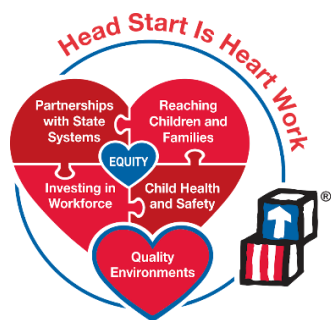


Mill Swan Head Start STEAM Play Space Development



Office of
Head Start



An Interactive Qualifying Project Report
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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This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, see <http://www.wpi.edu/Acedemics/Projects>



Abstract

The project was to develop plans for multiple STEAM-based play features to facilitate the curriculum through outdoor play at Head Start. To gain deeper knowledge of the design process, the team spoke with professionals at local STEAM learning centers. Using observation and interviews, we gained insight into the needs of stakeholder groups. Common themes emerged from the data and a set of criteria was created to determine the top five ideas developed. Two of these ideas were implemented at the preschool through an iterative design process. The team overcame several unexpected setbacks during construction. In our design booklets, learning outcomes, prices, and descriptions of all the designs were developed to assist Mill Swan and other Head Start locations in future play space development.



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Mill Swan Head Start STEAM Play Space Development: Executive Summary

The Project

The main objective of this project was to revive the two outdoor play spaces at Mill Swan Head Start preschool by implementing designs centered around STEAM. The playground and playscape at Mill Swan lack educational and engaging features. This issue has been recognized by all stakeholder groups, such as teachers, staff, and parents.

The teachers and staff care deeply about educational and emotional development of their students and have acknowledged how a renovation of the play areas would boost morale and STEAM learning capabilities. Our mission was to provide Mill Swan Head Start with implemented features that can help advance their STEAM learning and provide the students with a more enjoyable outdoor play experience.

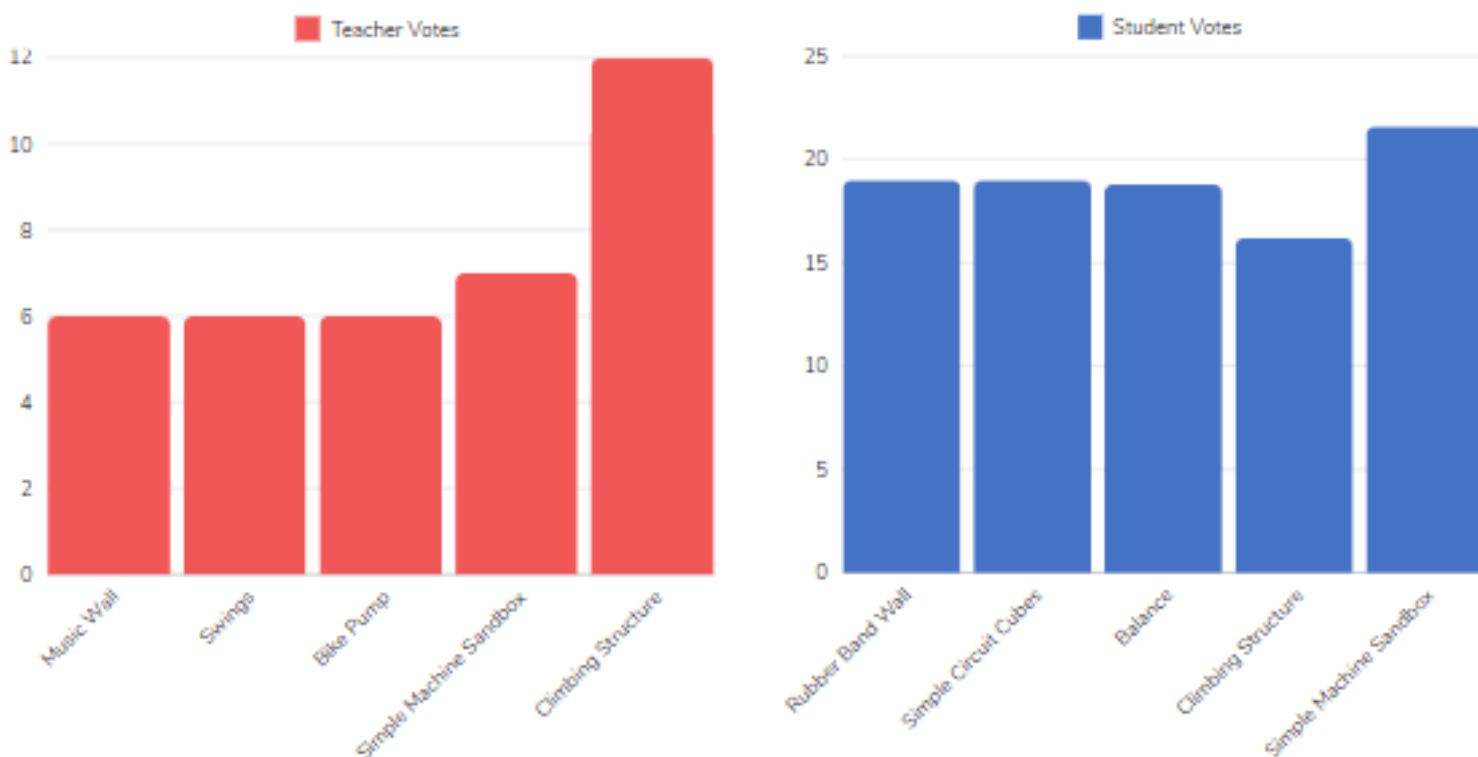
What We Built

**Balance
Bike Pump
Feature Catalog
Design Manual**

Our Research

Our first research strategy was a set of semi-structured interviews. We did these with teachers, parents, and local STEAM learning centers. With teachers and parents, we wanted to learn what the groups liked and didn't like about play areas as well as their dream play features. Additionally, our group wanted to gain advice from people of expertise at the STEAM learning centers to help us with our design and implementation process. Our team also had an interview with our sponsor to discuss the budget and staff restrictions surrounding new play features. Our next research method was observations of children interacting with the Mill Swan playground and playscape. We analyzed equipment popularity, educational benefits, and attention span when using different features. In addition, we went out to the play areas with an experienced Mill Swan staff member to design an interactive social map. The staff member discussed equipment popularity, safety concerns, the nature of the students, and other equipment that she felt was missing in the playground and playscape. With our results, we came up with a list of our top twenty-four designs.

One of our hopes was to get feedback from all groups involved in the Head Start community, and who better than the students who play on the outdoor play areas daily? We conducted a voting activity that allowed students to choose their favorite features from our top designs, hoping to find patterns in their responses and see which ones they liked best. We then conducted a very similar activity with the Mill Swan teachers. We created an online survey with our top twenty-four designs and told them to choose their five favorites.



Once we came up with our top five designs, we held a feedback session with a group of Mill Swan teachers and staff. This was to help get beneficial opinions from people with strong educational experience and make needed adjustments to our top designs before implementation.

What we Learned

The Investment of the Mill Swan Community

1. As a result of our research, we gained a wealth of knowledge to help advance the project. The first takeaway we discovered was how invested the teachers and staff at Mill Swan were. When walking around the school, conducting the interviews, and performing the feedback session, it was apparent how much they cared about the school and the well-being of the students. The sense of community was recognizable throughout our project.

STEAM is Within Reach for a Limited Budget

2. Our next takeaway was that there is inexpensive and attainable STEAM equipment around us. One of our biggest restrictions in this project was the lack of budget that we had to carry out implementation. Although this limitation constricted which features we could pursue, we were able to find inexpensive alternatives that provided strong STEAM benefits.

Curious Children Challenge Design Integrity

3. Our third takeaway was how young children are highly creative and find multiple ways to use the same feature. When doing our observations, we noticed that the students used different pieces of equipment in unique ways. For example, some students used the sandbox as a place to dig, whereas others used the edge as a balance beam. Keeping in mind how a feature can allow children to be as creative as possible became a central focus of our group.

Composing a List of Top Designs Based on Stakeholder Recommendations

4. Our final takeaway was coming up with our top twenty-four designs based on multiple different sources. By considering the viewpoints of all stakeholder groups, we conducted in-depth research into engaging STEAM play equipment. Through all of our research, we formulated our top twenty-four designs.

A Systematic Approach

Once we created our top twenty-four designs, our team wanted to narrow the list down to five features possible for implementation. We created a value analysis with the goal of systematically ranking our feature ideas with weighted categories. Each category has meaning to the overall importance and benefits of the feature. The categories include ease of construction, popularity among teachers, popularity among students, durability, weatherproofing, cost, STEAM benefits, maintenance, and risk factors. We achieved our top five designs based on the highest performance in the value analysis. These top five designs include the water bicycle pump and Lego water flow, the climbing structure, balance, a simple machine sand tool, and a shadow tarp.

The Top Five

1.



The **bike pump** is a structure that carries water up a PVC pipe track from a basin holding water underground. It is a hand-operated water pump with a rope that rotates around a bike wheel. There are stoppers on the rope that are airtight to the PVC pipe and suction water up the track and release out of the spout.

2.



The **climbing structure** allows the children to climb using rock climbing pegs and cargo nets. The feature also contains a slide, a handle made of PVC pipe for creating music, and a secluded area where children can go under the platform.

3.



The **balance** is a “t” shaped wooden structure where the horizontal post had buckets hanging from it. It can rotate based on its middle axis based on the weight of objects put into each bucket.

4.



The **Sandbox digging tool** is a piece that allows children to grab sand and move it around to other areas within its radius. It can rotate around and has a grabbing piece on the end that can open and close with handles that the user can control.

5.



The **shadow tarp** is a tarp with cutouts of different animals and designs that cast shadows on the playground. The children can use their creativity to play with the shadows and see how the direction of the sun changes over time.

Moving Forward



Due to this project's duration, we could not implement all our intended designs, so we left Mill Swan with recommendations for future consideration. The three designs from our top five that we did not have the resources to pursue were a climbing structure, a shadow tarp, and a simple machine sand tool. Our data analysis has proved that these designs will greatly benefit the space and student learning.

The next recommendation for Head Start is to contact individuals we met throughout the term to help them implement the additional play features. Our team has conversed with the Worcester Technical High School carpentry division head. They are open to new projects and have shown interest in building our climbing structure. We were also able to get in contact with the company BlueHive. They are a local exhibit company that we were told would consider giving our project team discounted material. We recommend Head Start reaches out to them for materials if they build the climbing structure.



Finally, we left Mill Swan with two informative booklets. The first one lists the top five designs, their description, and their educational benefits. The booklet also displays the designs that did not make the top five, if Mill Swan is interested in adding more to their play areas. The second booklet has the CAD (computer-aided design) drawings of our top five designs. If Mill Swan or any other Worcester Head Starts were interested in building any of our top five designs, they could bring the booklet with the CAD drawings to a manufacturer and they could build the feature for them.



Conclusion

In closing, we aimed to help better the play areas of the Mill Swan Preschool and we felt that we achieved that. We were able to implement three complex play features with strong STEAM benefits on a limited budget. By taking a systematic approach to the project, we were able to consider the needs of all stakeholder groups, research impactful and amusing features, and learn valuable information about both the design and implementation processes. We hope that our small impact on the Mill Swan community will help them give their students the strong educational foundation that they deserve.



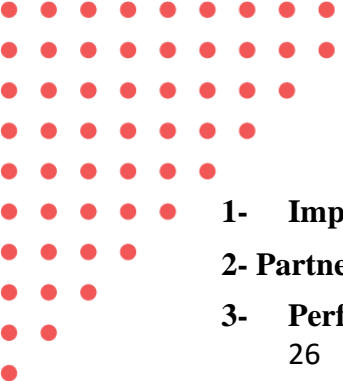
Acknowledgments

Our team would like to take a moment to thank those who helped to make this project possible and bring implemented play features to the child population of Head Start. We greatly appreciate the WPI Worcester Community Project Center for providing our team with the necessary funds to purchase the materials needed for the features designed. This project could not have been completed without the staff of Mill Swan Head Start Preschool who were always excited to get involved and happy to answer any of our questions. We would also like to thank Karen Waters, the Assistant Director of Head Start in Worcester, who worked closely with our team to make sure we were able to meet the needs of the community at Mill Swan. We would also like to give a special thanks to Professor Kurlanska, who assisted our team in taking on a difficult project with a limited time frame and seeing that it was completed. We also appreciate the time that the Worcester Community Project Center Cohort put into helping our group during implementation day. Lastly, we would also like to thank all of those who took the time to participate in our interviews, including parents, teachers, and staff members of the Ecoterium, Acton Children's Museum, and Connecticut Science Center.



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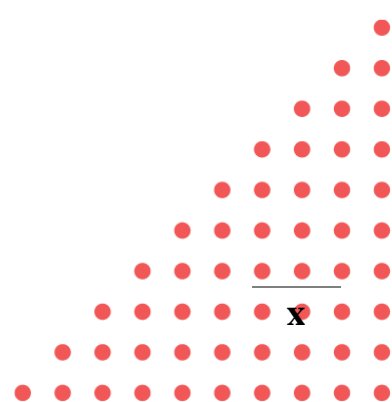




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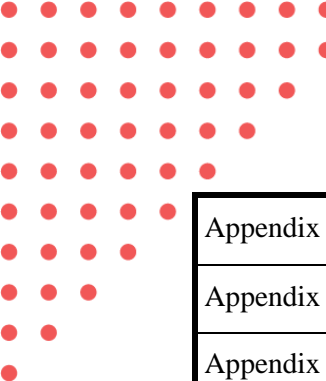


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Appendix A- Safety Regulations in Playgrounds	Mike Gates



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Appendix C- Parent Guide	Mike Gates
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Appendix F- Play Area Observation Sheets	Will Barton
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Appendix N- All Design Ideas from Stakeholder Interviews and Visits	Mike Gates, Will Barton
Appendix O- Value Analysis	Mike Gates, Will Barton
Appendix P- Feature Catalog	Madison Morales
Appendix Q- Design Booklet	Madison Morales, Mike Gates



Introduction

What happened to playing tag outside? Or make-believe games? Hopscotch? Children used to spend their free time running around outside, breathing in the fresh air, immersed in nature, and creating their enjoyment from the things around them. Nowadays, children binge-watch television or play the new hit video games. Online play leads to obesity, violence, impaired academic progress, and behavioral problems (Christensen, 2021). This shift in playtime habits can have a significant impact on a child's development, as screen time leaves little room for creativity and imagination (Christensen, 2021). When children are immersed in nature, they take an interest in science, technology, engineering, arts, and mathematics - called STEAM (Prins et al., 2022). These topics all share a common trait: curiosity, which must be encouraged in early childhood. STEAM learning implemented through play is an emerging concept prevalent in preschools all over. The Mill Swan Head Start Preschool is looking to do the same. The goal of this project is to create designs that can be implemented in Head Start locations everywhere and implement the top design in the play areas at Mill Swan Head Start. Let us inspire the next generation to connect with nature, explore their curiosity, and develop the skills they need to succeed in life.

To gain a better understanding of the key components of an outdoor STEAM play space we have conducted in-depth research within three broad topics. These topics include early childhood education, STEAM learning, and outdoor play spaces. We will summarize the information from each section and relate it to the problem we are addressing. Through our research, we have come to understand how the curriculum of early education is related to STEAM, and how we can integrate aspects of the curriculum and STEAM into the outdoor play spaces at the Mill Swan Head Start. In the following chapter, we will discuss how we used qualitative and quantitative research methods such as semi-structured interviews, observation, focus groups, surveys, and a voting activity to collect data. This data helped the group to understand the wants and needs of the Mill Swan community, learn about the design process associated with early education play features, and develop a list of potential features based on a triangulation of ideas from separate sources. In our findings chapter, major takeaways from our objectives will be explained. We will discuss how we came to learn how invested the stakeholder groups of this project are in its outcome, how budget constraints made room for resourcefulness, how designs can be adjusted to accommodate children's creativity, and how a list of ideas could be formulated from the qualitative data collected. We will end this report by discussing how we were able to come up with the most important ideas and create designs for them, as well as implement two of the designs at Mill Swan Preschool. We will also provide recommended steps for Mill Swan to take in the future with the designs and information gathered throughout the project.

