'd come inside and make fairy wings out of paper, children were happy with that. … They fall apart, they're not happy with the simple things and then the play just stops because they want the best and they don't take it further." (Nuttall et al., 2015).

2.2 Nature-Play Learning

As humans, we have an innate connection to the natural world. Several aspects of our development are embedded into our early experiences with our environment. This connection is crucial, as "life [itself] is a process of continuous creation of play-actions and interactions, thoughts and meanings, inextricably linked with the child's physical and socio-cultural surroundings and imagination. Children grow by interacting and playing in and with their world, continually discovering new elements and information that influence their relationships, opinions and interpretations." (Gurholt & Sanderud, 2016). In order to ground their interactions and experiences and provide a firm childhood foundation, we need to reconnect them. Offering the engagement of nature-play has the promise to "promote children's healthy development, well-being and positive environmental attitudes and values" (Gill, 2014).

Generally speaking, it is far easier to be physically active outdoors than indoors. The CDC itself recommends that children get a minimum of an hour/day of exercise and activity. This not only allows for better health, but for the advancement of locomotor and fine motor skills, as well as object control. In turn, such exertion allows for improved brain, heart and lung function, and the health of muscles, bones and joints (Kemple et al., 2016). This consistent exposure will also create a habit into adulthood; and it is far easier to achieve than trying to start at an older age. However just engaging in movement alone is not beneficial, and executing these practices outdoors can further support the body- including blood pressure regulation. (Beyer et al., 2015).

Nature additionally comes with numerous therapeutic benefits. In modern society, many face distress, anxiety, and loneliness in a technologically and alienating world. We are far-removed from the world, and begin to feel as if we lack meaning. Nature allows us to feel more present, and allows for the youth to gain a sense of security, since it is more tangible. (Berger & Lahad, 2010). This self-awareness and safety creates an atmosphere of resilience, creativity, and curiosity. Exploration and information-seeking behaviors gives way to logical thinking and assumptions, and helps to hone these skills naturally. Children build their play around the deconstruction of their surroundings, and build an understanding- and this is beyond the capabilities of an indoor setting (Ernst & Burcak, 2019).

2.3 Nature-Play Space Design

When developing a plan for an outdoor learning space, there is a careful balance in how one can naturally integrate a formatted playground or park while still allowing for the freedoms and facets of children's play. Instead of having established and unyielding metal and plastic structures that plague a typical playground; we define these areas as incorporating "the surrounding landscape and vegetation to bring nature to children's daily outdoor play and learning environments" (Nature Play Spaces, 2021). What makes a play space then, is the idea of some semblance of safety/comfort while also giving the sense of exploration. This means offering a flexibility or opportunity to simply observe the play of others, and providing shelter or shade; while providing "enough complexity, challenge, and intrigue to allow children to take risks, learn, and become completely involved in their play" (Masiulanis & Cummins, 2017).

We define a risk as a potential for injury or uncertainty, with different categories. Some examples of different hazards include heights, speed, dangerous tools or elements, rough play, and being alone. Allowing risk in play is an idea that can seem almost too hazardous, but by allowing children to experience this, we are able to offer a number of benefits. If we provide some element of risk, we are more likely to "increase children's physical activity, improve motor/physical competence, increase spatial and perceptual skills, and enhance [the] ability to assess and manage risk appropriately" (Sandseter et al., 2021). The essence of 'risk' can be summed up as offering independence as a catalyst for critical thinking skills. In traditional playgrounds for example, everything is uniform and offers no variety with regards to the spacing between elements. This leads to a sense of comfortableness, and children become disengaged in their play- as they do not need to focus on where they are placed relative to the world around them. Quite simply, this "equipment often offers little to no challenge or risk because of increasingly stringent safety regulations for outdoor play areas. Surprisingly, such low-risk environments can actually result in children playing in dangerous ways as they seek to challenge themselves" (Munroe, 2013).

Another aspect to a nature-play environment is natural sensory exposure and input. The space should be utilizing the nearby trees, water features, terrain, enclosures and any local elements that will resonate with the human senses. Such grounded connections "touch children's spirits, and kids are inspired to move, explore, create, and understand" (Striniste, 2019). One study concluded that "the diverse design elements provided through school ground greening (i.e. trees, rocks, shrubs, sticks, branches, leaves, logs, and stones), promoted more active play amongst a wider variety of students across light, moderate, and vigorous physical activity levels" (Stevens, 2017). By incorporating and embracing the setting, we are able to create a more engaging space for children that they will not only enjoy, but we will be able to reap the maximum benefits for their growth.

