GOODLAND MONTESSORI SCHOOL PLAYGROUND PROJECT RESEARCH

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Jordyn Purnell, and Terryon Brumby

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Element A: Presentation and Justification of the Problem

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Explanation of Problem and Summary of Evaluation

Our group has done research on the concepts we would like to use in our playground design. First, we started looking for organizations and individuals that we believe represent Goodland Montessori School's values regarding childhood learning and nature interaction. We also did some research in natural play spaces, and in what ways they benefit children and design ideas.

Below, we present this research, along with expert interviews, surveys, and a brief overview of preexisting ideas, designed for a natural playground.

Evidence from Experts in the Field

Expert Interview

In an interview with Lisa Johnson, the principal of Goodland Montessori School, and other members involved in the playground project, we stated the main requirements for the playground, as well as some constraints.

We presented them some of our ideas, showing them pictures of possible designs. Besides, Ms. Johnson contributed by adding some playground equipment she would like to see; such as pans and pots used as musical instruments or a small table used for children to eat and read. She also stated that this playground is expected to last a long time. She showed great interest in European green playgrounds, something we based our research on.

Talking about technical and safety constraints, we were informed of some details: the sand in the playground will be replaced by 9 inches deep of wood chips; the beams surrounding they playground space will be removed; the dimensions of the playground area are 36.1” long x 18.7” wide x 10.5” tall; not all kind of wood can be use when building playground equipment; and security space measures must be followed (such as 5 feet distance between two playground equipments or with the border of the area). We agreed on using the space as wisely as possible, mostly using the 5 feet border; for instance: planting plants, installing ground level equipment (as tire tunnels), or hanging pots and pans in the fence and using them as musical instruments.

The space provided to build the playground at Goodland Montessori School.

Evidence Gathered from Consumer / Stakeholder Survey and Research

The survey was extended to the students of Goodland Montessori School that will be using this playground. We believe that students should be involved in the decision, and that they will feel it belongs more to them if they get to choose what equipment they will have. The results will be taken into account when designing the playground, but other factors will be too.

The students were told to pick their two favorites, and this are what the results show:

1) Tire swings (48 votes): It was their second favorite. We decided to include it in the design, because they liked it, it is easy to build, and we have the necessary materials.

2) Tire mountain (24 votes): The students liked it. We will look at the space available and if it is possible to include it, we will. One positive thing about this

equipment is that it will just use tires (a material we can get for free) and something to keep the structure.

3) Balance path (76 votes): It is the students favorite, and even when we would have to buy the materials and it is challenging to design, we decided to include it.

4) Wood ship (41 votes): We discarded this equipment, because it would be really difficult to build, it would use a lot of space and a lot of new materials. In addition it is not one of the student's preferences.

5) Tire tunnel (14 votes): It was not one of the student's favorites, but we may still build it. It is an equipment that can be built next to the edge, and therefore use all the space provided.

6) Seesaw (12 votes): It was the least voted, so we decided not to include it in the design.

Circle your 2 favorites!

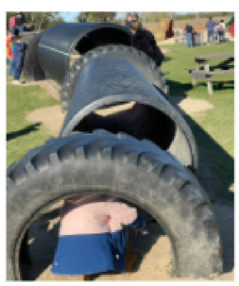
1) tire swing (48 votes)

2) tire mountain (24 votes)

3) balance path (76 votes)

4) wood ship (41 votes)

5) tire tunnel (14 votes)



6) seesaw (12 votes)

Evidence Gathered from Research

Montessori Education[1]

The Racine Unified School District opened its first Montessori school at Goodland School (4800 Graceland Blvd.) in 2016. Montessori education consists of a self-directed activity, hands-on learning and collaborative play; where children get a deeper understanding of the different areas of knowledge (mathematics, language, science, arts, music, etc.) and a greater development in their strengths. Besides, Montessori schools believe in the benefits of being in contact with nature.

Earthship Biotecture[2]

Earthship biotecture is a company that designs and builds earthships. “Earthship is a type of house built with natural and recycled materials with energy conservation in mind. It is designed to produce water, electricity and food for its own use.” Earthship biotecture was born with the idea of helping the planet, solving the problem of excessive trash and creating affordable housing. Earthship biotecture does more than just help the planet, it also helps people. It founded a non-profit organization that builds earthships, which later veterans, children and many other people in need of a house, a school or a clinic use. We believe those principles based on environmental awareness, compassion and generosity represent Goodland Montessori School; besides of their designs built with recycled and natural materials. This is why we did part of our research regarding their concept.

Jim Greenman[3]

Jim Greenman dedicated more than thirty years to the early childhood field as an educator, early childhood administrator, and author. Jim played a significant role in the facility and program design process for more than 100 early childhood projects, taught at the Institute on Child Care Design at the Harvard Graduate School of Design, and was senior vice president for education and program development at Bright Horizons Family Solutions. He defended the idea that childhood is the time period when children become the people they will be. He stated that all the experiences and interactions they have with their environment shape them, emphasizing the importance of an active education that supports their strengths. We believe this is an accurate description of

[1] *About Montessori education*. Montessori Northwest. (n.d.). Retrieved from https://montessori-nw.org/about-montessori-education
[2] *EarthshipGlobal*. Earthship Biotecture. (n.d.). Retrieved from https://www.earthshipglobal.com/
[3] Greenman, J. (n.d.). *Thoughts on early childhood*. Retrieved from https://www.brighthorizons.com/text-pages/thoughts-on-early-childhood

what Montessori education is. Supporting this mindset that could be applied when designing a green playground; regarding the importance of being in contact with nature to develop consciousness and gratefulness, and learn to take care of the Earth.

