Creating a Beaver Pond Learning Lodge to Aid in Facilitating Outdoor Education

An Interactive Qualifying Project Proposal Submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE In partial fulfillment of the requirements for the degree of Bachelor of Science

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Abstract

Turn Back Time (TBT) is a nature and play based learning school in Paxton Massachusetts that uses non-traditional classrooms to teach important educational and social subjects to their students. While many classes are conducted outside of a traditional classroom, there is still a need for a space by their beaver pond to store educational materials and to provide better opportunities for nature-based learning and engagement. The purpose of our project was to design and build a learning space and interactive stations that incorporate the natural features and educational opportunities provided by the beaver pond.

Acknowledgements

We would like to thank the many people who have helped us along the way throughout this term and have taught us valuable lessons during the course of our time working on our project at TBT.

We would like to thank Professor Derren Rosbach, our IQP advisor who has worked closely with us throughout the term to ensure we reached our full potential on this project and has driven us to greater aspirations while keeping us on track.

We would like to thank Professor Elizabeth Stoddard, our residential advisor who has ensured that we have everything we need from paper towels to spatulas to make the best of our time here at the farm.

We would like to thank Lisa Burris for working with us on final design elements to better understand exactly what would work best for TBT in terms of our project and making well informed decisions along the way in order to ensure the project reaches its full potential for excellence, and for funding the project when she saw the potential impact it could have.

We would like to thank Jim Burris for helping us keep the surrounding area around our building area clear by cutting down the few dying trees nearby that posed a threat to the longevity of the structure, for helping us get the woodchip flooring down to the lodge area, and for helping us solve the issue of spacing out our posts properly when things did not go according to plan.

We would like to thank Katie Baker for being our regular contact with the sponsor, and for helping us truly understand the importance and significance of the way Turn Back Time teaches its students and for being a consistently positive source of encouragement along the way.

We would like to thank the volunteers who came out to help us on construction day of our project: Professor Rosbach, Jesse Bordenca, Garret Hussey, Alex Marrinan, Joeseph Caponigro, Morgan Raposa, and Matt Kiszla.

We would like to thank Mia Dubosarsky, our contact at the STEM center at WPI for answering in great detail our questions on State guidelines on curriculum.

We would like to thank the wonderful people at Good Pickin's Farm who let us come out and interview them on what they do similar to/different than TBT, namely Tish Kilgore and Sandra Habe.

We would like to thank those who donated supplies for our project, including Lisa Burris, Joan and Tom Sunter, and Richard Messer, the latter of whom we would also like to thank for assistance with construction on one of the final days.

And finally, we would like to extend a general thank everyone at Turn Back Time, and all the workshop presenters that made our time here memorable and fostered a community for us to experience on our IQP.

The Team

Pictured above, Dale Messer (left) and Zachary Maynard (right)

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Executive Summary:

Goals and Objectives

We set out to create a structured area adjacent to the natural beaver pond to provide access to novel educational materials, with the focus of promoting literacy in different age groups.

We intended to do this by first researching effective classroom designs, keeping in mind the outdoor and play-based learning environment that our sponsor already provides.

We then set out to get a better understanding of the needs of Turn Back Time staff members and how to best engage their students with interactive educational materials.

Next, we got a better understanding of the curriculum elements required by the state guidelines and how TBT implements them into their classes.

We then designed both a Beaver Pond Learning Lodge (BPLL) adjacent to the pond to house educational materials and conduct classes, and a variety of educational interactive stations to be housed within the BPLL.

Finally, we built these deliverables and analyzed, assessed, and redesigned our project based on feedback from students and staff to incorporate in both the final deliverable and into our recommendations section.

The need for this project

Turn Back Time is a nature and play based learning school in Paxton Massachusetts that undertakes the important directive of incorporating a natural and organic learning environment for kids that may not be reaching their full potential in traditional classrooms. They offer a variety of educational programs and events on their 58-acre property, which houses many animals for the kids to interact with and locations for class curriculum to be taught while still connected to nature.

One of the more popular of these sites is the Beaver Pond which resides on their property and is often used as a location for the students at Turn Back Time to explore and interact with the flora and fauna around them and learn more about science from nature directly, while practicing important communication skills for their age group as dictated by Massachusetts State Curriculum guidelines.

This area is not without its challenges however, as its distance from the Kinderyurt classroom makes for difficulty in accessing educational supplies, such as books, educational materials, and paper, as they are a few minutes' walk into the woods on the property. This often causes the teachers to have to bring the students back to the classroom or miss out on a learning opportunity that may naturally occur as a child shows interest in a particular plant or animal found by the beaver pond. We set out to solve this problem by providing them with a form of “outdoor classroom” space near the pond.

Methodology

After our first initial visit to TBT, we were informed of the need for this space near the beaver pond and the issues frequently had with getting class materials out there. We promptly began researching play-based learning and nature education, to get a better understanding of the types of practices that our sponsor uses to teach. We then found research reports on the benefits of open/non-traditional classroom spaces and the positive impact it can have on students.

Upon arriving to the site this term, we met informally multiple times with our main contact with the sponsor, Katie Baker, one of the teachers at TBT, asking questions about classroom routines, curriculum components, and general educational practices down by the beaver pond. We then met with an expert in State curriculum requirements from the STEM Center at WPI, to go further in-depth into what Massachusetts state

standards require of the students of the age we were focusing on for the Beaver Pond Learning Lodge from Pre-k through Kindergarten. Lastly, to get a fully encompassing understanding of the type of environment we would be designing our deliverable for, we scheduled a time with our contact to observe a class of students learning and playing by the beaver pond and took detailed notes on elements that we considered important and useful in factoring into consideration when designing the lodge.

In making various choices for our design, we wanted to tailor everything as well as possible to the needs of both the Staff and Students, and to ensure that the structure will last as long as possible for the sponsor while keeping the budget as low as possible. In order to balance this, we approached the matter from 3 different angles. The first being creating a survey to send out to the staff at TBT in order to get a better understanding of the needs of the teachers and thereby also have them convey the needs of the students, and what elements would be most engaging to them of our proposed station designs. The second was researching several different options for almost every element of the design, from the material choice, to design aspects, to aesthetics, in order to give the sponsor a significant number of options and direct influence over the final design. Lastly, we created multiple design matrices for these various options on design elements so that we could lay out plain and clear for the sponsor the benefits and downsides to each decision, so they could better inform their own choices on what aspects mattered to them over others, such as cost to durability, and time to assemble to aesthetics and many other such examples.

Solving the problem

From our findings on the needs of Turn Back Time, we found that the most convenient solution would be to create a space for the teachers to store educational materials and to conduct classes while being somewhat sheltered from the elements of the various

seasons that Turn Back Time operates within. We wanted to ensure that we were still in keeping with TBT's values of outdoor education, so we designed an open floorplan with only two walls in a sort of amphitheater style arrangement for the students to hear their classes, while still providing shelter for the teachers and any students not eager to remain in the elements if it should rain or snow. It was implemented in our design options that we revised through feedback from TBT staff and from the sponsor directly, our final design and construction reflected what we had learned about Turn Back Time and the educational requirements, and through this data we created a space to best resolve the problem that we set out to initially. Our success will be assessed in the lasting life of our structure, the modularity of the design to allow for additional stations to be added to the lodge, creating further learning opportunities for the students well beyond the scope of our project, and lastly, it will be measured in the usefulness of the structure to the staff and students of TBT.

Authorship

As our project team split early into the term and we became a team of two, there is little area of this report that is primarily written by one team member or another, the exceptions to this are as follows: The design process section was done by Zach and looked over by Dale, while the Executive Summary/Introduction was done by Dale and looked over by Zach. The rest of the report is a joint effort, with much editing and revising being done by both parties and collaboration and consideration from the other always being taken into account.

Introduction

A teacher brings their group of kindergartners to Turn Back Time's beaver pond after lunch, they go to the shoreline and climb around on the logs at the shallowest point of the water, exploring the flora and fauna native to this ecosystem. One child picks up a fern, inspects it, and wants to try and draw it but has no paper or space to do so, another catches a frog and holds it safely in their hands and shows it to the teacher but has no place to place it to show the other students, and then it begins to drizzle. While most of the kids are fine with the small amount of rain, there are a few that would rather not get rained on, and worse still the teacher can no longer open the book they had brought to read to the children without getting it wet, so they must leave this outdoor trove of learning opportunities for the classroom a 3-minute walk back away from the pond.

This is precisely the scenario that we wanted to account for, and this led us to focus more on providing a more effective learning space that protects the students, staff, and learning materials from the weather, facilitates teacher and student needs, and adds further potential for educational value that may not have been there before. With our project we set out to create a structured area adjacent to the natural beaver pond to provide access to novel educational materials, with the focus of promoting literacy in different age groups. We researched state curriculum requirements, benefits of outdoor education, and various options for materials and design elements in order to make a tailored and versatile set of options for Turn Back Time. The first chapter provides an overview of the site and Turn Back Time and literature surrounding topics relevant to our project. The next chapter details the methods we used to collect data, interview, and survey local experts on education and members of the teachers at Turn Back Time (TBT). The third chapter covers the results of our research, things we found throughout the course of our project and through observation of the classes, and a detailed design

and plan of the structure we built for them to resolve their problem, and a detailed list of recommendations going forward.

Background

Description of site:

Turn Back Time's 58-acre farm serves as a place of learning and play for dozens of children year-round. They offer a variety of services including Preschool, Kindergarten, and adult education programs, to name some of the more popular ones. At any given time, they need to be able to engage their students through nature-based activities like reading in the woods or inspecting the local pond life in person (Turn Back Time, 2022) safely and effectively. As a result, they need to have proper spaces for kids to learn and play across their numerous programs. Turn Back Time has been consistently expanding over the past few years, with new additions being added from donations and WPI projects that serve to expand the farm's various educational features. These locations include a play space just a few dozen meters from the entrance to the farm, a little way off into the woods made entirely out of easily sourced materials like remnants of plastic play spaces, painted tires, and other playground amenities that greatly enrich the children of Turn Back Time. Also of note are the many animals on the farm that serve the dual purpose of both providing food and educational opportunities that fascinate and engage the children. There are also several classrooms, and while the preference is to teach outside in nature and in the moment, they also have indoor classrooms in the Kinder Yurt that they use when the weather is not accommodating, or they have a lesson that requires them sit down and learn indoors. They do not, however, give up their ideology of play-based learning and there are still plenty of opportunities for the children to interact with the learning material in a more engaging way: though use of a costumes and drama section for the children to play pretend, multiple stations where they can learn about wildlife and basic anatomy, and tables where they can do more traditional work if the curriculum calls for it such as math and writing. Finally, of importance to our project is the large pond just a short walk from the main yurt style

classroom that is home to several beavers and a multitude of other creatures for the students to spot, inspect, and be taught about in greater detail.

Description of the served population:

Turn Back Time has a student population that is composed of thirty percent underserved populations, including children below the poverty line, children with documented diagnoses, and children whose family is involved with the Massachusetts Department of Children and Families. (Turn Back Time, 2022) The Pre-K classes are comprised of students from ages three to six that operate from September to June. Turn Back Time also operates a Kinderkamp as an alternative to traditional kindergarten. Turn Back Time operates a curriculum for homeschooled students that operates in the evenings as a form of STEAM enrichment. Summer camps have weekly themes that relate to STEAM in nature.