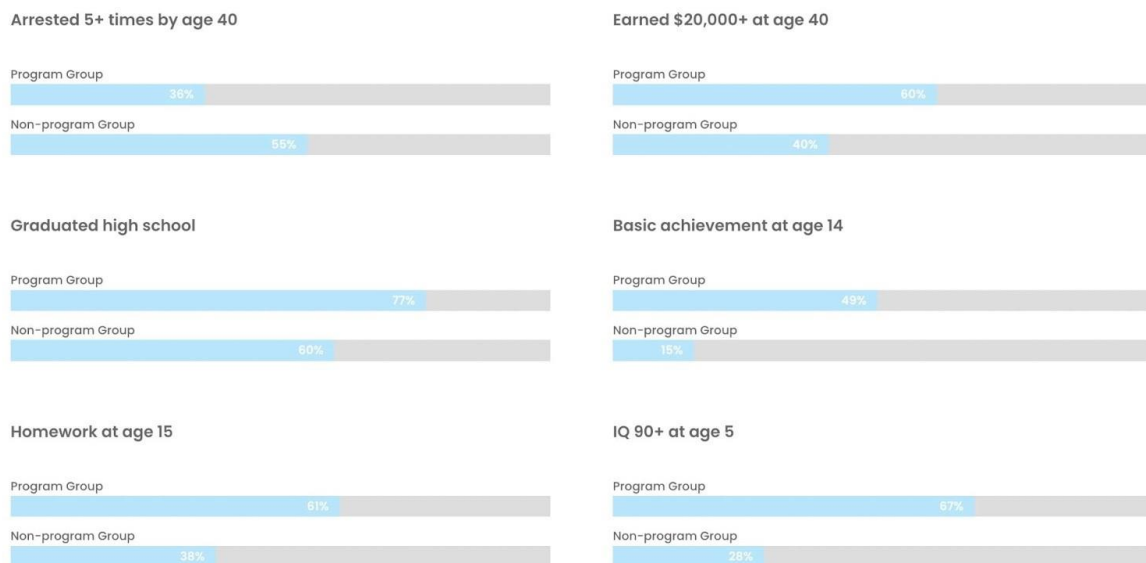
Background

Children are the future of society; it is important to nurture them and give them tools to be successful in the new tomorrow. Head Start allows students of all backgrounds to develop a strong educational foundation through interactive curriculum, STEAM (science, technology, art, engineering, and mathematics) learning, and play. Understanding these topics will assist in the design and implementation of play features for preschool-age children.

1 - Early Education

Early Childhood Education (ECE) plays a crucial role in the development of young children. Preschool attendance can alter a child's educational journey tremendously in the future. Preschoolers are typically between three to five years old. By the age of five, ninety percent of a child's brain is developed (Mirfattah, 2020), so it is important to implement learning skills before this stage. Children who attend preschool are proven to have greater future success than those who do not. This was found in two separate studies, the Perry Project and a federal outcomes study observing Head Start students. Results from these studies show the positive effects of attending a preschool and that children of all backgrounds should be able to attend an enriching preschool to set them up for life. In both studies, students who attended preschool were more likely to graduate high school, pursue higher education, and earn higher incomes (Highscope, 2018; Bailey, 2021). Figure 1 displays some results of the Perry Project.

Figure 1.
Statistics from the Perry Project



Note: The Perry Project results in 40 years after attendance/no attendance in preschool (Highscope, 2018)



1.1 How Play Correlates to Development in Early Childhood Education

During preschool, children learn social, emotional, cognitive, language, and physical skills. Preschoolers develop emotionally by learning how to regulate emotions when presented with an upsetting or angering situation. In addition, they learn self-confidence through play, stress management, and the trait of empathy (Early Childhood Learning & Knowledge Center, 2021). Socially, children learn the ability to interact with other children, collaborative skills, and trust (Early Childhood Learning & Knowledge Center, 2021). Cognitive development includes imagination and problem-solving. When entering preschool, the children are immersed in a unique environment and exposed to a new language, expanding their vocabulary (*Vocabulary | ECLKC*, 2018).

A contributing component of ECE that allows children to obtain these developmental milestones is play. At preschool age, play is one of the main ways children learn this wide set of skills to prepare them for future education in kindergarten (Burriss & Tsao, 2002). Various aspects of play support different areas of the classroom and development. For instance, the play preschoolers must partake in to develop these skills is self-directed as opposed to structured by an adult (Lockhart, 2010). Individually, children choose the direction and content of how they play, which develops strong language and literacy skills. An example of structured play is a teacher giving an instructed task on how to play with a certain toy, for example, building a house out of blocks. On the other hand, unstructured play looks like giving children a set of building blocks and allowing them to use their imagination and create anything. In addition, it has been shown, the use of physical play before an in-class lesson has been shown to increase attention span within an in-class lesson (Lundy & Trawick-Smith, 2020). Also, play helps a child develop their personality by discovering a combination of different skills (Burriss & Tsao, 2002).

The type of play that a child participates in encourages the development of different skills within the five development categories. There is a general list of eleven types of play which include unoccupied play, independent play, symbolic play, onlooker play, parallel play, associative play, cooperative play, dramatic play, competitive play, physical play, and constructive play (Harris, 2022). These stages of play start from birth and work their way up to childhood once children learn to play collaboratively. The combination of unoccupied, independent, symbolic, onlooker, parallel, and associative play allows the child to build crucial skills for participating in cooperative play (Harris, 2022). Cooperative play often begins around the age of three to five when children begin to play with other children interactively. More commonly this stage begins during preschool, since this is often the first time a child is introduced to other children their age in a larger group setting. However, to reach cooperative play, fundamentally, children learn the previous forms of play as stated above, it can be seen how these six stages of play correlate with each other in Figure 2.

Figure 2.
Types of Play



ILLUSTRATION BY JOSHUA SEONG

Note: Six of the eleven early childhood stages of play for development (Harris, 2022)

After children gain cooperative play skills they move on to dramatic, competitive, constructive, and physical play. All types of play may be found in a preschool environment; however, these are the main play types after cooperative play and may be conducted alone or together. Refer to Figure 3 below for descriptions and examples of these types of play.

Figure 3.

Descriptions of Types of Play

Type of Play	Definition	Developmental Skills Gained	Example of Play
Competitive Play	Occurs when a child interacts with other children in a type of game	Promotes teamwork skills, acceptance of failure, and following rules	Five-year old's playing kickball
Dramatic Play	A child engages in pretend scenarios sourced from their imagination or experiences, they have witnessed	Promotes self-confidence and individual language development	A child saw a coffee shop worker and pretended to make coffee
Constructive Play	As it sounds, a child uses physical building materials to construct objects	Helps children practice working memory recall and problem-solving skills	A child must remember what a staircase looks like to mimic and build it out of magnetic tiles (Lockhart, 2010)
Physical Play	A child partaking in play that utilizes their body for movement	Healthy lifestyle and develop fine motor skills (Brearley, 2022)	A child playing on a climbing structure

Note: Four of the eleven early childhood stages of play for development after cooperative play

1.2 Teaching Philosophies

Several specific approaches to early childhood education value different learning skills at various levels of importance. Some of these popular non-traditional learning styles include the Waldorf, Montessori, and Reggio Emilia approaches. The most important aspects of the Waldorf approach are a child's freedom and a comprehensive approach while, the Montessori approach focuses on the child's interests and values and the development of the whole child including heart and soul (Aljabreen, 2020). The approaches intertwine with similar importance of their philosophies but vary slightly and originated at various times.

The Reggio Emilia approach was founded in Northern Italy by Loris Malaguzzi looking to alter education after World War II (Aljabreen, 2020). The purpose of this education style was to be progressive, democratic, and social constructivist rather than the limited education during the war (Aljabreen, 2020) In this teaching style, the children are seen as capable of discovering and exploring the world referred to as "knowledge makers" (Aljabreen, 2020). The children are naturally creative and allowed to express their findings in 100 different languages, such as exploring an animal in a science context or an art context like clay (Hargraves, 2020). In addition to children learning through their experiences, the teachers are seen as professional researchers (Aljabreen, 2020). The teaching style is project-based, and educators are encouraged to adapt to the individual children and study their behaviors to develop activities the children would like to engage in. Lastly, the children's environment is their third "teacher" since they learn through experimentation by interacting with their carefully curated environment (Hargraves, 2020). The child is like a sponge in their environment, and they will only learn based on what they are given whether it be art, science, reading, etc. Going hand in hand with the framework of Reggio Emilia, STEAM concepts offer the same benefits of hands-on science and art learning experiences for its users.



2 – The Power of STEAM

STEAM is an expansion of STEM (Science, Technology, Engineering, and Math) by incorporating "Arts". It merges technical and creative spheres for a more comprehensive understanding. STEM, an interdisciplinary approach encompassing science, technology, engineering, and mathematics, aims to equip students with problem-solving skills for real-world issues. However, its analytical and technical focus can leave students lacking in areas like art and humanities (Educational Wave, 2024).

STEAM education promotes a comprehensive approach that challenges students to address real-world scientific issues with a focus on their impact on society. Students are more prepared to tackle challenges with compassion and contribute to a sustainable and socially aware future by recognizing the influence of STEAM education.

STEAM is perceived as an enhancement of STEM, emphasizing the development of soft skills such as collaboration and creativity. By intertwining arts with hard sciences, STEAM enables students to solve problems both creatively and analytically, fostering a well-rounded approach that balances technical knowledge with other disciplines (UCF online, 2020). 020).

As we delve deeper into the understanding of STEAM, it becomes evident that its principles naturally manifest in children's everyday lives as they explore, play, and engage in new experiences. Teachers influenced by integrated professional development in STEAM positively shape children's learning experiences (Wahyuningsih et al., 2020). Another notable outcome is the enhancement of children's self-confidence through exposure to STEAM. Additionally, the integration of skills needed by children is considered a hallmark of STEAM learning. By promoting observation, investigation, and questioning, STEAM encourages children to construct knowledge about the world around them (Wahyuningsih et al., 2020).

Young children mostly learn through participation, exploration, play, and investigation. STEAM is about interactive learning where the children are exposed to hands-on activities such as examining shapes and building forts from cardboard boxes, among others. It helps children establish a lifelong love for learning, build confidence and self-esteem, and improve communication skills both academically and personally (Team, 2022).

3 - Outdoor Play Spaces

In the scope of early education, it is important to understand the impact that outdoor play associated with STEAM education can have on students. Skills that have surfaced from STEAM-based play include creative thinking, problem-solving, and enhanced development in literature (Vartiainen, 2021; Opperman, 2016). Outdoor classrooms and learning result in the same child development that can be elicited from indoor STEAM education with an additive of physical development, and more opportunities for creative thinking (Kemple et al., 2016). The learning outcomes of outdoor environments are related to STEAM; creativity, cognitive development, and attention are all proven to be a result (Kemple et al., 2016). Students learn through discoveries generated by their autonomous interactions.

Forest Kindergartens, classrooms based outdoors with unstructured and structured lessons, are one example of the outdoors' beneficial effects. Data collection based on observed behaviors of the children in Forest Kindergartens was synthesized to discover three main categories: creativity, autonomy, and play (CAP) (Hunter-Doniger, 2021). Another study compared children (ages four to seven) playing in a standard playground versus a nature-based play space. The children played for ten minutes, and their speech was recorded. The children immersed in nature developed a more diverse set of words within their language. In addition, the language they used

was more STEAM-focused since they described their surroundings in the nature play space (Prins et al., 2022). Both examples highlight the importance of not only outdoor play, but also the involvement of nature with unstructured early education play. By implementing natural elements for children to observe and entertain, skills like creativity and cognitive abilities are expedited in their development. This is the main goal of a new play structure: playscapes.

3.1 - Playscapes and STEAM

Both playgrounds and playscapes can be effective ways of integrating STEAM learning into a child's curriculum. In coordination with the findings of the Forest Kindergarten, playscapes are a new concept in which nature is integrated into a child's surroundings. Playscapes are open areas with little human integration that make use of natural landscapes and features as areas in which children can play. (Carr, 2014) These spaces are often rich in natural features such as water and plants. The major principles of playscapes are to create an environment that encourages hands-on sensory experiences, allows for several different uses, incorporates plants and other natural materials, and encourages child-directed play. (Carr, 2014). Playscapes allow children to investigate natural elements and ask questions, facilitating scientific thinking. This investigation is a natural side effect of curiosity. Playscapes also allow children to create and develop their means of play, as opposed to the predetermined elements in a playground. Instead of sliding down a slide, children may play with the rocks in the ground, make up games in the tree line, or build forts out of loose natural elements (Figure 4).

Figure 4.
Child in a playscape.



Note: A child constructing a fort from loose sticks and logs in a playscape. (Carr, 2014)

The most beneficial aspect of playscapes is loose elements- objects that children can pick up and reimagine the use of. This fosters creative thinking, forcing the children to produce ways to have

fun and interact with their environment. This same style, and its positive results on CAP and STEAM learning, are described by studies of the Forest Kindergarten (Hunter-Doniger, 2021).

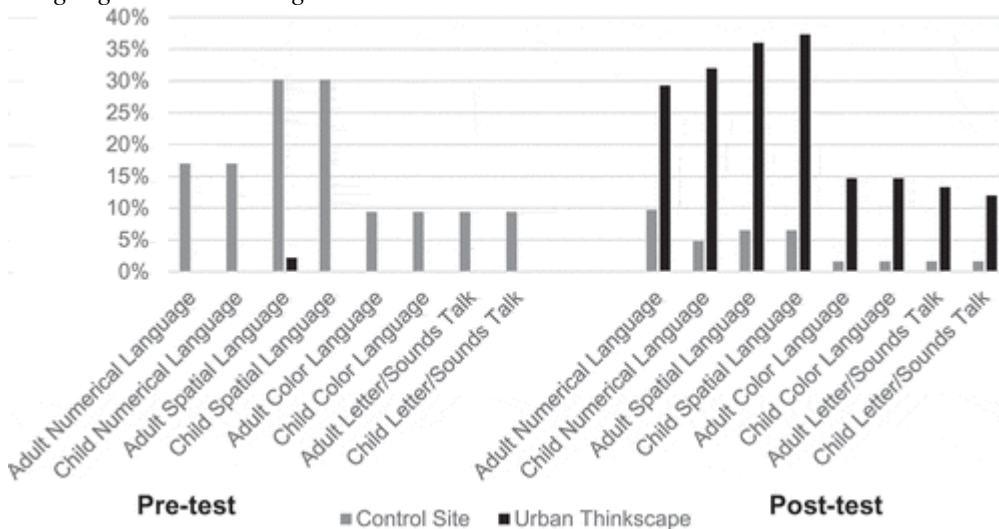
3.2 - Playgrounds and STEAM

While the benefits from nature-based outdoor play are overwhelming, the common playground still holds value as a vessel to bring STEAM education to play. With the lack of natural elements, there is room for manufactured elements that can target specific skills or topics. As a result, several different opportunities for features surface. The basic topics for these features, related to the STEAM acronymic meaning, include sensory adaptation, engineering, problem-solving, physics, and mathematics (May Recreation Content Team, 2023).

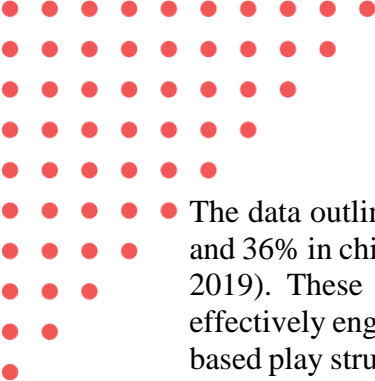
One example of a strategy to involve STEAM in a playground setting is the creation of simple machines based on the principles of engineering in the playground. These simple machines could include things like simple pulley systems between platform levels, moving platforms, shovels on wheels, or excavators in the sand pit (Zhu, 2022). These machines are the primitive aspects of subjects like mechanical engineering and physics and can introduce children to the fascinating aspects without the complex math and topics behind them (Zhu, 2022). Effectively illuminating their curiosity, these simple machines are efficient in introducing STEAM in a playground environment.

Another strategy for engaging children in creative problem-solving activities is to incorporate structures into urban settings such as public parks or bus stops. A concept called Urban Thinkscapes describes a variety of puzzle games and structures intended to initiate interaction. These structures target the same skills mentioned in methods like the Forest Kindergarten. To measure the influence of these structures, a study was conducted in which the language used by children in a control setting as well as an Urban Thinkscape setting was recorded and compared. Figure 5 depicts the data collected in this study.

Figure 5.
Language Use Percentages.



Note: Percentages of categorized language usage in a controlled setting and Urban Thinkscape (Hassigner-Das, 2019)



The data outlined in this study shows drastic increases of about 32% in child numerical language and 36% in child spatial language because of interactions with Urban Thinkscapes (Hassinger-Das, 2019). These language developments indirectly support the idea that Urban Thinkscapes are effectively engaging students in STEAM topics. The data also shows that the influence of STEAM-based play structures not only contributes to essential skills but also helps to develop the vernacular of children in subjects like numbers and in-depth descriptions early in their education. These kinds of structures are a straightforward way to implement learning in public spaces and can easily be applied to a setting like a public playground. One thing to consider when creating playground equipment is the safety regulations, which are described in Appendix A.

4 – Our Project

It has been demonstrated that encouraging STEAM-focused development through play is a crucial aspect of ECE. To ensure that children from all backgrounds have access to a STEAM-oriented education, Head Start has provided funding to underprivileged preschools. For more information on the history of the Head Start program, please visit Appendix B. One of the four Worcester locations, Mill Swan Preschool, is lacking in STEAM-designed outdoor play spaces. While the preschool has two designated outdoor play areas, they have not been updated to align with Head Start’s goal of enhancing young children’s exposure to STEAM. Our mission is to create two designs for these outdoor play spaces that incorporate STEAM into their current designs. In addition, we aim to create an engaging space that will be admired by the Head Start team, teachers, and parents, but most importantly, it will excite the children.

