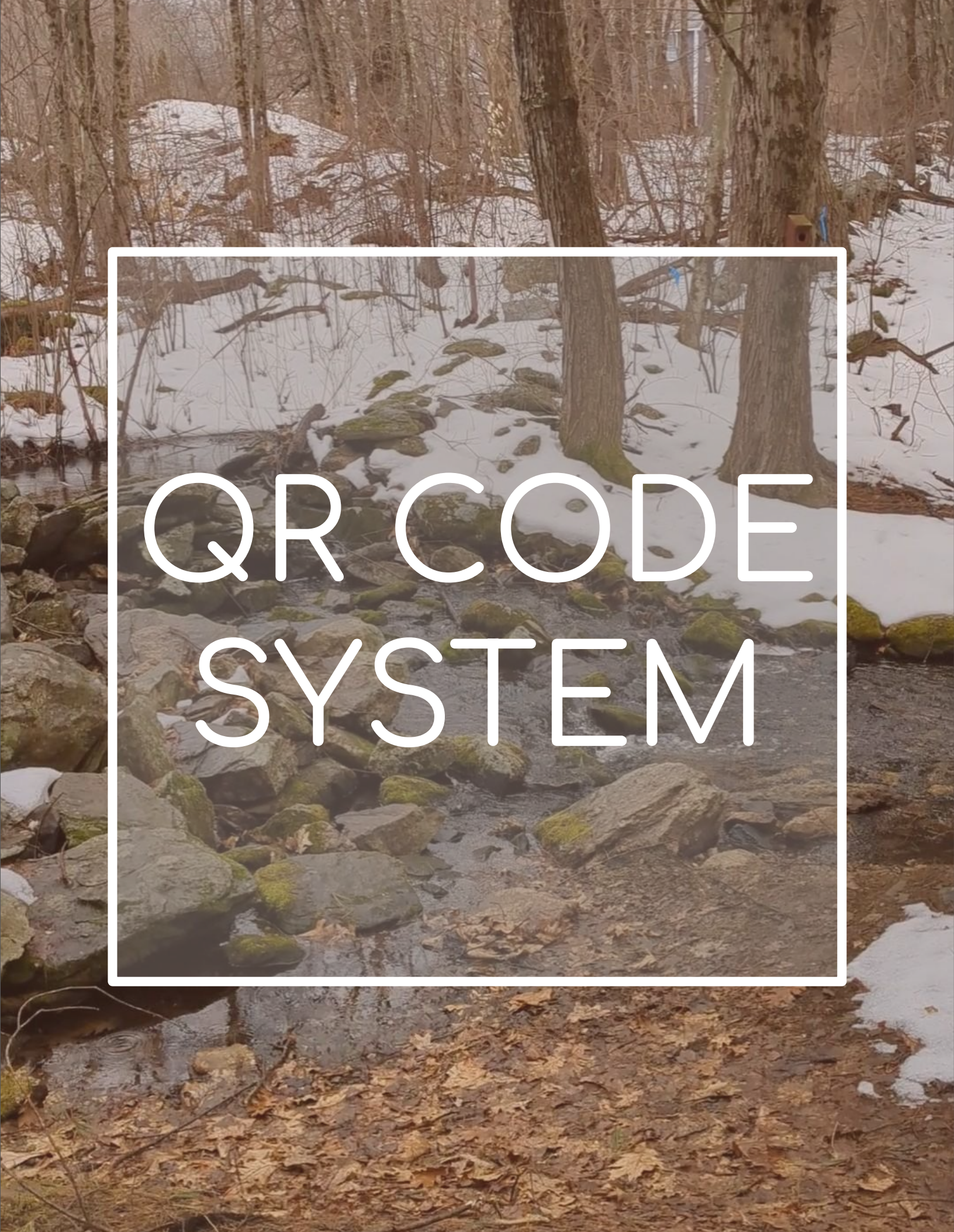
QR CODE
SYSTEM

QR Code System for Turn Back Time

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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Date: May 2, 2023

Report Submitted to:

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Abstract

Parents can be apprehensive about enrolling their children into a nature-based education program due to its nontraditional methods. This project aims to reassure and inform parents and visitors of Turn Back Time farm about the benefits of nature-based learning. Through interviews, surveys, site visits, and an iterative design process, we designed and built fairy doors with QR codes, and placed them at six different learning stations. The QR codes are linked to informational websites that detail key skills learned.

Our Team

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Loves ducks and cats

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Acknowledgements

We would like to thank our sponsors Lisa Burris and Katie Baker, our advisor Lisa Stoddard, and our ID 2050 Professor Corey Dehner for all the help and support throughout the process. We also would like to extend a big thank you to the Mud Kitchen Team and the TBT Teachers for helping test out our system.

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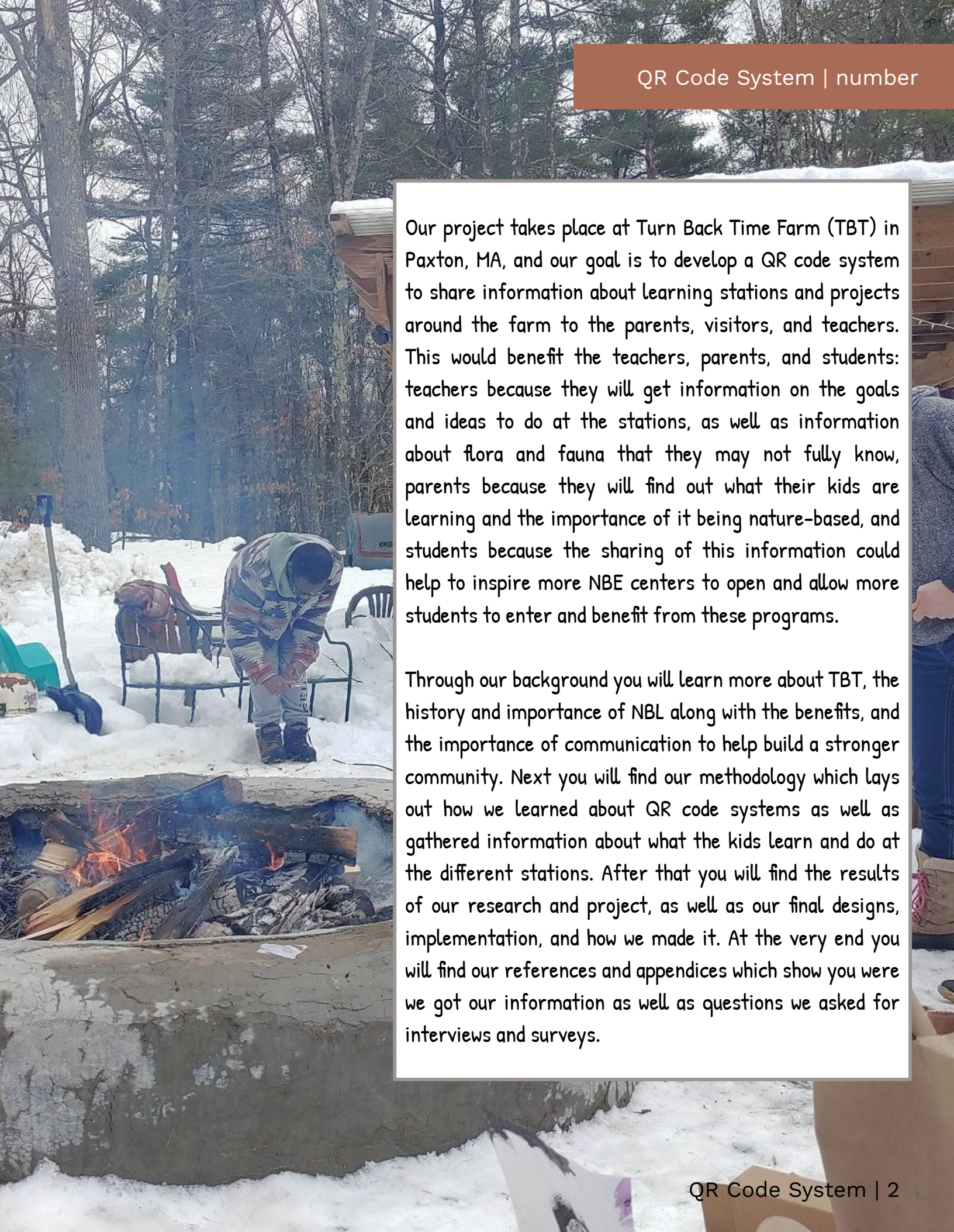
INTRODUCTION

When people think about education, they may only think about public or private schools, but there is another world of education options that people may not know about. One of these non-traditional options is nature-based education (NBE) programs. A study by researchers from Aydın Adnan Menderes University tested skills, such as questioning, evaluation, and reasoning, before and after a group of thirty-six 7th-grade students took part in nature-based education (Aladag et al., 2021). Aladag et al. found a statistically significant improvement in a student's abilities after attending a nature-based learning program (2021).

Despite these studies demonstrating proof of the effectiveness of NBE, parents are still understandably apprehensive with having their kids learn in a non-traditional manner. This is a challenge that comes along with NBE programs, and to improve parents' reception to NBE, they must find ways to inform people of the benefits.



Our project takes place at Turn Back Time Farm (TBT) in Paxton, MA, and our goal is to develop a QR code system to share information about learning stations and projects around the farm to the parents, visitors, and teachers. This would benefit the teachers, parents, and students: teachers because they will get information on the goals and ideas to do at the stations, as well as information about flora and fauna that they may not fully know, parents because they will find out what their kids are learning and the importance of it being nature-based, and students because the sharing of this information could help to inspire more NBE centers to open and allow more students to enter and benefit from these programs.

Through our background you will learn more about TBT, the history and importance of NBL along with the benefits, and the importance of communication to help build a stronger community. Next you will find our methodology which lays out how we learned about QR code systems as well as gathered information about what the kids learn and do at the different stations. After that you will find the results of our research and project, as well as our final designs, implementation, and how we made it. At the very end you will find our references and appendices which show you were we got our information as well as questions we asked for interviews and surveys.

Background

Turn Back Time Farm

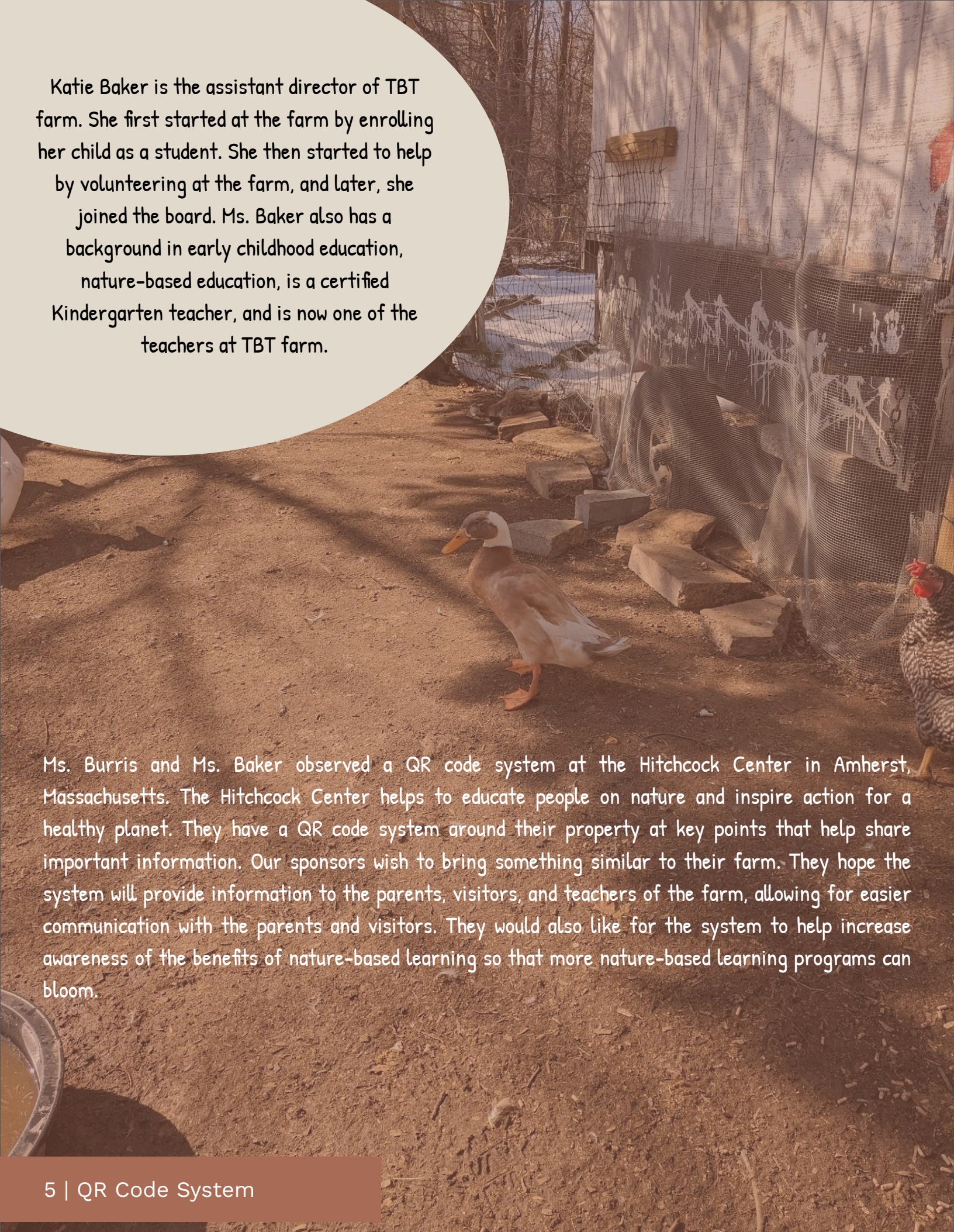
Katie Baker

Lisa Burris

Turn Back Time Farm is a non-profit nature-based education center, whose focus is kindergarten and preschool-aged children. They maintain a 5:1 student-to-teacher ratio to allow teachers to focus on the children and build a curriculum based on how the children are doing and responding to activities. This is a backwards curriculum design, where the teachers note what the students are learning through an activity, such as playing in a mud kitchen, and then extend the activity to meet additional learning outcomes as needed. This ratio also helps with the safety of the children, allowing them to explore more under teacher supervision without being afraid to take healthy risks (e.g. climbing a tree or rock) in a more unpredictable environment (L. Burris & K. Baker, personal communication, January 21, 2023).