Richard Dattner [4]

Richard Dattner was an architect, author of the book Design for Play, where he wrote: "A playground should be like a small scale replica of the world, with as many as possible of the sensory experiences to be found in the world included in it. Experiences for every sense are needed, for instance: rough and smooth objects to look at and feel; light and heavy things to pick up; water and wet materials warmed by the sun; soft and hard surfaces; things that make sounds (running water) or that can be struck, plucked, plinked, etc.; smells of all varieties (flowers, bark, mud); shiny, bright objects and dull, dark ones; things that are both huge and tiny; high and low places to look at and from; materials of every type, natural and synthetic, think, thick, and so on." Thinking about his words we decide to increase the different sensory perceptions children are able to experience in the playground with some of the ideas shown in the photos attached, where tires play a big role. Tires, as Dattner recommends, can be warmed by the sun, they can feel softer or tauter, they can vary in size and children can climb on them to look at the world from a different perspective.

Nature Play Spaces [5]

This article is a guide about nature play spaces that explains the benefits of green playgrounds (health, sensory stimulation, consideration for nature, community engagement…), as long as the resources used to build one, the precautions needed for it to be safe and the importance of including plants. As the writer states, “nature playgrounds […] provide children with a range of essential experiences: to engage senses; to observe and discover; to imagine, create, engineer, and build; and to play actively. Nature play spaces support social, emotional, and behavioral regulation and allow students and staff to decompress, regroup, and re-engage.”

[4] Dattner, R. (n.d.). *Picture perfect playgrounds*. Play Encyclopedia. Retrieved December 17, 2021, from https://www.pgpedia.com/d/design-play
[5] *Nature play spaces - national COVID-19 Outdoor Learning initiative*. Green Schoolyards America. (n.d.). Retrieved from https://www.greenschoolyards.org/nature-play

Evidence from Existing Products and Solutions

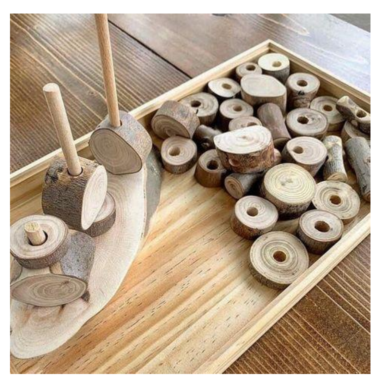
Part of the research we made was on existing products, green playgrounds already created, most of them around Europe. In the photos attached below there are some examples of our favorite ones. They are all built with recyclable or natural materials. They all are safe for children and offer them different sensory experiences,as well as a fun time playing in nature.











Conclusion

Our group has done research on the concepts we would like to use in our playground design. First, we started looking for organizations and individuals that we believe represent Goodland Montessori School's values regarding childhood learning and nature interaction (creating a bond with nature, hand-on activities and collaborative play). We also did some research in natural play spaces, in what ways they benefit children (health benefits, sensory stimulation and community engagement). We researched basic ideas based on existing European playgrounds, as the principal suggested in the interview. This research is presented along with a survey extended to the students of Goodland Montessori school who will be using the playground.

Element C: Presentation and Justification of Solution Design Requirements

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

Our design will withhold all Wisconsin regulations to allow the structure to be constructed on school grounds for the entertainment of children. The design will also rely on the feedback we receive from the students. We want the playground to be fun for the children and incorporate their ideas. The design ideas were chosen from the research we gathered from other playgrounds and are evaluated considering the pros and cons of each.

Stakeholders

Stakeholders of the playground will be the parents, the personnel of the Goodland Montessori School and the childcare providers. To form groups on various activities including site planning, equipment layout and design, recruiting construction volunteers, tools and materials required, Consulting, site preparation, and playground installation. A major key stakeholder would be the Principle (Lisa Johnson) they are responsible for attending the meetings, assisting in the site selection and other tasks related to the equipment installation.

Design Requirements[6]

An acceptable and successful solution to this problem will meet the following design requirements, which are listed in order of importance.

[6] *Public Playground Safety - cpsc.gov*. (n.d.). Retrieved from https://www.cpsc.gov/s3fs-public/325.pdf

1. The solution will have to fit in the available space provided by Goodland Montessori School to build the playground.
    a. It is important to follow the customer requirements and build according to the space provided
    b. Our design could not be larger than 36.1” long x 18.7” wide x 10.5” tall, but neither smaller. Our design is required to use all the space wisely.
2. The solution must be of sturdy construction with no sharp, rough, loose, protruding, pinching, or pointed edges, or areas of entrapment, in good operating condition, and anchored when necessary.
    a. Safety is a prime concern for this type of problem and solution because of the consumers of this product.
    b. Our playground is designed for children between the ages of 3 to 5. This public is not conscious enough to play in a safe way, therefore the equipment must be adapted to ensure their safety.
3. The solution must follow the law of safety distance, 5 feet distance between two playground equipments or with the border of the area
    a. Safety is a prime concern for this type of problem and solution because of the consumers of this product.
    b. The law states that in order to be safe a distance of 5 feet must be established, so if any kid falls there is no risk of hitting the border or any playground equipment.
4. The solution must follow the constraints regarding materials use, such as wood.
    a. Wood should be either naturally rot- and insect-resistant (e.g., cedar or redwood) or should be treated to avoid such deterioration.