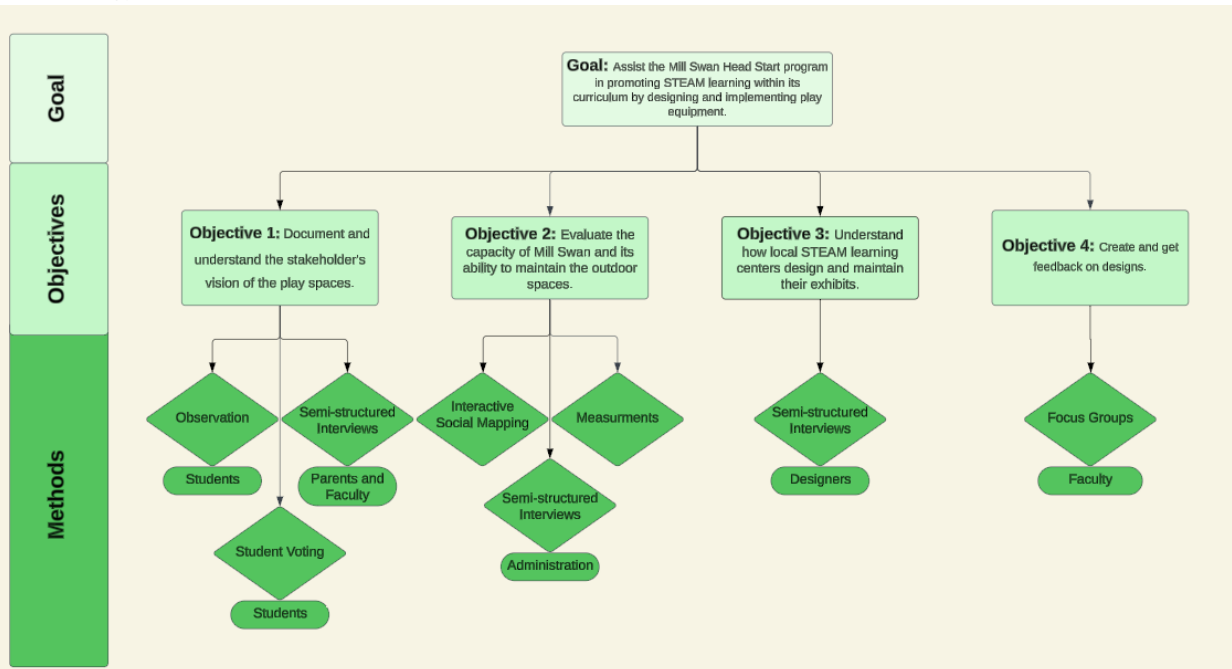
To appropriately prepare the next generation, early education must provide its students with the correct tools to implement on their journey. This task is accomplished by STEAM integration through play. Early implementation of STEAM thinking will allow for future educational success. The creation of playscapes and playgrounds with STEAM-focused attributes can fill the gap in STEAM education in places like Head Start. Stuart Brown, the founder of the National Institute for Play, delivers a summarized remark on the importance of play. “Play is anything that spontaneously is done for its own sake... appears purposeless, produces pleasure and joy, leads one to the next stage of mastery” (Lockhart, 2010). We hope, through the application of our background knowledge, we can augment the curriculum at Mill Swan and create plans to better the preschool through the addition of STEAM-based features in the playground and playscape.

Methodology

The goal of our project was to assist the Mill Swan Head Start program in promoting STEAM learning within its curriculum by designing and implementing outdoor play equipment. The equipment will aid in developing lifelong learning skills to carry into higher levels of education. For the successful completion of this goal, qualitative research on the program's stakeholders was required to develop an understanding of effective strategies for STEAM integration. To reach a valid conclusion in our research, we summarized our methods into four main objectives:

- 1) Document and understand the stakeholder's vision of the play spaces.
- 2) Evaluate the capacity of Mill Swan and its ability to maintain the outdoor spaces.
- 3) Understand how local STEAM learning centers design and maintain their exhibits.
- 4) Create and get feedback on designs.

Figure 6.
Methodology Flowchart



Note: Figure 6. Provides an outline of how our methods and objectives are related and helped us to reach our goal.

In the flowchart above (Figure 6), methods are shown that will be used to achieve the respective objectives. In this chapter, we will explain each method that is used in our project and justify its effectiveness regarding our need for qualitative information. Some methods are used multiple times, and each instance will be explained.



1 - Semi-Structured Interviews

We used semi-structured interviews with four different populations to target three different topics. We chose to implement semi-structured interviews because the questions included in this interview structure elicit different perspectives besides that of the interviewer. Semi-structured interviews also allow us to gather an insider's perspective while keeping the interview on task. (Berg, 2012).

Our first round of semi-structured interviews took place with teachers and parents. The interviews with the Head Start teachers lasted around 20 minutes each, and we did three rounds of interviews with separate teachers. Five teachers were included in the interviews, due to unexpected participants in the first round. We asked the same questions to each staff member and these questions are available in Appendix C. We recorded and transcribed the interviews identically. We also performed semi-structured interviews with ten parents individually to get their input on features their kids enjoy and what they wanted to see implemented in the Mill Swan outdoor play spaces. The interviews only lasted around two minutes each because they occurred at drop-off time at Mill Swan and parents were in a rush to leave. We asked three questions to each parent and wrote down their responses on paper. These questions can also be seen in Appendix C.

We also interviewed Karen Waters, the assistant director of Worcester Head Start, for another semi-structured interview. The focus of this interview was to understand the logistical limitations and capacity of the Head Start organizations in Worcester. The questions can be found in Appendix D. To analyze the data our team recorded and transcribed the interview to pull out valuable information such as specific budget details and how they envisioned sustaining our play space designs.

The last round of semi-structured interviews we did was with experts at local STEAM learning centers. Our team visited the Acton Discovery Museum, the Connecticut Science Center, and the EcoTarium. We sat down with members of their teams who had vast knowledge of STEAM learning, exhibit design, and feature maintenance. We asked numerous questions on how they came about their designs, what equipment they feel is most successful in their space, and how to best utilize the space you are working with. These questions are visible in Appendix E. We also had time to explore the facilities and gained inspiration from their exhibits for our designs.

For all three rounds of semi-structured interviews, all team members took notes of the responses, and those notes were then condensed into a single document. For the teacher, stakeholder, and STEAM learning center director interviews, we had audio recordings and transcribed the responses to strengthen our data. For the parent interviews, we relied on our notes due to the fast pace of the conversations. After consolidating the team's notes, each set was then coded to determine common themes and ideas that were brought to light with the interview questions. The codes used for each interview differed for the group and question sets. Coding is a process of dividing the interview notes into sections based on their main thematic ideas, and then dividing these themes into overarching codes. This allows the data to be organized productively for analysis (Beebe, 2014). In the margins, we wrote our thoughts as we read the data.



2 - Observations

To understand what kinds of play space features engaged and held the attention of preschoolers specific to Mill Swan, we observed their playtime. Differences in age and education level between the research team and the children prevented us from carrying out participant observation. The team's presence in the playground could have made the children act differently or made them (and their parents) feel uncomfortable (LeCompte, Schensul, 2010). Our team observed quietly in the play areas to try to let the children play as naturally as possible. We used descriptive observation, meaning we recorded as many details as possible. This is because our team was in the first stage of research without much information to narrow our focus (LeCompte, Schensul, 2010). We did observations in both the playground and play space areas at Mill Swan. Some of the key aspects the team looked for included the duration of interaction with playground features, the type of play occurring, and anything that drew the children's attention. A more detailed list of observation points is visible in Appendix F in the observation sheets we created. We each had an observation sheet and focused on one piece of equipment at a time for 15-minute intervals. The observations lasted around three hours, for twelve hours as a team. We then transcribed all our observation sheets and put them in a spreadsheet to have quantifiable data. This spreadsheet can be seen in Appendix G.

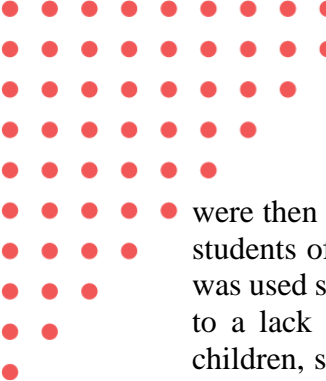
3 - Interactive Social Mapping

To deepen our knowledge of the play areas and their features we conducted interactive social mapping. This method allowed us to locate important attributes in various locations of the playground with a knowledgeable insider (Schensul et al., 2013). The population included our research team and one front-office faculty member who had been with the Mill Swan Head Start for a long time. Our team had a premade map of both play spaces, that was designed from a rough sketch of the play spaces with our initial walk-through. This map is shown in Appendix H. As we walked around with the faculty member, she told us about highly populated toy equipment, how they utilize it, and equipment that has been there for a long time. After the activity, we had a final guide map with notes written about the relevance of each piece of toy equipment and any areas of concern in the play spaces.

Our team acknowledged the physical constraints of the two outdoor areas through physical measurements. Some of the things we were looking for were areas with features already in them, the size of the play areas, and areas of open space. Measurements were conducted by our team with tape measures on the two outdoor play spaces. Specifically, physical measurements were taken of the distance between physical structures and measurements of the playgrounds currently in place such as length, width, and height. The data was written down into a measurement sheet seen in Appendix I while in the field and then transcribed into the premade map from the previous activity. We then created a two-dimensional CAD map of the two play spaces. This provided clarity on the physical constraints where we were looking to implement our new STEAM play space designs.

4 - Student Voting

Our team performed a voting activity with the Mill Swan students. We produced twenty-four different play equipment ideas based on prior semi-structured interviews and research. We then found images that resembled each idea and printed them out. The images were divided into three piles of eight and distributed so similar designs were in distinct groups. The groups of pictures



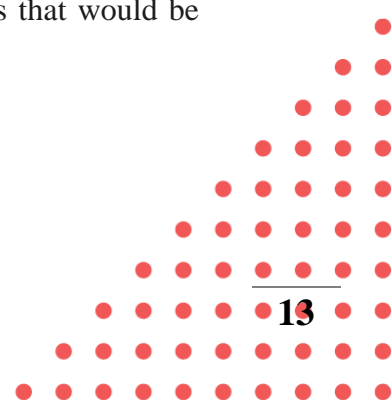
were then taped onto the front of beach pails. This activity was designed to gain insight from the students of Mill Swan since they will be the individuals using the play equipment daily. Voting was used since other research methods may not collect the information required from children due to a lack of question interpretation. In previous studies where information was needed from children, simple methods that used visual cues to communicate with children proved to be more useful than interviews (Roos, 1998). We then split into groups of two and distributed our activity across three different classrooms. The children were given three rocks and placed their rocks into whichever design captured their attention the most. At the end of the activity, we counted the rocks and recorded them by hand. After the first three classrooms, we found out which feature ideas got the highest percentage of votes in their classroom. We went based on percentage rather than rock count because each class size was different. The highest percentages amongst the twenty-four designs were selected for the final eight designs and the fourth classroom that participated in the activity. We then recorded the data from the last classroom to later determine the popularity of equipment designs with the population of students. We used the data from this activity to update our value analysis, which can be seen in the findings section.

5 - Survey

To gain quantitative data to see what the entire Mill Swan staff wanted to see in their play spaces, we created a survey on Google Forms with our best 24 design ideas and allowed them to choose their top five. These top designs were based on our qualitative research acquired during parent and teacher interviews as well as team brainstorming. The approach builds conceptual models using a combination of experience, previous literature, and qualitative data collection techniques and then validates or “tests” these models, both qualitatively and quantitatively (LeCompte, Schensul, 2012). We got 13 responses from teachers, which turned out to be around 59% of the total staff. This allowed us to get helpful quantitative data on the equipment's popularity. We tracked the data in Google Forms and updated our value analysis accordingly. Our value analysis can be seen in our findings section, and the Google Form is visible in Appendix J.

6 - Focus Groups

Upon the creation of our concept, we initiated contact with the Head Start leadership. We presented them with five photographs that highlighted our top potential design features, which were all centered around STEAM equipment. We inquired about their opinion on the benefits and drawbacks of each piece of equipment. This process constituted a focus group, during which we conversed with our sponsor and five other teachers for approximately 45 minutes. The focus group aimed to comprehend their preferences and how they envisaged organizing these features. This approach afforded us valuable insight into the Head Start leadership's preferences regarding our designs, which was crucial in making small adjustments before implementation. Questions asked in the focus group can be seen in Appendix K. The focus group facilitated a respectful exchange of ideas, allowing us to make every participant feel at ease to ensure the focus group's success (Beebe, 2014, p. 57). To analyze the data obtained through the focus group method, we transcribed and conducted a comparative analysis. This process entailed summarizing the recorded notes and transcribing the audio recordings. Our objective was to extract valuable insights that would be incorporated into the final design.





Findings

Copious amounts of laughter and giggles warm your heart when stepping into Mill Swan Preschool. The children are running around freely, exchanging interesting conversations with each other, and playing with everything you could imagine. The children are friendly, waving as you walk by, smiling, and creating pretend scenarios with what they have. Inside the school, there are varying toys and learning features that help promote underlying learning in STEAM. However, there are minimal features to conduct a STEAM mindset outside. Though the students are creative, it is important to implement features that can carry them to learning skills such as brainstorming and problem-solving. The idea of developing new STEAM features at Mill Swan has allowed us to discover the needs of the community and the limitations that have withheld them from fulfilling them already. Our team has learned how to successfully capture a child's interests while promoting STEAM from an educator's side.

1 – The Investment of the Mill Swan Community

The first thing our team discovered when we first visited the Mill Swan Head Start was the sense of community. Every teacher that we walked by seemed fully engaged with their students. The sense of pride in the school was present from the start but began to shine once they brought us in as part of their community.

One of the first objectives that our team did was to sit down with select teachers and talk about their views on the current playground and their dreams for what we could achieve. The first thing that we noticed when sitting down with the staff members was their gratitude and care for the school and their students. This stems from the Reggio Emilia learning approach that Mill Swan has taken up. In this teaching style, teachers learn alongside the students. The teachers master the subject and carry out activities before they are taught to the children, so they are better suited for lessons. When we asked a question about their dream playground at Head Start, all five of the teachers that we interviewed got excited thinking about the possibility of a better educational environment for the children. The love that the teachers expressed towards their job was apparent, but the resources in the playground and playscape were not at the same level. During the teacher interviews, they discussed the lack of features outside of the play areas. Many teachers mentioned how they would love to conduct STEAM-related lessons out on the playground, but they cannot due to a lack of equipment. Our team could sense the desire for better outdoor capabilities from the teachers. This lack of equipment at Mill Swan is not a result of a choice, but rather, a lack of financial resources. Head Start is a federally funded preschool that is dependent solely on the United States government's grant system. With much of the budget going towards fixed costs, there is only a minuscule percentage of the budget that can go towards outdoor equipment. Many of the teachers have conducted online fundraisers to help provide the children with better toys and learning activities.

The parent community at Mill Swan is strong as well. When performing our parent interviews at drop-off time, the parents were very invested in the well-being of their children's school. When bringing up the chance of new play features being implemented at Mill Swan, the parents' excitement was evident. Mill Swan's parents also showed their interest when the school rented out a local STEAM learning center, the Acton Discovery Museum. The school filled up the museum and the parents seemed very pleased with the learning opportunity.

2 – STEAM is Within Reach for a Limited Budget

Our next finding was that there is inspiration for inexpensive and attainable STEAM features all around us. We found inspiration for playground features when we visited the local STEAM learning centers. When we went to the Connecticut Science Center, one of the features that we noticed was a Lego water flow. This feature can be seen in Figure 7, as it is a slanted base covered in Lego sheets with a steady water flow descending from the top of the base. It allows the children to understand how water moves and how obstacles can affect its path. Our team identified it as an inexpensive feature that would be easy to implement and had strong STEAM benefits.

Figure 7.

Lego Water Flow



Note: Figure 7 displays the Lego Water Flow feature from the Connecticut Science Center.

Another location that helped us generate ideas for features was the Acton Discovery Museum. One of the feature ideas that we noticed was a balance structure. This feature can be seen in Figure 8, as it has a horizontal wooden post with buckets hanging down. The horizontal post shifts based on the weight of objects placed into the various buckets, teaching the viewers how weight affects the tilt of the beam. Our team thought it was also an inexpensive feature that had strong STEAM benefits.

Figure 8.
Balance Structure



Note: Figure 8 displays the balance structure our group found at the Acton Discovery Museum.

When we were at the Acton Discovery Museum, we sat down with the Director of STEAM and the Director of Exhibits for an interview. One of the topics we discussed was how to be creative and resourceful when designing exhibits. Instead of buying a wind tunnel feature for thousands of dollars, they embraced their inner thriftiness and used a box fan and scrap material, and it worked well for around fifty dollars. Our group also went to visit local parks to find ideas for potential features. We visited Coes Park and Rutland Recreation. Coes Park was a well-kept park with many music features. Many of these ideas were inexpensive and easy to implement. One of these pieces of equipment was a wall of PVC pipe with a flat mallet, where children could hit the pipes and create different pitched music notes. We also found feature ideas when talking to those close to the project and online. When talking to one of the Mill Swan teachers during our interactive social mapping, she discussed how the children loved the water pump that was in their playground before it stopped working. This led us to investigate inexpensive alternatives for water pumps. When we brought this idea up to Professor Kurlanska, she remembered an idea that used a bike wheel to bring water up from an underwater basin. Our team then searched YouTube for bike pump ideas and found multiple videos demonstrating how to create these concepts.