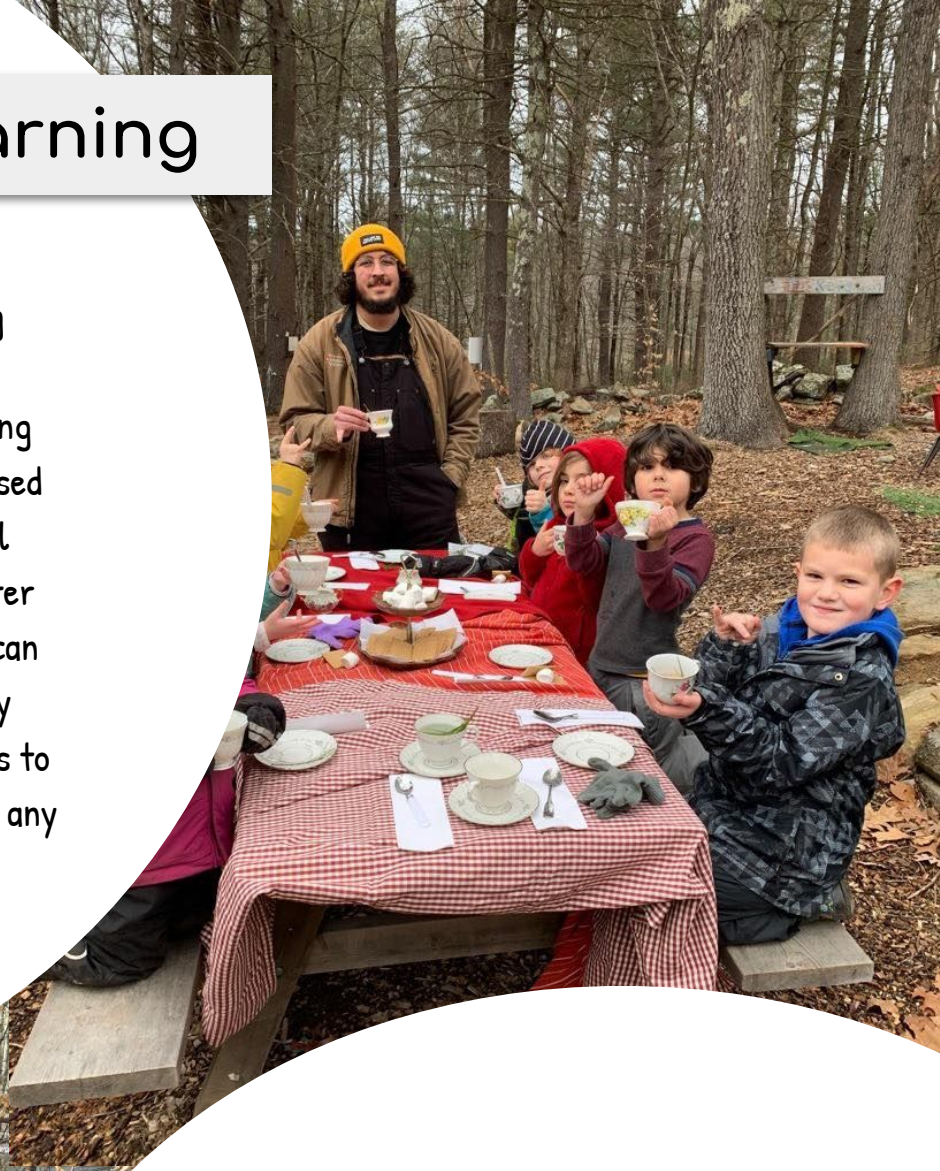
Lisa Burris is the owner and executive director of TBT farm. She has five children, two of which are adopted and have functional needs. She started the farm program in 2012 after seeing the healing effects of nature on her children. This included seeing changes in her own son whose verbal communication improved while being outdoors. At the time, her farm was one of roughly 25 nature-based learning programs in the country (L. Burris & K. Baker, personal communication, January 21, 2023). Over time, TBT farm has grown alongside nature-based learning as a whole. There are now about 650 programs in the United States, and even more are in progress (L. Burris & K. Baker, personal communication, January 21, 2023).

Katie Baker is the assistant director of TBT farm. She first started at the farm by enrolling her child as a student. She then started to help by volunteering at the farm, and later, she joined the board. Ms. Baker also has a background in early childhood education, nature-based education, is a certified Kindergarten teacher, and is now one of the teachers at TBT farm.

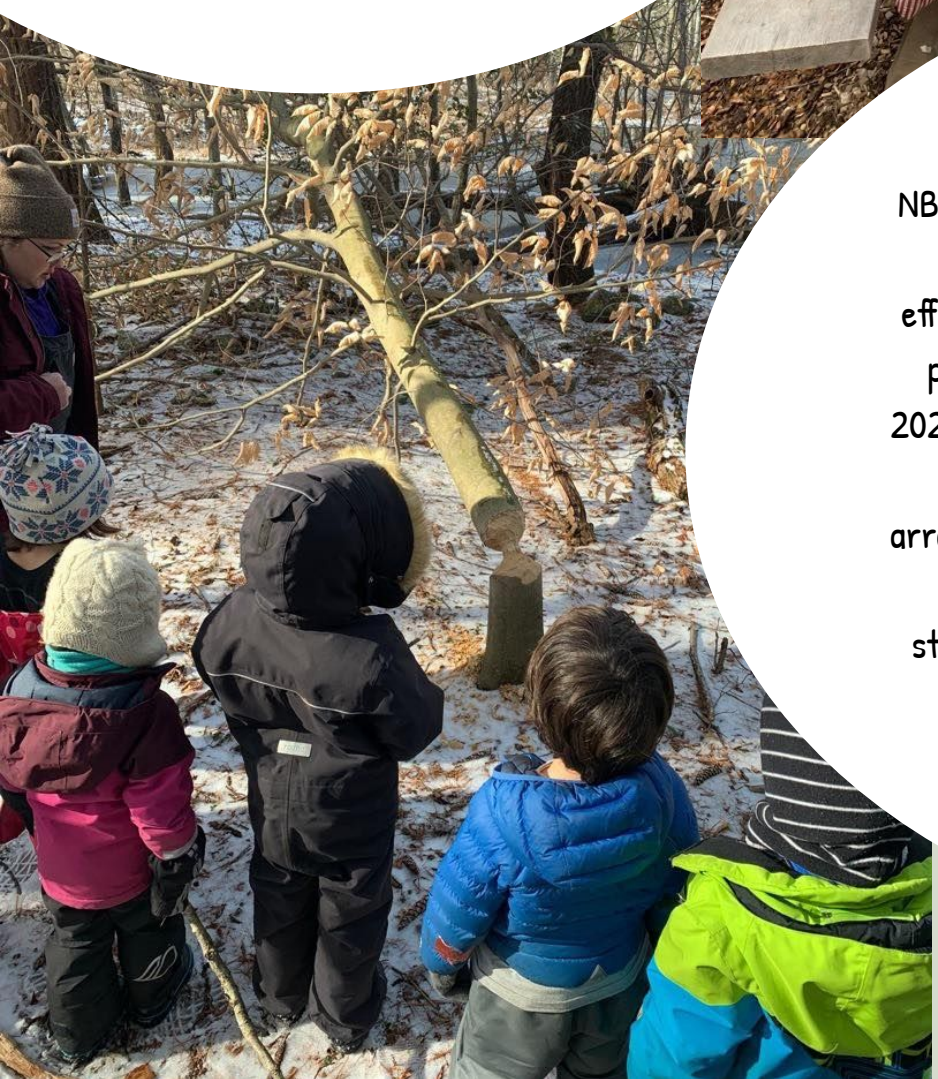


Ms. Burris and Ms. Baker observed a QR code system at the Hitchcock Center in Amherst, Massachusetts. The Hitchcock Center helps to educate people on nature and inspire action for a healthy planet. They have a QR code system around their property at key points that help share important information. Our sponsors wish to bring something similar to their farm. They hope the system will provide information to the parents, visitors, and teachers of the farm, allowing for easier communication with the parents and visitors. They would also like for the system to help increase awareness of the benefits of nature-based learning so that more nature-based learning programs can bloom.

Nature-based Learning

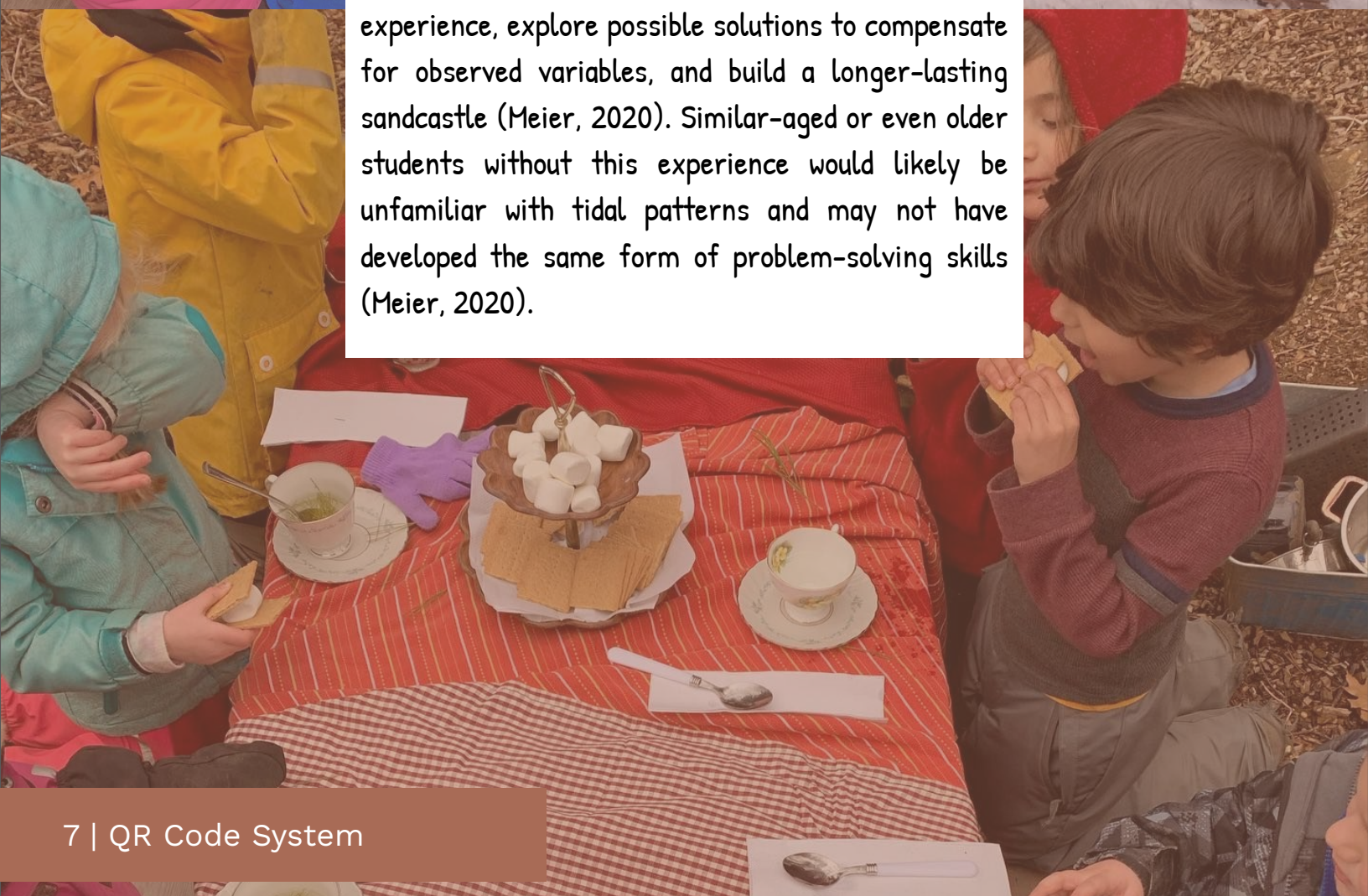


According to the Nature-Based Learning Collaborative Research Network (NBLR Network), nature-based learning is learning through exposure to nature and nature-based activities in an environment with natural elements, such as plants, animals, and water (Jordan & Chawla, 2019). These activities can range from instructors teaching directly outside while students sit on wooden stumps to students exploring the forest, and bringing any questions they have to their instructor.