Literature Review

Benefits and benefactors of outdoor learning settings

The focus of Turn Back Time is engaging students in an outdoor environment. To establish this against traditional classroom practices, a review of literature surrounding outdoor education was conducted. A study out of Thailand recorded the responses of pre-service teachers regarding their opinion on outdoor STEM education and found that out of the 29 teachers, 24 had already used outdoor STEM education in their teaching methods. Teachers felt that their students responded well to being taught outdoors. Both the teachers and researchers feel that STEM education should be a focus in early education. (Khwaengmek et al., 2021). The researchers also noted opportunities for education to be integrated with the wider community. A direct comparison of Thailand's early educational system and the United States is not reasonable, but the study suggests that there is a positive attitude about using the outdoors in early childhood education.

Traditional vs Non-traditional classrooms (Pre-k)

When comparing the settings of traditional to non-traditional classrooms, a non-traditional classroom deviates from the standard setting of indoor education methods (such as the utilization of role memorization and lecture to instruct students) often opting for more hands-on, experiential, or outdoor methods of education. (James, 2017). Within the last 20 years, the associated negative consequences of low-test scores have caused schools to narrow their curriculum efforts down to test preparation, consequently de-emphasizing the material that does not show up on standardized testing and student-centered, experiential learning. (James, 2017) However, the advantages and benefits of non-traditional classroom learning systems carry several advantages over their traditional counterpart. One such advantage is in personal interest and attention vested by students; in a 2013 Gallop poll, it was revealed that 45% of

students through grades 6-12 were disengaged with the school system of teaching due to the standard curriculum involving rote memorization, lecture, and drill. Yet conversely, within a middle school survey involving participants experiencing outdoor learning, 79% reported that it was a worthwhile experience, while many students with special needs or academic interests became highly participatory and engaged in the process despite otherwise often struggling with the standard school curriculum. (James, 2017) Furthermore, recorded results have demonstrated that active and experiential learning is significantly more memorable and committable to long-term memory compared to rote memorization, and when the environment is integrated into a school's learning curriculum, the degree of academic achievement rises. For instance, in one key study, children who participated in outdoor learning had their test scores improved by 27%, indicating a boost in academic performance. (James, 2017) Not only does outdoor learning improve student interest and learning, but it additionally facilitates the growth of social and personal skills, with outdoor collaboration improving behavioral and intellectual development. (James, 2017) In the current age of increasing involvement with electronic devices, the standard amount of time outdoors that children spend has also declined. Currently, approximately three-fourths of children in the UK spend less time outside than prison inmates. (8 Proven Benefits of Outdoor Learning for School Children, 2019) Despite the importance of outdoor activities for children, both the school system and at-home trends have been heading in the direction of greater indoor activity at the expense of outdoor experience and learning.

Literacy

The impact of literacy at an early age has been extensively studied and has led to numerous important findings. Early literacy is directly linked to graduation rates, with third graders unable to read at their grade level being found to be much more likely to drop out of school later in life. (Weyer, 2019) Early difficulty reading leads to dropout odds being up to four times as likely, with approximately 88% of people who failed to get a high school diploma being those who also struggled with literacy in the third grade. (Weyer, 2019) The third grade is identified as an important pivot point for literacy because it is considered to be the final year that children learn to read, after which they read to learn; causing students with underdeveloped literacy skills to further fall behind as time passes. (Weyer, 2019) In addition, family income inequality leads to differences in a child's reading level due to environmental influences; families with fewer resources have a harder time exposing their children to early literacy; 61% of children from low-income families do not have children's books at home, and of the 68% of fourth graders below the reading proficiency level, 82% of them are from low-income families. By age 3, this can lead to a 30-million-word gap in terms of the number of words a child has been exposed to. As a result, children from financially challenged families often perform academically lower than their peers and may fall behind within their school years. Early age education plays a critical role in brain development; by age two, a child's brain is as active as an adult, and by age three it is twice as active. Exposure to learning materials at an early age is highly important for development and has lasting impact that carries over into adulthood. (The Importance of Early Literacy, n.d.)

Pre-K:

Pre-kindergarten, also referred to as Pre-k, is a voluntary classroom-based program for kids under five. Pre-K has a big impact on early childhood schooling. In recent years there has been an ongoing debate between state and federal lawmakers regarding the central focus of pre-k. The debate is regarding whether to focus on play versus academic preparation. For many kids, a skipped pre-k can leave them behind their peers. Good early mathematics skills are linked to improved reading skills and executive functioning, as well as future math achievement. (Mattera, 2021). The Pre-K math program had small but not statistically significant effects on children's math skills by the end of kindergarten, and statistically significant effects on children's math attitudes and working memory. The kindergarten math clubs had positive effects equivalent to an additional 2.5 months of math learning on one of two math measures at the end of kindergarten. (Mattera 2021)

Furthermore, according to a survey done in Estonia about teachers' opinions on making use of outdoor learning for Pre-K, there are no official guidelines regarding the frequency of outdoor learning or the content that children should experience. (Tuuling, 2018)

Reasons to Design and Build an Outdoor Focused Classroom:

- Open spaces facilitate better discussion, better attention, and more quality interactions between student and teacher, (Gansemer-Topf, Rands, 2017) this lends to the outdoor environment we plan to make our learning space and to the notion of it having a roof but minimal walls.
- Creating an environment where the instructor is in a shared space with the students, helping to eliminate the psychological line between student and teacher, aids in the learning process. (Gansemer-Topf, Rands, 2017)

- The inclusion of various learning tools being provided in classrooms can both aid in understanding and visualization of the educational topics being taught. (Gansemer-Topf, Rands, 2017) This backs up the plan that we currently have, to provide the kids with tools to both enhance their ability to analyze the wildlife they find by the beaver pond, and it also suggests giving them something akin to white boards in order to allow them to visualize their learning more for those which that system works better.
- Open-designed rooms can facilitate focus by allowing the students to be more comfortable than they may otherwise be sitting down in a typical classroom. Additionally, the incorporation of audio-visual components into a classroom can further aid learning efficiency. (Gansemer-Topf, Rands, 2017)

Methods

Conducted interviews to understand curriculum requirements and needs of TBT

Throughout any research endeavor, such as the one we needed to undertake at the beginning of this project, the best way to yield quality data is to get it directly from those that would be affected by said research, from a primary source. In addition to the literature research that we conducted and took with us into our design process, we also interviewed many experts on the subject matter where we had our knowledge gaps, and also those that would be directly impacted by our project in order to get a sense of what would be best for them to implement into our final design.

We had two formal interviews that will be discussed here, while our numerous informal meetings and questions that we asked of the Staff at TBT will remain unaddressed in this section.

The first of these interviews was with Mia Dubosarsky, our contact with the STEM Center at WPI, the education hub for Pre-K through 12th grade standards. We asked her questions such as “What are the core educational topics for the age group on which we are focusing? [Pre-k through 1st grade]” and “How can we best read educational standards and the framework associated with them, and how have other teachers implemented these into their classes organically?”. This gave us a sizable portion of useful information regarding the criteria and requirements of Massachusetts State guidelines regarding education at the age groups we are looking at. Additionally, we received many useful resources from her on other locations we could use to do further research on curriculum elements and places we could get inspiration from for our interactive stations we were designing, along with the advice to not “reinvent the wheel” but rather to adapt preexisting lessons we can find to fit our interactive station designs, which helped us a good deal in assessing what we could put into our Learning Lodge.

The second interview was a more formal meeting with Katie Baker, one of the teachers at TBT and our main contact for education at the site. We went over similar matters of education that further reinforced the understanding we had of the curriculum required of this age group, however a notable difference in perspective was gained through our meeting with her. She was able to convey in detail how Turn Back Time strives to incorporate all of the state mandated curriculum elements into its classes, while still maintaining their ideology of nature and play-based learning, and the unique and creative way they do this is through a sort of facilitation of what the children are discussing and discovering about the world, but still leaving them "the reigns" enough, so to speak, to direct their learning to some degree, and along the way develop important social emotional learning skills as they do so. This is the beauty of Turn Back Time, it connects the students to not only nature in more depth than a traditional classroom ever would, but also to each other and directly to the material being taught more than the traditional classroom setting could accomplish. We make note of this unprecedented level of autonomy that Turn Back Time provides for the children to direct their learning while still touching upon all that they need to cover to be prepared for future grades, this will come back and be reinforced in our findings section.

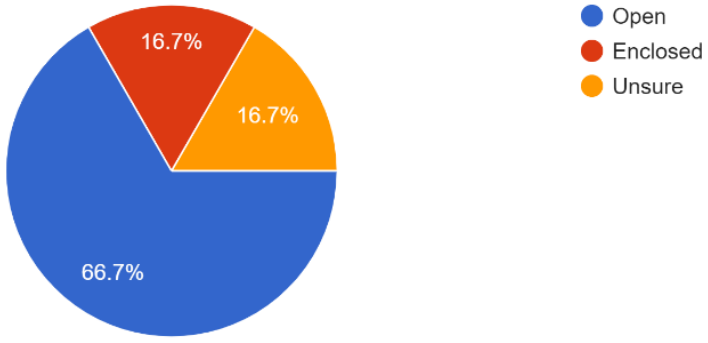
Survey of staff for design choice feedback

In order to get a better sense of what the various classes had in common for needs for a location down by the beaver pond, we wanted a way to anonymously get information from all members of the TBT staff. We decided that the best method for getting efficient and detailed results not obstructed by the concern for needing to respond in a certain manner since they work at TBT, would be to conduct a survey. After multiple drafts and revisions, we curated a survey that had the proper disclaimers and would answer the questions that we needed to know to further factor into our design matrices before we made significant decisions regarding the types of design we were going to present and

more importantly what we were going to recommend to the sponsor. The survey was broken into 10 questions and received 6 responses from the staff surveyed, they are as follows:

Would you prefer a more open floorplan for the BPLL or a more enclosed space

6 responses



Please explain the answer you selected above

6 responses

I guess I would need to see the options. Enclosed makes me feel safer at first glance however an open space might provide for a stronger educational experience.

Would have to see design plan first

Open floor plan will allow a flowing environment, allowing the teachers to feel connected to all students in the space & out of the space

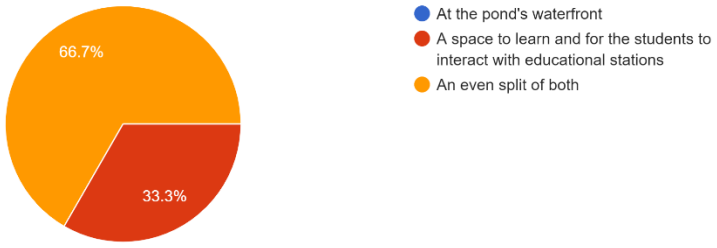
It's easier to see everyone when it's open

Several small group stations tend to work better for the 3-4 year olds.

I think a open space is more practical for learning at beaver pond

Which area would be more effective in aiding your teaching of the curriculum?

6 responses



Please explain why you find the choice you made above important

6 responses

Could there be a bridge or something safe over the water?