3 – Curious Children Challenge Design Integrity

As the team began to observe how children play, strengths and weaknesses common between features became apparent. Our observations and STEAM center visits helped us to find aspects of an effective STEAM playground feature, based on children’s creative nature. After organizing the data collected during observation, some of the major themes we found include the popularity of individual features and the short attention span of preschool-aged children. When observing, the most popular features were the sandbox on the playground and playscape and a plastic house on the playscape. In both cases, the feature was consistently being used in unexpected ways. For example, the edges of the sandbox designed to hold the sand in were used by multiple children as a balance beam. There were also multiple instances when the sand was brought out of the sandbox and to other features, despite sand play being designated to the sandbox area. The house was used as a conduit for make-believe, recognized as a kitchen, home, clubhouse, and hideout. These observations are organized in Appendix G.

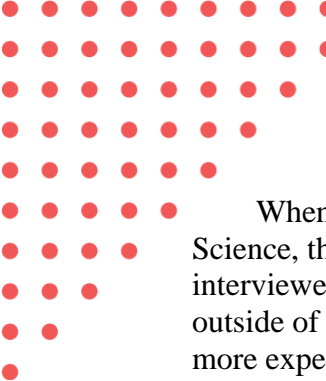
Another theme that was common in observations was the lack of time spent engaged with a feature. For example, simple features like balance beams, climbing tubes, tables, plastic ramps, and the thunder wall (a metal sheet in a wooden frame that creates a loud noise when struck) all had a measured attention span of a minute or less. A commonality among these features is that there is little room for creativity. On the other hand, features like the sandboxes and plastic houses that encouraged children to use creative thinking engaged them for longer periods. These observations are organized in Appendix G. During interviews with parents, it was identified that a specific feature at Coes Park (a nearby public playground) had a noticeably short attention span among children. The feature in question is shown below in Figure 9. A parent stated that this feature was never used because it was too time-consuming, and their child would just smack it and run by it. This also suggests that some features may not capture the attention of a preschool-aged child if it is something that they are not interested in.

Figure 9.

Coes Park Play Feature



Note: A matching game that is incorporated at the local Coes Park playground.



When discussing important design features with local design teams at the Acton Museum of Science, the durability of the feature was an issue of high importance. The designers we interviewed stated that every feature breaks when kids play with them. They pointed out that outside of the actual design of a feature, the durability and cost often present a distinct trade-off—more expensive materials are more durable. For example, metal is extremely expensive but also exceptionally durable. The design team also suggested that features be built in a way that anticipates breaking and is easy to fix. The design team at the Connecticut Science Center also pointed out that their features are built to withstand the use of thousands of kids every day, and that the robustness of the feature is important to consider in the design. Notes from these interviews can be seen in Appendices L and M, respectively. Children are curious, as well as unknowingly destructive. When they play with features in ways that are not intended, features break. While our designs do not need to withstand the use of thousands of kids, they do still need to be designed to last. Our sponsor also voiced concerns about previous features in the playground not lasting exceptionally long, and that more durable and lasting features are something Mill Swan Head Start is interested in.

Children’s curious nature leads to unexpected interactions with play features, and if these interactions are ignored in design it can lead to uninterest in the feature as well as damage to the feature itself. Therefore, all designs must consider unorthodox ways that children may interact with the design and build to ensure the feature’s robustness. The design must also be engaging and modular to hold the attention span of the children.

4 - Composing a List of Top Designs Based on Stakeholder Recommendations

Using input from different groups that are a part of Mill Swan, along with team brainstorming, we were able to come up with a list of our top 24 designs. Our first objective where we got feature recommendations was the teacher interviews. When sitting down with the five selected teachers, they gave us a few ideas for what could be added to the playground. Some of these features included climbing structures, slides, music equipment, a new water pump, and sensory areas. In the parent interviews, slides, climbing structures, teeter totters, swings, digging tools, and trampolines were the ideas frequently brought up. When visiting the local STEAM learning centers, we found numerous ideas that piqued our interest. These include the balance, Lego water flow, rubber band wall, gear wall, ball wall, simple circuit cubes, and many more. For a full list of ideas given by all stakeholder groups, visit Appendix N. When we visited Coes Park, the music features stuck out to the team. PVC pipe with a rubber mallet to make different pitched sounds was one of the ideas that we found. Our group also found many other fascinating music concepts such as xylophones and wind chimes. We felt as though we had a lot of great ideas for potential features in the Mill Swan play areas but took some time to brainstorm and research other pieces of equipment online. Some of the additional ideas that we came up with were the shadow tarp, puppet ecosystem, inflatable raft, and treasure hunt. After considering all stakeholder groups and resources, we narrowed down all the features to what we considered to be the best twenty-four features based on all the information we received. Figure 10 below lists our top twenty-four designs and where they came from. Some of these ideas drew motivation from multiple sources.

Figure 10
Top Design Origin

Feature	Teacher Interviews	Parent Interviews	STEAM Learning Centers	Parks	Online Research/Brainstorming
Bike Pump	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Climbing Structure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Balance	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Simple Machine Sandbox	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Shadow Tarp	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Lego Water Flow	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rubber Band Wall	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Towers of Hanoi	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Magnetic Gear Wall	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sand Pendulum	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plinko	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Raised Sensory Table	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Pulley System	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Music Wall	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Simple Circuit Cubes	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Raised Garden Beds	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Big Dice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Inflatable Raft	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Puppet Ecosystem	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Stream Table	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Treasure Hunt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Note: This table shows which stakeholder groups or locations the design originated from in order of performance.



Discussion

After coming up with our top twenty-four designs, our team had the goal of narrowing this number down to five serious candidates with the chance of being implemented at Mill Swan. The team wanted to develop a systematic way of accomplishing this goal, instead of choosing features that we liked as a team. Instead, we wanted to consider all the possible factors that could determine if a design was the best design for Mill Swan. We achieved this through a value analysis.

1 - Value Analysis

Our value analysis was conducted by ranking the features on a scale of one to five based on performance in significant categories. These categories were given significant scores ranging from 50 to 100. The process is explained in the details below.

We felt that all these categories were important to the overall importance of a successful feature. Cost became a very important factor for construction when we found out that we were limited to a \$500 budget for building our desired features. This was discovered in our logistics meeting with Karen Waters. Ease of construction was chosen because our project took place over a stringent time frame, and we did not have the luxury of taking weeks to implement our designs. STEAM benefits were one of the main components of our project and providing the children with equipment that is beneficial to their learning is critical to achieving our goal. In our teacher interviews, the Mill Swan staff said they want to involve their curriculum when playing outside but feel like the play areas are not suited for that. Having our features be sustainable and not needing tedious fixes from the Mill Swan custodial team was a category that we felt was necessary to include in our value analysis. When talking with our sponsor in the logistics meeting, she emphasized the importance of keeping the children safe when playing on the playground and playscape. This increased our awareness of the importance of safety when choosing our features. Weatherproof and durability are two similar categories that test the features' ability to withstand the natural elements and the destructive tendencies of the children playing with them. We want our implemented pieces to last a long time, so making sure they are built to withstand any force is critical. Our next category is popularity among teachers. We had our interviews with select staff members and got a lot of helpful qualitative data, but now that we had our designs, we wanted quantitative data to see which pieces of equipment they liked most. We created an online survey with our twenty-four design ideas and told the teachers to choose their five favorites. Of the twenty-two teachers at Mill Swan, we received thirteen responses to our survey. Because Mill Swan uses the Reggio Emilia approach, teachers are very involved in the student's learning process, so their input is very valuable. Finally, we wanted the input of the students, seeing that they are the ones who will be using the play areas. We facilitated a voting activity that allowed the students to pick their favorite play features. How our group gave meaning to the one through five scoring for each category can be seen in Figure 12 below.

The one through five ranking is multiplied by the significance score for each category, and all these numbers are added up to get a total score for the value analysis, which can be seen in Figure 11.

Figure 11.

Value Analysis Category Scores

Category	Value Analysis Significance Score
Ease of Construction	80
Popularity Among Students	90
Popularity Among Teachers	70
Weatherproof	70
Durability	65
Maintenance	50
Risk Factor	80
STEAM Benefits	90
Cost	70

Note: These categories were valued based on importance to the value analysis.

Figure 12.

Value Analysis Scoring Key

Cost	Rank	Ease of Construction	Rank	STEAM Benefits	Rank	Maintenance	Rank	Risk Factor	Rank
\$200+	1	20+ hours	1	None	1	Everyday care	1	High chance of injury	1
\$150-200	2	15-20 hours	2	Little	2	Weekly care	2	Chance of injury	2
\$100-\$150	3	10-15 hours	3	Moderate	3	Monthly care	3	Some chance of injury	3
\$50-\$100	4	5-10 hours	4	High	4	Seasonal care	4	Little chance of injury	4
\$0-\$50	5	0-5 hours	5	Very High	5	Doesnt need to be attended too	5	No Risk	5
Weatherproof	Rank	Durability	Rank	Popularity among Teachers (Number of votes)	Rank	Popularity among Students (Percent of votes in each classroom)	Rank		
Can't withstand outdoor use	1	less than 1 year	1	0	1	0-6%	1		
Can withstand small amounts of inclement weather	2	2 years	2	1 - 2	2	6-9%	2		
Moderate deterioration over a year long period	3	3 years	3	3 - 4	3	9-12%	3		
Slight deterioration over a year long period	4	4 years	4	5-6	4	12-15%	4		
Stable in all conditions	5	5+ years	5	7 +	5	15%+	5		

Note: This is the value analysis key for how the team gave categorical scores to each feature idea.

2 - Top Designs

After giving meaning to the scores for each category, our team went through feature by feature and decided on an appropriate score for each category. Once we added up the total scores for each feature and calculated a total value considering the weights of each category, we were able to determine our top five ideas. Those ideas were as follows:

1. Bike Pump and Lego Water Flow
2. Climbing Structure
3. Balance
4. Sandbox Digging Tools
5. Shadow Tarp

In Figure 13 below, you can see the cells in our spreadsheet that make up the formula for the cumulative score. See the formula at the top of Figure 13. To see the entire value analysis, see Appendix O.

Figure 13.

Value Analysis Calculations

$$= (D5 * \$D\$3) + (E5 * \$E\$3) + (F5 * \$F\$3) + (G5 * \$G\$3) + (H5 * \$H\$3) + (I5 * \$I\$3) + (J5 * \$J\$3) + (K5 * \$K\$3) + (L5 * \$L\$3) + (M5 * \$M\$3)$$

	Options	Ease of Construction	Popularity among Students	Popularity among Teachers	Weatherproof	Durability	Maintenance	Risk Factor	STEAM benefits	Cost
Rank	Weight	80	90	70	70	65	50	80	90	70
2	Climbing Structure	2	4	5	5	4	4	2	5	1
1	Bike Pump	2	2	4	5	5	5	4	5	4

Note: This is how we construct the cumulative score for the value analysis.

The bike pump is a structure that carries water up a PVC pipe track from a basin holding water underground. Figure 14 below shows a CAD (computer-aided design) drawing of the design of the bike pump next to the implemented version.

Figure 14.

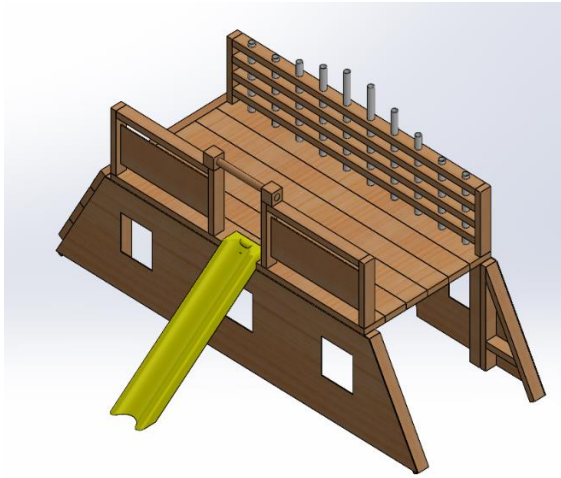
Bike Pump CAD drawing and installed version.



Note: Figure 14 comparison of design plans vs. actual feature.

The climbing structure allows the children to climb using rock climbing pegs and cargo nets. The feature also contains a slide, a railing made of PVC pipe for creating music, and a secluded area where children can go under the platform. Figure 15 displays an in-depth CAD drawing of the climbing structure.

Figure 15.
Climbing Structure CAD Drawing



Note: Figure 15 shows the SolidWorks design that our team created.

The balance is a “t” shaped wooden structure where the horizontal post had buckets hanging from it. It can rotate based on its middle axis based on the weight of objects put into each bucket. For a CAD drawing depicting the balance structure and our implemented feature, Figure 16 below has a picture of both.

Figure 16.
Balance CAD Drawing and Installed Version



Note: Figure 16 comparison of design plans vs. actual feature.

The Sandbox digging tool is a piece that allows children to grab sand and move it around to other areas within its radius. It can rotate around and has a grabbing piece on the end that can open and close with handles that the user can control. Figure 17 shows a picture of the digging tools we recommended.

Figure 17.
Simple Machine Sandbox



Note: Figure 17 shows the digging tool that we recommended to Mill Swan.

The shadow tarp is a tarp with cutouts of different animals and designs that cast shadows on the playground. The children can use their creativity to play with the shadows and see how the direction of the sun changes over time. For a CAD drawing of our proposed shadow tarp design, see Figure 18 below.

Figure 18.
Shadow Tarp Design



Note: Figure 18 shows the drawing of the shadow tarp we recommended.



3 - Implementation

Once we finalized our top five designs, we made initial designs online to get ready for our focus group with a select group of Mill Swan teachers and staff. During this focus group, we received beneficial feedback on which features they liked, which ones they didn't, and minor adjustments that they felt could improve our ideas. The focus group was a supporter of the bike pump and Lego water flow. They liked the climbing structure but understood that our team did not have the time or financial resources to complete it in our limited time. The teachers were also happy with the balance and gave a helpful recommendation that we should make the back side a tape measure for the children and use other sides to paint nature-themed items such as pinecones and feathers. The focus group thought the sandbox digging tools could be a good idea but thought that the children would fight over it if we only purchased one. Seeing that we could not find multiple digging tools before our implementation period, we decided not to pursue the idea. Finally, the teachers did not particularly like the shadow tarp idea. They thought it was not worth replacing their current tarp and did not think it would generate much use from the students. After gaining valuable responses from the teachers, our team decided to go all in on the bike pump, Lego water flow, and balance structure for our implementation period.

We started the implementation period with three days of building away from the Mill Swan school. We used the first day to cut all the wood to size, and the next two days to build the body of the bike pump and balance. We ran into a couple of obstacles in our first few days. One thing we did not realize was wood from the hardware store is not always on scale for example, a 2"x 4" piece of lumber is 1.5"x 3.5". This caused one of our support beams that we cut to be too short, and our water basin to be slightly exposed so dirt could penetrate in. We were able to adjust with minimal delay. The following day was our first day of implementation. We gathered the other two Worcester IQP cohorts to help us install our playground equipment. We installed the Lego water flow and balance on the first day with no issues. However, the bike pump was a whole other story. When we began digging the hole to bury the bike pump, we struck concrete. This caused a large delay in our time to complete the digging process and forced us to spend a large portion of our budget on a sledgehammer. We were able to dig the entire hole by the end of that day. The second day of implementation was a day of setbacks. All we needed to do was get the rope to generate water and the feature to work in unison. The first time we tried to get the rope to rotate, it got stuck in the basin. This was due to large washers preventing the flexibility of the pool noodle stoppers. Our team then tried to trim the stoppers made of pool noodles so they wouldn't get stuck anymore. We succeeded in not getting the rope stuck anymore, but we made the stoppers too skinny, so no water was trapped on the way up the PVC pipe. We were able to get water on the third day of implementation, which was very encouraging. We used stoppers made of flip flops instead of pool noodles as well as smaller washers to support the stoppers. This was successful in getting water to come out of the bike pump, but the pump would be hard for a preschool-aged student to rotate. We came back on the fourth day and trimmed the flip-flops by a tiny amount. This allowed the rope to rotate much easier while still releasing water from the basin. We then buried the bike pump and concluded our implementation period.



Recommendations

Our findings have identified our top five designs as the Bike Pump, Climbing Structure, Balance, Shadow Tarp, and Simple Sandbox Machine. However, due to constraints such as time, budget, and safety considerations, we have decided only to implement two of these designs: the Bike Pump and Balance. Our value analysis has underscored the significance of each design. While we wish we were able to implement all of them, we intend to leave the others as recommendations for future consideration.

1- Implement additional playground features.