NBL is a non-traditional form of education that is most commonly applied to - and most effective for - younger students, ranging from preschool to elementary school age (Meier, 2020). Compared to traditional education, where students learn by sitting in an organized arrangement in a classroom and listening to the instructor, nature-based education is less structured, more hands-on, and promotes the growth of skills related to exploration.

For example, a preschooler or kindergartener who learns in a nature-based setting near the seashore would be more knowledgeable of tidal patterns and ocean movement due to spending time building sandcastles and watching them get swept away at high tide (Meier, 2020). They would learn from this experience, explore possible solutions to compensate for observed variables, and build a longer-lasting sandcastle (Meier, 2020). Similar-aged or even older students without this experience would likely be unfamiliar with tidal patterns and may not have developed the same form of problem-solving skills (Meier, 2020).



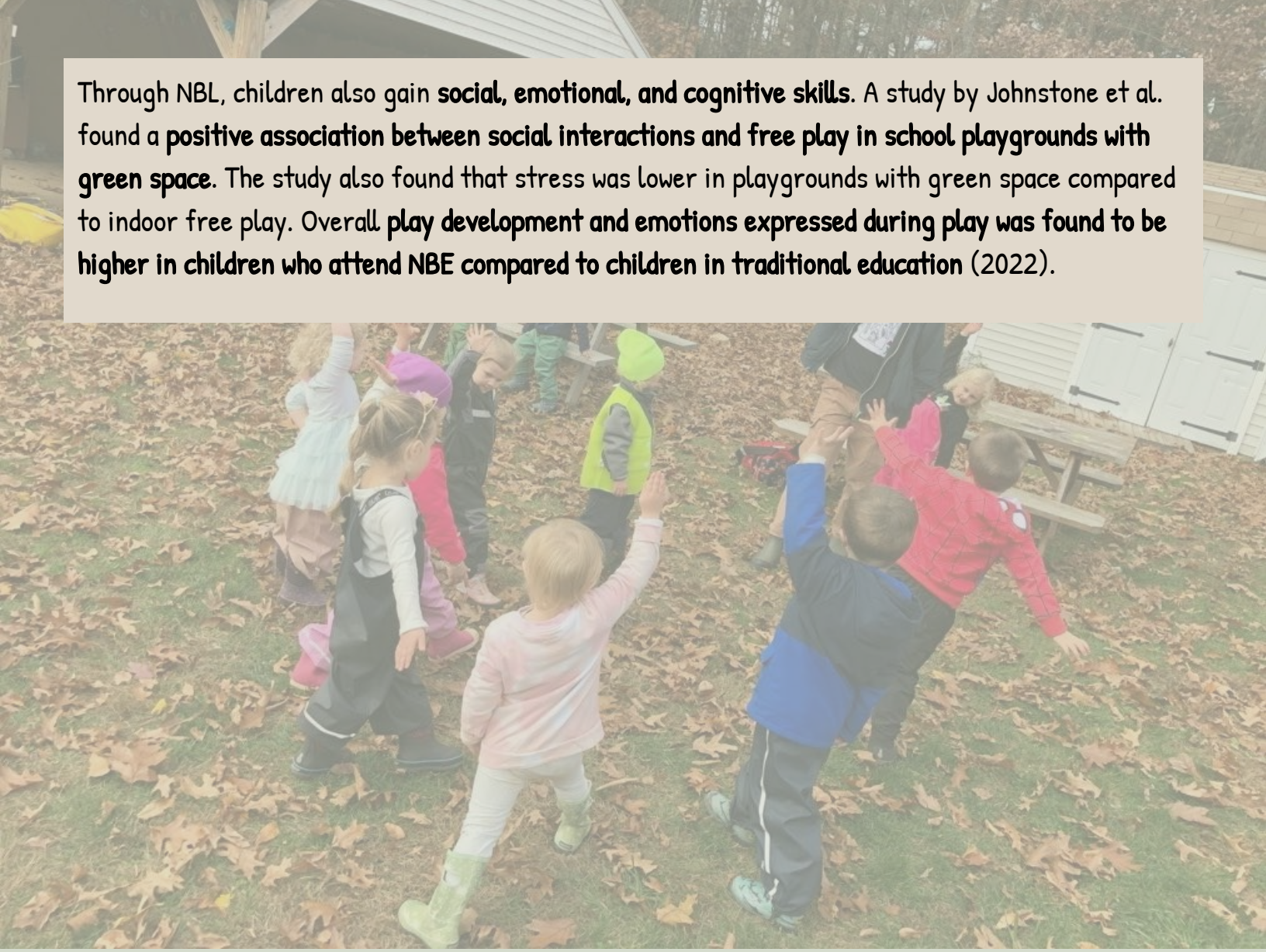
Another benefit that comes with nature-based learning is **environmental awareness**. A study by Nihal Yildiz Yilmaz and Ayşe Mentiş Taş explores the effects of nature education on the level of environmental awareness of elementary school students from varying socioeconomic backgrounds. Students were assessed using the **Primary School Environment Awareness Scale** (SPEAS), which includes subjects on living in nature, renewable energy sources and their use, environmental responsibility, and continuity of living things.

The sample size consisted of **78 4th-grade students** from Konya, Turkey, from a variety of socioeconomic backgrounds. Students from **lower and middle socioeconomic backgrounds had statistically significant increases** in SPEAS ratings (Yildiz Yilmaz & Mentiş Taş, 2018).

Outdoor education can **improve skills such as spatial awareness, questioning, evaluation, and reasoning**. As mentioned earlier, a 2021 study on NBL led by Elif Aladag, Alaatin Arikan, and Hatice Ozenoglu, focused on testing categories relating to questioning, evaluation, and reasoning using a scale called Reflective Thinking Skill Scale (RTSS).

The study tested **36 7th-grade students** from Aydin, Turkey using the RTSS before and after a week of nature-based learning. In summary, **questioning and evaluation skills improved significantly**. Reasoning ability also improved, but less significantly (Aladag et al., 2021).

Through NBL, children also gain **social, emotional, and cognitive skills**. A study by Johnstone et al. found a **positive association between social interactions and free play in school playgrounds with green space**. The study also found that stress was lower in playgrounds with green space compared to indoor free play. Overall **play development and emotions expressed during play was found to be higher in children who attend NBE compared to children in traditional education** (2022).



Since NBL is non-traditional, teachers and parents **have their reservations on its effectiveness compared to traditional learning**, discipline, and attention-span. Other's wave off all positive claims of NBL, stating that they are the beliefs of biased views of nature and optimists. While these views may have once been valid, attention to NBL has caused numerous studies, such as the ones mentioned before, to **explore just how NBL compares to traditional learning**. These studies turn claims into evidence, demonstrating how on average, NBL is more effective than traditional learning (Kuo et al., 2019).

NBL has a plethora of benefits that can be **seen from first hand experiences of parents as well as through research**, yet people may still be unsure because they don't have all the proper knowledge. By communicating the benefits backed by research, people may be persuaded and more open to NBL.

Communication as a Tool

An easy way to diminish skepticism is by **communicating the correct information.** Effective communication can increase parental involvement. Increased parental involvement can improve student success, and can range from homework and studying help, volunteering, attending Parent-Teacher Association meetings, and participating in parent-teacher conferences. Yotyodying & Wild found that **increased two-way communication between the school and the parents led to parents feeling a greater level of inclusion, allowing for an open and flowing discussion about the child's behavior and overall academic progress** (Yotyodying & Wild, 2019).

An additional study investigated the impact of parental involvement on children. While two-way communication allows for greater levels of inclusion, **another study found that it can build a foundation of trust**. Lekli and Kaloti found that meeting with parents regularly allows for trust to build between the teachers and parents (Lekli & Kaloti, 2015). **This two-way communication between the school and the parents allows the parents to collaborate to offer support and help their children improve, especially in reading, writing, and math** (Yotyodying & Wild, 2019; Lekli & Kaloti, 2015).

When it comes to communicating with parents and visitors, being able to keep in touch with readily available methods is essential. In a Worcester Polytechnic Institute Interactive Qualifying Project completed in collaboration with the Worcester, Massachusetts branch of the YMCA, a group of WPI students surveyed families about parent-teacher communication. The YMCA supports a community that is **diverse with communication barriers such as language and culture**, so building effective communication is necessary to create their desired community feel. To connect the community-parents, visitors, and staff must be included. **Parents of these children reported feeling out-of-the-loop with communication** as they would frequently be sitting around waiting to pick up their child, especially during transition times of groups. **By surveying what has worked for similar nonprofits as well as asking parents what forms of communication would be most convenient for them, the YMCA installed a mobile application to both communicate with parents and keep track of the children's whereabouts** (Guzzi, Harty, Greenalch, & Balicki, 2017).

A similar study focused on a Montessori school. Like nature-based learning, Montessori education is non-traditional in that it focuses on student interest, hands-on learning, and collaboration. The objective of Montessori schools is for teachers to connect students to their surroundings, promoting self-guided learning (Lillard, 2019). The study found that a balanced, two-way communication system was a key factor in deciding whether there was a disconnect between parents and teachers; in other words, parents are more likely to be discontent or distrusting when they do not fully understand their child's non-traditional learning environment (Seril, 2015). **By improving communication, the school in turn improved how parents view the more non-traditional school.**

One Montessori school decided to improve their two-way communication to help parents better understand what their child was doing at school. They created an online platform where the teachers would post what the children were involved in, what was learned, and what tools they used. The parents could then directly chat with the teachers if they had any questions or comments. After implementing the new parent-teacher communication, **parent satisfaction rose from 13% to 69%**. Many parents commented how they enjoyed seeing detailed information on what their children did and accomplished each day (Seril, 2015).

Approximately 30% of the children on the farm are considered to be at-risk, including children who are neurodiverse, those with attention deficit disorder, and those children who are involved with the Department of Children and Families (personal communication, January 21, 2023). While all families need clear communication with teachers, parents with children who have exceptional needs may require additional assurances or additional opportunities for communication with teachers (Yotyodying & Wild, 2019) or a better understanding of how NBE benefits their children. **This means that a clear and informative communication system would greatly benefit the parents of the children at TBT farm.**

In addition, TBT wants parents and visitors to understand **all the benefits of NBL**. Most people generally do not know the difference that having a nature-based education can make on a child as they are used to traditional methods of teaching and education. Through this project, people can learn about the important skills that children can get out of nature-based learning. **Having a quick and easy way to share information on what the children are doing would increase parental involvement and help build community.**

The Power of QR Codes

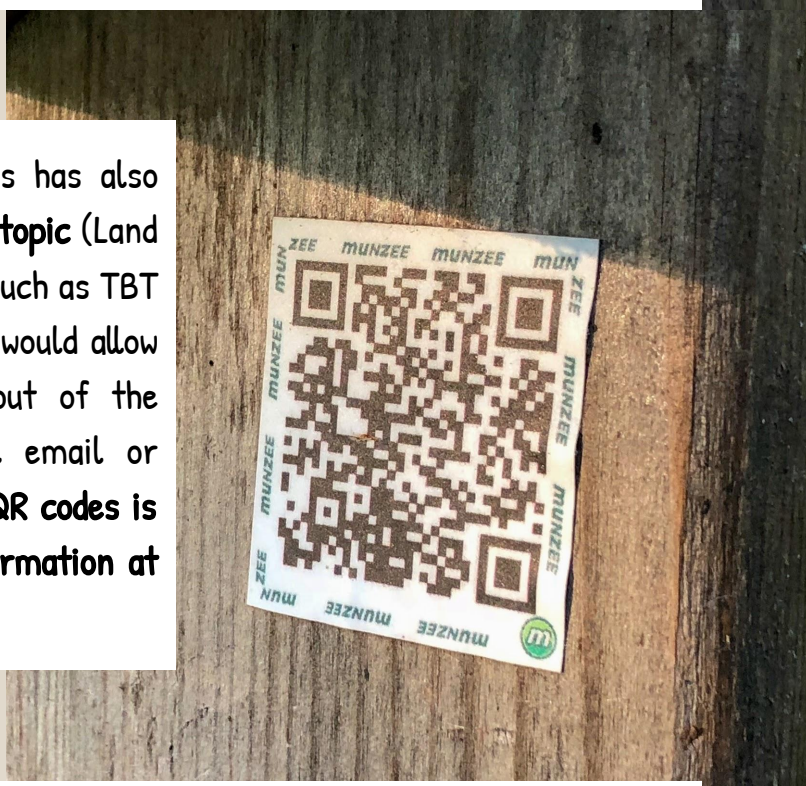
Quick response codes, more commonly known as QR codes, have been around since the mid-'90s and gained popularity in the digital era of the early 2000s thanks to the cellphone. These codes are easily accessible and scanned by opening the photo or camera app, redirecting the user to the connected hyperlink in an instant - **a powerful tool for sharing information** (Durak et al., 2016).