Engagement with the pond itself would be super cool and interactive for all the kids to witness life outside of themselves and learn to respect nature

Be nice to have an area undercover for stories and learning. As well as a safe spot at the waters edge

I think the waterfront should stay untouched for a natural space

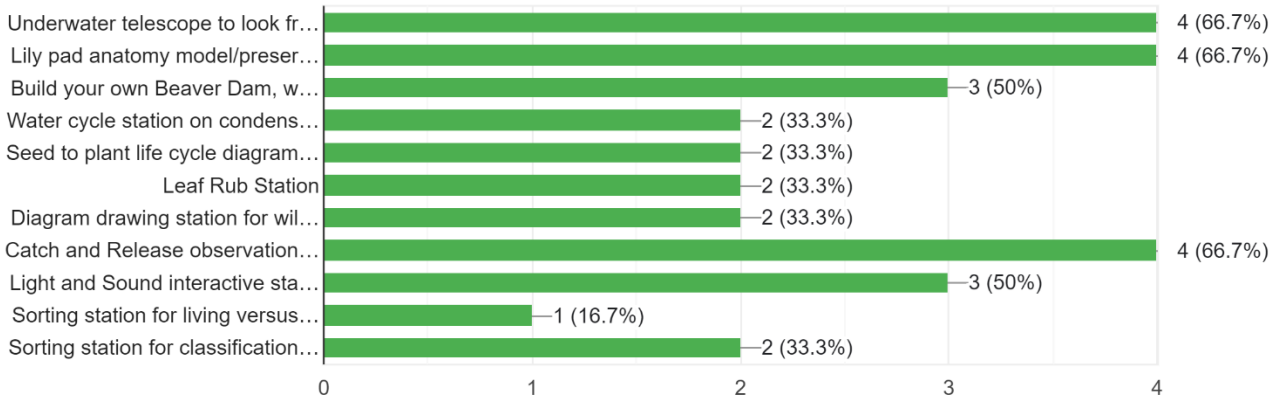
I like the idea of learning right there while we are experiencing it

Information along the way to the waterfront about what we may see and what that looks like. I.e. the inside of a beaver hut

Both are valuable

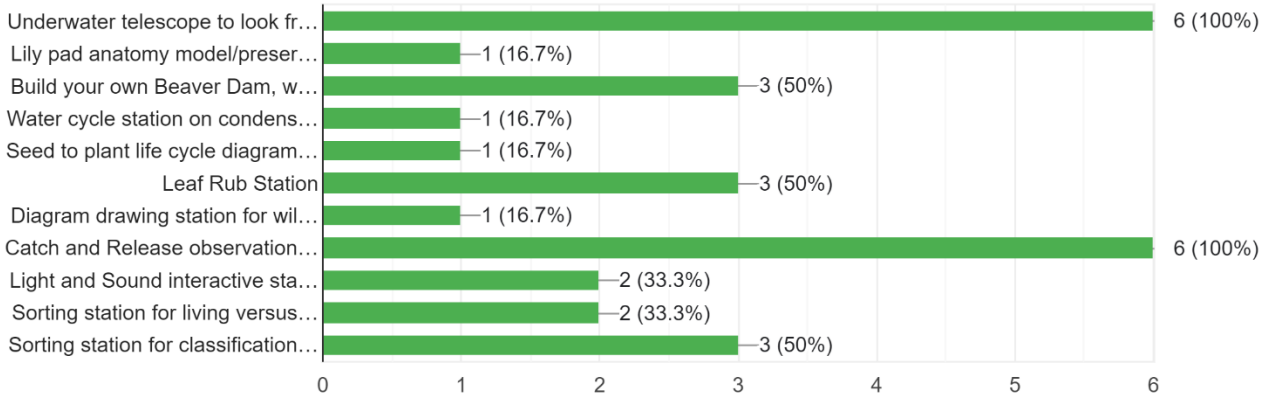
What of these early potential stations do you find to align the most with your curriculum? (Please select your top 5 for now, this will not be the final time you are surveyed on this)

6 responses



Which of these early potential stations do you think will be most engaging to your students and most likely for them to be drawn towards naturally? ...ill not be the final time you are surveyed on this)

6 responses



How much time (in minutes) do you usually spend down by the Beaver Pond with your students per day? Per week?

6 responses

I am not actively in the classroom all the time :) but I think this could increase beaver pond time!!

35 mins, 1 a week but would like at least one more day so 2 a week.

2-3 hours per week

45 minutes a week

Varies. Not consistent at this time

20

What are three of the more valuable educational topics that you cover in your curriculum? (This can be as broad as hands on learning, or as specific as the anatomy of certain plants and animals, the more specific the better, but anything helps us)

6 responses

N/A

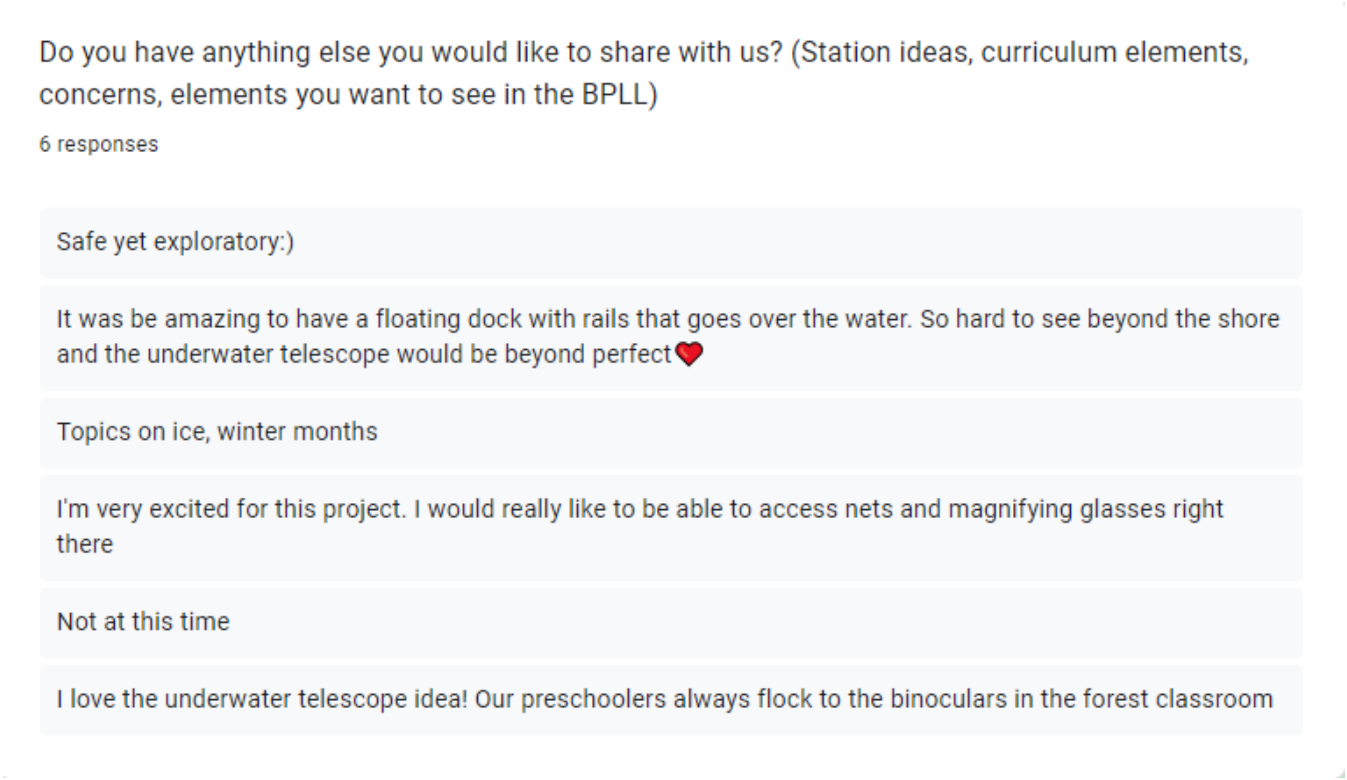
Frog life cycle, what lives in this water, they are always using nets to capture critters. Observation telescope is amazing and maybe observation jars.

Life cycles, things in nature, hands on

Native animals and plants, farm animals and growing our own food

Touching,observing close up and afar, listening to nature

Safety
Stewardship
Exploration



Do you have anything else you would like to share with us? (Station ideas, curriculum elements, concerns, elements you want to see in the BPLL)

6 responses

Safe yet exploratory:)

It was be amazing to have a floating dock with rails that goes over the water. So hard to see beyond the shore and the underwater telescope would be beyond perfect❤️

Topics on ice, winter months

I'm very excited for this project. I would really like to be able to access nets and magnifying glasses right there

Not at this time

I love the underwater telescope idea! Our preschoolers always flock to the binoculars in the forest classroom

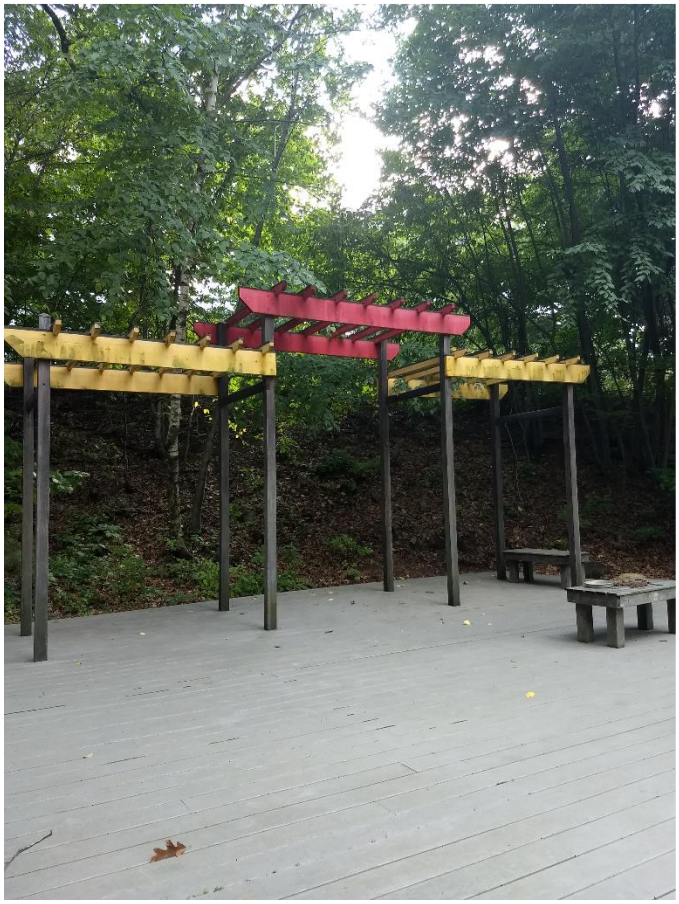
These questions were a key asset in determining what elements of our initial designs and station ideas were going to be a good fit for Turn Back Time, and which were something that should be pushed farther down the priority list. From this survey we discovered several key findings, the first is that, as we had speculated, our water scope station idea ranked very popular in both the categories of being useful to the curriculum and being fun and engaging to the students in keeping with TBT's philosophy of play-based, self-directed learning. It also gave us initial ideas for what types of learning were going on in the classrooms and out in nature, which allowed us to further refine our station ideas, as a large component of our project was not only creating this space by the pond to store educational materials but also to make engaging interactive stations to further the educational value of the space, and to serve as a template for future stations that could be housed within the Learning Lodge in years to come in conjunction with the curriculum being currently taught there.