We recommend three additional designs that would enhance the space: the Climbing Structure, Shadow Tarp, and Simple Sandbox Machine. Using the following recommendation as well as the materials provided in the catalog and manual shown in appendices P and Q respectively, this is a possible feat for Mill Swan and Head Start locations in general.

2- Partner with local organizations.

Given that Head Start is federally funded, we suggest reaching out to certain organizations or individuals for support: Bluehive for material donations, the Connecticut Science Center for design assistance if needed, and Worcester Technical High School as a potential working partner. These are connections that we were able to build throughout the time of the project that we passed along to Head Start.

3- Perform integrity checks and regular maintenance on the Bike Pump and Balance.

Regarding maintenance of the designs, if the Balance seems a little loose, we recommend tightening the large bolt in the middle, for the bike pump, there is a potential issue with the rope disconnecting from the wheel due to our design. To address this, we recommend either replacing the rope and cutting some flip-flops or rubber into circles about $1 \frac{9}{16}$ inches in diameter. Additionally, you can reuse the washers that were already there if you use flip-flops as a support to prevent disconnection. The inside opening measures about $1 \frac{5}{8}$ inches.

4- Share our designs with other Head Start locations!

We hope to share these designs with other Head Start locations, where they can utilize them to enhance their play areas. We have developed two booklets for future design implementation to provide comprehensive insight into the features and construction processes involved. One booklet focuses on design aspects, containing 24 designs and descriptions outlining their purpose and associated learning outcomes. The second booklet comprises technical drawings of the top five designs, detailing the materials used for each component, as well as their dimensions, lengths, widths, and diameters. Additionally, this booklet breaks down the cost of each component for further clarity.



Conclusion

In conclusion, this project aimed to assist Mill Swan Head Start in renovating two outdoor play spaces with STEAM-based learning equipment. Through our research, methodology, and data analysis, it became evident that several factors must be considered to achieve this objective. Firstly, design features play a crucial role, as each one offers distinct learning outcomes and play activities. Secondly, safety considerations are paramount, given the fragility and curiosity of children. Additionally, budget constraints are significant, particularly as Head Start is federally funded, requiring careful budgeting for design implementation. Lastly, durability is essential, as the outdoor play space location necessitates weatherproof designs. After thorough consideration, we developed five designs to enhance the two outdoor play spaces: Water Bike Pump, Climbing Structure, Balance, Simple Sandbox Machine, and Shadow Tarp. To provide further suggestions and reference materials, we have created two booklets to offer additional insights into enhancing the outdoor play spaces.

Participation in the project has been a deeply meaningful journey that has surpassed the project outcomes. We have acquired valuable knowledge about the intricacies of playground design, implementation, and safety for children. Working with diverse stakeholders has enriched our comprehension of teamwork across disciplines and the positive influence of thoughtful design on community involvement. Witnessing the joy of children on the newly renovated playground reaffirms the significance of empathy, innovation, and sustainability in shaping meaningful contributions to communities.




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Appendix A

Safety Regulations in Playgrounds

With the incorporation of outdoor play in a learning environment with children, it is crucial to consider the safety aspects associated with playground and playscape design. In 2019, 23% of emergency room visits of children ages five to nine were a result of playground injuries (Pinyao, 2019). Other statistics suggest that over 200,000 injuries occur annually (CPSC, 2015). With almost a quarter of injuries resulting from play, some precautions need to be taken to minimize this number. These precautions are often outlined in regulations, and there are a multitude of different organizations that create these guidelines for different environments. The Head Start organization, and specifically the Mill Swan Head Start, requires that all play equipment is standardized to the guidelines in the Public Playground Safety Handbook, as well as the policies outlined by the Department of Early Education and Care. Areas of concern include fall height, entrapment, surfacing, hazards, and supervision.



Appendix B

History of Head Start

Head Start was founded in 1965 during the Lyndon B. Johnson presidential administration. In his 1964 State of the Union address, President Johnson declared a War on Poverty. New research on the effects of poverty suggested that the government should assist disadvantaged communities throughout the United States who face inequalities. To effectively assist these low-income households, a detailed plan of action was created to strengthen the emotional, social, nutritional, and educational skills of preschool-aged children (Administration for Children & Families, 2023). Throughout its history, the program has helped provide a strong educational foundation for 38 million children. Most recently, in the fiscal year 2022, it had 2,809 locations, taught around 592,000 students, and received just over \$11 billion in government funding.

Head Start's mission is to promote the school readiness of young children from low-economic families by enhancing their cognitive, social, and emotional development (Administration for Children & Families, 2018). As children from lower socio-economic backgrounds are more likely to drop out of school and engage in criminal behavior (Ludwig 2007), Head Start works to reverse these trends and advance young minds. In a study performed by the American Economic Review, Head Start students from the 1980s were compared to low-income students who either went to another preschool or did not go to preschool at all. Over the next couple of decades, their future success was measured. Like the results of the Perry Project discussed above, it was found that Head Start students were 2.7% more likely to graduate high school, 8.5% more likely to attend college, and 12% more likely to graduate college than the control group. The Head Start cohort was also 23% less likely to fall into poverty and 27% less likely to receive public assistance once they reached adulthood (Bailey, 2021). Providing a strong two-year early education program at no cost to financially disadvantaged families is one of the U.S. government's largest yearly investments of taxpayer dollars. In a cost-benefit analysis performed by the National Bureau of Economic Research in 2007, it was determined that the program has both long-term and short-term benefits for its students. It was also determined that the \$7,000 per year per student was worth the investment by the federal government (Ludwig, 2007).



Appendix C

Semi-Structured Parent and Teacher Interview Guide

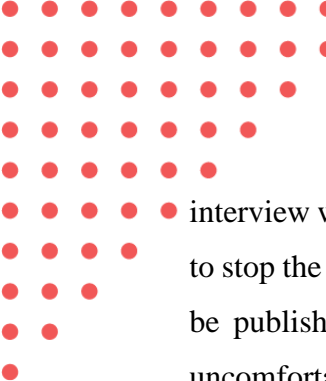
Parent Guide

Thank you for participating in this interview! Our names are Mike, Marco, Madison, and Will. We are conducting interviews to learn what the Mill Swan community wants to see included in the design of new play spaces. These interviews will be a part of a larger research project to design STEAM-based play spaces in the Mill Swan Head Start establishment. The research will be published online when the study has concluded. This interview will take approximately fifteen minutes. All responses will be investigated and analyzed by the team, but transcriptions of the interview will not be published. With your permission, this interview will be recorded. If you wish to stop the interview at any time, you may do so. Your name or other personal information will not be published as a participant. This interview is voluntary, and if any question is difficult or uncomfortable you may ask to skip it. To contact the team about the study or any other concerns, please email gr-headstartd24@wpi.edu or cbkurlanska@wpi.edu. Are you comfortable with these terms? [Y/N] Before we begin, do you have any questions about the study? [Y/N]

- 1) How is your child's experience at Mill Swan?
 - a) Does your child require any specific accommodation?
 - b) Could you share a story that highlights their feelings?
- 2) Do you have a favorite outdoor park or space that you bring your child to?
 - a) Why is this place your favorite?
 - b) What kind of features does the space have that your child enjoys playing with?
- 3) Finally, could you please describe to us your vision of the dream playground or playscape if no restrictions apply?

Teacher Guide

Thank you for participating in this interview! Our names are Mike, Marco, Madison, and Will. We are conducting interviews to learn what the Mill Swan community wants to see included in the design of new play spaces. These interviews will be a part of a larger research project to design STEAM-based play spaces in the Mill Swan Head Start establishment. The research will be published online when the study has concluded. This interview will take approximately fifteen minutes. All responses will be investigated and analyzed by the team, but transcriptions of the



interview will not be published. With your permission, this interview will be recorded. If you wish to stop the interview at any time, you may do so. Your name or other personal information will not be published as a participant. This interview is voluntary, and if any question is difficult or uncomfortable you may ask to skip it. To contact the team about the study or any other concerns, please email gr-headstartd24@wpi.edu or cbkurlanska@wpi.edu. Are you comfortable with these terms? [Y/N] Before we begin, do you have any questions about the study? [Y/N]

- 1) How did you become involved with Mill Swan Preschool?
- 2) STEAM can be interpreted in multiple ways; how would you describe it?
 - a) What does the ‘A’ addition mean in your view?
- 3) Do you incorporate STEAM in any way in the classroom?
 - a) What learning outcomes do you see resulting from this kind of education?
- 4) How do you put the current playground and playscape to use within your current curriculum?
 - a) In your opinion, do these spaces serve as just a place for children to play, or as an extension of the classroom?
- 5) We are aware of the STEAM room here at Mill Swan. How often do you use it in your class?
 - a) Are the features in the STEAM room helpful to your curriculum?
 - b) If you could add anything to the STEAM room, what would it be?
- 6) How long have you been associated with ECE?
 - a) Is Mill Swan the first preschool you worked at? How is it different?
 - b) How do the play spaces at Mill Swan compare to other preschools?
 - c) If you have an opinion, what is the best preschool playground you have interacted with?
- 7) While outside in either the current playground or playscape, as a teacher, have you noticed any safety concerns?
 - a) Could you describe to us a situation in which a child was put in danger (of any magnitude) while interacting with the Mill Swan play spaces?
- 8) Can you think of any playground or playscape features you could use to assist in your curriculum?
- 9) Finally, could you please describe to us your dream playground or playscape if no restrictions apply?



Appendix D

Structured Budget Interview Guide

Hello, I am Madison, Will, Mike, and Marco. Good afternoon [Head Start Personnel]/ [Mill Swan Personnel], the WPI Head Start team would like to thank you for your time today. We are researching the capacity of the Mill Swan Head Start team's resources to implement/add to their outdoor play areas. This interview is designed for directors of the Head Start Stakeholder group. We would like to ask a series of questions; at any point you feel uncomfortable you can end the interview or decline to answer. The answers will be recorded through an audio recording for reference later. Answers may be published online later, however, personal identities will remain anonymous, and information only will be published. Can you please verbally consent to these conditions before we begin? This interview should only take 15 - 30 minutes. You can contact our team with questions or concerns at gr-headstartd24@wpi.edu, as well as our advisor, Courtney Kurlanska at cbkurlanska@wpi.edu.

- 1) When were the two outdoor play spaces last updated?
- 2) What type of surfacing is present in the two outdoor play spaces?
- 3) How often are parts of the play spaces replaced due to overuse?
- 4) If applicable, how many people are responsible for the maintenance of the outdoor play spaces?
- 5) If applicable, how often do people maintain the outdoor play spaces?
- 6) Do you have the ability to have someone maintain the newly implemented outdoor play spaces?
- 7) How many funds are allocated to the implementation of the two outdoor STEAM play spaces?
- 8) Does the budget exclude certain playscape materials?
- 9) With the implementation of the new designs, are you going to discard the current physical play structures?
- 10) If applicable, would the budget include the cost of removing current structures?

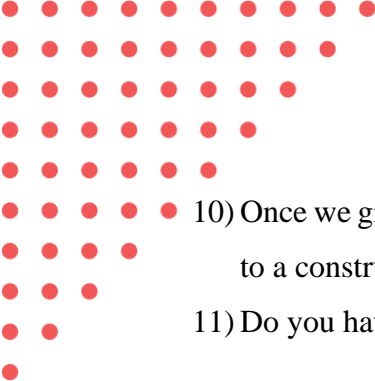


Appendix E

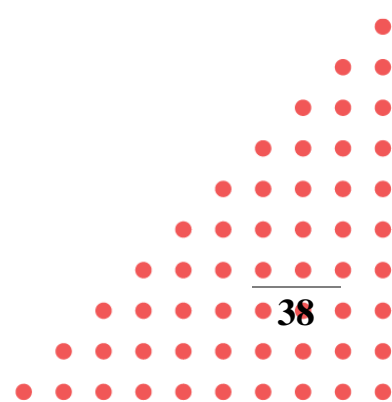
Semi-Structured Interview Guide for STEAM Learning Center Design Teams

Hello, I am Madison, Will, Mike, and Marco. Good afternoon [EcoTarium/Acton Children's Museum/Connecticut Science Center] representatives, the WPI Head Start team would like to thank you for your time today. We are researching other STEAM learning centers close to Worcester Polytechnic Institute hoping to find potential STEAM equipment to implement into our designs, see what toys are popular amongst children, and gain knowledge from learning center leadership. We would like to ask a series of questions; if at any point you feel uncomfortable you can end the interview or decline to answer a question. The answers will be recorded through an audio recording for our reference later. Answers may be published online at a later date, however, personal identities will remain anonymous, and information will only be published. Can you please verbally consent to these conditions before we begin? This interview should take approximately 20-30 minutes.

- 1) How long have you been working at [The Worcester EcoTarium/The Acton Children's Museum]?
- 2) What was your role in the design process for any STEAM learning equipment here?
- 3) What was your process of choosing beneficial STEAM learning equipment?
- 4) Some of the types of equipment that Head Start parents and staff were interested in implementing were equipment with the following components: sensory, electricity, and measurements. How were you able to successfully develop equipment with these components in your building?
- 5) How important is durability to an outdoor play space? Head Start lets their kids play outdoors year-round.
- 6) Show them the current playground and play space: Have you ever had any experience building around a current play area? If so, how do you add pieces while still letting the area flow smoothly?
- 7) Did you design the equipment yourself, or was it already available to buy from a manufacturer?
- 8) What is your budget for pieces of equipment? How much can we achieve with the budget that Head Start has given for the project?
- 9) How do you work along with state safety requirements when designing play areas?



- 10) Once we give Head Start our designs, how easy would it be for them to give these CAD designs to a construction contractor to implement?
- 11) Do you have any other words of advice for our team?



Appendix F

Play Area Observation Sheets

We will be observing the playground and play spaces at Mill Swan Head Start. We will be sitting at a table with a sign describing our affiliation with WPI and the Head Start administration. All team members participating in the observation will wear clothing identifying themselves as WPI students and name tags. We will have information related to our research as a print-out page for anyone interested. Times of observation will be discussed and agreed upon with Karen Waters, assistant director of Mill Swan Preschool.

Playground Observation Checklist	
Playground or Playscape?	<input type="checkbox"/> Playground <input type="checkbox"/> Playscape
Structured or unstructured playtime?	<input type="checkbox"/> Structured <input type="checkbox"/> Unstructured
Feature being observed:	
Number of children who interacted with the feature:	
Attention Span/time spent engaged with the feature:	
Types of play taking place:	<input type="checkbox"/> Unoccupied <input type="checkbox"/> Solitary <input type="checkbox"/> Onlooker <input type="checkbox"/> Parallel <input type="checkbox"/> Associative <input type="checkbox"/> Cooperative
Language Use:	
Interests that appear outside of the play feature:	
Games that are created or organized:	
Violations of safety standards:	
Situations in which safety is compromised:	
Skills that are possibly being enhanced:	