2.4 Inclusive Spaces

An outdoor recreational space should be designed to have high accessibility in order to maximize its value to a community. Accessibility is defined by the ease of navigating the trail. One example is the walking surface's size and slope. Additionally, one must consider the usability of the trail's interactive elements.

The Forest Service Trail Accessibility Guidelines (2013) advice for all trail tread surfaces to be stable and firm. Stability refers to resisting deformation, such as indentation, being unaffected by weather, and sustaining wear and tear (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013). The Accessibility Guidebook for Outdoor Recreation and Trails (Zeller et al., 2012) expands on the previous suggestion by explaining a firm surface can prevent assistive devices from sinking into the ground, which allows the area to be more accessible to persons using crutches, canes, wheelchairs, or other assistive devices. This guidebook also advises the use of soil stabilizer and artificial surfacing if the natural soil cannot provide a firm and stable surface.

When considering the proper trail width, it should have a minimum clearance of thirty-six inches. If this can not be achieved due to natural factors, the width of the trail should not be reduced below thirty-two inches (*Forest Service Trail Accessibility Guidelines*, 2013). This ensures that a wheelchair can pass unobstructed. If there is a desire for a section to allow for two wheelchair users to pass, the minimum is increased to sixty inches. If this scenario is difficult to implement, a passing space should be provided at least every 200 feet to allow cross traffic (Zeller et al., 2012). The Forest Service Trail Accessibility Guidelines (2013) adds that the maximum interval without a passing space is 1000 feet, the passing space should have a minimum width of sixty inches and a minimum length of sixty inches. Both the ground cross and running slope of this space should be less than 3 percent.

Cross slope is defined as the change in elevation perpendicular to the direction of travel, and the running slope is defined as the change in elevation parallel to the direction of travel (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013). Along all sections of the trail, cross slope should be less than five percent. If the trail is elevated above natural ground, the cross slope should be lower than two percent. The running slope for all trail sections should not exceed twelve percent. The total length of the trails with a running slope over 8.3 percent should be less than 30 percent of the total trail length (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013). A running slope under five percent is allowed for any trail length. If slope is steeper, a resting area should be provided to allow users, especially in wheelchairs, to rest before continuing another trail section (Zeller et al., 2012). When a running slope is steeper than five percent but lower than 8.3 percent, the appropriate trail interval between two resting places is less than 200 feet. When slope exceeds 8.3 percent, but lower than ten percent, the interval should be less than thirty feet. If it exceeds ten percent, the interval should not be more than ten feet (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013). In a resting space the slope should be less than three percent in any direction. (Zeller et al., 2012).

An opening is categorized as “a gap in the surface of an outdoor recreation access route” (Zeller et al., 2012). Openings include gaps between tread on a walkway and drainage gap. It is advised for all openings to be perpendicular to the primary direction of travel and to be less than half inch in width (Zeller et al., 2012).

When telescopes or periscopes are provided, each viewing location should have more than two telescopes or periscopes (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013). If it is intended to be used in a sitting position, the height of the eyepiece should be higher than forty-three inches and lower than fifty-one inches. For standing position, eye piece is adjusted to an approximate sixty inches (Zeller et al., 2012). A minimum of thirty-six inches by forty-eight inches ground space- with a slope of less than two percent- is recommended to be cleared for users to approach the telescope or periscope. If the ground is not paved or elevated a three percent slope is allowed for water drainage (*Forest Service Outdoor Recreation Accessibility Guidelines*, 2013).

2.5 Bridge/Walkway Design

A bridge is a complex structure that not only introduces many variables into surrounding systems but is also influenced by a variety of factors like landscaping, hydraulic, structure, architecture and economics (Pipinato, 2016). When introducing such a complex structure into an ecosystem, all the factors this structure can influence need to be considered. A research team that studied the ecological damage done by infrastructure in China has found ecological damage can be caused by one factor, or a combination of multiple factors ranging from ecosystem capacity to use efficiency or finance. From this, the team suggested that a designer needs to understand and consider the capacity of an ecosystem and all the factors which could be impacted by their decisions (Yang & Li, 2016).