Research Trips for inspiration

During our term on IQP we took several trips to various places surrounding the topics of farm education or natural learning, and these trips gave us inspiration for structure design and for stations we could implement, as well as teaching us a good deal about the variety of styles of outdoor nature education learning sites, which is noted in our findings.

The first of these trips was organized by our IQP advisor, Professor Rosbach, and it was part of the Farm Stay site's regular trip to Burlington Vermont. We visited New Village Farm, which also acted as a school akin to what Turn Back Time does, however with an important distinction. Turn Back Time was created as a place of learning first and the farm element came about when they wanted to focus on natural outdoor education and engaging the students directly in nature and familiarize them with animals. New Village Farm began as a farm and created an educational program as a further source of income first and a way to give back to the community as an afterthought. Thus, their approaches to nature education differ somewhat, with Turn Back Time being more of a traditional learning experience moved into outdoor classrooms and self-directed play-based learning. Whereas New Village Farm focused more on the children developing a sense of contribution to their community and pride in their work through doing farm labor and interacting with the animals directly. This distinction is explored further in our findings section.

The second of these trips that we took was to the EcoTarium in Worcester, this was not a farm school like TBT or any of the others we reached out to, but it was a place of learning and did contain many elements of natural learning focus which was pertinent to our project.



Figures 1 and 2: the Music pavilion at the EcoTarium (left) and a viewport (Right)

Figure 2: Dried and pressed water lily display at the EcoTarium

This trip taught us a significant amount about early childhood education by inferring what methods and approaches that the designers of some of the educational components at the EcoTarium used to engage the children that come there while also facilitating their learning. We also saw several standing structural designs whose features we factored into our early design process, such as the pergola shown above. Finally, we saw many examples akin to the "stations" we intended to either implement or recommend to TBT to be housed within the Learning Lodge.

The next trip we went on was to "Good Pickin's Farm", which was the most similar to Turn Back Time, in that they were a place of learning that wanted to incorporate an outdoor farm educational aspect, and not an educational program created around a farm as a form of funding, however, they did have some notable differences. Notably,

they had mixed grade groups which was unique to both traditional school settings and amongst the nature learning centers we had previously been to. This mixing of grades allowed for a better sense of community between the students of different age groups to be fostered and it allowed the younger students to learn from the older students and occasionally, vice versa. The way that this was accomplished was through presenting the learning material in a way that made it modular and accessible to the variety of age groups that they were teaching it too. For example, when conducting a lesson on geometry, the lower grade levels could be learning about cutting circles into halves and thirds, while the upper-level students could be learning about radius and diameter. This unique method of teaching a spread of age groups with similar subject matters while still allowing them to learn at their own pace is the exact ideal we wanted to capture with our stations, with providing something to Turn Back Time that could be educational to a variety of the age groups represented there. This would hopefully bring a bit of that philosophy and style of teaching from Good Pickin's Farm to better incorporate our design into the TBT curriculum.

Design Philosophy

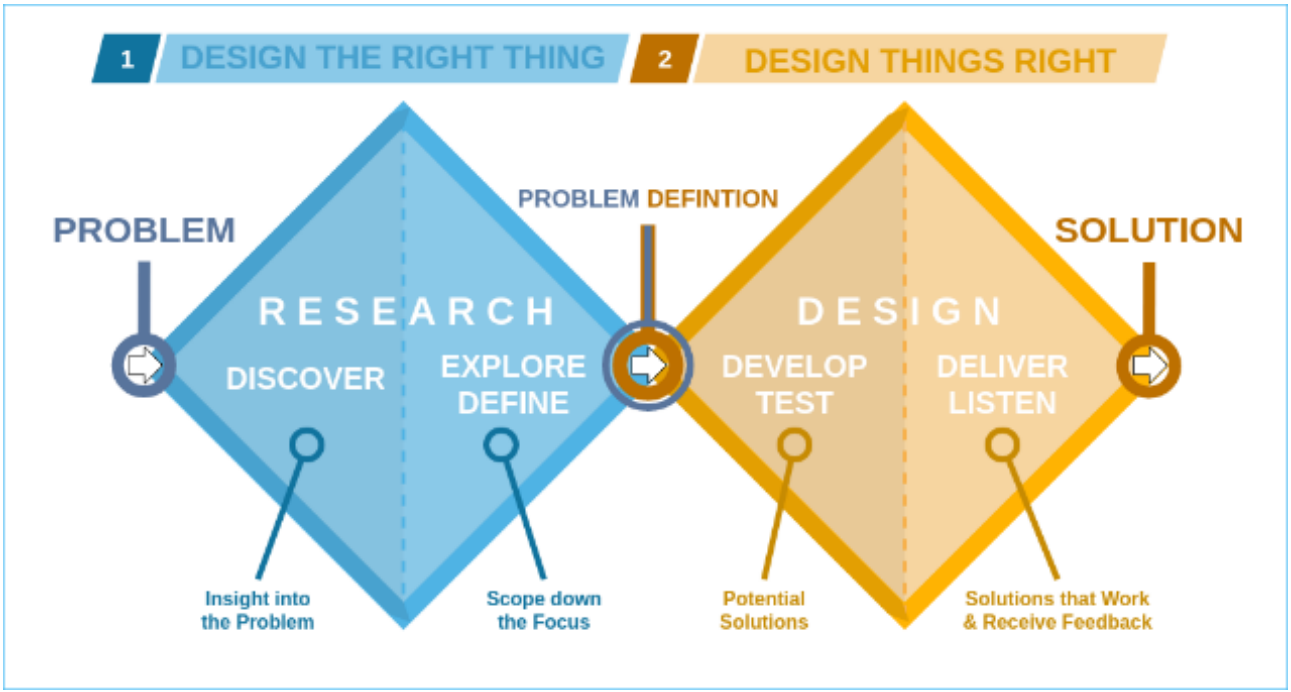


Figure 3: Béla H. Bánáthy's original Double Dimond

By Digi-ark - Own work, CC0 https://commons.wikimedia.org/w/index.php?curid=94113884

Design Theory

We used a double diamond design process as our process philosophy. It was created by Béla H. Bánáthy in 1996; the version that we used was the Revamped Double Diamond by Dan Nessler. Dan modified It to better encompass UX (User eXperience, a field associated with computer science) design but will suited our needs to use as a foundation. The process is split into two halves; the first half comprises of conducting research and synthesizing, and the second half encompasses creating actionable ideas and implementation.

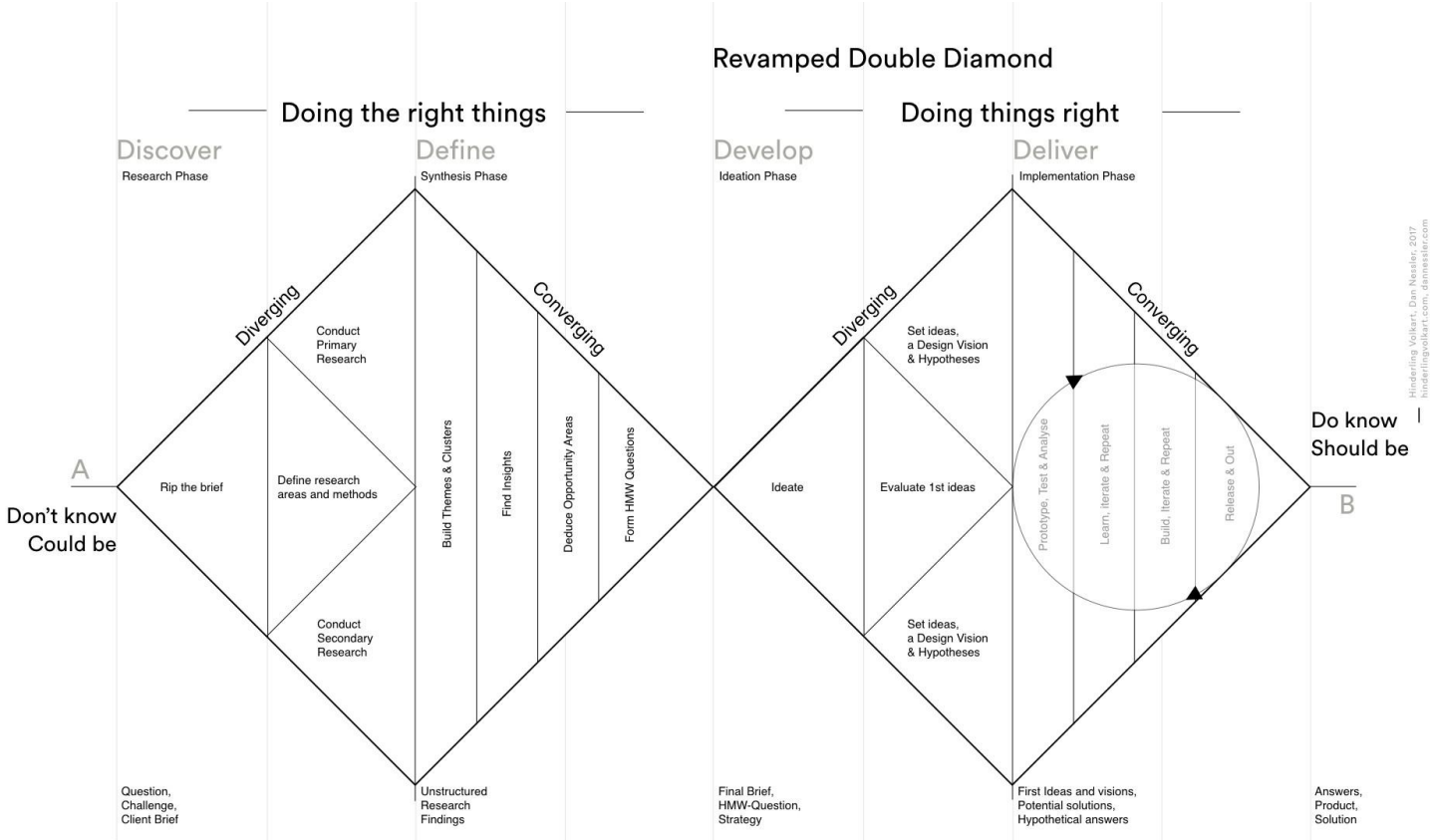


Figure 4: Revamped Double Diamond by Dan Nessler (Nessler, 2018)

The value of using the Double Diamond design process was keeping track of what was part of the research process and what was part of the design process. The trouble that we had before moving to the Double Diamond design process was trying to figure out when we had done enough research to make informed design choices. We came into the term with preconceived notions of exactly what the Lodge and materials inside would look like before we had enough research to make those decisions in an informed manner. The Double Diamond design process forced us to slow down and start with the research as opposed to making designs and then going to research to determine if what we designed was feasible or productive.

Using the Double Diamond design process, we created 8 designs for what may be housed in the Lodge and created 2 primary designs with more than a dozen permutations each. To start converging on the Lodge design and inside designs, we created design matrices for the interior designs and exterior designs. Those matrices will be discussed in a later section.