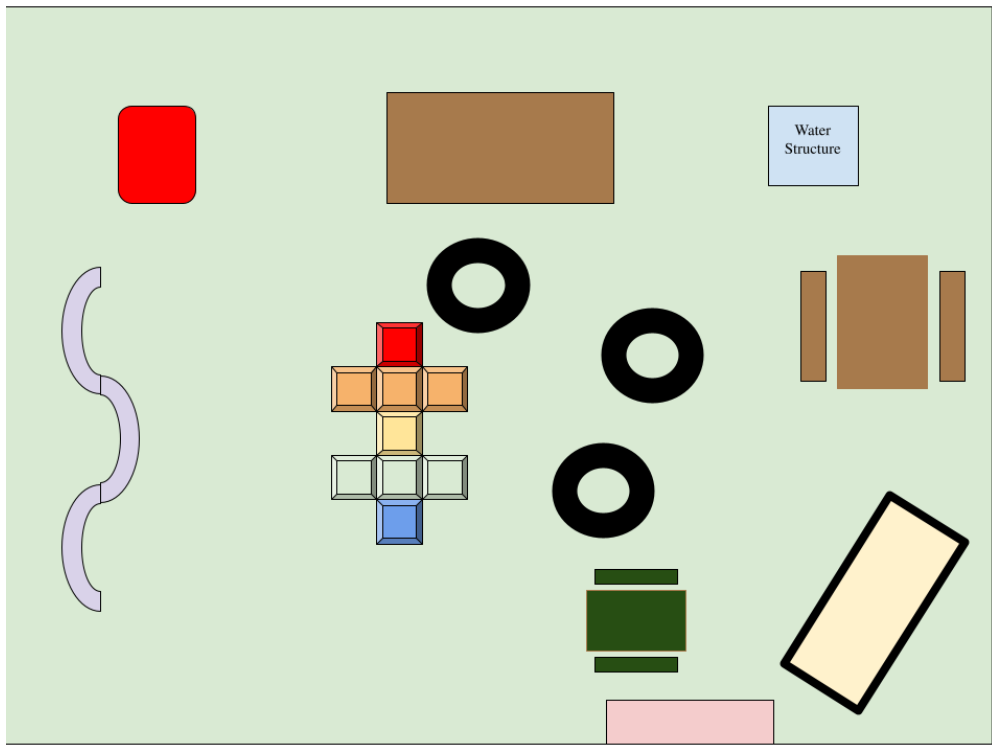
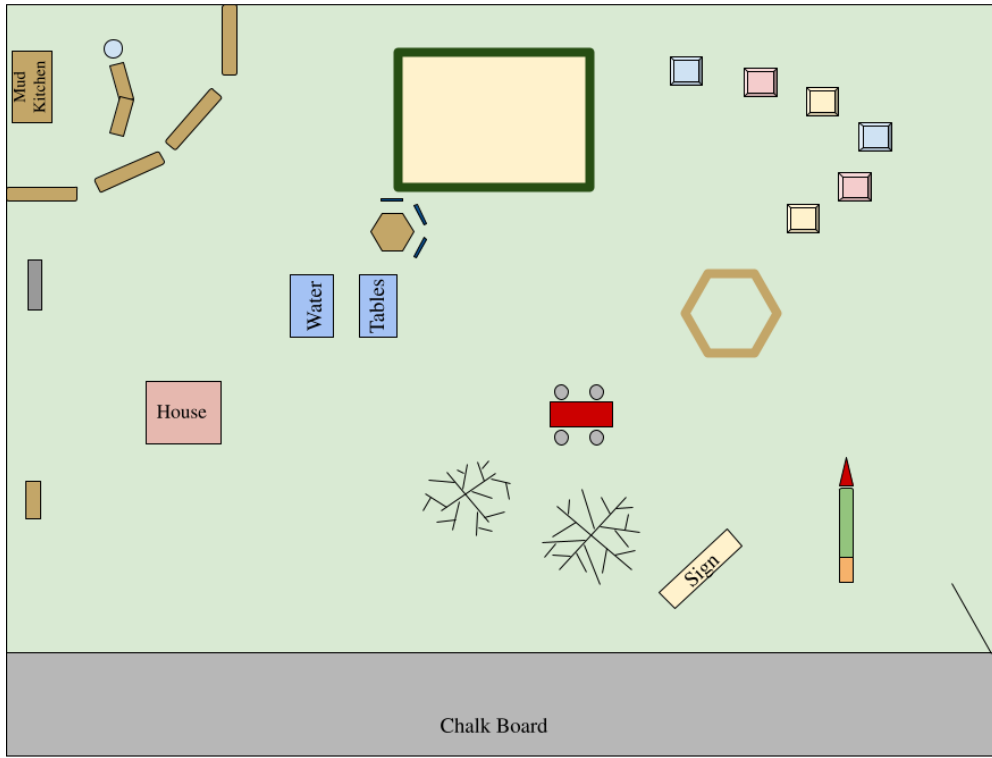
Appendix G

Observation Spreadsheet

Questions	Observation Number														Coding Key
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Sheet	1	2	2	3	4	4	5	5	5	6	6	7	7	7	
Playground or Playspace	Playground	Playspace	Playspace	Playspace	Playspace	Playspace	Playground	Playground	Playground	Playground	Playground	Playspace	Playspace	Playspace	
Feature Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Feature	Sandpit	Water Tables	Balls	Sandbox	Sandbox	Balance Blocks	Sitting Tables	Butterfly Tube	Roamers	Balance Beam	Tires	Plastic Ramp	House	Thunder Wall	
Structured or Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	Unstructured	
Number of Children (avg)	4	3	5	3	3	1	2	1	8	1	2	1	4	1	
Total Children Using It	10	7	8	10	7	2	5	3	13	9	8	11	20	9	
Attention Span (avg)	15	5	5	5	7	1	3	1	3	3	5	10	5-15	0-20	
Time of Observation	20	35	35	20	35	35	20	20	20	20	20	35	35	35	
Type of Play	Unoccupied, Solitary, Cooperative	Parallel, dramatic	Competitive, collaborative	Solitary, Onlooker	Solitary, Parallel, Cooperative	Solitary	Solitary, Cooperative	Cooperative, parallel	Parallel, cooperative	Physical	Physical, Collaborative, Dramatic	Physical	Dramatic, Collaborative	Physical	
Language Use	Don't break it, teachers chiming in	N/A	Screams, "I got you!"	A lot of exaggeration and story telling	"chocolate milk", "Not how you mix it", "boys don't know how to mix", "I found treasure digging", "Don't break my castle"	"I win"	N/A	Screams	"come, come, come"	N/A	N/A	N/A	"In cleaning the house", "This is a witch", "The boys allowed", "Fire on the house", "Do you want to be a witch?"	N/A	
Interests outside of feature	Using the sides as a balance beam, Using rain water from tires, Bringing sand to the tables	Go to sandbox	Take a breather.	Using sand tools with much	Using the edges as a race track for	N/A	Run off and chase classmates.	Run off and chase classmates.	Go back to one of the other activities	N/A	N/A	N/A	N/A	N/A	
Interests inside of feature	Building sand castles, Picking up and dropping sand, Packing buckets, Shape molds, Wetting sand and making mud	Make creations, give them to classmates or teachers	Hiding, throwing at other people playing	Filling buckets, cooking, digging	Building sand castles, filling buckets, water in the sand, filling buckets with a toy tractor, moving tires, and jumping in sand	Racing	Building with sand, water and mulch.	Hang on the edge, crawl through it	Stomp around and chase other kids.	Walk across balance beam	Roll/flip tires, put sand/mulch in tires, sit in tires	Walk across balance beam	Clean the house with a bucket of water and a sponge Wiping down the outside. Cook with utensils found in the house & sand brought from somewhere else. A group of witches inside the house making potions. Poured the wolf howling outside the house.	Run up and hit the wall. Throw dodgell at the wall to create sound. Stomp and bang the wall repetitively.	
Safety Compromised	Yes, tripping on the edge of the sand pit	No	Yes, hit in face. Had to take a break	No	Yes, throwing poles in the air	No	No	No	Yes, hit shi in balance beam	No	No	No	No	No	
Skills Enhanced	Building, Sensory	Sensory	Hand eye coordination	Sensory	Teamwork	Balance	Building, resting	Balance, Physical	Teamwork	Fine motor skills, balance	Fine motor skills, language development	Fine motor skills, balance	Fine motor skills, language development, social skills	Fine motor skills	
Notes	More girls were interested in building structures and boys enjoyed knocking them over and digging				Two people were working together to fill a bucket with watered-down sand, getting sand and water in multiple trips and filling the bucket with a										

Appendix H

Interactive Social Mapping





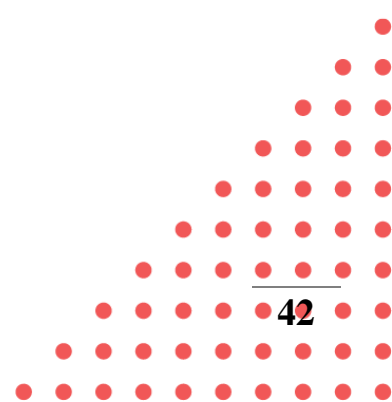
Appendix I

Play Area Measurements

Physical Measurement Collection

Circle: Playscape OR Playground

Name of Structure	Measurement (inches)



Appendix J

Google Form Survey

Mill Swan Survey on Potential Playground Equipment

mgates.wpi@gmail.com [Switch account](#)
 Not shared

Please pick your FIVE favorite pieces of play space equipment that you would like to see implemented at Mill Swan! The results of this survey will influence our team's decisions on the possible features for your play areas!

Disclaimer: This survey and your responses do not guarantee the implementation or design of any one feature. Final decisions will be made with other factors of consideration such as cost and feasibility as well as your input.



Swings: A new set of swings for the playground



Pulley System: A set of pulleys to transport a child's favorite material across the play area



Raised Garden Bed: An area for children to practice their gardening skills in the playground



Treasure Hunt: A sand table with buried treasure ranging from small toys to dinosaur bones. The contents can be varied for many days of fun exploration.



Raised Sensory Table: A table with different sections of sensory based materials



Balance: A wooden outdoor balance to compare the weights of natural elements in the playscape



Slide: A small slide for the children



Simple Machine Sandbox: An array of simple machines installed in the sandboxes that the children can use to play with the sand



Stream Table: A table that simulates water flow and erosion through the use of small pebbles, sand, and a water pump source



Big Dice: A set of large foam dice for playground games



Inflatable Raft: A large raft for the children to bounce around in and go on creative adventures from the safety of the Mill Swan play area



Lego Water Flow: Using Duplo lego blocks to control the flow of water down a ramp



Bike Pump: A new water pump system that makes the children think about how the water is flowing



Sand Pendulum: a hanging funnel for sand to flow through, and create designs on a surface below



Simple Circuit Cubes: Small enclosed circuit components that children can make basic circuits with



Animal Puppets: A puppet show enveloping the ideas of natural ecosystems and fostering creativity with



Plinko: Drop a ball through a series of pegs and evaluate what happens!



Shadow Tarp: A large canopy to take the place of the current shaded area in the playground with cutouts to lay fun shadows on the ground



Climbing Structure: A wooden structure for the kids to climb on with some fun STEAM features added in



Rubber Band Wall: Use your creativity to make designs out of rubber bands!



Music Wall: A wall of fun recycled music features that the children can compose a masterpiece with



Towers of Hanoi: A large scale version of a classic puzzle



Appendix K

Focus Group

The goal of our project is to assist the Mill Swan Head Start program in promoting STEAM learning within its curriculum by designing two outdoor play spaces. These spaces will be used to develop lifelong learning skills for higher levels of education among the youth enrolled at the center.

The population would be Mill Swan teachers, parents, and sponsors.

Hello, our team is Marco, Madison, Mike, and Will. Our team would like to thank you for your willingness to participate in this interview. We are conducting focus group Interviews for Worcester Polytechnic Institute and Mill Swan to gain a deeper understanding of their preferences for different design features and how they envision organizing these features. We would like to ask a series of questions; at any point you feel uncomfortable you can end the interview or decline to answer. The answers will be recorded through an audio recording for reference later. Answers may be published online later, however, personal identities will remain anonymous and only the information may be published. Can you please verbally consent to these conditions before we begin? This interview should take approximately 20-30 minutes.

For more information, you can contact the team at:

gr-headstartd24@wpi.edu or cbkurlanska@wpi.edu

- 1- Please rank these elements. (Will you use pictures of potential elements?)- is this an individual or a group ranking (since you are in a focus group you need to clarify)
- 2- What strengths/weaknesses do the elements have? Do you want them to comment on each element?
- 3- Are there any immediate problems you see with any of the elements?
- 4- Are there any problems that you believe could arise in the future?
- 5- Are there any elements you think are not feasible?
- 5- Do you believe our methods were adequate in collecting data?
- 6- Do you have any suggestions for any one of the elements?



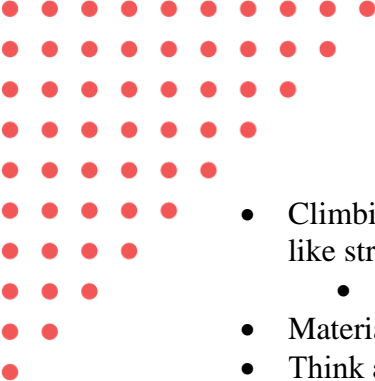
Appendix L

Acton Discovery Museum Interview Notes

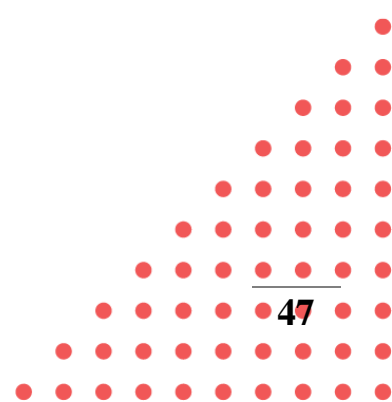
3/21/2024

1:30 pm

- We had the chance to meet [REDACTED] for this interview both were part of the design process of the museum
- [REDACTED] has 12 years of experience and [REDACTED] has 2 years
- Acton Museum used to be separated into two buildings then for a more universal place, they closed one and expanded the other.
- They focus on physical science meaning more engaged with phenomena (hands-on) and Sound, they explore different sounds so they can hear, feel, and touch them.
- The museum team and staff across the department brainstormed and built a concept, and then two designers took the concept and brought it to life.
 - All departments are involved in brainstorming, and then specific departments do their respective duties to bring the idea to a design
- Main design thought process
 - Think of a phenomenon, develop a hands-on activity for that phenomenon, and then develop a design that incorporates that activity
- They build the component around cause and effect. Cause and Effect is the newest building
- Sensory is a major thing to consider in early education
 - Sound- water play, kinetic sand
 - Airplay- face up to create a wind tunnel, natural texture varies, durability, metal, wood
- Universal design standard 36" of clearance
- To determine what features to keep, think about trade-offs, what is the most important, and what is negotiable
- Placement should be determined with usability in mind so that the feature is accessible and being used as intended.
- Things break all the time
- Parts WILL break
- The trade-off between durability and cost
- Think of things that are easily repaired
- Good outdoor building materials are pressure-treated wood, wood cedar, decking material
 - When deciding on a material, you also need to consider trade-offs. For example, wood is sustainable and easy to come by but can cause splinters. Metal is very expensive but very sturdy.
- If equipment online is too expensive, you can always build things yourself to save money.
 - One time, they were looking to build a wind tunnel, but it was around \$5,000 to purchase online, instead, they used a box fan and scrap materials. It was just as effective, and they saved a lot of money in the process.



- Climbing structures do not need to be stereotypical play structures. Think of climbing like structures:
 - cargo net scramble, Da Vinci bridge, rock scramble
- Material, measure what is around it, and don't forget the doorway.
- Think about what you loved to do as a kid and don't forget to have fun.





Appendix M

Connecticut Science Center Interview Notes

3/22/24

1:00 pm

Experience

- 10 years of previous classroom teacher experience
- A part of the design team at the Connecticut Science Museum
- Worked on engineering space, genomic, and new space center

Science museums all have similar features

- New England science museums use the same design firm out of Boston which is why designs are so similar
- There is a “small circle” of science museums, and they often work together and share ideas

Connecticut Science Museum

- They have one large design team that much of the staff is a part of, and they break up into smaller focused design teams to tackle larger projects
- Ensure skill development and deep engagement with features

Play Based Learning

- STEAM
- They ask themselves: What do we want them to get out of it? Possible examples include:
- Tactile experience?
- Fostering curiosity
- Water activity (Where did the water go?)
- STEAM at their level
- What will foster creativity?
- What will increase social interactions?
- Also important to note who your target audience is
- You want to build something that will provide the user with an experience that will be meaningful after they leave the site, and foster creative thinking in the things they come in contact with outside of your design (like the river after seeing a water design)

What works for them

- Build for robust activities, easy to clean
 - Features need to withstand the use of a bunch of kids every day
- What is going to pull people in? The design needs to be attention-grabbing
- Bring in local attributes - Connecticut River
- Work with LEGO

- LEGO is likely an activity that the children have played with before
- What do people know from home but can use differently?
- Repurpose things
- To place features, they use the idea of “Pods”, people explore two or three things that are not linear
 - The pods should have a common theme
 - People get things out of exploring together, so try and make the design for more than one user

ECE

- Mobile step stools
- Core equipment but change out small parts
 - Important to allow for variability so that small parts of a core feature can be changed so the kids won't get bored with the experience
 - Flexibility is key
- Stay away from drawing since you cannot maintain
- EX: Balls and ramps iteration to keep them engaged
 - Different balls and tubing

- Lead exhibit designer
- Can send him our designs and he will give feedback
- Conceptual design, SketchUp prototype
- Likes to use cheap materials to make up prototypes

Our design

- Ramp prototypes
 - Several heights
- Instructible
 - Our spin
- Flexibility
- Getting to be able to do the skills
- Noticing, observing, not even the product
- Stream table
- Different ways to get up and balance
- Document how things got there
- Narrow into two things to complete
- If it is too complex the kids will give up
- The simpler the better, intuitive use
- Leverage the space
- In their garden, they have little boxes and hide things to collect
- Combine actions/ objects to make different shadows
 - Color projections and puppets