Conclusion

Within Element C we discussed the requirements needed to successfully design our product. We discussed the safety constraints to ensure the structure is safe for the entertainment of children. These restraints will help guide us through the design process within Element D.

Element D: Design Concepts Generation, Analysis and Selection

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Concept Generation Methods and Procedure

Our initial research revealed many different playground elements that incorporate wood and tires. Of the results, we selected six and compiled them into a survey that was given to the students for their feedback. We have taken the results from said survey into account when designing the playground. Different favored elements were selected and combined into a coherent, safe playground structure.

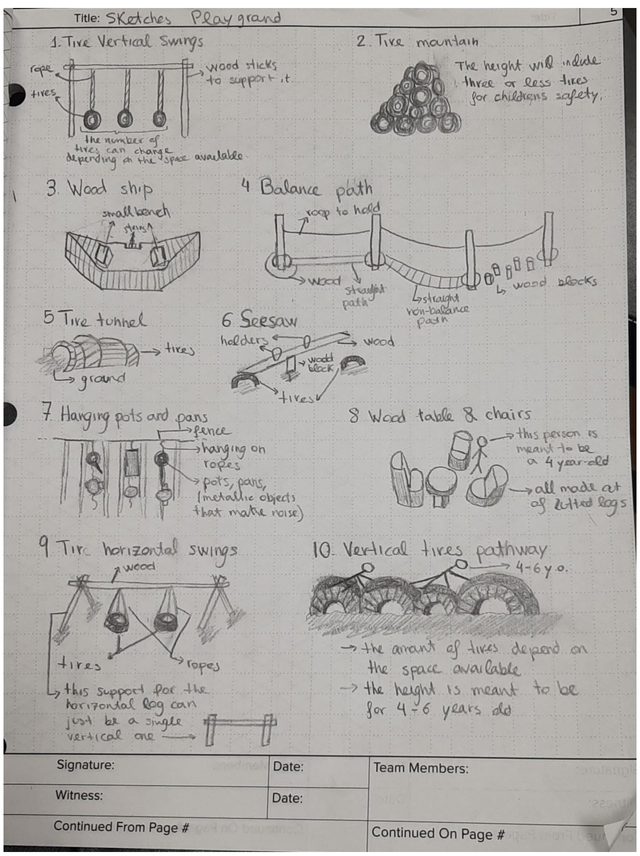
Initial List of Solution Concepts

Tire vertical swings	Tire ladder	Tire climbing wall	Jumbo Jenga
Tire mountain	Tire obstacle course	Wood building blocks	Horseshoe pit
Wood ship	Still rings	Wood stairs	Tire swing
Balance path	Tire climbing tower	Wood climbing elements	Teeter-Totter
Tire tunnel	Vertical climbing walls	Tire hiding spots	Giant wooden strider
Seesaw	Noodle climbing wall	Wood slide	Tether ball

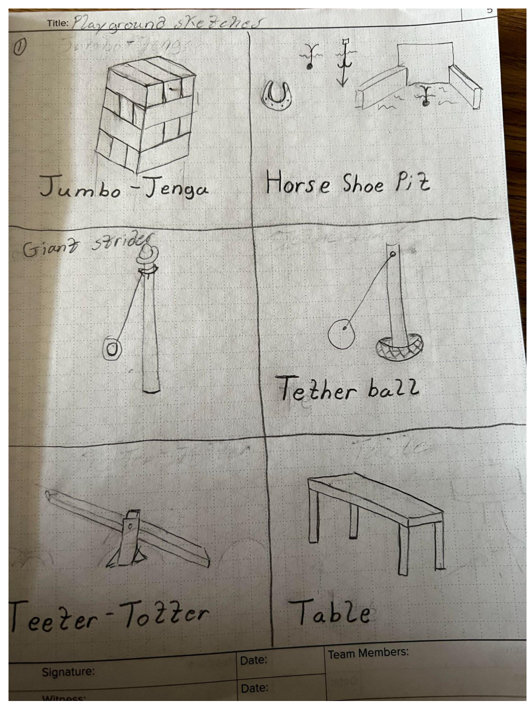
Hanging pots and pans		Rope swings	Faux log tunnel
Wood table and chairs		Spiral climbing pole	Tree stumps
Horizontal tire swings		Monkey bars	Bench
Vertical tire pathway ("climbing")		Musical pots and pans	Table