Design Process

Our design process started with looking at other examples of free-standing structure and researching the requirements for a structure. Looking at examples of free-standing structures took the form of research trips and looking at examples published online. We also referenced structural requirements dictated in Paxton, Massachusetts, United State, and international building codes.

Looking at Other Examples

We started creating our design by looking at examples of free-standing structures, namely pergolas, gazebos, sheds, carports, and pavilions online to see if there was a set of plans on a design that we liked and that would fit within the constraints. All the structures that we looked at either had too large a footprint and would require a building permit or were locked behind paywalls with prices that did not have enough substance to justify the price tag. One convenience that we were looking for was a set of plans that passed design inspection somewhere in the U.S. so that we knew that what we built from the plans would be structural. In our looking, we found no plans that had been designed and passed design inspection nor did we find a design that we liked enough to be worth the ~$90 price tag most designs asked for. We knew that we would have to design our own Lodge and custom tailor it to match our goals and design considerations. We looked back at the designs that we considered previously and found a ten-foot by twelve-foot pavilion that we could copy and modify to match the aforementioned constraints and consideration.

Design Considerations

Zoning

Determining the zoning that Turn Back Time was considered as was an important first step for us, as the need for permitting and the type of permit required dictated the feasibility of building a completed lodge during the allotted time. Residential building permits versus Commercial building permits are important in four ways. A commercial building permit would take longer to be approved for, would require us to build to a more stringent set of building codes, would require more inspectors to sign off on the building, and be possible subjected to a town vote. Per the zoning map available on the town's website, the location that Turn Back Time is on is zoned as residential. (Paxton Zoning Map, 2005) Turn Back Time exists as a Schrodinger's property type, once it is observed, it exists in the least convenient state. However, in conversation with Lisa Burris, we were told that in the past Turn Back Time has been able to apply for residential building permits in the past. She also said that the permit that they have to apply for depends on the mood of the inspector at the time.

Fortunately, under the advice of the Director of Turn Back Time, we did not need to apply for a building permit. The reasons that we felt comfortable not applying for a building permit were size and complexity

For size, as long as we have under 120 square feet of floor space, the city of Paxton does not have provisions which would require us to apply for a building permit. (Town of Paxton Building Permit Fee Schedule, 2003) In terms of complexity, the Lodge that we planned to build would not be lived in, would not be taller than one story, and would have no utilities attached to it.

Sightlines

In conversation with one the teachers of Turn Back Time, she stressed to us the importance of being able to see from the playground to the pond in case a child is in the water when they should not be. This is not something that we considered before our conversation, and we are thankful that it was brought to our attention early in the design process. To ensure that our Lodge would not block any sight lines, we inserted rebar into the ground and tied tape around the rebar to allow us to visual understand where our Lodge would be placed in a manner to maximize the area that can be seen past it. In our experimentation, we noticed that the area in which we planned to build

Figure 5: The area we planned to build in before all the vegetation was removed.

was already partially blocked by saplings and other woody plants. As such, we chose a spot that was already partially blocked, as viewed in figure 6.

Space

The constraint on the space that we could build our learning lodge was determined by our ability to remove vegetation and other ground obstacles, as well as the area that the students played in. One of our major focuses for the placement of the Lodge was to set it

back far enough so that the Lodge did not interfere with the natural patterns of play that we observed the students take. In our observations, we saw how students played within four feet of the water and how the students played in and on the woody plants. We knew that we needed to find an area that did not contain woody plants that the students enjoyed playing on and an area that was far enough back from the edge of the water so that students did not need to go through or around the Lodge.

Size

To determine the size of the Lodge, we staked rebar into the ground to create three different sized squares. The squares measured six-foot on each side, seven-foot on each side, and eight-foot on each side. (Figure 3) As with determining sightlines, the psychical nature of the layout helped us wrap our heads around the best size. We ultimately went with the eight-foot on each side, as it would ensure that there is enough space for all of the stations that we thought up and it would also accommodate the use of four-foot by eight-foot sheets of material.

Openness

We considered building the lodge with two walls, three walls, or four walls. In our research we discovered that open classrooms lead to better educational outcomes. (Rands & Gansemer-Topf, 2017) we did not want to build an enclosed area with four walls, like a shed, because we were concerned that a fully enclosed area would be underutilized. The concern with a fully enclosed area was that we did not want to create an additional classroom because of the higher level of formality as compared to the open play space that the beaver pond served as. We also wanted some walls for mounting station materials too and to provide some protection from inclement weather. To determine the number of walls we built we included the openness question in our survey of the teachers. The teachers favored a more open space for the Lodge. We decided on

building two walls as a compromise between having an open space, like a pergola and fully enclosed, like a shed.

Sloped roof

We looked at modelling our Lodge from one or more of the following existing styles of structure: pergolas, gazebos, pavilions, amphitheaters, and sheds. We liked the pergola idea because it keeps the space open and provides some protection from the elements when a roof is installed. The issue with a flat-topped pergola is water and snow will not be directed off the roof. We observed this with the outdoor kitchen project. The clear roof panels were placed on top of the pergola without lap sealant to prevent water from slipping between the roofing panels. This caused water to become stuck between roofing panels and allow for the growth of algae in addition to water leaking from the roof. To prevent the buildup of water and ensure that water would not leak into the Lodge, we decided to slope to the roof. In addition to keeping the Lodge dry, sloping the roof will reduce the snow load that the Lodge will experience. Snow load will be discussed in a later section.

Lumber size

The design that we used as a reference when designing our own Lodge used 6x6 lumber for every aspect of the framing of their pergola. This is an acceptable choice when cost is not a concern but created a dilemma for our design. We knew that using 6x6 lumber would be such a level of overkill that we did not need to worry about the structure failing but that the price for using 6x6 lumber would have been difficult to convince Turn Back Time to approve the budget. We conducted a cost analysis of the lodge and determined the cost of doing the framing with 6x6 lumber would cost $540, excluding the roof, walls, and all other aspects of the Lodge. We thought that the use of 6x6 lumber would be overkill and could be substituted for 4x4 lumber instead.

To determine if replacing the 6x6 lumber with 4x4 lumber would be feasible, we used the static force simulation environment in Fusion 360.

We modeled the base structure of the Lodge with the posts, top plates, and bracer to apply a force to. We then brought that model into the simulation environment, enabled automatic contacts, and set the bottom of the posts as static so the simulation was able to run. Using automatic contacts was not optimal as the program considered the lodge to be one solid object and not a series of individual bodies joined together. In addition, we had to set the material to MDF (Medium Density Fiberboard) as Fusion 360 cannot use solid wood in the simulation environment. The issue with trying to simulate solid wood is the non-linear and orthotropic nature of the material. Unlike metals or polymers, which can be considered to behave uniformly under stress, wood stresses around the growth rings of the tree and would fail differently depending on the individual pieces of wood. To get around the issues with trying to simulate a non-linear material in a linear environment, we used the MDF material profile. MDF is weaker than solid wood, which meant that any deformation that we saw in the simulation would be less when we went to build with solid wood.

We selected to have the force be applied to the top of the top plates to simulate the possible snow load conditions that the Lodge could experience. To determine the force that we applied to the Lodge, we used the ground snow load for the city of Paxton; as found in the Massachusetts Building code. For the city of Paxton, the ground snow load is 50 pounds per square foot. (Ninth Edition CMR 780, 2018) We used the ground snow load instead of the minimum flat roof snow load as we wanted to simulate the absolute worst conditions that the Lodge would be subjected to. The square footage of the Lodge is 64 feet^2 so we needed to apply 3200 pounds of force to the lodge, we added an additional 25% so that we were certain that using 4x4 lumber would not compromise the structural integrity. We could have reduced the snow load force as we used a sloped roof in all of our proposed designs, but again we wanted to account for the absolute worst-case scenario.

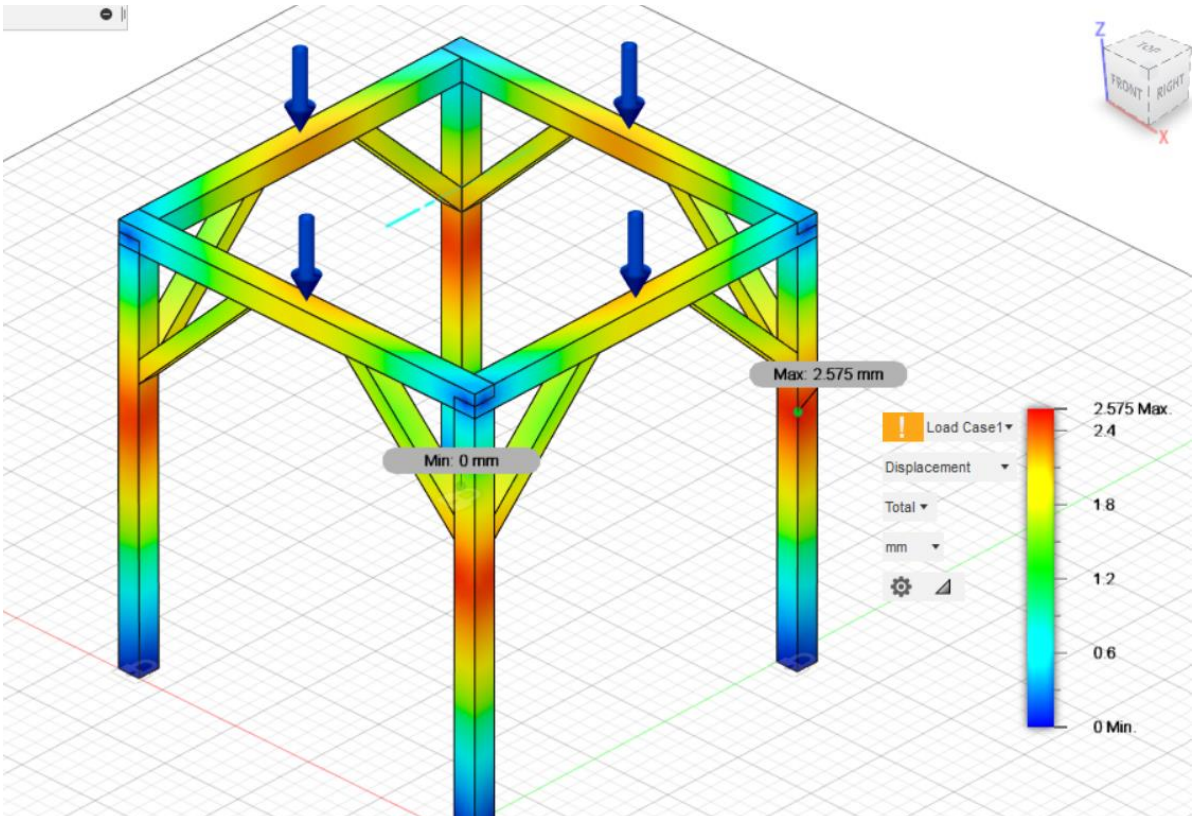


Figure 6: Total displacement for a lodge constructed of 6x6 lumber. The maximum total displacement, which is the sum of the displacement in each axis, was 2.575 mm. (0.1 inches)