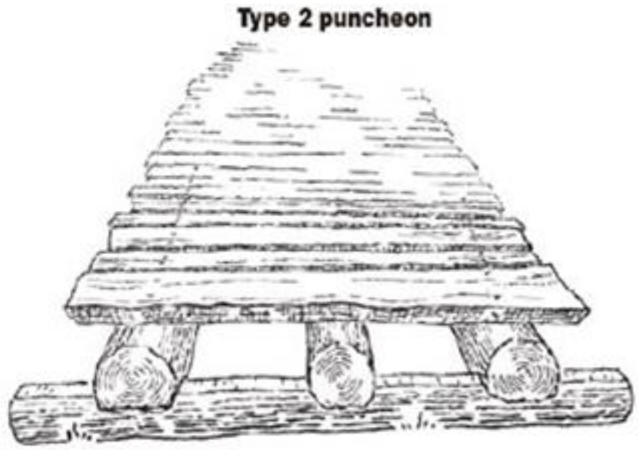
As McHarg suggested in his book *Design With Nature*, a designer needs to view earth as a biosphere in which all organisms and all ecosystems act as one superorganism rather than separate entities (McHarg, 1969). Therefore, before the start of any land altering project, the designers should consider the physical, biological, and social value of the land and make sure their project is adding value to the land and thus beneficial. McHarg states that it will be ideal if a project can only add value to land at no cost, but this circumstance is unlikely to happen. The added value then, should be greater than the cost incurred and irreversible loss to the land value should be minimized as much as possible. This is also pointed out in the North Country Trail handbook which stated that the design consideration usually falls into one of two categories - user and environmental (NCT Handbook, 2019). Often conflicts arise between the two concerns and the designer must prioritize one that makes the most sense for that particular situation.

Although architects can not agree on one definition or rule for the aesthetic pleasing bridge, Alessio Pipinato suggested three basic concepts for aesthetic design. Firmitas - the ability to preserve physical strength, Utilitas - the practical function or the usefulness of the bridge, and Venustas - the ability for the bridge to cause delight in the observe or the user of the bridge (Pipinato, 2016).

There are a few different options that are frequently employed for trail bridges. Particularly, certain bridges are used where areas of wet soil are present. These short span-footbridges/beam bridges are all categorized under the term ‘puncheon’. However, this can mean different things depending on the location. For example, a “puncheon on the Appalachian Trail is not the same as [a] puncheon built in the Cascades, Rocky Mountains, or Sierras. [A puncheon] built in easily accessible areas may not be the same as [those] built in the backcountry. ” (Steinholz & Vachowski, 2007). What complicates this, is that some areas use “bog bridge” and “puncheon” synonymously. For our purposes, we will refer to this using the colloquial term.

Figure 1

Illustration of a Type 2 Puncheon Bridge (Steinholz & Vachowski, 2007)



Puncheon bridges often have three components: sleeper, stringer and decking. Sleeper are the logs contacting the ground erving as the foundation of the bog bridge. The stringers are the span support structure beams that are placed on top of the sleeper and often do not contact ground. The deckings are placed on top of the stringer to allow pedestrian travel. Deckings are often wood planks that are six to twelve inches in width, to six feet in length. The cross slope of the puncheon could vary depending on location and climate. In a dry area the allowable cross slope of a puncheon can be up to 0.5 inch per foot. But in a wet climate where rain, snow, and ice are expected the cross slope should be fewer than 0.125 to 0.25 inch per foot (Steinholz & Vachowski, 2007).

2.6 Wood and Treatment

The lumber material that is the most sufficient for outdoor constructions (provide water and weather resistance) consist of wood that is treated with creosote, chromated copper arsenate, pentachlorophenol, or copper naphthenate. This is because they do not result in rapid corrosion, especially when compared to untreated wood. Although creosote is the oldest treatment method, it is not advised for structures that are expected to contact human skin due to health concerns. Pentachlorophenol is a treatment method that has been widely used in the US for bridge timber, although it should not be used if the specific part has frequent contact with skin. Both creosote and pentachlorophenol are listed as RUP (Restricted Use Product) by EPA due human health concerns (Groenier & Lebow, 2006). Instead, another approach is to choose lumber from tree species that are naturally rot resistant like eastern hemlock and cedar. During construction with these materials however, the crew is required to remove all the barks from the log without leaving any indentations to aid the resistance and longevity of the lumber (Bushey, 2016).