Brainstorm Sketches

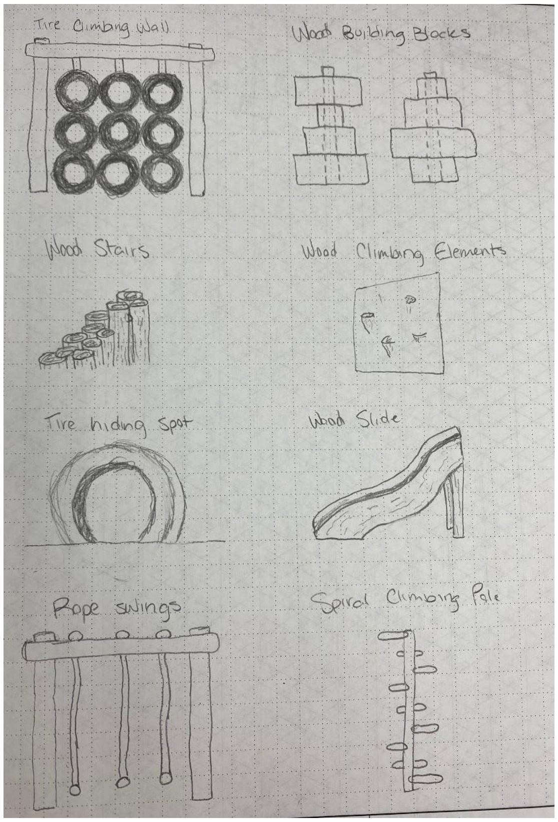
Matilde Llacer Lopez

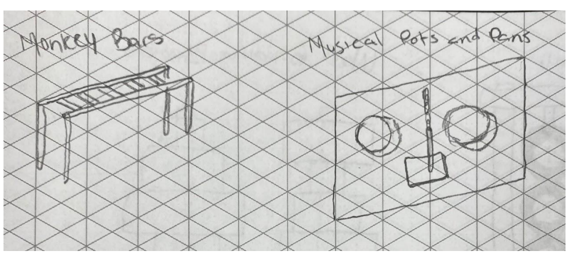


Ernesto Hernandez



Jordyn Purnell





Terryon Brumby

Top Solution List

Once we conceived and sketched possible designs, we selected the designs we favored most. The top six are highlighted above and described, in more detail, below.

1. Tire Mountain
    a. A structure constructed out of used tires. The tower is pyramid shaped with vertical tires forming the sides and a hollow center. Wood supports the tires from the center.

2. Musical Pots and Pans

   a. Pots and pans tied together to form multiple continuous lines. The ropes are then tied to a structure and anchored to the ground. The hanging pots and pans can be hit to make sounds.

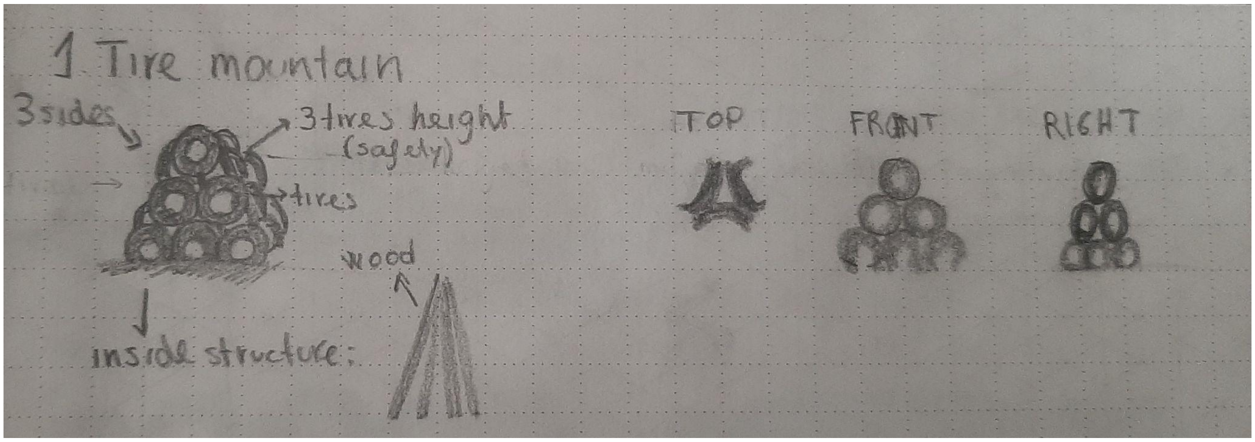
3. Horizontal Tire Swings
   a. Classic tire swing. A tire is anchored to the above structure by three or four ropes, horizontally. The swings can be used by multiple students at a time and can rotate along with swing.

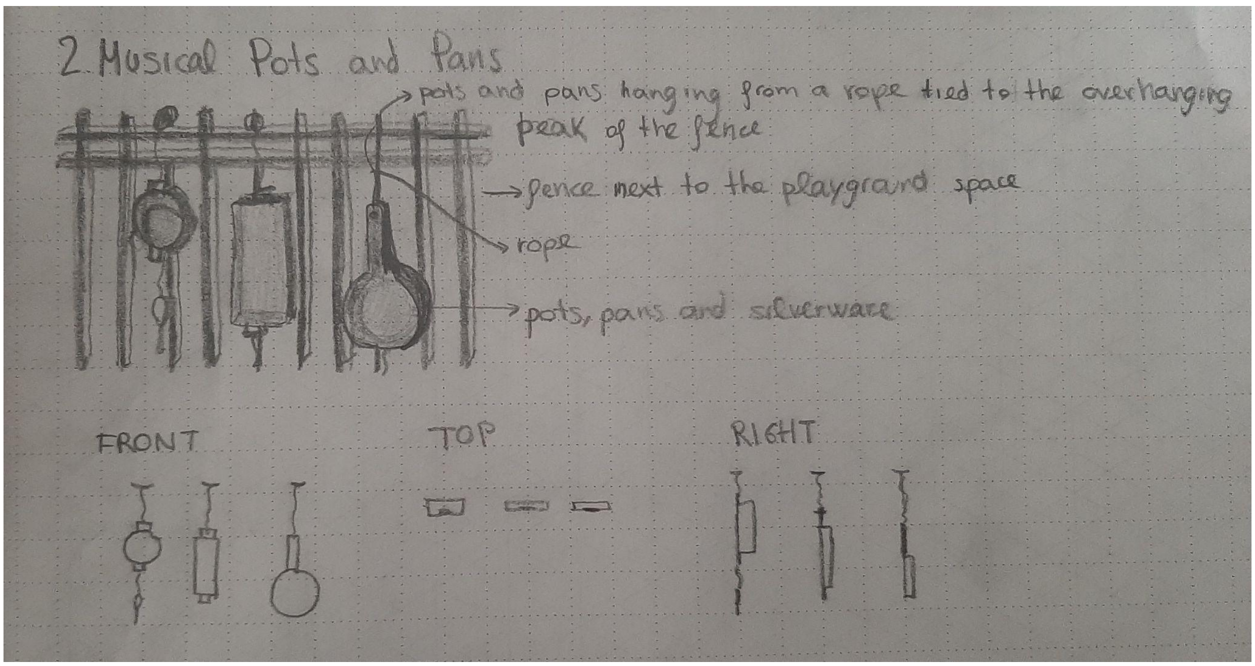
4. Vertical Tire Pathway
   a. A line tires cut along the diameter and placed cut side down. The tires should be properly anchored to the ground. Children can play on the line of tires.