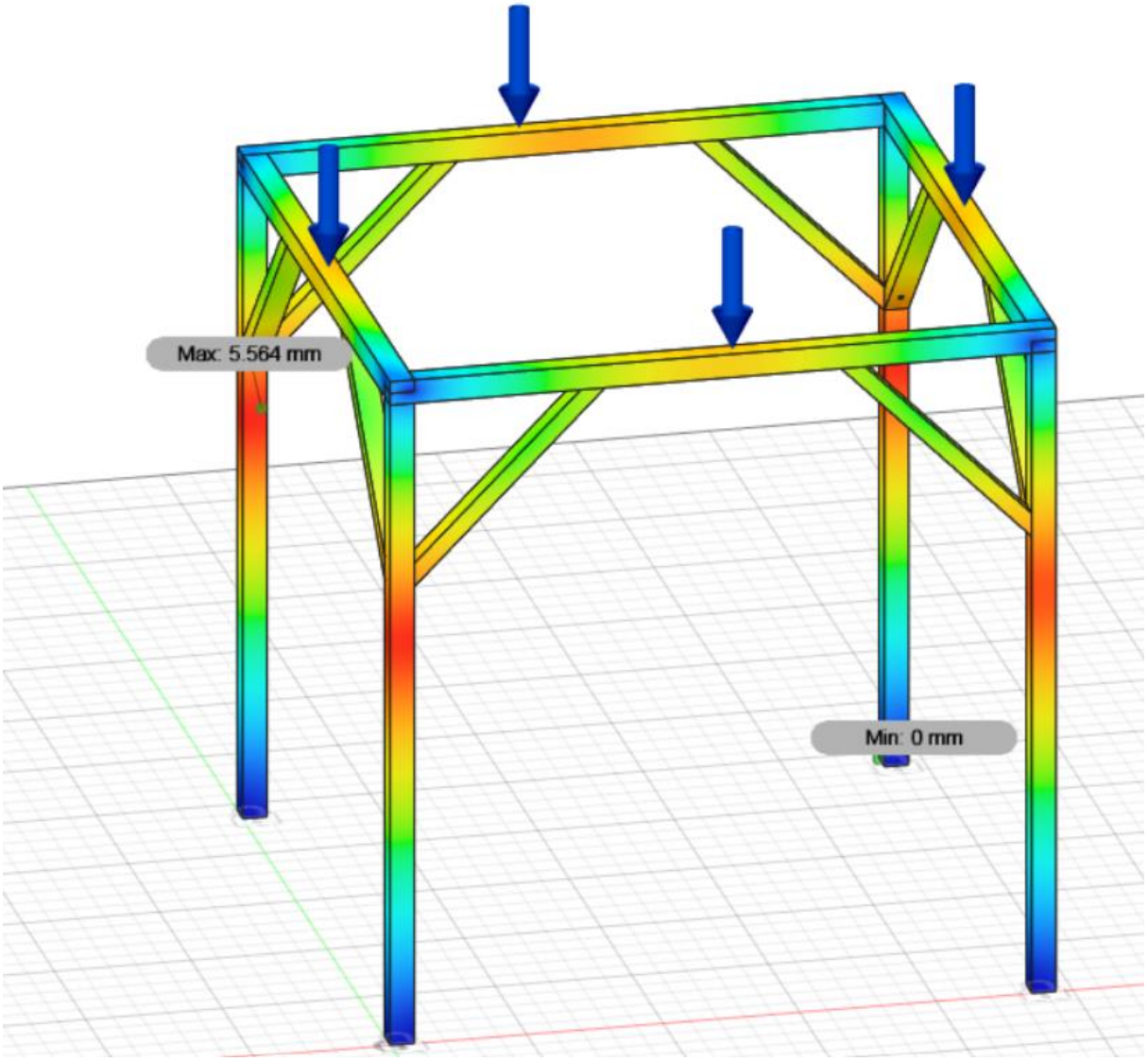


Figure 7: Total displacement of a Lodge constructed from 4x4 lumber with an applied force of 18,000 Newtons. The maximum total displacement, which is the sum of the displacement in each axis, was 5.564mm. (0.22 inches)

The simulation strongly indicated that the use of 4x4 lumber is sufficiently structural to replace the 6x6 construction of the reference plans. Using 4x4 lumber costs $170, which is a savings of $400.

Using Trees already felled on-site

Figure 8: Felled wood already on the farm. Taken in April of 2022.

We considered using trees that were already felled and stacked as an alternative to buying lumber from the hardware store but decided against it. The reasons that we considered using sections trees were two-fold; using the trees would have been more thematic than using dimensional lumber and would eliminate the cost associated with the posts and the braces. The big issue with using wood that has been piled up for an unknown number of years and has been left unprotected is knowing the condition of the wood. Wood bought from a hardware store or other supplier will have a moisture content that is below 30%, been milled, be mildew and rot free, and has been evaluated to the appropriate standards. Wood that is procured on site will not have a guarantee of

any of those aforementioned qualities. This can be managed by selecting tree trunks once the ends are cut off to identify the amount of mildew and rot that has built up from being left exposed to the elements. Removing the bark is an important step as it exposes any possible rotten spots or other surface imperfections. Even with these steps taken, unless the wood is milled or otherwise cut along the entire length of the tree, the condition of the wood is uncertain. This can be mitigated by using tree trunks with larger diameters as the spots where the wood is less than optimal will be reinforced by the surrounding good wood. We would have wanted to use tree trunks that were 12 inches in diameter to ensure the structural quality of the lodge would not diminish over time. A builder can get lucky and the wood that is procured on site is in perfect condition, but we did not want to take any risks that could be avoided. As such, we decided to use 4x4 lumber instead of 6x6 lumber or tree trunks.

Roof Type

We considered four types of roofs throughout the project: corrugated galvanized steel panels, clear PVC (Poly-Vinyl Chloride) panels, clear polycarbonate panels, and a cover tarp. We considered panel roofing for two reasons: Durability and ease of installation for inexperienced builders.

Durability depends on the material of the panel, with galvanized steel being considered the toughest of residential roofs. (Roy et al., 2022) PVC is the weakest of the panel options as it is susceptible to having holes punched in it from hail and breaking from failing tree limbs. (Ivanič & Lubej, 2022) Polycarbonate is a middle ground as it is stronger than PVC, but weaker than galvanized steel. The cover tarp was considered as a sever cost saving measure in the event that Turn Back Time wants to save money in the short run and be able to upgrade to a different roofing in the future. The PVC and

polycarbonate roofs would be clear, which further adds to the unobtrusive nature of the Lodge discussed earlier.

Panel roofs are easier to install for inexperienced builders than asphalt or roll roofing as the means to install it do not require special tools nor does it require the heating of adhesives, which would make any mistakes difficult to fix. Using either asphalt shingles or roll roofing requires sheathing to be installed on top of the rafters, which adds complexity and an additional cost. Using roofing panels eliminated the need for us to buy or rent the required tools for installing traditional roofing, as roofing panels only require a drill/driver with a socket bit to install roofing screws.

Anchoring

We spent a lot of time trying to determine how to attach our Lodge to the ground. To start with we looked at the Massachusetts building codes. Massachusetts building code requires that concrete posts are dug 1-foot below the frost line. The frostline in Paxton is 3-feet, which would mean that we would need to pour a post that was 4-feet deep. The reason that code specifies that building have footings below the frost line is so that the building will not shift doing freeze and thaw cycles from the seasons changing. The ground below the frost line does not move appreciably and keeps the house from settling and subsequently cracking to the point of failure.

We went to price that out and discovered that the cost to do that, as we would need an auger to dig that deep without destroying the surrounding soil and a cement mixer, would have been $460. To reduce the cost of doing the anchoring, we decided that we would not use the code required anchoring method. We were comfortable with not using the code for the reasons that were discussed in the zoning section.

The Lodge did not need to be built to the same standards that a house would need to be built to.

From that point, we looked at the options that we had. There were shed blocks, using shorter piers that would not be below the frost line, then also sinking the wood posts directly into the concrete. We immediately ruled out sinking the wooden posts into the ground or concrete as even pressure treated lumber will rot at the junction between the concrete and air. (Specifying with AWPA Use Categories for Construction, 2020) When we posed shed blocks and 1-foot-deep concrete posts with cast in anchors, the director said to do the shed blocks because she wanted to make the Lodge temporary enough so that the Lodge could be moved in the future. The temporary aspect of the lodge also would mean that if the water level encroached upon the Lodge, it could be moved in such a manner that the Lodge would not need to be ripped out of the ground. Furthermore, if the city or other agency declares that the Lodge is too close to the pond, it could be moved to a different location without needing to take the Lodge apart.

We had concerns about the shed blocks being insufficient to keep the Lodge from being knocked over by the wind. Even though the Lodge weighs about 1,900 pounds, a freak accident could spell disaster. We continued to look at other options until we stumbled upon the ground screw by the American Ground Screw Mfg. and Supply Store. (Figure 7) The ground screw works by having a piece of rebar act as a lever to draw the screw down into the ground. The particular model we went with was the 27-inch model. 27 inches will not get down past the frostline, as the ground beneath the Lodge is held rigid with roots, it will not move during freeze-thaw cycles. Going with the ground screw also saved money over using the foot-deep posts with cast anchors. The ground screws, for all four posts, came out to $120 or $30 per screw. Using the foot-deep posts would have been nearly $180 for a less secure result than the ground screws.

Figure 9: U-model Premium No Dig Ground Anchor – Screw in Post Stale- 27 inch by the American Ground Screw Mfg. and Supply Store.

Materials Acquisition

In budgeting a project of this scale, one of the primary costs was raw building materials, in order to shave down our cost from the original amount, if we were to buy every component that was going into our project at market price, we would use the resourcefulness often required of engineering students and take into consideration Turn Back Time's ideology of re-purposing materials to be made useful again. Following along with this way of thinking we did research on places to get building materials for either less expensive than the market price, or even for free if possible. Thankfully, since TBT is a non-profit, we were able to take a trip to Flexcon, which has allotted runoff stock to go to schools free of charge, from which we got some felt material with an adhesive side to use in further safety-proofing the Learning Lodge. Next, we spent the required time and effort to catalogue and categorize the various supplies on the farm and assess the condition of the wood that was not being used, which got us a decent portion of our building materials. Finally, we did some community outreach and found that Dale's family had a lot of spare wood and pallets that were not being used, including several pallets from Dale's father's place of work which were significant in number and size. From these industrial sized pallets, with a good deal of time and effort put into disassembly, we got a large portion of the wood needed for the project and significantly cut back on budget, at the cost of more time and labor on our end.

Results and Findings

Types of Nature Learning Schools

Throughout our time spent at Turn Back Time, we spent a significant portion of that researching and developing methods to improve the learning experience of the students by the beaver pond by providing access to educational resources that may not have been otherwise available to them due to weather conditions and distance from their Kinder Yurt classroom on the farm. There is also, however, a notable other finding that serves to put our project into context within the nature-based educational community, and that is of the differing types of nature learning schools that we encountered in our research. The farthest end of this spectrum of these unique nontraditional classroom settings are farms that simply have an educational program component for a variety of reasons, giving back to the community, teaching the next generation of farmers, and occasionally simply as another means of income in the ever-changing farming industry. Sites like New Village Farm, in Burlington Vermont serve to have the most focus on causing the children to feel that they are contributing members in their society even at a young age, but this focus causes there to be the least time among the varieties of these sites for state guidelines on education to make it into any sort of structured curriculum.