Due to their simplicity, these small, square, black-and-white pictograms can be **used in various settings ranging from college campus tours, paying for goods and services, and even museum exhibits**. Anyone can search for and set up their QR code in a matter of minutes, and anyone with a smartphone can scan said QR code in a matter of seconds.

These little squares may have seemed foreign in the past, however with the pandemic **their use has become common practice**. They are also now being **used by schools to aid in education and the sharing of information**. A study done at Balikesir University had 100% of participants report that the use of QR codes had a positive effect on their learning (Durak et al., 2016).

In an outdoor learning setting, **QR codes can help learners engage by combining explanation and observation** (Land & Zimmerman, 2015). The explanation side is the information that is provided after scanning the QR code. The observation side is what they see in their current surroundings. The photos, videos, and text they consume on their device leave them with a stronger understanding and long-lasting memory of the new information due to making **real observations alongside the given explanations** (Land & Zimmerman, 2015).

Receiving information in more informal settings has also been shown to lead to an **increased interest in the topic** (Land & Zimmerman, 2015). When applied to a location such as TBT farm, using QR codes as a communication device would allow the parents and visitors to get much more out of the information as opposed to receiving a formal email or presentation. This is because **the setting of the QR codes is more informal and the users can intake the information at their own pace**.



Using QR codes as a way of sharing information comes with a variety of pros and cons (see table 1). **One of the main downsides of QR codes has nothing directly to do with the QR codes**. Most issues revolve around either the person not having a smartphone with a working camera or the QR code linked to a site that doesn't adequately display on their device (Kulkarni & Malagi, 2016). **Another challenge is QR codes' reliance on strong wifi or a phone service signal**. An IQP group discovered this issue while trying to create a self-guided tour at historical sites around the town of Princeton, Massachusetts. They were able to overcome this barrier by incorporating a downloadable version of the information available via QR code. In this way, the QR code brings users to information that can be accessed offline (Holt, Luga, Tafesse, & Yun, 2016).

Other challenges that the IQP group faced while creating an effective tour included **finding a balance between using different media**, accessibility of technology/needing a phone, references used for information, and the length of information provided at each site (Holt, Luga, Tafesse, & Yun, 2016).

As mentioned earlier, TBT farm wants to **share more information with parents and visitors** regarding what the children are accomplishing at the farm to help build a community connection. **Ms. Burris and Ms. Baker love sharing what the children are up to** via photos on their Facebook page, but they want an easy way to share information when parents and visitors come to see the farm in person.

	QR Code Systems
PROs	Easy access User-friendly Limited (or no) financial barrier Pull-based tool Gives consumers choice Can combine explanation and observation Can link to multiple forms of media
CONs	Requires wifi or phone service Require smartphone Require working camera Requires monitoring code for broken links Need to update sites when changes occur

Table 1: this information comes from Kulkarni & Malagi, 2016; Acuti et al., 2022; Holt, Luga, Tafesse, & Yun, 2016.

This information would also help the teachers with **the goals of each station at the farm**. Our sponsors decided that a QR system would be the most suitable solution. After seeing a similar approach implemented at the Hitchcock Center be used with ease, they confirmed the need for such a system to be put in place to better inform the parents, teachers, and visitors of the goals at each of their stations. Ms. Burris and Ms. Baker believe a **QR code based information system will help to build a stronger sense of community at the farm**.

To accomplish this, we will work in collaboration with Ms. Burris and Ms. Baker to develop a QR code system to share information and build community for TBT. **We discuss our methodological approach in the next chapter.**


Methodology

The goal of our project is to create a QR code system that will inform visitors, parents, and teachers about the importance of the Turn Back Time farm (TBT) learning stations, how to properly use them, and to help build a stronger community and **raise parent engagement** at the farm.

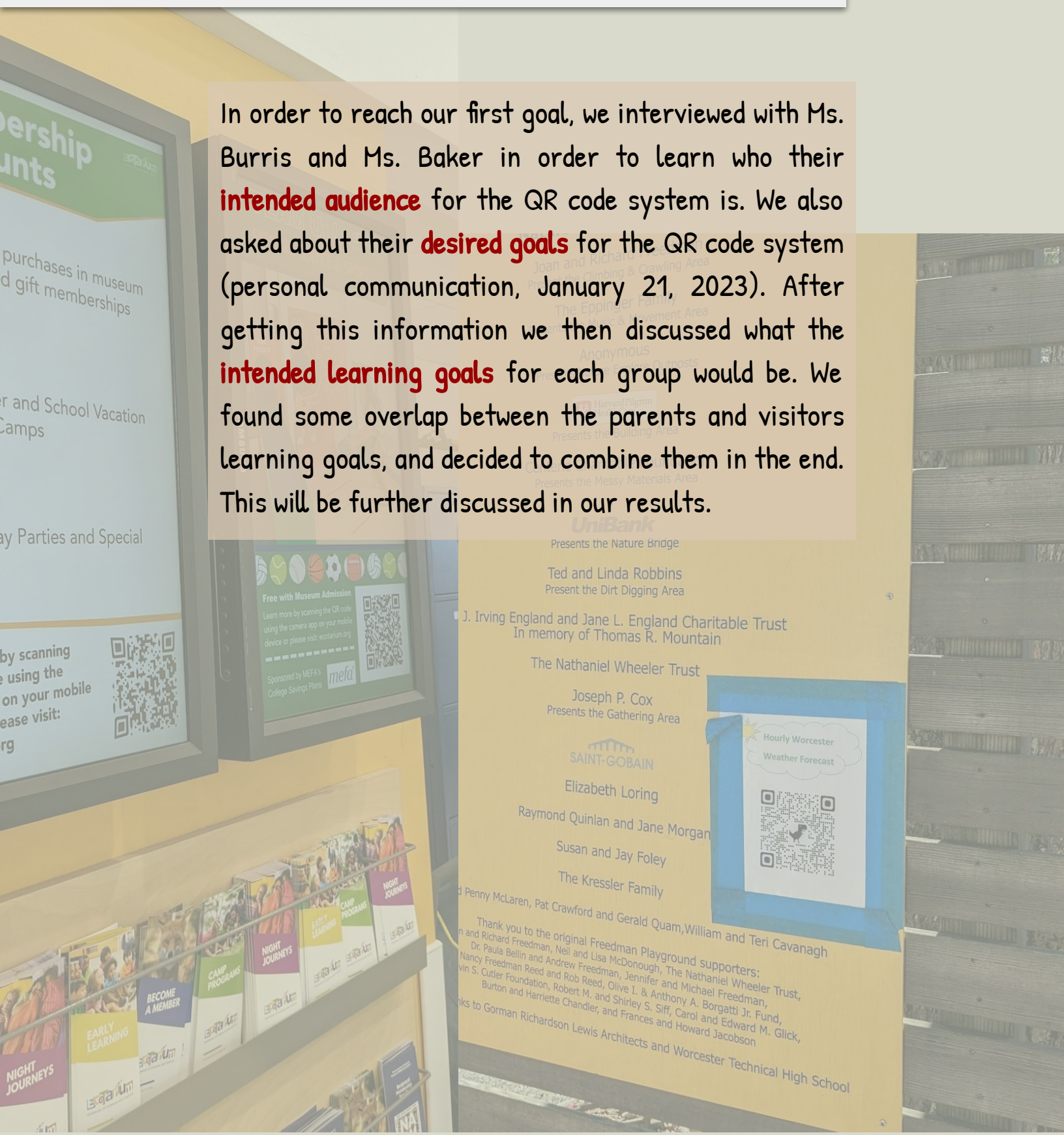
To accomplish our goal, our team **identified the following objectives**: (1) **identify** the target audience and goals of the QR code system, (2) **explore** existing QR code systems in order to find the best approach for our system, (3) **analyze** information about the stations and participant observation of community members using and interacting with the stations in order to build an accessible and user friendly system, and (4) **create** a QR code system through an iterative design process to find the best approach and help to build a **community connection** through raising engagement (see table 2 for a summary).

01. Target Audience and System Goals	02. Existing QR Systems	03. Analyzing Stations and Interactions	04. Create QR System
-Parents, teachers, and visitors -Easy to use -Easily expandable	-Hitchcock Center -Worcester Art Museum -EcoTarium	-Interviews with teachers	-Think-aloud with parent volunteers and others -Iterative design process

Table 2: our objectives along with a summary of methods used for each.

Objective 1: Identify Target Audience and Goals of the System

In order to reach our first goal, we interviewed with Ms. Burris and Ms. Baker in order to learn who their **intended audience** for the QR code system is. We also asked about their **desired goals** for the QR code system (personal communication, January 21, 2023). After getting this information we then discussed what the **intended learning goals** for each group would be. We found some overlap between the parents and visitors learning goals, and decided to combine them in the end. This will be further discussed in our results.



Objective 2: Explore Existing QR Code Systems

In order to assess the utility of QR code systems, we explored locations that already have them in place. We have found four nearby locations with QR code systems, or similar devices, that have been successful.

We conducted a focused interview with **Katie Koerten at the Hitchcock Center**. The Hitchcock Center was the original inspiration for the QR code system at TBT.

We also interviewed **Jeffrey Forgeng at the Worcester Art Museum (WAM)** to get a different perspective and use participant observation with their QR code.

Next, we interviewed **Clair Degutis, a member of the Princeton Historical Society**, and a sponsor of the 2016 WPI project in which the authors created a virtual, downloadable self-guided tour of historical sites around Princeton, Massachusetts (Holt, Luga, Tafesse, & Yun, 2016).

We then spoke to **Kerry Castorano at the EcoTarium** since they seemed to have the largest QR system in place out of all the places we spoke to.

To read the specific questions asked of each location, see appendix A.

Objective 3: Analyzing The Stations and Interactions

Next, we aimed to **foster a community connection** between visitors, families, and anyone else who interacts with the farm, by **raising engagement from parents and visitors and showing them what the children are learning at the farm**. Our sponsors informed us how at drop-off and pick-up, parents tend to sit around on their phones. Our QR codes will help to raise parent and visitor engagement by adding a device for them to interact with while on the farm.