In common practices wood is often immersed into chemical perseverance and then applied with high pressure until the desired amount of chemicals are absorbed. The wood produced by this treatment is referred to as pressure treated wood. There are three common practices to produce pressure treated wood: full-cell process, modified full-cell process, and empty-cell process. Full-cell processes are often used when preserving chemicals that are water borne preservatives; empty-cell process are often used when preserving chemicals are oil based preservatives; modified full-cell process is similar to full-cell process with a more extensive post process vacuum process to driven out unused persevering and thus reduce weight. Although the pressure used in the pressure treating process can vary from 345 to 1723 kPa the most common pressure applied only ranges from 860 to 1207 kPa due to many wood species being sensitive and can be damaged by high pressure. Heated treated woods are often used to achieve higher chemical penetration. The pressure should not exceed forty nine degree celsius, as the high temperature can affect the wood properties and it's chemical stability. The chemical penetration is the most important factor in determining the pressure treated wood's quality. The depth of chemical penetration varies from 1.6 mm to 12 mm due to different wood species having different levels of resistance for chemical penetration (Groenier & Lebow, 2006).

3.0 Methodology

The following sections describe the methods that were used to meet the established project objectives: (1) to provide structures that would span hard-to-cross areas of woodland footpaths and (2) to develop nature and play based curriculums tailored to three- to ten-year-old children walking woodland nature trails.

For objective 1, we used non-participant observation to examine bridges. During construction, we used stonework and carpentry skills. For objective 2, we utilized semi-structured interviews and non-participant/active observation.

3.1 Semi-Structured Interviews

We need guidance in implementing play and nature-based learning, and receiving guidance on the local wildlife, from experts and professionals. This will allow us to gain a better sense of the communities surrounding each topic, and common practices or thoughts held amongst those directly involved.

To do this, we conducted three semi-structured interviews. These are interviews in which the interviewer asks more open-ended questions. The person answering is not limited to answering with a simple “yes” or “no” response. This allows for a more efficient discussion. The interviewer can now ask for follow-up questions and to elaborate on the statements made (Doyle, 2020).

Interviewees consisted of one teacher at Turn Back Time, one member of the Paxton Conservation Commission, and one education consultant/specialist in nature education.

In our interview with an educator at Turn Back Time, we discussed the principles behind nature play, and how it is executed at TBT.

At the meeting with a member of the Conservation Commission, we discussed how to interact with and identify various animals in Paxton.

With our consultation with a nature-play/education specialist, we focused on how humans and nature should not be viewed as separate entities, the multi-faceted benefits of nature-play, and how this learning style creates an equal playing field for all.

3.2 Non-Participant Observation (Structures)

Additional knowledge was needed on designing and constructing bridges. This would help to create a viable bridge for TBT. Reviewing pre-existing structures that serve a similar purpose our project would give a firsthand look at material and construction choice.

Non-participant observation was conducted on several walkway/bridge structures. Three locations - Moore State Park, Niquette Bay State Park, and Elm Park, were chosen due to their relatively close proximity at that time in the term, and the existence of a bridge or walkway structure in those locations.

Figure 2

Bridge at Niquette Bay State Park

A wooden pedestrian bridge was observed at a lake over Elm Park. The bridge provided information on the materials and construction of the bridge posts, decking, and handrails. A wooden and roofed bridge spanning a lake runoff in Moore State Park was also studied. Its foundation, materials, and overall construction were observed. In the visit to Niquette Bay State Park, there were several types of bog bridges, a metal framed wood bridge, and several paths of turnpike trails. Particular attention to water drainage and filling material was given to the turnpike design.

3.3 Non-Participant and Active Observation (Children)

TBT consists of students from a diverse age group, from kindergarten to elementary school. This results in a diverse set of needs for each age group. The classes at TBT also vary from five to fifteen students, with different class objectives. To design a classroom/ recreation area for TBT, we need to experience and observe different teaching sessions. Particularly, we want to know how students and teachers will interact within the space.

Both participant and non-participant observation were utilized during several classes on the project trail. This allowed us to gather data and work towards developing the layout, structures, and modules for the outdoor classroom and play space. Each class consisted of various age ranges, purposes, and number of students. This accurately reflects the diverse class structure, and ensures that the area is tested under potential uses. Students were observed in the clearing of the play center, with some wood scrap and logs scattered within the center. Students were then allowed to create their own hybrid learning/playing space and structures, and to use them how they saw fit.