Next comes sites like Good Pickins Farm and Turn Back Time, both with their similarities and differences, they largely serve a similar purpose of being a school primarily, with farm elements that they incorporate into their educational programs under the ideology of having students learn in ways that may not be accommodated in traditional classroom settings. They also follow the philosophy which is backed up by a significant portion of the research that we did before beginning the design portion of our project, which states that teaching children in open spaces and letting them play and learn in conjunction with each other and direct their own education to some degree

while being facilitated is one of the most effective ways to teach children from Pre-K to Kindergarten. These “farm schools” are becoming increasingly popular as the results of them are apparent to see through the testimonies of families that have students attending some of these educational institutions. They bring great benefits to educational value while also allowing the children a more hands-on approach that makes them feel connected to their learning process, and has many benefits over traditional classroom settings, which further showed us how important places like this are for early childhood education and gave us further contextualization for our project.

Observational Findings

While observing the classes at TBT in the space by the beaver pond that was already in use for educational purposes, we findings for our project that either inspired or reinforced needs for the space.

We observed the areas in which the students naturally congregated and seeing the natural path that they took between these areas let us clear a natural pathway into the space we were planning for the Beaver Pond Learning Lodge. We noticed the natural interest that the students took to the flora and fauna around them, including the children’s inclination to pick up newts and frogs they found in the water, which enforced the idea of the Catch and Release Critter Station as being a useful asset to the teachers of TBT by the pond. This observation also inspired the Lily pad anatomy station idea, as we saw the fascination the children had for them and decided that would be an excellent place to tie into the biology and life sciences aspect of the state curriculum that we were studying the requirements of. We noticed their interest in ferns and this further gave credence to our leaf rub station idea as children could trace, outline, and then draw the ferns that a significant portion of the students seemed to take great interest in. Finally, the last important bit of data that we collected from our observations of the class was

that the students would often wade out into the pond a bit, about up to their boots, which allowed us to design our Water Scope station to incorporate being a few feet out into the pond when using certain of the scope designs which helped us resolve some logistical issues on how to make them long enough to get into the pond enough to be useful.

Building Process of the Lodge

We started with placing rebar at the corner of where we thought we would place the posts in a future step. We measured two pieces of the rebar at 8 feet then placed a tape measure at the second piece of rebar and another tape measure at the first posts and measured 135-3/4 inches away from the first post. This was repeated for the final post. This was supposed to ensure that the outside corners of the 4x4 post would be in the exact place so that the Lodge was square and plumb. Doing so would have made the rest of the building of the lodge easy as we could reference the posts. We screwed in the first ground screw and attached the first post so that it was plumb and square, then we did the second post and noticed a problem. When we measured the outside edges of the posts it was not eight feet, it was a little less than eight feet at the bottom and a little more than eight feet at the top. It also looked like the posts were not in line with each other, we were trying to push through with the posts so that we could attach the top plates and walls that day. Placing a level across the posts revealed that the ground anchors were not level and subsequently neither were the posts. We decided that we would attach the top plates to the posts that we set to try and force the post to be as square as possible. While Zach and his crew were attempting to set the posts so that Dale's crew could attach the walls that they were building. The walls were constructed from the pallet wood that we salvaged from the pallet that Dale's Father brought to us. To construct the walls, we used 2x4s collected from the pallets and spaced them so that the outer dimensions of the wall would be eight feet tall and seven and a half feet wide

so that the walls could be placed between the post for a flusher look. We started by nailing the pallet shingles to the bottom 2x4 and second to bottom 2x4. Then we placed the second row of singles on top of the first row so that the bottoms of the second row of shingle would stick out from the first row a little bit, creating the shingled appearance that we desired. This was repeated until we had two walls of the pallet shingles.

Figure 10: A wall using the pallet wood.

At the same time as the walls were being constructed, Zach and crew were still setting the posts into their final home. We installed the first top plate on top of the first two posts, and that forced the posts to be slightly squarer than they had previously been. We installed the second top plate onto the last two posts before putting them up and attaching them with the third top plate. Instead of trying to put the ground screws in the theoretical locations, we would make the frame out of the posts and top plate and mark

where the posts ended up, then rotate the posts a little so that we could install the ground screws and place the posts into them before screwing everything together for the last time. To create the last top plate to place on top of the posts, we used a 4x4 by 10-foot piece of wood and carved out half laps to match the half laps that were cut in the previous top plates. To cut the half lap, we measured a foot away from the ends of the 10-foot section of 4x4 and marked a line, then we measured 15-1/2 inches away from the ends and marked a line. We then used a circular saw with the depth set to 1-1/2 inches to cut the half lap so that it would sit flush against the other top plates. Before we got a chance to install the last top plate, it got too dark to continue working. We ended the first day of building with one post securely anchored, one post anchor loosely and

the other posts resting on the ground and attached to the first two posts with only the top plates.

Figure 11: Progress from the first day.

We started the next building day by attaching the last top plate to the posts and started to move the posts so that the lodge was level and as square as possible. We had to place one of the posts on top of some off cuts to bring it up to being level. Once we have everything

level and square, we marked the location on the ground with spray paint so that we could place the ground screw in the correct location. We unscrewed the second post so that we could rotate the posts out of the way of installing the ground screws. When we rotated the second post, the structure became unstable and fell. Zach attempted to stop it falling and took most of the force in his wrist before slowly bringing it down to the ground. We were fortunate that no one was hurt, and that none of the wood split and only a few of the screws bent or otherwise sheared off.

Figure 12: the Lodge, after it fell down.

As the locations that the posts were supposed to end up in were marked, we installed the ground screws and took apart the Lodge to salvage the wood. When we went to install

the posts and top plate the next day, we discovered that where we marked the posts and installed the ground screws was not correct. We spent the next three hours trying to unscrew and place the ground screws and posts in the correct place, but nothing that we tried fixed the alignment issues. We called it close enough after it got dark.

Figure 13: the Lodge with all the posts and top plates installed, as well as one of the walls and two of the braces

The next day we installed the top plates first to once again force everything into square. One of the back posts was severely out of square but trying to force the ground screw did not work as it was skipping off a rock in the ground. We tried to install the walls by screwing the 2x4s at an angle into the posts. This was not working, and we needed another option. The walls were also too heavy to lift into place reliably. The first thing we tried was to unscrew the rows so that only a 2x4 and its attached shingles could be lifted into place and screw it in that way. What we discovered was the walls were so far out of square that we could only attach one side and the other side would be left

hanging. To solve this, we cut short sections of 2x4 into blocks which we first screwed onto the posts and then screwed on the 2x4 with the shingles attached to those blocks. This worked quite well and both walls were installed within two hours.

We then installed the braces, which were cut out of the landscape timber. We created the braces by cutting a 45-degree cut into one end, flipping it around, marked out the dimension specified from the 3D model and cut an opposite 45 degree cut into the other side. We cut out eight of the braces but were only able to use four as the walls prevented us from installing the other four. We used long screws to attach the braces by screwing from the braces into the posts. We then installed the two risers, which were 4x4 pieces of wood cut to one-foot-long sections. We used angle brackets to attach the risers to the top plates. The risers were placed so that they were directly over the front posts. We then attached the final top plate to the riser and moved on to the rafters. The rafters are 2x4 by 10 feet. The rafters were attached to the top plates with the use of hurricane ties. We lined the first rafter with the ends of the top plates and nailed the hurricane ties into rafters and top plates. We then attached the cover plates, which are sections of 2x4s that were cut into 22-3/16-inch sections. The cover plates go between the tops and bottom of the rafters to create a more finished look. The cover plates also space the rafter so that the rafters end up in the correct place. We screwed the cover plates in at an angle into the rafters to hold everything together. We repeated these steps until all the rafters were installed.

Figure 14: the Lodge with both walls installed, and the rafters installed.

To install the roof, we used horizontal closure strips. These screw into the cover plates and the PVC roof panels sit on the closure strips and roof screws attach the panels to closure strips. We installed the closure strips on the top cover plates and installed the roof. We brought up the first panel and screwed the panel into the closure strip. We brought up the next panel and overlayed it so two of the valleys from the second panel line up with two of the valleys from the first panel. We then screwed in the second panel and repeated the process until the rest of the roof was installed.

Building Process for the Water-Scope

To build the water scope station, we cut a section of 4-inch schedule 40 PVC pipe down to three feet. We then cut a piece of acrylic to match the outside diameter of the pipe. We used a laser cutter, but the acrylic lens can be cut by using a jigsaw with an acrylic blade and sandpaper too. The outer diameter of a 4-inch pipe is 4.9 inches, so that is the diameter of the circle of acrylic we cut out. We used a coupling as the inside has a lip in the middle which will hold the acrylic lens against the pipe. We then applied silicone RTV sealant and adhesive to the lip of 4-inch coupling and placed the acrylic lens against the silicone sealant. We then placed more of the silicone sealant around the perimeter of the lens. We then applied PVC primer to the outside of the 4-inch pipe and the inside of the coupling. After giving the primer 30 seconds to setup we applied the PVC cement on top of the primer and pressed the coupling and pipe together.

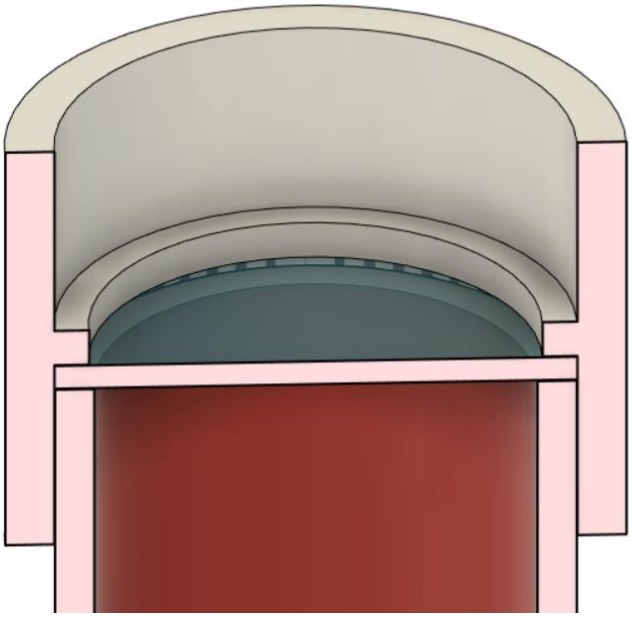


Figure 15: Cross section of the water scope.

Recommendations

Maintenance and repair

To maintain the Lodge, a few checks should be made monthly to ensure that the lodge remains in the best condition. What follows is a list of the things to check and the recommended steps to remedy:

The Lodge turns grey over time:

The lodge will naturally grey over time as the wood is exposed to the air. We have applied a layer of outdoor stain to slow down the oxidation process that turns the wood grey, but it will not stop it. If the wood is desired to be returned to its original color, either sand through the greyed wood and apply a new coat of stain or apply an oxalic acid based cleaner to clean some of the greying.