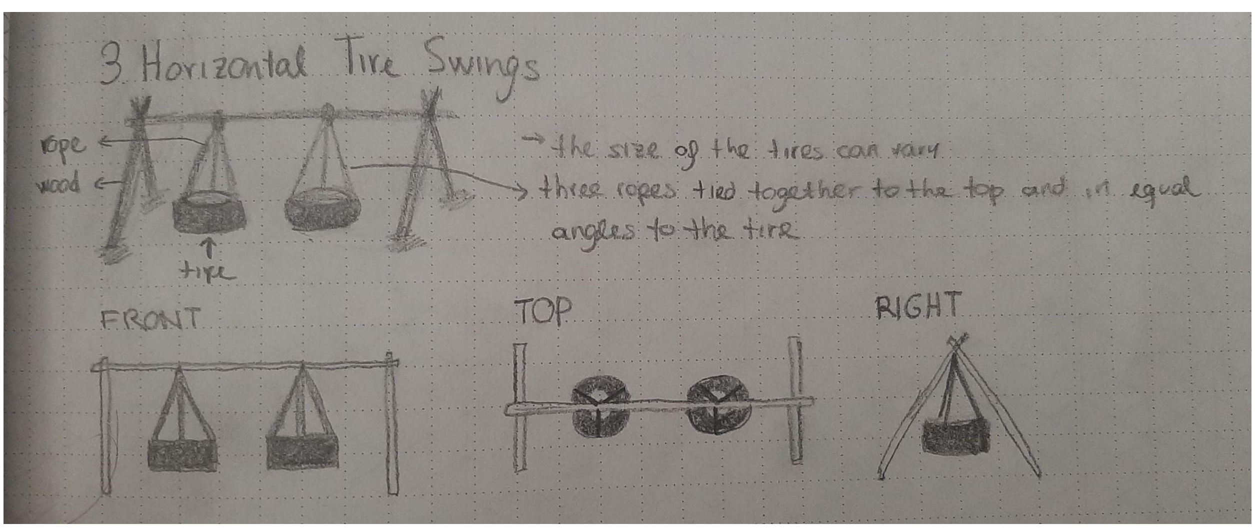
5. Rope Swings
   a. Ropes attached to a structure above, hanging freely. There are knots along the length and can be swang on.

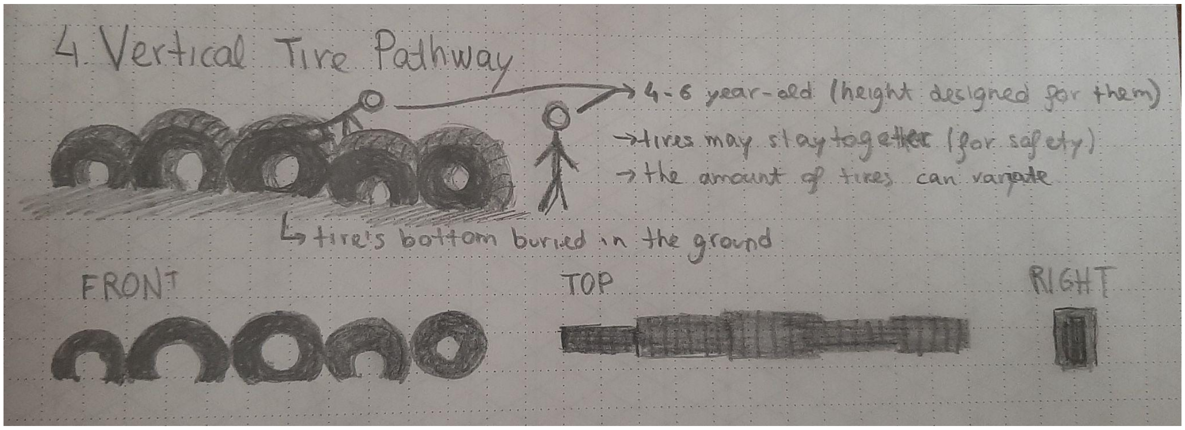
6. Monkey Bars
   a. Classic monkey bars. The height will have to be adjusted to account for the size of the students and overall safety. The children can hang on the bars and sing from bar to bar.