Appendix N

All design ideas from stakeholder interviews and visits

<ul style="list-style-type: none">• Teacher Interviews<ul style="list-style-type: none">• Climbing Structure• Music Wall• Slides• Water Pump• Swings• Sensory Corner• Cave/Hiding Area• Gears• Pulley Systems• Parent Interviews<ul style="list-style-type: none">• Slides• Climbing Structure• Swings• Teeter Totter• Trampoline• Music Features• Sand Pendulum• Digging Equipment• STEAM Learning Centers• Acton Discovery Museum<ul style="list-style-type: none">• Balance• Lego Water Flow• Rubber Band Wall• Magnetic Gear Wall• Magnetic Ball Wall• Sand Pendulum• Plinko• Music Wall	<ul style="list-style-type: none">• Simple Circuit Cubes• Connecticut Science Center<ul style="list-style-type: none">• Lego Water Flow• Towers of Hanoi• Inflatable Raft• Stream Table• EcoTarium<ul style="list-style-type: none">• Balance• Music Wall• Parks<ul style="list-style-type: none">• Climbing Structure• Music Wall• Online Research and Brainstorming<ul style="list-style-type: none">• Shadow Tarp• Bike Pump• Simple Machine Sandbox• Raised Sensory Table• Pulley System• Big Dice• Puppet Ecosystem• Treasure Hunt
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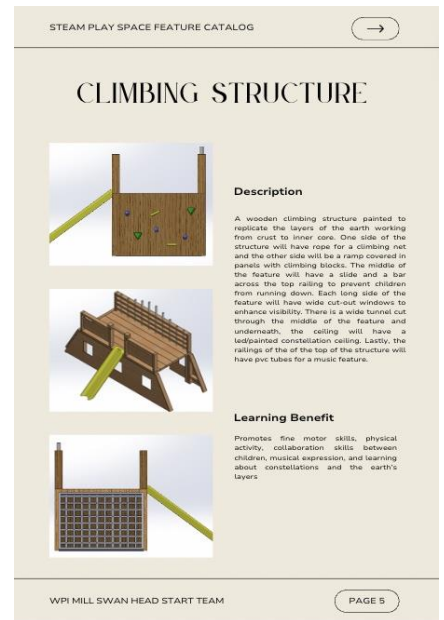
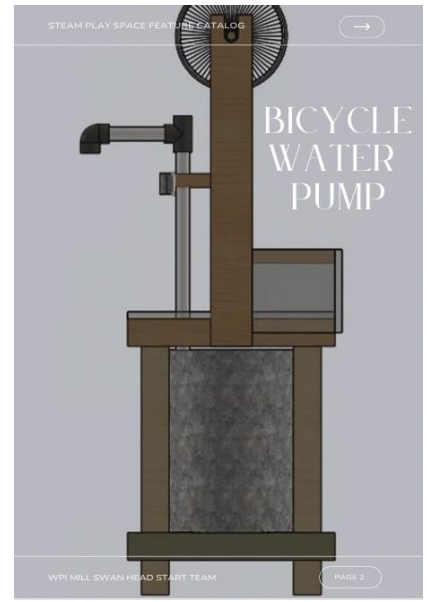
Appendix O

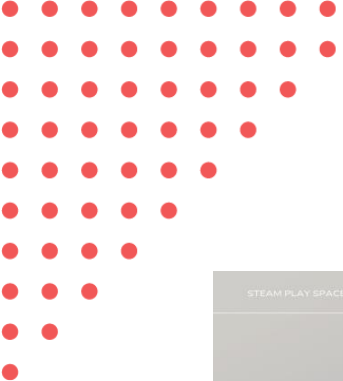
Value Analysis

	Options	Ease of Construction	Popularity among Students	Popularity among Teachers	Weatherproof	Durability	Maintenance	Risk Factor	STEAM benefits	Cost		
Rank	Weight	80	90	70	70	65	50	80	90	70	Raw Score	Weighted Score
2	Climbing Structure	2	4	5	5	4	4	2	5	1	32	2360
1	Bike Pump	2	2	4	5	5	5	4	5	4	36	2595
13	Music wall	4	1	4	3	3	3	5	4	5	32	2355
11	Raised Sensory Table	3	4	2	4	5	1	5	4	3	31	2365
12	Pulley system	4	2	3	4	4	3	4	4	4	32	2360
17	Simple circuit cubes	2	5	1	1	5	4	3	4	4	29	2155
4	simple Machine sandbox	2	5	4	4	5	4	3	5	2	34	2525
19	Raised garden bed	3	2	2	4	5	1	5	3	3	28	2095
6	Magnetic ball wall	4	2	2	4	5	4	5	4	4	34	2485
6	Magnetic gear wall	4	4	1	4	5	4	4	4	4	34	2515
8	swing	5	5	4	5	5	4	2	2	1	33	2415
2	slide	5	5	5	5	5	5	3	2	1	36	2615
5	shadow tarp	5	3	1	3	4	4	5	4	5	34	2520
18	Big dice	5	4	1	2	3	5	4	1	4	29	2105
21	Towers of Hanoi	3	1	1	4	3	4	5	3	3	27	1955
1	Lego Water Flow	4	4	3	3	4	5	5	4	4	36	2650
20	Inflatable Raft	5	4	1	5	2	3	3	2	2	27	2020
3	Balance	3	5	3	4	4	4	4	4	4	35	2600
10	Plinko	3	5	1	4	3	4	5	3	4	32	2385
9	Rubber band wall	4	5	2	3	3	4	3	4	4	32	2395
7	Sand penduleum	4	4	1	4	5	4	4	4	4	34	2515
16	Animal Puppets	4	2	1	2	3	4	5	5	4	30	2235
14	Stream Table	4	2	3	4	4	3	5	4	2	31	2300
15	Treasure Hunt	5	3	2	4	2	1	5	3	5	30	2290

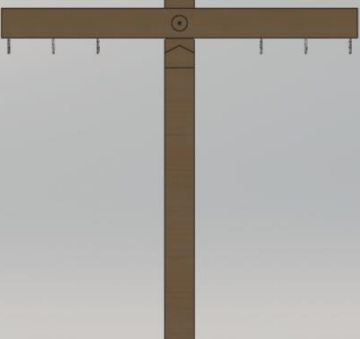
Appendix P

Feature Catalog





STEAM PLAY SPACE FEATURE CATALOG →



BALANCE SCALE

WPI MILL SWAN HEAD START TEAM PAGE 6

2024 PRODUCT CATALOG →

BALANCE SCALE



Learning Benefit

Explore mathematical weight differentiation and balance. Promotes measurement skills and comparative thinking by referencing the child's height to nature-based objects or between different children.

Description

A wooden structure that allows the horizontal beam to move up and down similar to a seesaw, based on the weight of buckets placed onto the eye hooks. There are three eye hooks on the left and right side of the beam. On the vertical post, there are three different measurement tools. On the middle back side there is a realistic ruler painted onto it. On the left and right side of the vertical post, there are pinecones and feathers painted vertically so the children can reference their physical height to the nature-based objects.

WPI MILL SWAN HEAD START TEAM PAGE 7

STEAM PLAY SPACE FEATURE CATALOG →



SIMPLE MACHINE SAND TOOLS

WPI MILL SWAN HEAD START TEAM PAGE 8

STEAM PLAY SPACE FEATURE CATALOG →

SIMPLE MACHINE SAND TOOL



Description

A simple machine where the child sits in the excavator and uses two hand levers to scoop and drop sand.



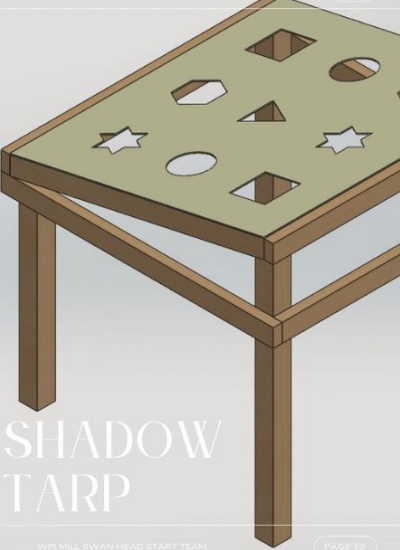
Learning Benefit

Improves a child's manual dexterity, hand-eye coordination, fine motor skills, and directional vocabulary (up/down and left/right).



WPI MILL SWAN HEAD START TEAM PAGE 9

STEAM PLAY SPACE FEATURE CATALOG →



SHADOW TARP

WPI MILL SWAN HEAD START TEAM PAGE 10


STEAM PLAY SPACE FEATURE CATALOG →

SHADOW TARP



Description

A movable wooden figure with a removable tarp top that casts shadows on the ground below of shapes, colors, animals, its up to you!

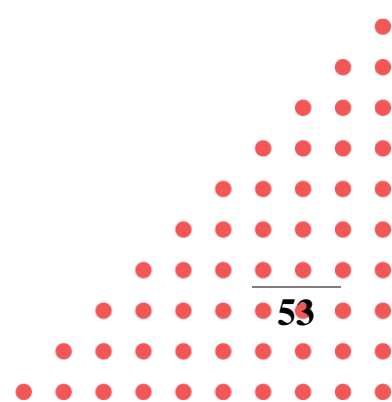


Learning Benefit

Improves children's spatial awareness, recognition of shapes, colors, sizes, ecosystems, and development of creative thinking.



WPI MILL SWAN HEAD START TEAM PAGE 11



ADDITIONAL IDEAS



Rubber Band Wall

Use your creativity to make designs out of rubber bands!



Towers of Hanoi

A large scale version of a classic puzzle



Magnetic Gear Wall

A metal wall with arrangeable gears

ADDITIONAL IDEAS



Sand Pendulum

A hanging funnel for sand to flow through, and create designs on a surface below.



Plinko

Drop a ball through a series of pegs and evaluate what happens!



Raised Sensory Table

A table with different sections of sensory based materials

ADDITIONAL IDEAS



Pulley System

A set of pulleys to transport a child's favorite material across the play area



Music Wall

A wall of fun recycled music features that the children can compose a masterpiece with



Simple Circuit Cubes

Small enclosed circuit components that children can make basic circuits with

ADDITIONAL IDEAS



Raised Garden Bed

An area for children to practice their gardening skills in the playground



Big Dice

A set of large foam dice for playground games



Inflatable Raft

A large raft for the children to bounce around in and go on creative adventures from the safety of the Mill Swan play area

ADDITIONAL IDEAS



Puppet Ecosystem

A puppet show enveloping the ideas of natural ecosystems and fostering creativity



Stream Table

A table that simulates water flow and erosion through the use of small pebbles, sand, and a water pump source



Treasure Hunt

A sand table with buried treasure ranging from small toys to dinosaur bones. The contents can be varied for many days of fun exploration.

Appendix Q

Design Manual

PLAY FEATURE

design manual

PRESENTED FOR:
HEAD START

PRESENTED BY:
WPI TEAM-MIKE, WILL,
MARCO, & MADISON

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- 02 Bicycle Water Pump
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- 34 Resources

Bicycle Water Pump

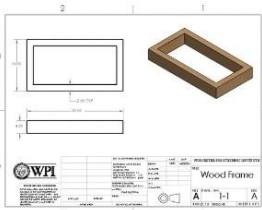
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	wood_frame	Top and bottom structural frames	2
2	dowel_holder	Supports to hold up the wheel	2
3	bike_wheel	Bicycle wheel	1
4	2in_pvc	2 inch PVC pipe	2
5	pvc_elb	45 degree elbow of PVC pipe	1
6	3in Tee	3 inch Tee	1
7	2in Tee	2 inch Tee	1
8	3in Elbow	90 degree elbow of PVC pipe	1
9	flexible_tube	flexible tube	1
10	4x4_2ft	Pressure treated 4x4	2
11	plastic_tarp	Plastic tarp	1
12	2x4 16ft	WOOD support to hold the wheel	1
13	2x4 8ft	Connection to hold the pipe	1
14	dowel_holder	Support to support the pipe	1
15	4x4 12ft	Pressure treated 4x4 support	1
16	ground	Ground to the pipe	1
17	plastic_tarp_top	Attach up the plastic tarp	1
18	plastic_tarp_bot	Attach up the plastic tarp	2
19	plastic_tarp_top_bot	Front side of the plastic tarp	1

WPI
WOOD CENTER POLYTECHNIC INSTITUTE
Bike Pump
Exploded View
SCALE: 1/4"=1'-0"
SHEET 1 OF 1

OVERARCHING DESIGN

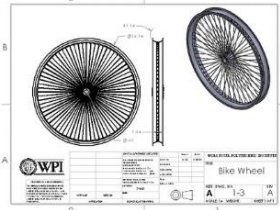
BICYCLE WATER PUMP

2



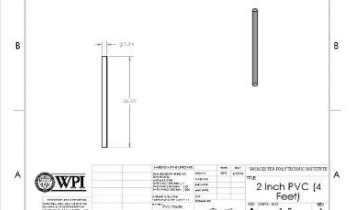
BICYCLE WATER PUMP

3



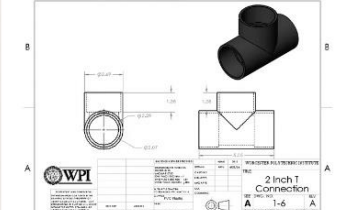
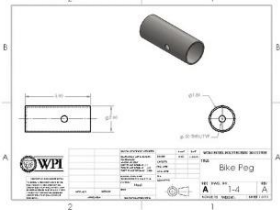
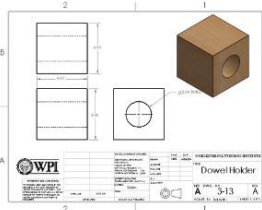
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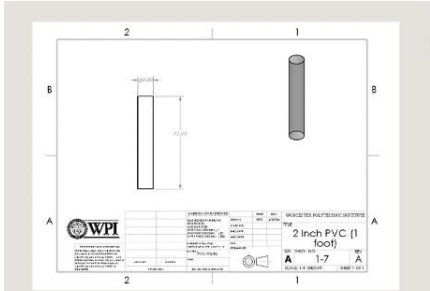
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BICYCLE WATER PUMP

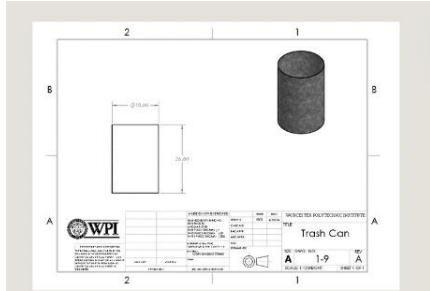
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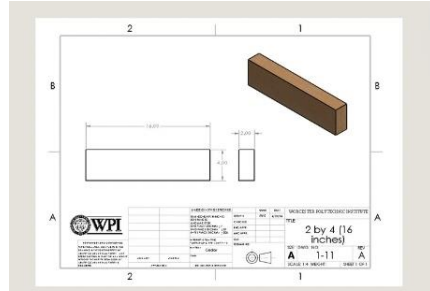
BICYCLE WATER PUMP

6



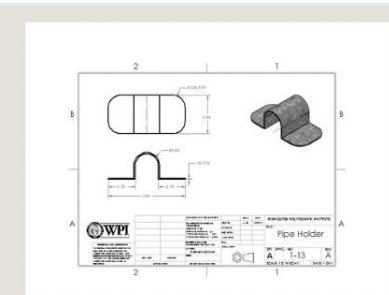
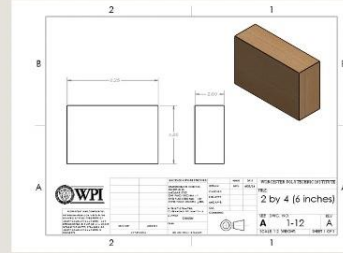
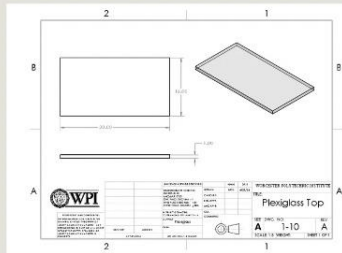
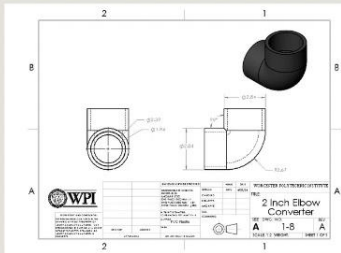
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7



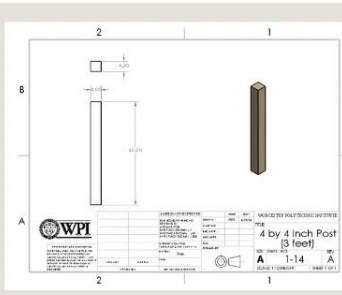
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8



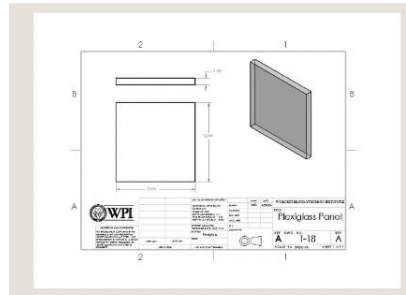
BICYCLE WATER PUMP

9



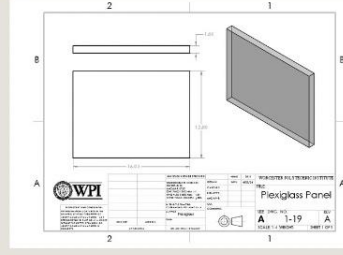
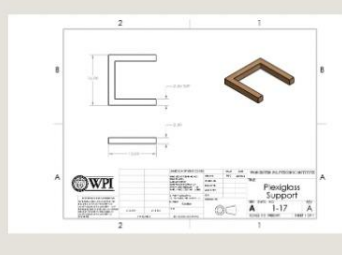
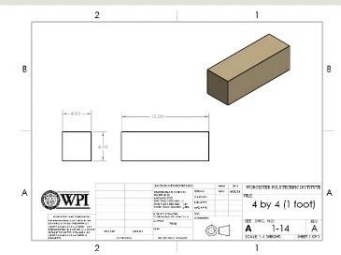
BICYCLE WATER PUMP