The non-participant observer took notes and drew dynamic maps for each class observed, which were then organized into journals for later use and analysis. After each class both observers meet to recall and document events that happened. The active participant was directly playing or talking with the children, engaging with their commentary or reactions to their surroundings and occurrences within the space.

Afterward, both team members would meet with the teachers who taught that class to understand their perspective, and their observations from the point-of-view as an educator. In each question session, the team asked about the opinions on the new classroom space, how they felt their class performed, potential problems, and any additional needs or wants.

3.4 Basic Carpentry/Woodwork Skills

Wood was determined to be the main material for construction. This applied to both the bridge and all additional basic structures. Thus, the need for basic carpentry skills arose. This means we require foresight into tools, specific materials, and measurements.

We initially planned all designs with an intensive list of parts- detailing purchasables, pre-existing tools, measurements, and site considerations. Once materials were on-hand, we then took measurements using a tape measurer. Line levels were used to ensure that our guidelines and materials were straight and accurate. All cuts were also planned out, along with the appropriate number of screws and nails to secure components together.

3.5 Basic Stonework Skills

The trail area TBT requested a bridge for, consisted of a stone wall system, and large underlying rocks. Traditional post and helical piles constructions would therefore be difficult to utilize. The skills required to form stone structures were needed to construct the bridge foundation and allow for terrain manipulation.

In order to reorganize stones in a more efficient manner, we first cleared the space and rebuilt the nearby stone walls. This involves stacking the rocks haphazardly into a line, slowly building up a raised structure. Once we had cleared enough within the workspace, we then moved onto clearing the larger stones. The larger bolder-sized and unmovable rocks had to be leveled using a pickaxe and sledgehammer. Once the area was built to the desired height and width, we then set down the planned structures and rebuilt the surrounding walls for support.

4.0 Results

The following section describes the results obtained from our methodology studies. Results are split between our two objectives - (1) to provide structures that would span hard-to-cross areas of woodland footpaths; (2) to develop nature and play based curriculums tailored to

3-to-10-year-old children walking woodland nature trails. To reiterate, objective 1, we used non-participant observation to examine bridges. During construction, we used stonework and carpentry skills. For objective 2, we utilized semi-structured interviews and non-participant/active observation.

4.1 Objective 1

During the non-participant observation session, the team has visited five bridges. Each was constructed differently, serving similar purposes at assumed different price points. Most pedestrian bridges are constructed with pressure treated wood. Only one bridge used steel beams, due to long span length and high ground clearance. Oftentimes, only two beams were used as support. There was also a correlation between handrails and ground clearance. The lower the structure, the lack of side protection.

From observation of existing bridge structure, evaluation of the construction site team, and communication with TBT owner, the team concluded a simple bog bridge is the most appropriate structure to construct. The bog bridge should only consist of two span support beams due to low expected load and short span distance. No handrail or edge protection is necessary due to low ground clearance.

4.2 Objective 2

Both the interviews and observations allowed us to understand how to approach designing the space.

Observing classes highlighted the difference in behavior between older and younger students. Older students had a preference to make the obstacle course more challenging. This was reflected in how they spaced apart the modules. They would also support their built structures less, and would compare results amongst each other. The younger students preferred a ‘safer' course with less gap between obstacles. Often, they would stop progressing on the obstacle course if they perceived it to be too ‘scary’. Both age groups however expressed the desire to have a seesaw, and interactive set displays. Some students would also leave the clearing to explore the woods. This led us to leave an opening for classes to head off-trail.

Figure 3

Student-built Play Area

The interviews helped us to further understand the concepts behind play, and borders for safe interaction. Both the TBT educator and nature-play consultant had similar views on the discussions of forest schooling. They expressed that humans are not separate from nature, and that the benefits go beyond ‘psychology’. An active engagement with nature is needed to reap the social, physical and emotional benefits. This relates to place-based pedagogy, and that we should keep in mind that the space should be elevating what nature is already providing. They proposed the questions of ‘Why are our structures needed?’ and ‘ Is it just for access or is there a lack of resources?’ to help guide our development. The conservation commission member echoed this, by ensuring that we were balancing the benefits of play and disturbance of nature. Oftentimes, the advantages take precedence. Children are able to grasp concepts such as empathy more organically, however we should not be encouraging destructive habits.