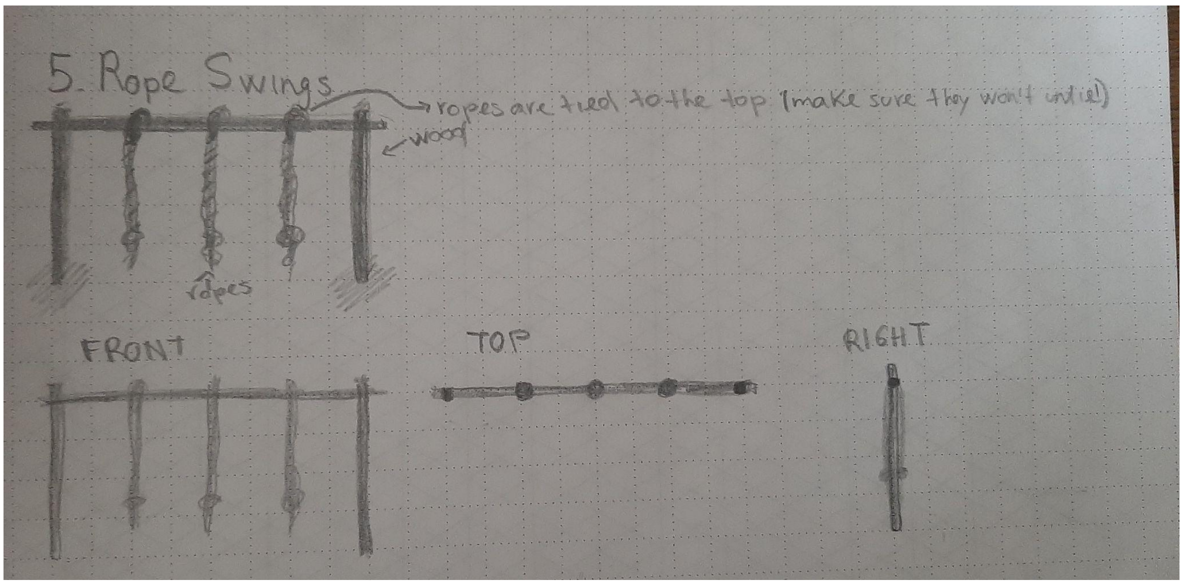
Detailed Drawings

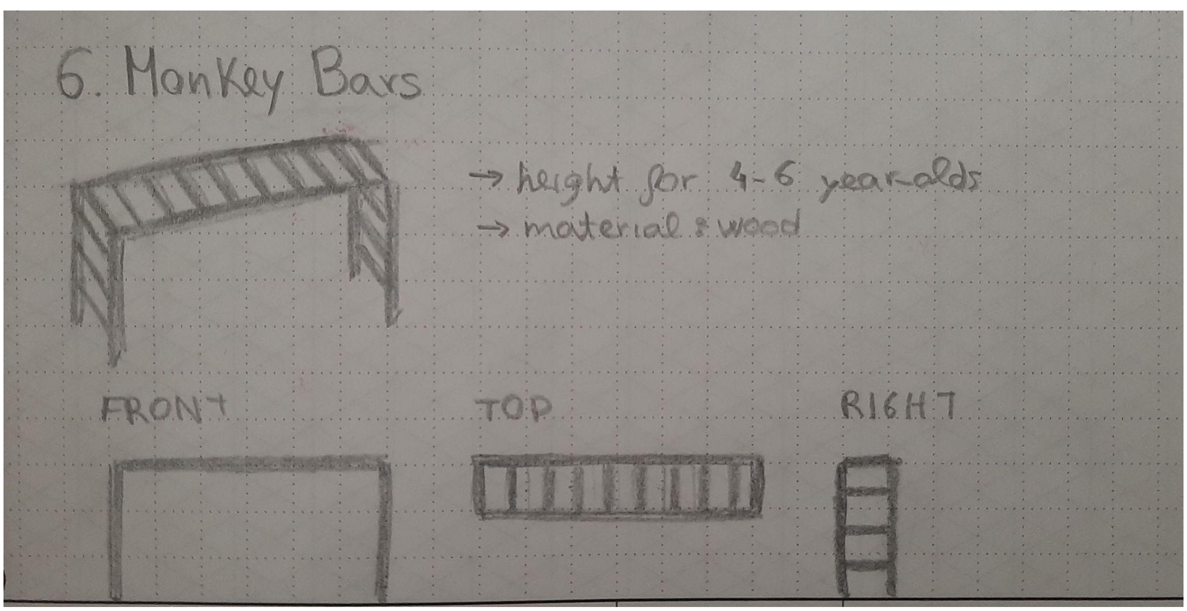







4. Vertical Tire Pathway
4-6 year-old (height designed for them)
→ tires may stay together (for safety)
→ the amount of tires can variate
tire's bottom buried in the ground
FRONT
TOP
RIGHT


5. Rope Swings
ropes are tied to the top (make sure they won't untie!)
wood
ropes
FRONT
TOP
RIGHT


6. Monkey Bars
→ height for 4-6 year-olds
→ material: wood
FRONT
TOP
RIGHT

Decision Matrix

Criteria	Tire Mountain	Musical Pots and Pans	Horizontal Tire Swings	Vertical Tire Pathway	Rope Swings	Monkey Bars
Safety	3	5	4	4	4	3
Price	3	4	4	3	5	3
Size	3	5	4	2	4	3
Access to Resources	4	5	4	4	5	3
Enjoyment	5	3	5	4	4	3
Weather Resistance	4	4	3	5	3	4
Average	3.67	4.33	4.00	3.67	4.17	3.17

Analysis and Selection

The design process went through different playground elements to determine which is most fitting for our situation. While we will use multiple of these elements, the musical pots and pans proved to be the best fitting. We will use this information, along with the other grades given on the decision matrix, to construct a cohesive play structure. We will still have to find ways to combine the elements to create a design for the overall playground; however, this process has demonstrated to us the elements we need to prioritize.