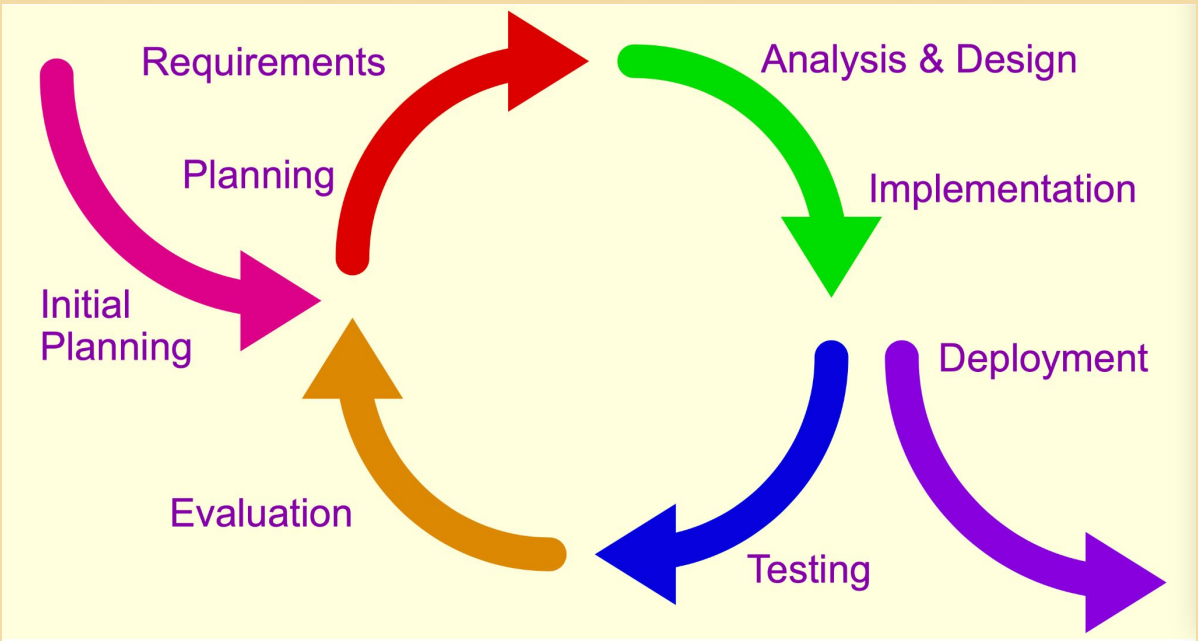
We **interviewed four of the teachers** in order to find out what information they wanted to get from the QR code system. This included asking about: learning station goals, skills to focus on, and activities the kids enjoy most.

We also gave a survey to the parents at TBT to find out what they think of the QR Code pages and what they would like to see on the QR code pages. In this survey the parents rated what the question asked on a scale from 1 to 4. These questions included the usability and ease of the QR Codes. We **designed the questions on the survey to be quick, simple, and required to get responses that either sit more positive or negative**. This allows for better feedback since people may tend to choose the neutral option when given the choice (Phair & Warren, 2022).

By gathering information from teachers and parents, we were able to build a QR code system that **best meets the needs of the community**.

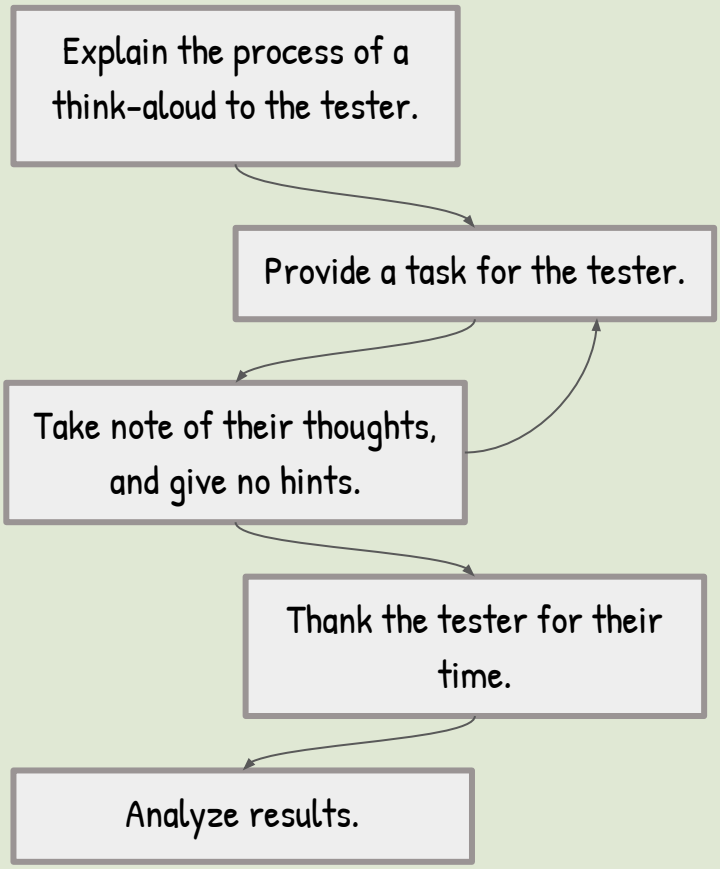
Objective 4: Create a QR Code System

Our final step is to **develop and implement the QR code system**. To do so, we plan to use an **iterative design process**, where we create a prototype and then ask for voluntary testers to review and give feedback. We will repeat this process until we reach the end of this IQP or until we are satisfied with the product.



One method of collecting feedback from testers will be through **think-alouds**. Think-alouds are a type of interview where the interviewer provides the tester with a task, and the tester must complete this task, all the while speaking aloud their thoughts (Nielsen, 2012); ideally, the tester should not stop speaking for any longer than five seconds at a time. The interviewer is not permitted to engage with the tester in any way related to the learning stations until after the think-aloud is complete.

Process of a Think-aloud



The point of a think-aloud is to **obtain the thoughts of the tester that they may never say aloud or would forget soon after completing the task**. Those thoughts may provide insight to any parts of the prototype that seem confusing or need work. Not giving the tester any hints or indications of satisfaction with the task removes possible biases they may infer from the interviewer's comments. After the think-aloud, the interviewer would be free to speak and optionally ask for feedback.

Some possible tasks we may give the testers (given a QR code) include:

- Imagine you are a parent. Find and state what the beaver pond water scope is.
- Imagine you are a teacher. Find and state an interesting fact about beavers.
- "Send" a suggestion to TBT Farm.

For the think-alouds, our original tester pool included our sponsors, Lisa Burris and Katie Baker, another WPI student group who will be working at TBT, friends and family of our group members, the parents of the students at TBT, and other farm visitors. However, due to certain restrictions, we decided to reduce our testing pool to the other student group, friends and family of our group members, and possibly our sponsors.

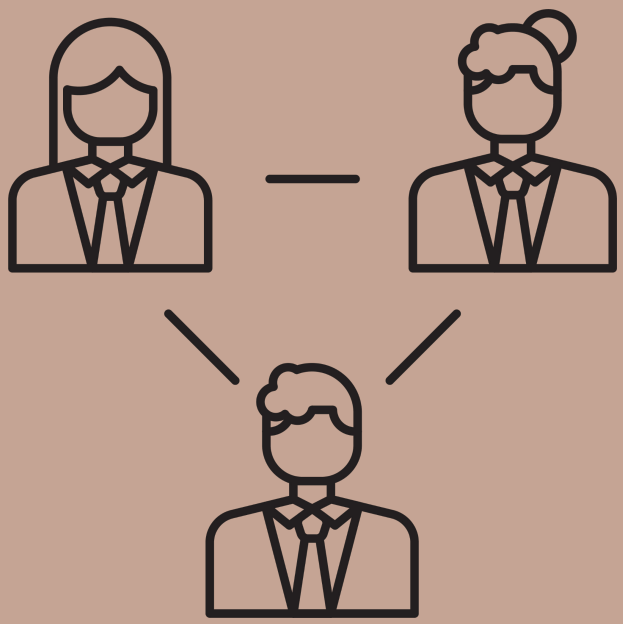

Results

Objective 1: Identify Target Audience and Goals of the System

From the interview with Ms. Burris and Ms. Baker, we learned what their **intended audience**, or users, are of the QR code system and their **desired goals** (personal communication, January 21, 2023). The target groups for this system are the **visitors, families, and the teachers** of the farm. To complete our overarching goal, we first had to identify the learning objectives of each group.

-For teachers, the purpose is to **learn how to use each station for their lessons**.

-With the parents, the aim is to **discover what their children are learning at the different stations** on the farm.



-Lastly, for visitors, the goal is to see **the importance of what the kids are accomplishing** at each station concerning nature-based learning.

By having different information geared toward each of the target audiences, TBT will be able to **share the benefits of nature-based learning and build a community connection** to the farm. After speaking with Ms. Burris and Ms. Baker, we found the following overall goals for how the system works: **easy to use, easy to change and expand on**, and able to share the proper information to each target audience (personal communication, January 21, 2023).

Objective 2: Explore Existing QR Code Systems

From all of our interviews, we found **4 different themes**: interaction with the site and environment, ease of changing for the owner, using mixed forms of media, and having sites that are accessible for all.

Photo of the WAM armory display and QR code

The first main theme we found was the **importance of the audience interacting with what they see in front of them and what they see on their phone.** The most prominent example of this was at WAM. Mr. Forgeng told us about how the QR code leads to a site which has a very similar visual layout as the cases the people see in front of them. This allows for them to easily choose the item they wanted to learn more about. They can then read more while still viewing the item in front of them (J. Forgeng, personal communication, March 22, 2023).

The second theme we found was for **the sites to be easily accessed and changed by the owner**. Most places we visited seemed to use a third party for their sites, which makes it more difficult for them to make small, quick changes. However, our interview with Ms. Koerten of the Hitchcock Center showed us how Google Sites can be used and easily edited on demand (K. Koerten, personal communication, March 28, 2023).

Photo of the QR codes created and used for a project by the Hitchcock Center

The third major theme we found was **the use of mixed medias to help engage the audience**. Our interview with Ms. Degutis showed us how their self-guided tour can be done via a print out pamphlet, or an online, downloadable version. Both contain a mix of photos, text, and facts to help engage the audience (C. Degutis, personal communication, March 20, 2023).

QR Codes used at the EcoTarium

Lastly, we found **the importance of having sites that are accessible to all**. Every place we interviewed seemed to be easily accessible to all of us. This includes being easy to see, read, and scan. This also means having access to good cell service or wifi in order to load the associated page. The EcoTarium specifically has made it their goal to be as accessible as possible. Currently, **they are working on QR codes for each of their interactive stations that will lead to the information listed in different languages** (K. Castorano & Tom, March 29, 2023).

From all of our interviews we found the main areas for us to focus on: **ease of use, accessibility, changeability, affordability, weatherproof ness, and audience engagement**.

Objective 3: Analyzing the Stations and Interactions

Our first half of objective three included our teacher interviews. Through our interviews with Katie, Beth, Katrina, and Veda, we were able to **craft our sites to our audience's needs**. We interviewed each of the teachers about what they would like in terms of the content on both the public and teacher pages of the different sites and their feedback on the sites thus far. **This feedback helped with phrasing and design inspiration for the sites and the doors**.

Parents & Visitors Site

With the public pages, the target audience is **the parents of the children who go to school on the farm as well as visitors who are curious of the different places on the farm.** With this in mind, we asked our sponsors what they wished would be on these pages that the audience could read about and learn. We learned that our sponsors wanted to share what **specific skills the children learn through their play at each station as well as shed light on the WPI projects around the farm**. We then interviewed the four teachers and asked them questions to learn about goals, activities, and guidelines for our main 6 stations (see appendix B).

Nature Classroom

For the Nature Classroom, we learned about the space being **a previous IQP project, how the kids love to find salamanders and climb around, as well as other skills** that the children use at the station (K. Baker, personal communication, March 27, 2023). [See Nature Classroom Site Here]

Atelier

For the Atelier, we learned about the importance of **process-oriented art VS product-oriented art**. This is art without outside adult judgement. We also learned about the specific language that parents and teachers should use (V. Bleau, personal communication, April 5, 2023). [See Atelier Site Here]

Teachers Site

Unlike with the public pages, the Teacher site would be viewed by only teachers. Our sponsors gave us a baseline of what they would expect to see on the teacher side, which we then asked the teachers on what they thought. They all agreed with having the following main sections: **activity ideas, what the kids enjoy most, some fun facts about the flora and fauna, and the Massachusetts education standards they get covered at the station**.

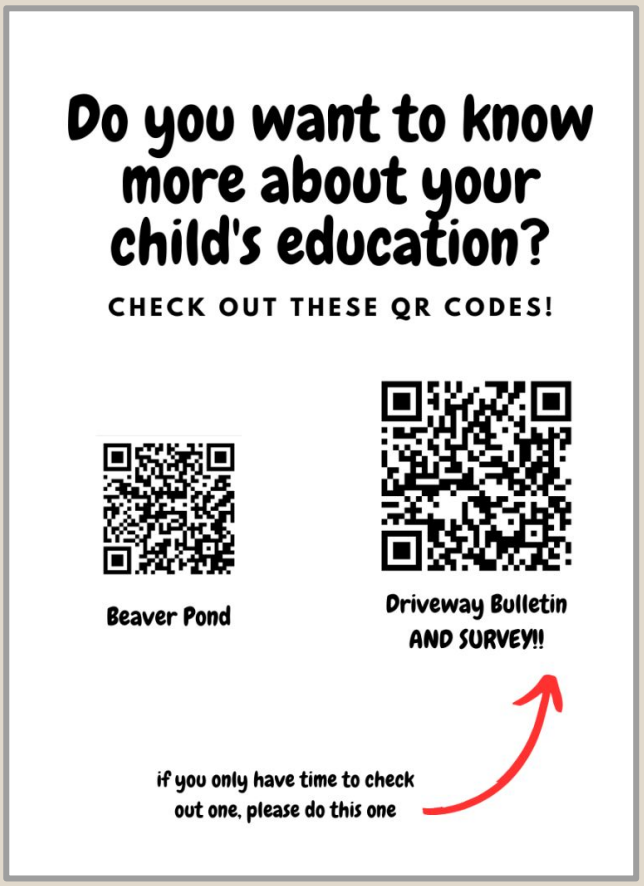
For the Chicken Coop, we learned from Beth about how **the children practice calm voices and calm bodies**, as well as being gentle with collecting the eggs and counting what they gathered (B. Preston, personal communication, March 28, 2023).