5.0 Discussion

During an initial site visit, it was determined another route would be preferable. The desired area was a muddy stormwater runoff location, making construction difficult. The ground consisted of a thin layer of topsoil and a thick rocky layer making it difficult to construct any foundation posts. Second, the mud pit has a turn that is approximately 150 degree turn. If the walkway would have followed that turn, it would make this structure more difficult and costly to construct. Third, there was a small natural depression that could provide a smaller bridge span. Last, many children enjoy walking in the mud pit. According to the TBT teachers, the mud pit can be a form of sensory education and is beneficial to their development.

Three bridge designs at three price levels were developed. After discussion with Lisa Burris and Katie Baker, (the executive and assistant director respectively) the cheapest design was chosen. TBT only needed a simple passageway to safely bypass the muddy area, thus an advanced walkway system was unnecessary. Lack of a heavy workload crossing the bridge meant there was no need for strong reinforcement. This structure was also more financially feasible for TBT.

5.1 Bridge

The team marked the outline of the bridge with rebar connected with paracord and highlighted with orange flags. Rebars were inserted at four corners of the future bridge with a mallet. The four-rebar sticks were then lined with a paracord to mark the outline and the height of the bridge. A level was used to ensure the paracord was on the same level. Finally, orange-colored flags were attached to the paracord for better visibility.

Figure 4

Bridge Outline/Visualization

The ground assessment found an unstable stone wall constructed on a rocky soil on one side of the depression and a rock with approximately twenty-five-degree slope on the other side of depression. It would be impossible to construct a traditional foundation post. The team then decided the stone wall can be taken down and reconstructed. A bigger, flatter and more stable stone wall would function (with flattened rock) as an alternative.

The old stone walls were taken down and its stone reorganized. The bigger irregular shaped stones were used as the lower portion of the new stone wall and the flat rock were used as the top layer of the new stone wall, and the smaller stones were used as filling rocks for more stability. Some bigger rocks were broken down to smaller pebbles by a sledgehammer and used as filling rocks. The big rocks on the other side of the bank were broken down and leveled by pickaxe and sledgehammer. The smaller rock pieces broken off from the higher side were used to raise the lower side. The levelness of both new stone wall and reformed rock foundation and their levelness to each other were confirmed by placing two levels on one piece of wood board and placed onto each area and across each other. Finally, three gallons of water were poured onto both reformed rock foundation and stone wall to ensure each foundation had well water drainage.

A bog bridge was constructed over a natural depression for rainwater runoff. The bridge support foundation is made with stone. One side of the bridge is located on a reconstructed stone wall platform; another side of the bridge is located on a flattened rock. There are additional stones laid above the foundation structure to act as support for the span beam. A dirt ramp was also constructed on the entrance and exit side of the bridge for higher accessibility.

Figure 5

Bridge Foundation

The beams of the wooden walkway are two sixteen-foot-long telephone poles which were dragged onto the construction site by a tractor and assisted with two 2 by 4 wood beams, one held by each team member. The team constructed a rail with two wood beams in order to place each telephone pole in the desired location. Team then used 2 by 4 wood beams as levers to move each beam above and over the stone wall and onto the wood rail after which the telephone pole rolled into location. Thirty-two 5/4 inches by 6 inches by 4-foot pressure treated deck boards were purchased from Home Depot and a line was drawn 2 inches from the left side of the board to assist alignment during final assembly. During the final assembly, four flat head 3 inches deck screws were used for each deck board. Each screw was inserted into the point where the deck board is tangent with the beam by a power drill.

5.2 Nature Education/Play Area

All the wooden parts for the structures in the playground were first measured with a measuring tape, and then had guidelines drawn. The wood parts were cut with a wood saw, and assembled with either a two- or three-inch wood screw and a power drill, or with nail and a hammer. A mallet was used to adjust the position of parts in a tightly fit position before connectors were put in.

The wire cover for the insect hotel was first cut roughly by a bolt cutter and then trimmed down by a plier before it was held onto the frame by a galvanized framing nail.

The ball run module consists of a wood frame, with a large metal plate attachment. This plate is magnetic, and allows the user to move the tracks freely. The pipes are two inches, which were cut in half. A large circular magnet was attached on the back to hold it onto the board.

The animal displays were simply carved from scrap wood. A Dremel was used to first engrave the figure. This ensures that it will be more resistant to weathering. Afterward, the outlines were then burned with a wood burner.