Element E: Application of STEM Principles and Practices

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

Our design consists of a playground for children between the ages of 4 and 6. To design this playground we had to take into account different STEM principles to help us evaluate and analyze our solutions to build a safe playground for the students.

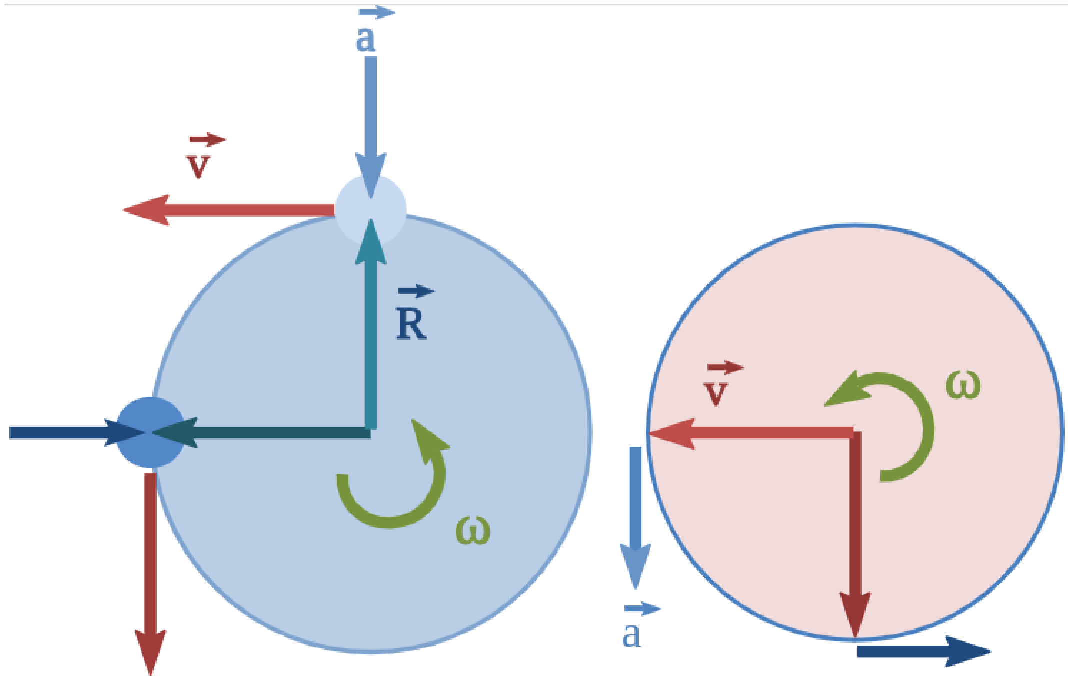
Science

One of our science practices is related to the chemicals contained in some of the materials used, such as tires, spray oil and treated lumber.The tires contain sulfur, heavy metals, carbon black and isoprene. The spray oil paint contains acetone, xylene, and toluene. The treated lumber contains alkaline copper quaternary, borates, polymeric betaine.


These are pictures of spray oil paint, tires and treated lumber, in that order. Those are the materials used that contain the largest amount of chemicals.

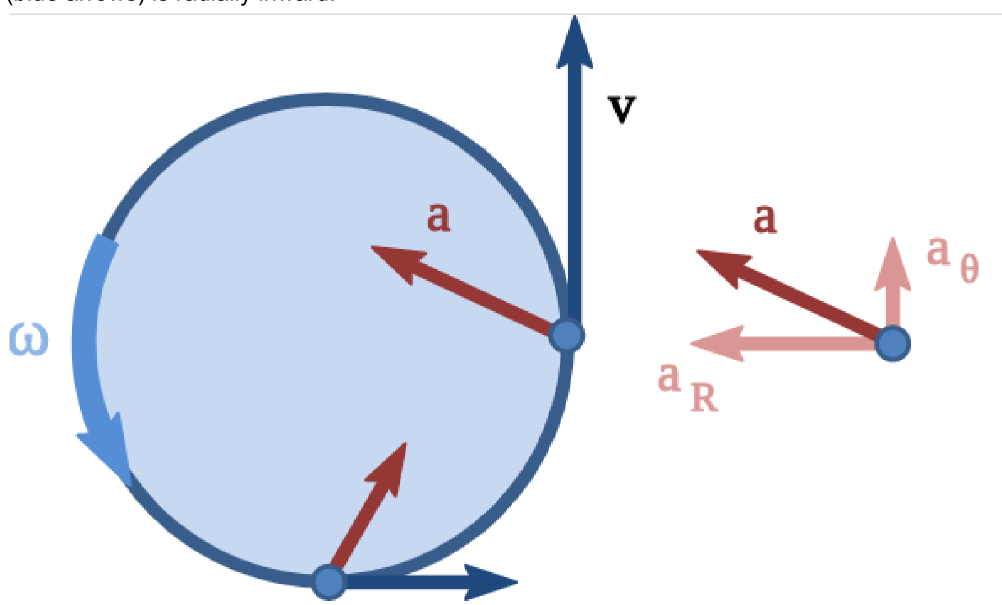
Another science principle is the motion of the tire swing. The centripetal force (the force required to keep a body moving in a circular path) and centripetal acceleration (the acceleration of a body moving in a circular path) cause the tire to spin in a circular motion.