For the Nature Classroom, we learned from Katrina about the amount of **different mosses and ferns that the children can see and compare in the area**. We also learned about the different games that help teach the children balance and other gross motor skills at this station (K. Smaltz, personal communication, April 4, 2023).

For the Beaver Pond, we spoke to Katie and observed her class in order to see **how the children use and learn in the space**. We saw how they play as animals, catch critters in the water, and identify plants and bugs (K. Baker, personal communication, March 27, 2023).

For general, overall feedback on the usability and what parents would like to see on the sites, we sent out survey in person and linked on the driveway bulletin. Each of these questions asked the parent to rate each criteria on a scale from 1 to 4. Overall, we got four parent responses, but no extra feedback on anything else they would like to see.

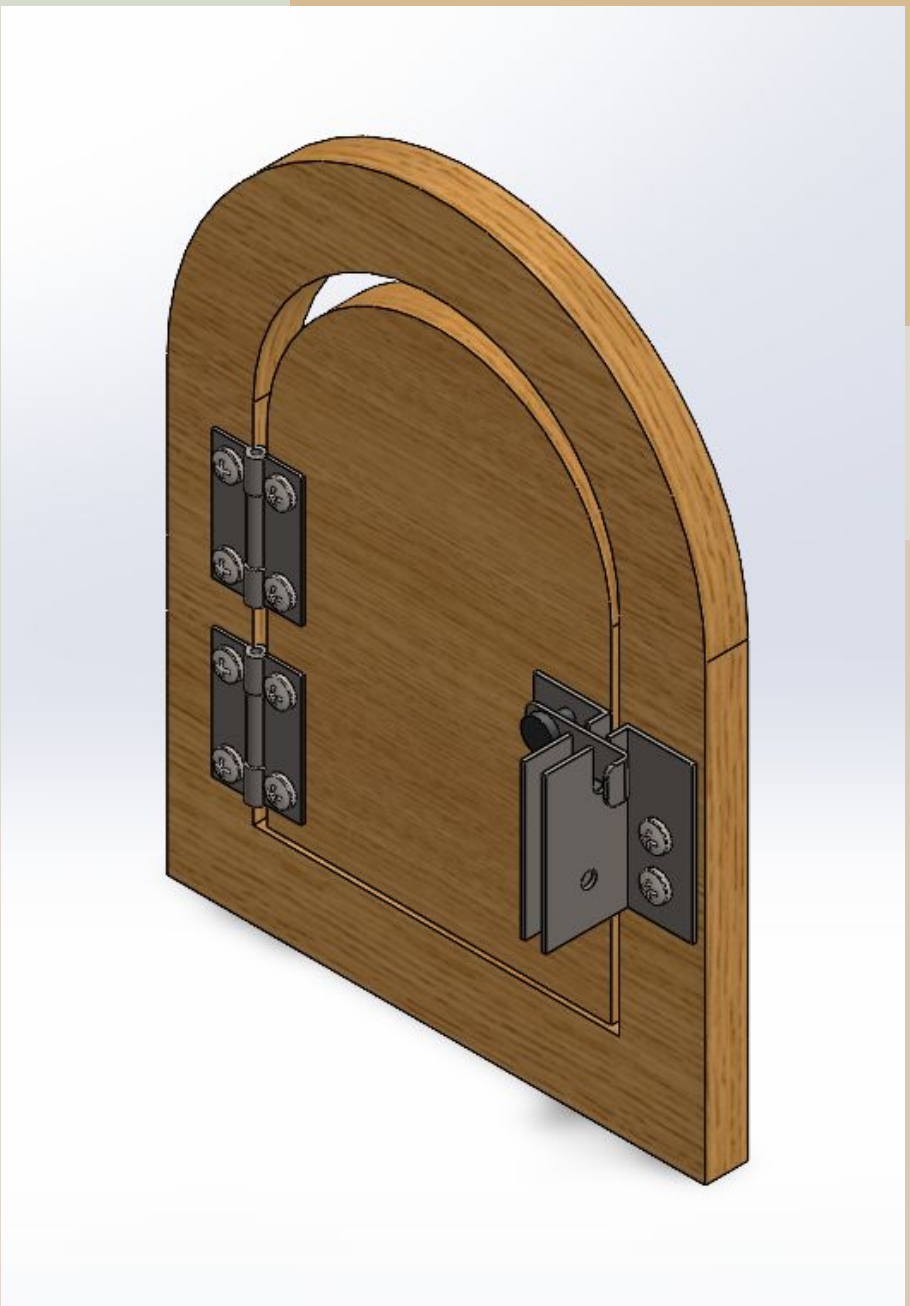
	Question	Answer
1)	How easy was it to use the QR code? (on a scale from one to four)	Average 4
2)	How easy was it to get information from the webpage? (on a scale from one to four)	Average 4
3)	How easy was it to click links to find out more information? (on a scale from one to four)	Average 4
4)	How much did you enjoy viewing the page? (on a scale from one to four)	Average 4
5)	Would you use this page again to check on any information that TBT has to share with parents and visitors? (on a scale from one to four)	Average 3.75



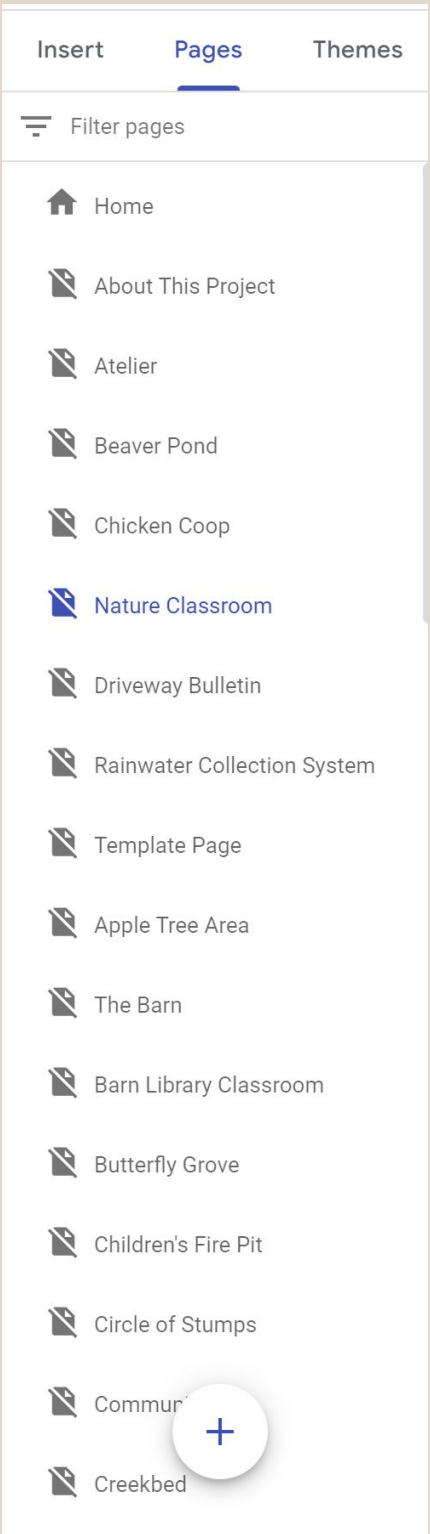
An example of our flyer that we handed out to each of the parents at pick up.

Objective 4: Create a QR Code System

Our method for creating a QR code system was through iterative design and obtaining feedback through surveys with the parents and think-alouds with our IQP cohort and sponsors. In order to complete this, we needed to consider multiple factors, such as website host/design, materials needed/budget for the fairy doors, and designing/building the doors.

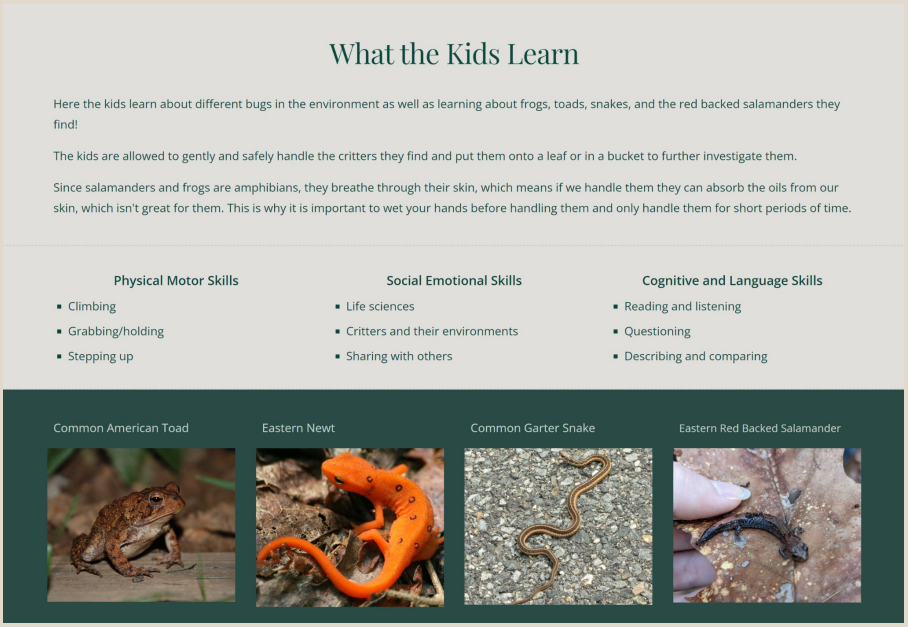


Building The QR Site



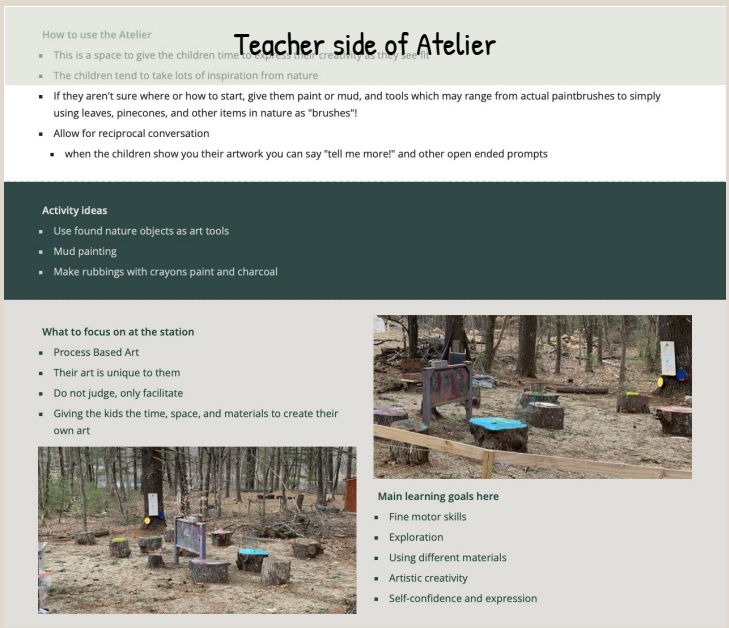
For our QR code system, we had to **set up a website to which the QR codes lead to.** The considered website creators included WordPress, Squarespace, HTML, and Google sites. Of all of them, **Google sites was by far the simplest and easiest to manage and free to use.** With that in mind, we went with Google Sites.

We also created a separate Google account to **help manage where all the information, and QR codes, would be located.** This also is best for the future since having the site saved under a different account will ensure nothing is accidentally deleted.