The wood shingles are rotting away:

The shingles were attached with screws to the 2x4 stretchers, they can easily be removed, and a new shingle can be installed in its place.

A hole has appeared in the roof:

Use clear roofing tape over the hole. If the roof panel is deemed irreparable, unscrew the roof panels next to the broken panel and slip in a new panel. Ensure the new panel overlaps one of the panels and is overlapped by the other by 2 or more valleys. Once the new panel is placed correctly, screw the panels down using roofing screws into the closure strip.

Water is leaking in from the roof:

If water is leaking in from the roof, use a clear sealant in the gap that the water is leaking through. Alternatively, use the butyl tape that was left between the closure strips and the cover plates and butyl tape between the closure strips and roof panels.

Winterization steps:

While the structure of the Lodge will remain usable throughout the year, some of the stations housed within will not survive repeated exposure to winter conditions. The clear, waterproof storage box(es) should be housed inside an area that does not see freezing temperatures. The critter holder that is made of clear materials should also be protected from freezing temperatures. The Water-Scopes will be safe to use in below freezing temperatures but should be brought inside when not in use, so that the acrylic does not crack.

The lodge will be slightly warmer than the air outside as the sunlight will warm the ground and the warmth will be trapped by the walls and roof. To make the lodge warmer, and better protected from the elements, tarps or other sheet materials can be attached to the open sides of the Lodge to create a more enclosed area. Tarps or other covering should cover the gaps between the top plates and the rafters to limit the amount of warm air that escapes from those areas.

Conclusions

A teacher brings their group of kindergartners to Turn Back Time's beaver pond after lunch, they go to the shoreline and climb around on the logs at the shallowest point of the water, exploring the flora and fauna native to this ecosystem. One child picks up a fern, inspects it, and wants to try and draw it, so the teachers make a learning experience out of this, by having the students make leaf rubs of the ferns, and the older grade levels even can begin naming the basic anatomy of the plant. Another day, a student catches a frog and holds it safely in their hands and shows it to the teacher and so they put it into a Catch and Release Observation station for the other students to inspect while keeping the animal safe, the staff can then turn this into a lesson that arose naturally, on the topic of animal behavior, or habitats. It begins to rain, and while most of the kids are fine with the small amount of rain, there are a few that would rather not get rained on, and so those students not eager to play in the mud and the teachers seek shelter underneath the clear roof of the Beaver Pond Learning Lodge and read a story to the children while some are keeping dry underneath the roof, and those who chose can listen on the log seating just a few feet away while playing in the mud. This has made it possible for them to remain in this outdoor trove of learning opportunities, rather than take the 3-minute walk back away from the pond to their classroom.

This is precisely the scenario that we wanted to accommodate for with our project. We set out to enhance the already thriving learning environment of the beaver pond present at Turn Back Time, with a space that allows for more of the organically occurring learning experiences that arise to be taken when noticed by the dedicated staff of Turn Back Time. Our goal was to create a structured area adjacent to the natural beaver pond to provide access to novel educational materials, with the focus of promoting literacy in different age groups and that is precisely what we did. Along the way we found out about

the distinctive styles of nature education that are being relatively newly implemented across the country and how they positively impact the children they reach. We observed behaviors in the students that informed and influenced our designs for stations and the main structure of the lodge alike, and further gave us a sense of the need for the project at TBT. We learned a great deal about building outdoor freestanding structures and took this information and created a space that we are hoping will be used by the people of Turn Back Time for years to come. Lastly, we did significant research and met with multiple experts on the topic regarding Massachusetts State curriculum guidelines for Pre-K through Kindergarten and utilized these findings to better design our stations so that we may further enhance the educational value that Turn Back Time can get out of the Beaver Pond space.

We are proud to have created this space for Turn Back Time through our project that will help them facilitate the important work they are undertaking in ensuring that every child gets to learn in a way that comes naturally to them. The education of children, especially those that may not reach their full potential in traditional classrooms is and has always been one of the most significantly crucial undertakings to preparing a better world, after all “Children are one third of our population and all of our future.” — Select Panel for the Promotion of Child Health 1981

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Appendix 1: Cost Analysis of Proposed Lodge Designs

Number needed	Name	Unit Cost at HD	Total Cost at HD	Category
4	12"x4' concrete form tube	$ 15.98	$ 63.92	Anchoring
24	80 lbs concrete mix bags	$ 5.97	$ 143.28	Anchoring
4	PB ZMAX Non-standoff post base for 6x6 lumber	$ 29.86	$ 119.44	Anchoring
16	3/8"x6" Hex Drive PowerLag Spax bolts	$ 3.47	$ 55.52	Braces
1	#9x3" Deckmate Flat head wood deck screws 5lbs box	$ 37.47	$ 37.47	everywhere
13	6x6x8' Pressure Treated Beams	$ 36.18	$ 470.34	Posts, Risers, and Braces
20	Hurricane Ties-H2.5A	$ 0.88	$ 17.60	Rafters
14	2x6x12' Pressure Treated Studs	$ 11.38	$ 159.32	Rafters and Trim
7	2'x12' galvanized steel roofing panel	$ 31.48	$ 220.36	Roof
1	F8 mill finish aluminum drip edge flashing 10ft	$ 10.44	$ 10.44	Roof
3	C3 mill finish aluminum drip edge flashing 10ft	$ 4.40	$ 13.20	Roof
1	24" horizontal plastic closure strips 6pack	$ 7.98	$ 7.98	Roof
1	Butyl sealant tape	$ 5.25	$ 5.25	Roof
1	#9 x 1-1/2 in. External Hex Zinc Plated Steel Hex Washer Head Roofing Screws (100-Pack)	$ 14.87	$ 14.87	Roof
3	Flashmate Flashing Sealant 10oz	$ 6.47	$ 19.41	Roof
1	Rooftop SafeTie Bucket kit	$ 111.33	$ 111.33	Roof
1	#30 216 sq. ft. Felt Roof Deck Protection	$ 32.98	32.98	Roof
4	4'x8' 7/16" OSB Sheathing	$ 14.50	$ 58.00	Roof
2	6x6x10' Pressure Treated Beams	$ 36.18	$ 72.36	Top Plate
9	4'x8' 19/32" Plywood	$ 40.42	$ 363.78	Walls
4 hours	2 man Auger Rental	$ 77.00	$ 77.00	Anchoring
1 day	Electric Cement Mixer 3.5 cu. ft. rental	$ 54.00	$ 54.00	anchoring
1 week	Miter Saw 8.5" Rental	$ 160.00	$ 160.00	Framing
			$ 2,287.85	

Figure 16: Total cost analysis of a Lodge constructed from 6x6 lumber forming an 8'x8'x8' with 25-degree roofing using steel corrugated roofing and anchor and post system

8'x8'x8' sloped pergola using 4"x4" with a 9.5 degree roof using clear PVC and Cast foot-deep anchor				
Number neede	**name**	**unit cos**	**total**	**category**
4	4"x4"x8' pressure treated posts	$ 11.98	$ 47.92	Posts
7	4"x4"x8' pressure treated posts	$ 11.98	$ 83.86	Top plates and braces
2	4"x4"x10' Pressure Treated	$ 18.88	$ 37.76	Top plate
8	2"x4"x10'(non-PT) (only appearance grade sold)	$ 7.92	$ 63.36	Rafters
4	2"x2"x10' (non-PT)	$ 2.98	$ 11.92	Purlins
6	24" horizontal plastic closure strips 6pack	$ 7.98	$ 47.88	Roof
2	24" vertical plastic closure strips	$ 7.98	$ 15.96	Roof
4	C3 mill finish aluminum drip edge flashing 10ft	$ 4.40	$ 17.60	Roof
1	Butyl sealant tape	$ 5.25	$ 5.25	Roof
2	10.1 oz. 212 Clear All-Purpose Patch	$ 11.98	$ 23.96	Roof
1	Flashmate Flashing Sealant 10oz	$ 6.47	$ 6.47	Roof
9	26 in. x 8 ft. Clear PVC Roof Panel	$ 18.98	$ 170.82	Roof
1	#9 x 1-1/2 in. External Hex Zinc Plated Steel Hex Washer Head Roofing Screws (100-Pack)	$ 14.87	$ 14.87	Roof

Figure 17: Total Cost Analysis for a Lodge constructed from 4x4 lumber to create an 8'x8'x8' sloped pergola using 4"x4" with a 9.5-degree roof using clear PVC and Cast, foot-deep anchor

8'x8'x8' sloped pergola using 4"x4" with a 9.5 degree roof using clear PVC and Ground Screws				
Number needed	**name**	**unit cost**	**total**	**category**
2	4"x4"x8' pressure treated posts	$ 11.98	$ 23.96	Posts
4	Landscape timber	$ 6.38	$ 25.52	Bracers
6	2"x4"x8'(non-PT)	$ 3.75	$ 22.50	Top plates
5	2"x2"x10' (non-PT)	$ 2.98	$ 14.90	Purlins
4	24" horizontal plastic closure strips 6pack	$ 7.98	$ 31.92	Roof
2	24" vertical plastic closure strips	$ 7.98	$ 15.96	Roof
3	Butyl sealant tape	$ 5.25	$ 15.75	Roof
1	1-1/2 in. (4D) Hot Dipped Galvanized Smooth Common Nail (348-Count)	$ 7.63	$ 7.63	Walls
2	2 in.x2 in. x 4 in. 12 gauge angle plate	$ 2.51	$ 5.02	Risers
6	26 in. x 12ft. Clear PVC Roof Panel	$ 27.48	$ 164.88	Roof
4	5/16 in. x 4 in. Powerlag Hex Drive Washer Head High Corrosion Resistant	$ 1.97	$ 7.88	Top plates to Posts
16	Hurricane Ties-H2.5A	$ 0.88	$ 14.08	Rafters
1	1-1/2 in. 0.131 in. SCN Smooth-Shank HDG connector nails (150)	$ 6.98	$ 6.98	
			$ 356.98	
	screw posts		$ 120.00	
			$ 476.98	
	Grand total		$ 570.96	

Figure 18: Final amount spent (pre-taxes) for the Lodge and stations.

Wood Cleaner and Sealer		
Item	**Purpose**	**Cost**
1 gal. All-In-One Wood and Deck Cleaner	Cleaning wood so that the sealer is more effective	$ 11.63
1 gal. Clear Exterior Wood Sealer	Sealer, ensures that both pressure treated and non pressure	$ 17.98
1 Gal. Pump Sprayer	apply cleaner and sealer according to the instructions	$ 11.97
		$ 41.58

Figure 2019: total amount spent on the cleaner and stain for protection of the lodge.

Station Bill of Materials			
number	**item**	**unit cost**	**total**
1	3 oz. Clear Silicone Adhesive Sealant	$ 5.47	$ 5.47
1	8 oz. Purple CPVC and PVC Primer and Regular Clear PVC Cement Combo Pack	$ 10.94	$ 10.94
3	PVC S&D Coupling, 4 in. Hub X Hub	$ 3.67	$ 11.01
1	75L/79.3Qt Waterproof Clear Latch Tote IP-67	$ 24.98	$ 24.98
			$ 52.40

Figure 20: total amount spent on the stations, namely the waterproof storage and water-scopes.