The obstacle course was also built using the wood TBT already had. The balance beams were built with beams and screwing together the planks. Carved tree stumps were incorporated to create a natural element. A swing/climbing rope was purchased to create a vertical element. This is mounted onto a wood plank, screwed between two trees. An additional support structure is placed under each end, to ensure safety.

A set of play binoculars that overlook the forest were installed. This plastic set is embedded onto a 6x6 wood beam.

The outdoor library is set into a tree within the classroom. This wood box also has a support structure underneath. The doors are built with scrap, with plexiglass windows and pipe brackets for handles.

Leaf-imprint stepping stones were also created. Using a pizza box, a thin chicken wire was cut and placed before pouring concrete. This creates a square mold, with an inner wire support structure. Once the concrete was poured and flattened, leaves were pressed into the surface. After everything has cured and dried, the leaves can be removed and the stone can be placed.

Magnifying posts were constructed to allow TBT to have more permanent tools in place. By cutting into a 6x6 post, we were able to slide in a magnifying sheet. Screws were placed on either end to act as clamps, ensuring a firm hold with ease of replaceability.

6.0 Recommendations

How To Use The Learning Stations Provided

Since the outdoor classroom was designed for flexibility, there are a variety of uses. Each module can be used as needed for particular lessons, or simply as a destination to visit during class time for free-play.

The fence displays offer students examples of what to look for as they walk throughout the trail. There are displays of local animals that children may encounter, and hanging clothespin sections to display their findings.

The obstacle course provides space to practice motor skills and engage naturally with the environment. Teachers can challenge students to navigate in a particular way, and think about how animals engage in similar spaces.

The magnifying posts are permanent structures that eliminate the need for teachers to bring magnifying glasses. Students can pick up objects and have this tool on-hand within this space without needing to bring extra materials while walking the trails.

The binoculars offer teachers to help students develop skills with nature observation. With an accompanying fake deer, students can practice trying to find objects within a space. This created a sense of focus and patience, amplified by the forest setting.

The ball run can be used by children to understand concepts of gravity and movement naturally. They can try different objects (at different shapes, including water) to see how they navigate the course. They are also able to design their own maze, and explore different configurations.

Outdoor classroom space can be used for nature journaling, gathering students, and story time. The tiered seating offers a natural classroom environment. The library allows teachers to leave books for the upcoming curriculum, or to keep field guides on-hand.

Overall, these new components create more options for engaged learning. Through enhanced sensory play, promotion of natural elements, and creating a safe space for exploration.

Maintenance Recommendations

The constructed walkway is strictly for pedestrian use only, no motorized vehicles should be driven on it at any time, with the exception of a motorized wheelchair. When a motorized wheelchair is accessing the walkway, it is recommended to drive across one at a time under the assistance of at least one Turn Back Time staff member, due to the lack of edge protection. Due to the width of the bridge, it is recommended to only have one direction of traffic at a time and all pedestrians should ideally break their march when crossing this walkway.

Regular maintenance of the bridge is also highly suggested. The walkway should be swept once a month and checked for any cracks formed in the treads. If one is found, we recommend removing and replacing the cracked piece promptly, for user safety and structural integrity.

During snowfall, the snow should be shoveled off the walkway. There should be an inspection on the dirt ramp every month and after heavy rainfall to confirm no major soil loss is present. Some signs that suggest there have been a detrimental loss of soil are as follows: the exposure of bridge beams and rock that are meant to be covered, or the dirt ramp has lost its original firmness and is loose/unstable. When any of these signs are observed, an appropriate amount of soil should be reintroduced to the site, and the ramp should be reconstructed as soon as possible.

The outdoor classroom and play area also need to be maintained in order to ensure long term use. Every spring through summer any vegetation growing in the outdoor classroom area should be cut back. There should be a particular vigilance towards poison ivy for the next 3-to-5-year period, and this should be checked for routinely. A thin layer of WD-40 should be applied to the magnetic sheet twice a week to prevent rust, and a part check for the PVC pipe ball course should be performed every day. If any part is missing it should be replaced as soon as possible.

There are multiple dead and near dead trees that post a threat to both the integrity of the playground area and the safety of the users. Team recommended before the playground is in use the marked dead tree should be cut down and removed. Multiple surrounding trees should have their dead branches trimmed for user safety.

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