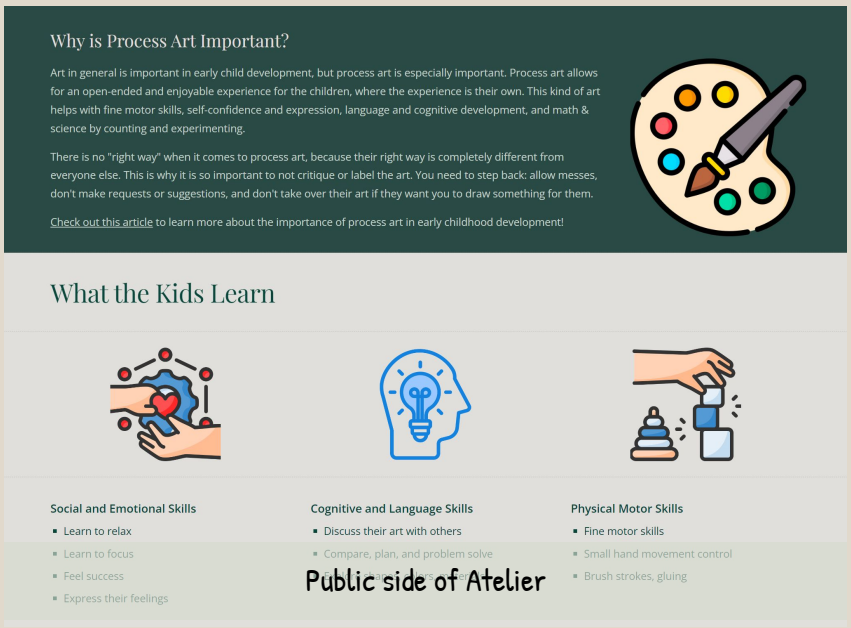


From there, we made a page for each station that our sponsor Ms. Baker listed out for us and then **decided on 6 main sites to work on**: Atelier, Beaver Pond, Chicken Coop, Nature Classroom, Driveway Bulletin, and Rainwater Collection System. We decided on the 6 sites by the **ranking of importance that our sponsors gave us** for each station. We made a separate teacher site and public site to keep the proper information visible to the correct audience.

For the teacher side pages we focused on **what teachers want to know at the sites based on the interviews we conducted**. This includes things the kids enjoy most, different ideas for activities, any safety specifics, and what Massachusetts Education criteria is covered. This will be especially beneficial for newer teachers, but will also be helpful for teachers who have been here a while. This is because **we gathered information from four of the different teachers here, who all have different ideas that the others may have not thought of before**. For example, Veda Bleau gave more suggestions and feedback for the Atelier than the other teachers we interviewed, suggesting us to **use confident language, such as "Say ..." instead of "Try saying ..." to induce confidence on the information on the page**. Another is to give more explicit examples of language to use when speaking with the kids, such as saying **"Wow, you put a lot of time and effort into that, that's great!" instead of "Wow, what a nice beaver you painted!"** to put emphasis on the process of making art rather than the result (V. Bleau, personal communication, April 5, 2023).



Teacher side of Atelier



Public side of Atelier

The public side pages also touch a bit on the teacher side information, but have a **stronger focus on what the kids are learning**. The main things included on each page are: what the station is, what the kids do at the station, some fun facts or links to additional information, social, emotional, physical, & cognitive skills learned, and any articles or IQP project that relates to the station.

At the end of our time here, **we recommend that our sponsors continue to use the Google sites and the account we made for them. It is easy to use and we will provide a tutorial on adding pages and QR codes.**

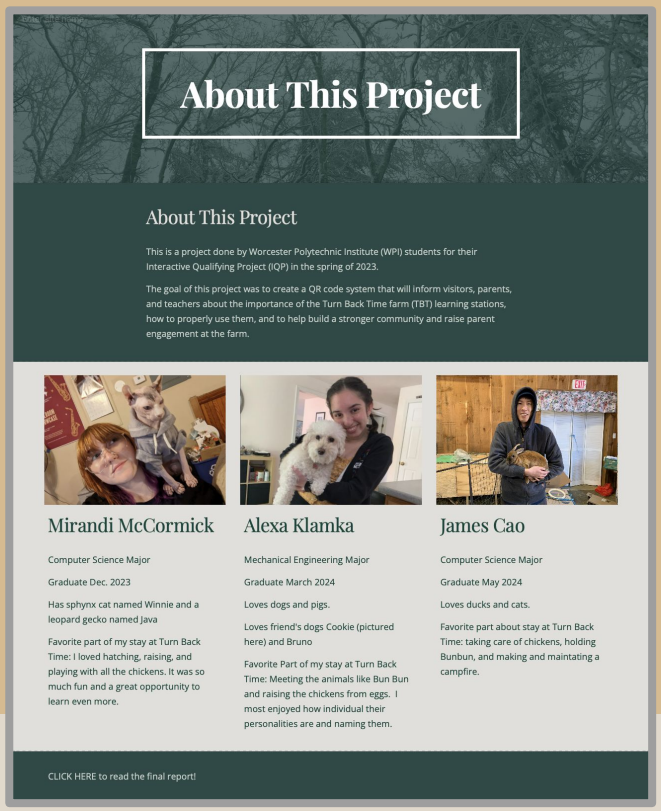
Design Feedback Process

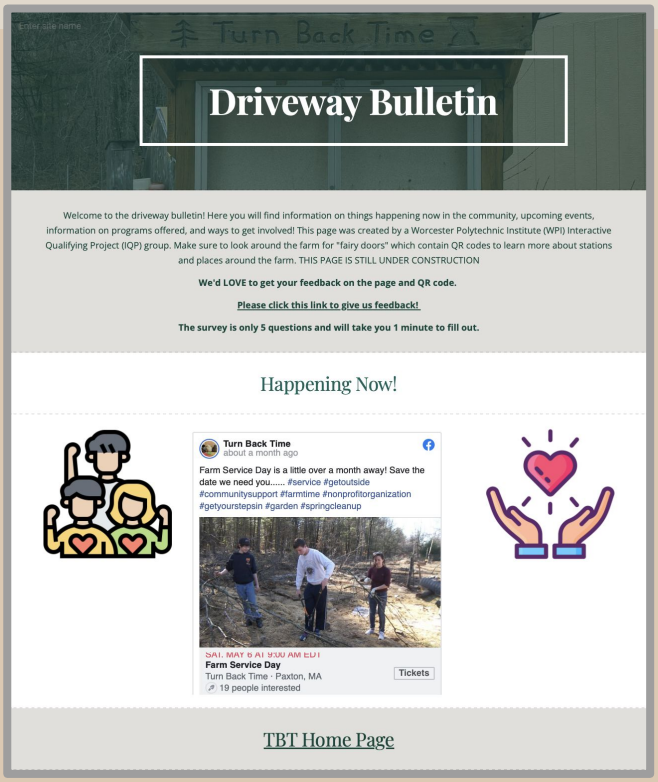
After we created the first iteration of pages, we started gaining feedback from think-alouds with the other IQP at TBT and one of our sponsors. After gaining feedback, we applied our findings to improve our pages through multiple iterations.

One of our findings was **making important links to other websites/pages more obviously clickable** (S. Appiah Kubi, personal communication, April 21, 2023). We implemented this by underlining and bolding links as well as adding "Click here ..." to the more important links.

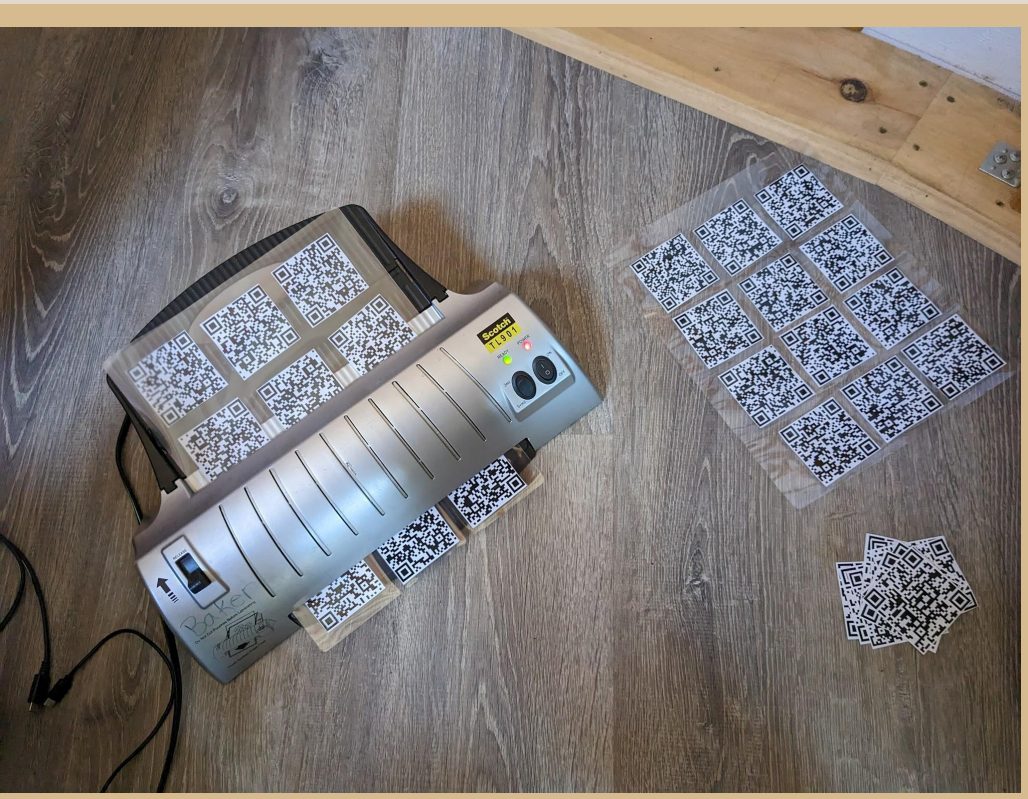
Another finding was that **the front page, or Driveway Bulletin in our case, needs more information about the project itself** (K. Begin, personal communication, April 21, 2023). We made changes based on this by adding more details to the "About this Project" page and adding more details about our project directly on the Driveway Bulletin page. We additionally tweaked the design of the Driveway Bulletin page to differentiate our project from another featured IQP related to the Driveway Bulletin.

Our final major finding was that **the key links of a page should be positioned either at the top or the bottom of the page** (K. Baker, personal communication, April 24, 2023). We implemented this by moving the TBT homepage link closer to the top of the Driveway Bulletin page.



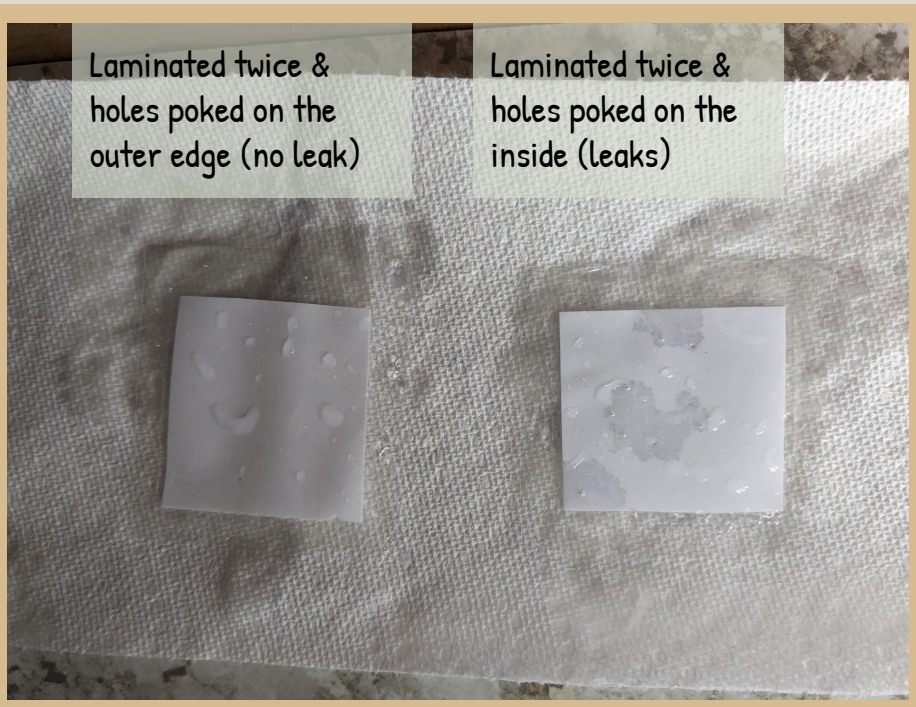


Creating QR codes



For creating the QR codes, we used an **online QR code generator called QR Code Monkey**. It is completely free, and the QR codes do not expire.

In order to keep the QR codes weatherproof, we decided to print them out onto paper, **then double laminate them.** While double laminating them isn't strictly necessary, it allows them to be stapled or nailed in case the epoxy glue holding them to the fairy doors doesn't hold up.



We **tested the double lamination waterproofing by poking holes in double laminated papers** and then submerging them in water. The code was dry when poked on the outer edge, and wet when poked on the inner edge.

We recommend that in the future, if our sponsors need to create more QR codes, they use the same website and laminating method for the best results.