10



BICYCLE WATER PUMP

11



Balance Scale

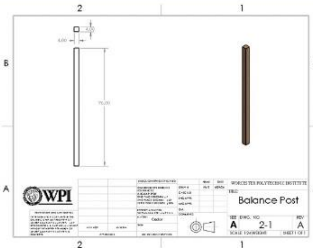
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	balance_post	4 by 4 cedar post	1
2	block	wooden block between the post and balance beam	1
3	balance_beam	balance beam	1
4	cupper_pipr	Copper pipe for the bolt to pivot in allowing the beam to pivot	1
5	HOOK	3/8 inch eye hooks	6
6	pivot	Wooden block to hold the pivot middle of the beam	1

Balance Exploded View
 WPI PROJECT: POLYTECHNIC SYSTEMS
 DATE: 11/11/2011
 SCALE: MINOR
 SHEET 1 OF 1

OVERARCHING DESIGN

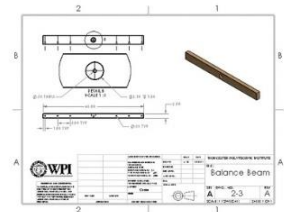
BALANCE SCALE

12



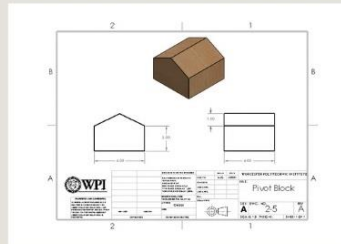
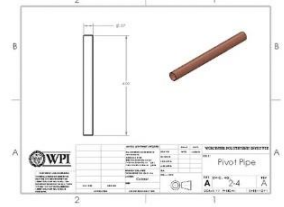
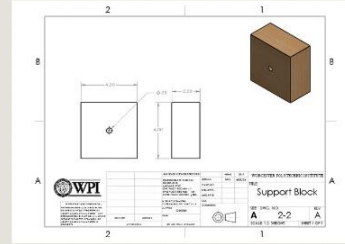
BALANCE SCALE

13



BALANCE SCALE

14



BALANCE SCALE

15

Climbing Structure

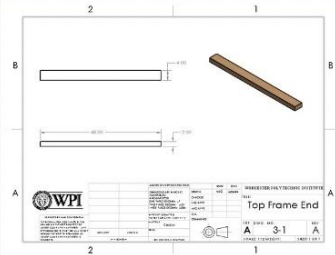
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	2x4x8	Top Frame	1
2	2x4x8	Top Back	1
3	2x4x8	Top Middle	1
4	2x4x8	Main Frame	1
5	2x4x8	Support Frame	1
6	2x4x8	Support Frame	1
7	2x4x8	Support Frame	1
8	2x4x8	Support Frame	1
9	2x4x8	Support Frame	1
10	2x4x8	Support Frame	1
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100	2x4x8	Support Frame	1

Climbing Structure Exploded
 WPI PROJECT: POLYTECHNIC SYSTEMS
 DATE: 11/11/2011
 SCALE: 1-1
 SHEET 1 OF 1

OVERARCHING DESIGN

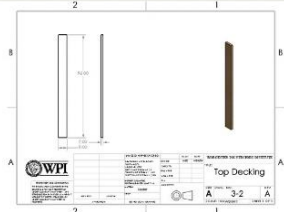
CLIMBING STRUCTURE

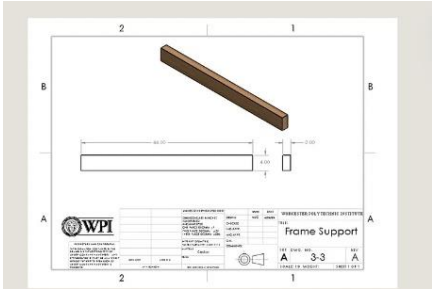
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CLIMBING STRUCTURE

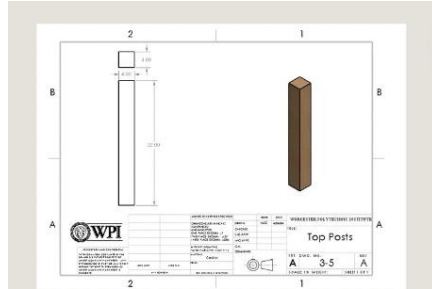
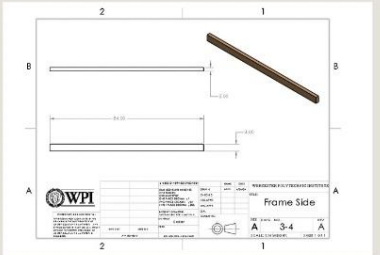
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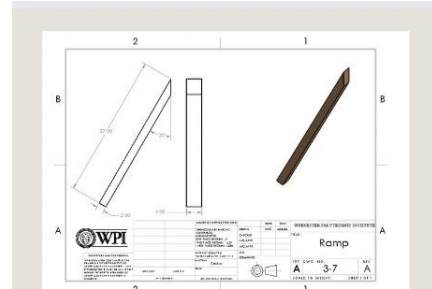
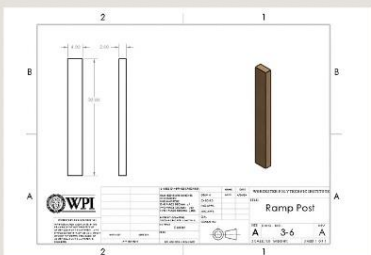
CLIMBING STRUCTURE

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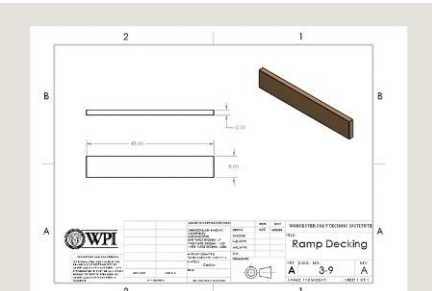
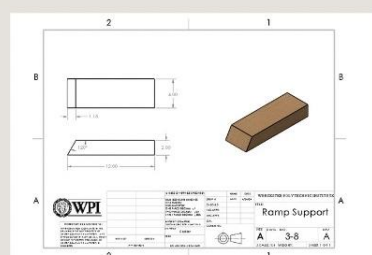
CLIMBING STRUCTURE

19



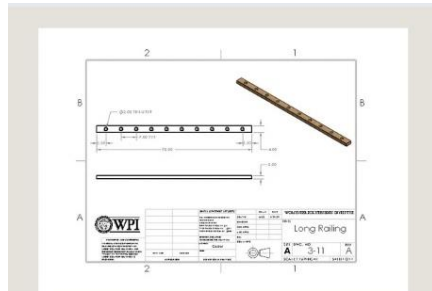
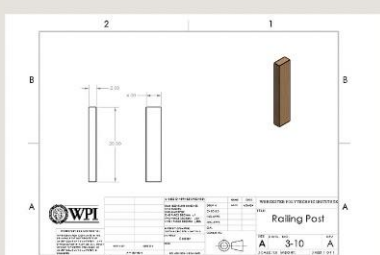
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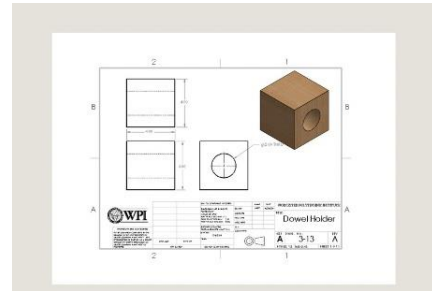
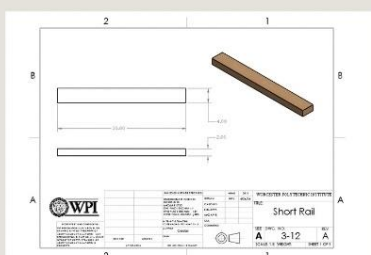
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21



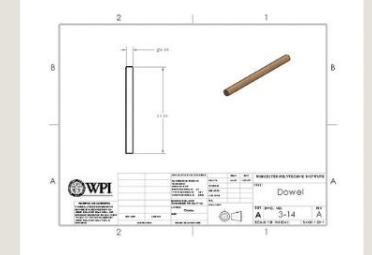
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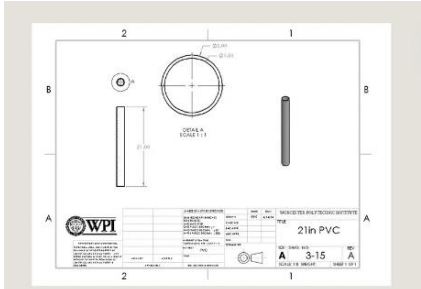
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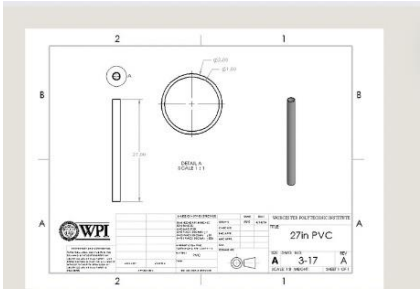
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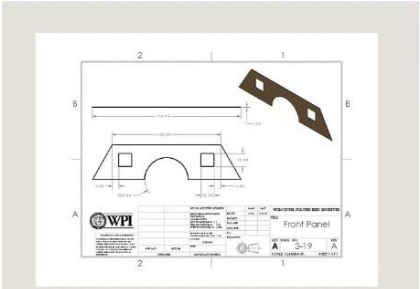
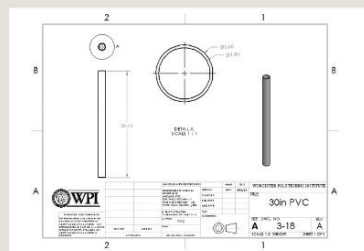
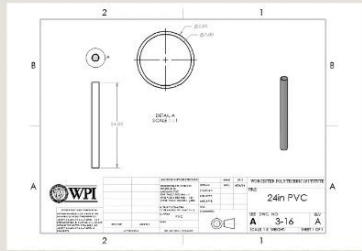
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24



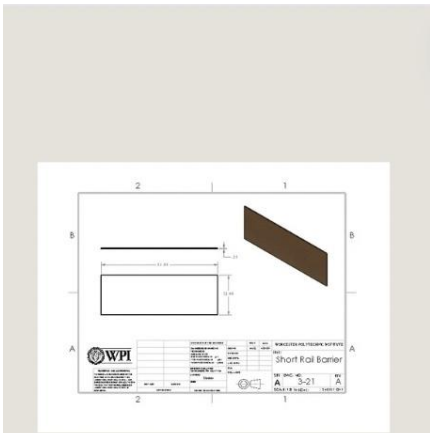
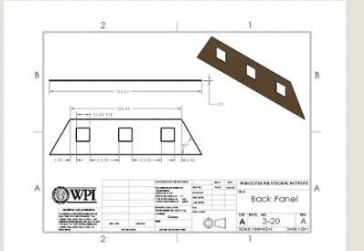
CLIMBING STRUCTURE

25



CLIMBING STRUCTURE

26



CLIMBING STRUCTURE

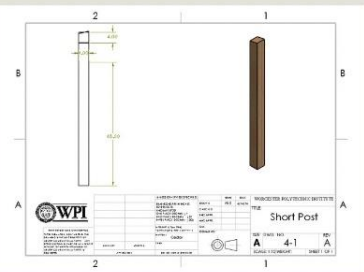
27

Shadow Tarp

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	4x4 8ft	Long Post	2
2	2x4 diagonal	Diagonal 2x4 Support	2
3	2x4 straight	Straight beam Long	4
4	2x4 8ft	Straight beam Short	2
5	Tarp_16ft	Model Tarp	1

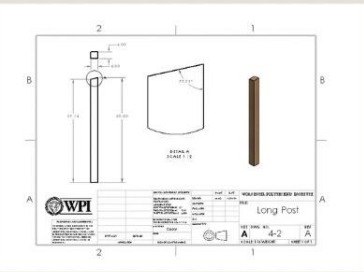
SHADOW TARP

28



SHADOW TARP

29



OVERARCHING
DESIGN

Diagonal Beam

Straight Beam

SHADOW TARP 30

Short Straight Beam

Model Tarp

SHADOW TARP 31

Cost² Breakdown Bicycle Waiver Pump

Part	Price	Store	Amount	Total price	Total Cost
offtop pipe pipe	\$5.21	Home Depot	1	\$5.21	\$415.55
upps pipe	\$14.99	Acad Hardware	1	\$14.99	
top pipe pipe	\$6.29	Home Depot	1	\$6.29	
Clear pipe 2 1/2"	\$114.00		1	\$114.00	
per pipe (2 1/2 in x 10 ft)	\$49.94	Home Depot	10	\$499.40	
hose pipe (1/2")	\$25.51	Home Depot	15	\$382.65	
1 in by 4 in by 8 ft cedar	\$30.68	Lowe's	6	\$184.08	
2 1/2 by 4 cedar	\$8.49	Lowe's	6	\$50.94	
2 1/2 by 6 pressure treated pine		Home Depot	6		
4 by 6 pressure treated pine	\$11.19	Home Depot	6	\$67.14	
Post Noodles	\$4.99	Acad Hardware	2	\$9.98	
1/2 in wood	\$13.00	Ball's	1	\$13.00	
2 in Galvalume pipe bracket	\$1.12	Home Depot	2	\$2.24	
1 in x 1/2 in wood panel	\$10.88	Acad Hardware	1	\$10.88	
1 in 1/4 in wood face cap	\$11.48	Lowe's	1	\$11.48	
2 1/4 in Blue Base Curves	\$29.96	Lowe's	1	\$29.96	
1 1/2 in Blue Base	\$1.97	Home Depot	1	\$1.97	
Playground Curve	\$4.99	Home Depot	1	\$4.99	
#10 x 1 1/2 in Star Drive Screws (17)	\$10.48	Home Depot	1	\$10.48	
#10 x 1 1/2 in Star Drive Screws (17)	\$10.48	Home Depot	1	\$10.48	
wood		Lowe's	4		
nut		Lowe's	2		
20 galvanized steel mesh	\$33.00	Acad Hardware	1	\$33.00	
Elkman Tape	\$1.78	Home Depot	1	\$1.78	
Mounting Tape	\$4.74	Home Depot	1	\$4.74	
Dust Tape	\$3.08	Home Depot	1	\$3.08	
PVC glue	\$8.18	Lowe's	1	\$8.18	
ABS glue	\$5.90	Home Depot	1	\$5.90	
Blue Base	\$1.00	Home Depot	1	\$1.00	

Bike Pump 32

Part	Price	Store	Amount	Total price	Total Cost
score book	\$3.98	Home Depot	6	\$23.88	130.72
4 by 4 Cedar post 8ft	\$49.98	Lowe's	1	\$49.98	
2 by 4 cedar 8ft	\$8.98	Lowe's	1	\$8.98	
Metal Pails	\$5.98	Lowe's	6	\$35.88	
1/2 in x 1/2 in bolts		Lowe's	28		

Balance Scale

Part	Price	Store	Amount	Total price	Total Cost
2 by 4 cedar 8ft	\$8.98	Lowe's	13 (104ft)	\$116.74	\$1,339.99
4 by 4 Cedar post 8ft	\$49.98	Lowe's	2 (16ft)	\$99.96	
2 in Wood Dowel	\$10.98	Lowe's	1 (4ft)	\$10.98	
2 by 4 Cedar 8ft	\$44.98	Lowe's	3 (48ft)	\$339.84	
2in PVC Pipe (10ft)	\$17.74	Lowe's	3 (30 ft)	\$53.22	
Slats	\$164.33	Amazon	1	\$164.33	
Cedar Plywood 6ft by 8ft	\$54.39	Home Depot	5	\$271.95	
Rock Climbing Holds	\$26.99	Amazon	1 (10 pcs)	\$26.99	
Climbing Net	\$187.50	Jamaica Nets	1	\$187.50	
#10 x 1 1/2 in Star Drive Screws (475)	\$47.48	Home Depot	1	\$47.48	

Climbing Structure

Part	Price	Store	Amount	Total price	Total Cost
2 by 4 cedar 8ft	\$8.98	Lowe's	3 (48 ft)	\$44.94	\$275.20
4 by 4 Cedar post 8ft	\$49.98	Lowe's	3 (24ft)	\$149.94	
#10 x 1 1/2 in Star Drive Screws (17)	\$10.48	Home Depot	1	\$10.48	
score book	\$3.98	Home Depot	4	\$15.92	
Canvas Tarp	\$45.96	Crutchfield	1	\$45.96	

Shadow Tarp

33

RESOURCES

01	Ecotarium Exhibit Constructor	Dan Oumette doumette@ecotarium.org
02	Worcester Technical High School - Carpentry Division	Kevin Letourneau letourneauk@worcesterschools.net
03	Exhibit Companies	-Blue Hive
04	Feature Vendors	-Kodo Kids -Natural Playgrounds Company -Nature Explore

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