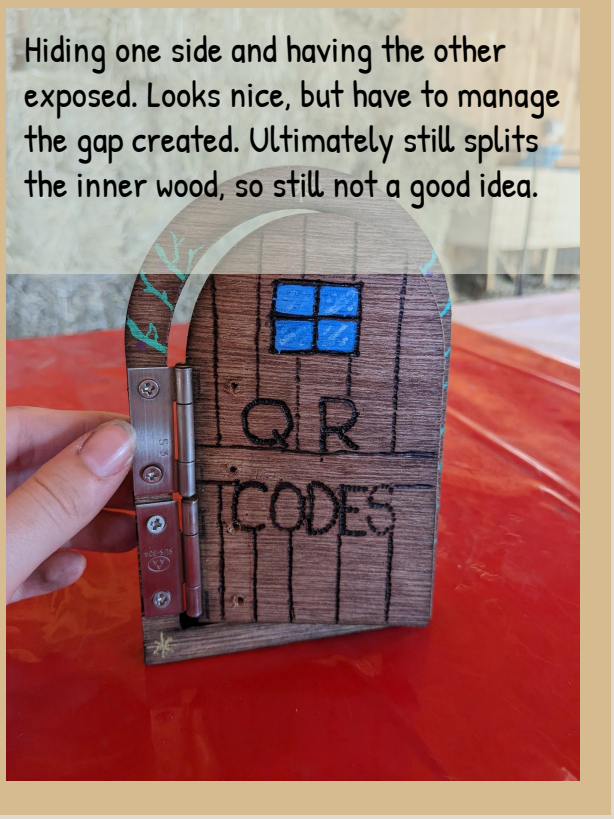
Building The Fairy Doors


Using the laser cutter before we had to stop.

To build the fairy doors, we **used marine grade plywood as the base material since it will last 10-25 years outside** without additional coating. For the hinges and latches we decided on **stainless steel since they will not rust or corrode outside**.

Our original plan was to cut out the doors using a laser cutter at the WPI makerspace. However, a couple of hours into laser cutting, **the plywood created a large amount of fumes**. We were forced out of the makerspace due to being alerted that arsenic may be present in the fumes. We had thought since it was a type of plywood, and plywood was listed on the safe to cut materials, that we would have been okay. However, in retrospect we should have done more research into the specifics.

Below you will see the **original attempt at a laser cut door**, which we successfully cut out on our first time in the makerspace. We then **tried a couple different ways of attaching the hinges** and determined that attaching both parts of the hinge to the front, while not the most aesthetically pleasing, is the best choice for longevity of the doors.



Modified design for ease of cutting

Afterwards, we decided to **manually cut out the doors using a band saw**. We were lucky enough to have access to a band saw that our sponsor provided. We modified our design by **cutting off the bottom in order to allow us to easily cut out the inner piece** with the band saw. Without making this modification, it would have been almost impossible for us to cut out the center part without cutting through the frame.

We then sanded all of the edges down to make them smooth and ensure there is no possibility of getting a splinter from the doors. Next we attached the hinges and latches to the doors. **We then discovered that the latches catch on the door a bit, so we had to sand them down more.**

Next we attached the QR codes to the doors. In order to make sure we knew which was which, we first very lightly wood burned the station names onto the doors. **We then used the epoxy to secure the QR codes onto the back of the doors and finished the wood burning afterward.** We then decorated the doors with the acrylic paint pens and sealed it all up with sealant provided from our sponsor. Finally, we hung the doors using a single screw at the top and 2 u-shape nails, one of each side, to stop the door from swaying when opened and closed

James using the bandsaw

Epoxying the QR Codes on the backs of the doors

Applying Spar Urethane on Doors 1/3

In the end, we made 55 door frames, 50 of which were assembled, and of those, 9 that were fully wood burned, painted, and had a QR code attached. We only hung up 6 plus the driveway bulletin since those were the ones which had completely finished sites.

Chicken Coop Door hung and secured

Rainwater Catchment System Door secured with zipties

Atelier Door hung and secured

Mud Kitchen Door hung and secured

Beaver Pond Door hung and secured

Nature Classroom Door hung and secured

Budget Narrative

In general, **QR codes can be created with little to no cost**. There are many free QR code generators where the QR codes don't expire. The only cost is printing out the codes onto paper. In our case, **we need a solution that will be able to withstand the rain, snow, and sun**. Laminating is an effective method to protect paper because it is easy to do ourselves, and holds up extremely well outdoors. The Ecotarium, a children's science museum with outdoor exhibits, uses this method as well. Our sponsor, Turn Back time, has a laminator that we can use; **so there will be no associated cost**. The QR codes are hosted on a website. Our current plan is to use Google Sites to create the pages, **and Sites is a free service**. As such, **these essential materials for the project are covered by what we have access to at the farm**.

The next part we had to think about was **integrating the QR codes with nature**. The goal was to design the QR codes so they blend in with the natural aesthetic of the farm, but are also eye-catching enough that people notice and want to use them. Here we analyzed three different options: fairy doors, shadow boxes, and bird houses. Our first choice was bird houses because they are commonly found outdoors and pre-made ones would hold up in the weather without much work on our part. **However, most bird houses don't have doors that open**, and the QR code will be hidden inside for aesthetic reasons. In addition, **if a bird family moved into the birdhouse, having people opening the door could be disruptive to their nesting**, and if a mother bird is present she may attack and abandon the nest (Dowd, 2021).

Next, we considered fairy doors. They are simple doors that would sit fairly flush to the surface, and be openable to access the QR code inside. **These would be easy enough for us to make and assemble ourselves. They also would blend well with the environment but still be eye-catching** enough to grab people's attention. Each year, TBT holds a **Fairy Festival** where they have fairy related activities and families bring Fairy Houses they created. **These doors would fit in well to the aesthetic of this major event** and families attending may **be more inclined to interact with them**. Next we analyzed what would be needed for weatherproofing the fairy door - the structure that holds the QR code.

We found Marine Grade Plywood and Stainless Steel mini hinges. **Marine Grade Plywood will hold up outside with no other coating for 10-25 years, and stainless steel will not rust or corrode with the weather**; this will ensure the fairy doors hold up for at least 10 years. We tried to laser cut the doors at the WPI innovation studio, but ended up cutting and assembling them at the farm, and **all of the tools involved were free for us to use**. We then epoxy glued the laminated sheets onto the back of the door frames to hold the QR codes on, the epoxy was only eight dollars. After that we attached the **hinges and swing latches which we purchased on amazon and were a major cost, but necessary.** We then used decking nails from the farm to secure the top of the door frame into trees to hold it in place, these are already at TBT so there is no cost to buy them. For places on the farm which don't have any nailable surface or trees nearby, we plan to use zip ties, which the farm has and does not need to buy, on another nearby surface, such as a rail.

Budget & Materials

Source	Price ($)	Items	Purpose	Notes
Amazon	115.00	10 x Mini Hinges (100 pcs)	Hold Door to Frame	Pack of 10, 2 per door comes with screws, SS, 1.5-inch, #8-32 Holes/Screws
Amazon	140.27	13 x Mini Latches (52 pcs)	To Open Door	pack of 4, 1 per door comes with screws, SS, Brushed Nickel, 1.8" x 1.65", unknown screw/hole size
Home Depot	7.48	Gorilla Glue 2pt epoxy	Adhere QR Code to Door	
McMaster Carr	116.67	Marine Grade plywood 1/2 inch 36" x 48"	To Open Door	Shipping = additional cost, lasts 10-25 years w/out sealing, would create 72 doors in a perfect world, more realistically creates 57
TBT	0	Acetate Sheet	Weatherproof/Hold QR Codes	
TBT	0	Paper	Print QR Codes	
TBT	0	Laminator	Laminate QR Codes w/ Acetate	2x to lock in moisture, leave a space as a border for each
TBT	0	Deck Screws	Hold Door Frame to Tree	about 4" in length
TBT	0	Zipties	Hold door frame to horizontal bar	mainly for rainwater collection station since there are no trees nearby, considering ziptying to metal "cage" at the hose
TBT	0	Wood Burner	Decoration	
TBT	0	Paint/Stain/Sealant	Decoration	Any leftover paint/stain on the farm
TBT	0	Band Saw	Cutting	

Total Price ($)	379.42

**Roughly $8 per door, for a total of 50 doors

	PQP	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7
Assess current information that the sponsors have								
Assess information that we need to gather								
Interview Hitchcock and WAM on the success of their QR systems								
Determine the best way to implement a QR system at TBT farm								
Create outlines for the different sites/docs that the QR codes will link to								
Conduct interviews with teachers and a survey for parents and other testers								
Implement the full QR code system around the farm through an iterative process								

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Authorship Page

Section	Author	Editors
Abstract	James	Mirandi, Alexa, and James
About Us	Mirandi, Alexa, and James	Mirandi, Alexa, and James
Introduction	Mirandi	
1. Background		Mirandi, Alexa, and James
Turn Back Time Farm	Mirandi	
Nature-Based Learning	James	
Communication as a Tool	Alexa, Mirandi	
The Power of QR Codes	Mirandi	
2. Methodology		Mirandi, Alexa, and James
Objective 1	Alexa	
Objective 2	Mirandi	
Objective 3	Alexa	
Objective 4	James	
3. Results		Mirandi, Alexa, and James
Target Audience and Goals	Alexa, Mirandi	
Exploring Systems	Mirandi	
Comparative Analysis	Alexa	
Budget Narrative	Mirandi, James	
Budget & Materials	Mirandi, Alexa, and James	
Teacher Interview Results	Alexa	
Parent Survey Results	Alexa	
Creating QR Codes	James, Mirandi	
Building the QR site	Mirandi, James	
Think-Aloud Results	James	
4. References	Mirandi, Alexa, and James	
5. Authorship	Mirandi, Alexa, and James	
6. Appendices	Mirandi, Alexa, and James	

Appendices

Preamble

We are a group of Worcester Polytechnic Institute students, located in Massachusetts. We are working with Turn Back Time Farm Inc. located in Paxton, Massachusetts, to create a QR code system around the different stations of their farm. These QR codes will provide general information about the importance of nature-based learning, what the stations are and how to use them. Your participation will help us build a community connection at the farm by finding out how to get people to engage with the stations and learn while visiting the farm.

Any interviews and focus groups should take no more than an hour to complete, and surveys should take around 5 minutes. All interviews, focus groups, or surveys are completely voluntary and you can withdraw at any time, and any information gathered will be completely anonymous for surveys and confidential for focus groups. Interviews may be confidential on request.

If you have any questions, comments, or concerns, please feel free to contact us at our group email alias: gr-d23.qrcodes@wpi.edu or our faculty advisor/sponsor eastoddard@wpi.edu

We would also be more than happy to share a final copy of our research with you upon request. This would be sent to you at the conclusion of our study around May 3rd, 2023.

Appendix A: Objective 2 Interviews with QR System Creators

Questions
1) Can you tell us about the process of creating this type of system?
2) How were you inspired to have this kind of system?
3) How long has your system been in place?
4) How does the system work, do you use a website?
5) Have you received feedback on the system from visitors?
6) If you could redesign the system, would you make any changes?
7) Do you have recommendations for someone making a similar system?
8) Do you have any resources that would be helpful in implementing this kind of system?

Appendix B: Objective 3 Interviews with Teachers

Questions
1) What is the main goal of the station?
2) Is the station user-friendly and easy to understand?
3) Is there anything else they would like to see added to the station?
4) Is there any other information they need to know about the station?

Appendix C: Objective 4 Think-Aloud

Tasks
(Beaver pond code) Find and state what the beaver pond water scope is.
(Atelier code) Find and state a cognitive and language skill learned from this station.
(Driveway Bulletin code) Find/reach the “about us” page or equivalent (relative to the QR code IQP).
(Nature Classroom code) Reach the associated WPI IQP page of this station.
(Driveway Bulletin code) Reach the Turn Back Time home page.
(Driveway Bulletin code) Go through the motions for sending a suggestion to TBT Farm (or in this situation, complete the survey).

Appendix D: Objective 4 Feedback Survey

How easy was it to use the QR code? *

	1	2	3	4	
Very Hard	○	○	○	○	Very Easy

How easy was it to get information from the webpage? *

	1	2	3	4	
Very Hard	○	○	○	○	Very Easy

How easy was it to click links to find out more information? *

	1	2	3	4	
Very Hard	○	○	○	○	Very Easy

How much did you enjoy viewing the page? *

	1	2	3	4	
Did not enjoy at all	○	○	○	○	Enjoyed very much

Would you use this page again to check on any information that TBT has to share with parents and visitors? *

	1	2	3	4	
Very unlikely to use it again	○	○	○	○	Very likely to use it again

Any other feedback for suggestions or improvements?

Long answer text