If the tire swing traveled in a uniform circular path, the tire would move in a circle and the velocity would be tangent to the orbit and the acceleration would be radially inward. A tire swing moves more in a nonuniform circular motion, where the velocity is tangential to the orbit and the acceleration is not radially inward and the tangential component increases the rate of rotation.



[7]

Uniform Circular Motion. The tires move in a circle. The velocity (red arrows) is tangent to the orbit. The acceleration (blue arrows) is radially inward.



NonUniform Circular Motion. The velocity (blue arrow) is tangential to the orbit. The acceleration (red arrow) is not radially inward.

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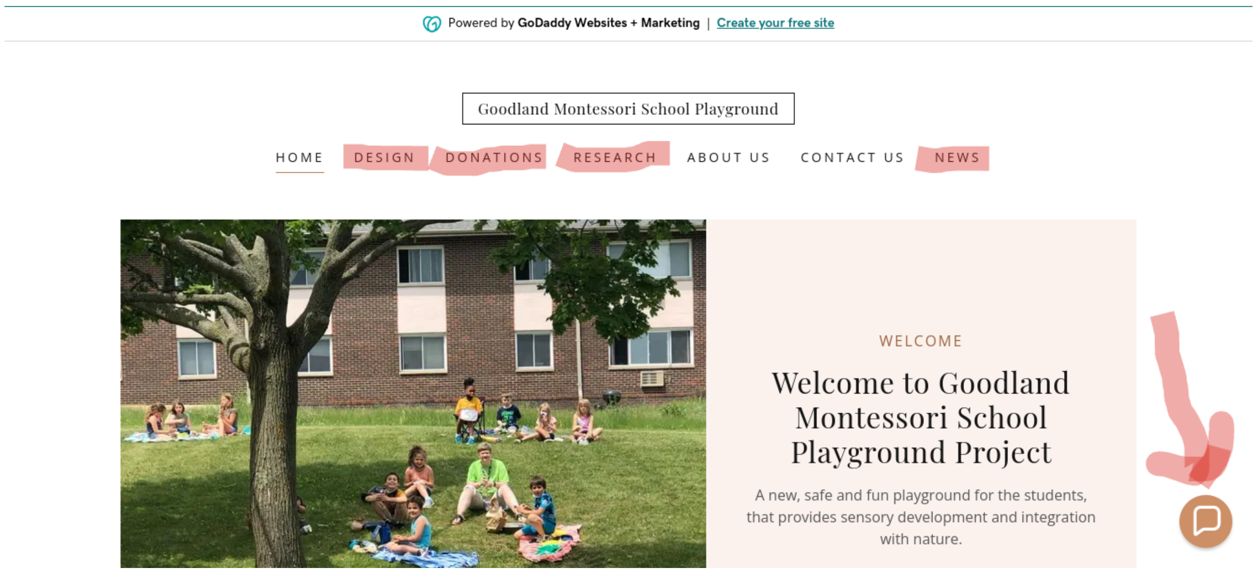
[7] *Tire Swing Motion*. Tire swing. (n.d.). Retrieved from http://ffden-2.phys.uaf.edu/212_spring2011.web.dir/Samantha_Porreca/tire%20swing.html

Technology

In order to bring an insight into the playground project, a website was made to bring in donations, give out news, research, and illustrate the design. Computers were used alltime and identified for being the main source with information being gathered, communication through online chats and overall the design, engineering and compute research. In addition 3D printers assisted in building the 3D model designs.



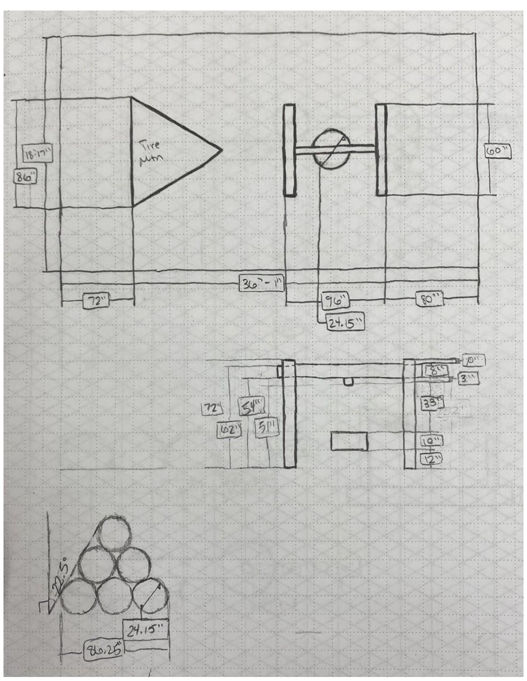
The red highlight on the image above demonstrates the design, research and news about the project including the donations and message chat.⇉Link to website https://goodlandmontessorisplayground.godaddysites.com/

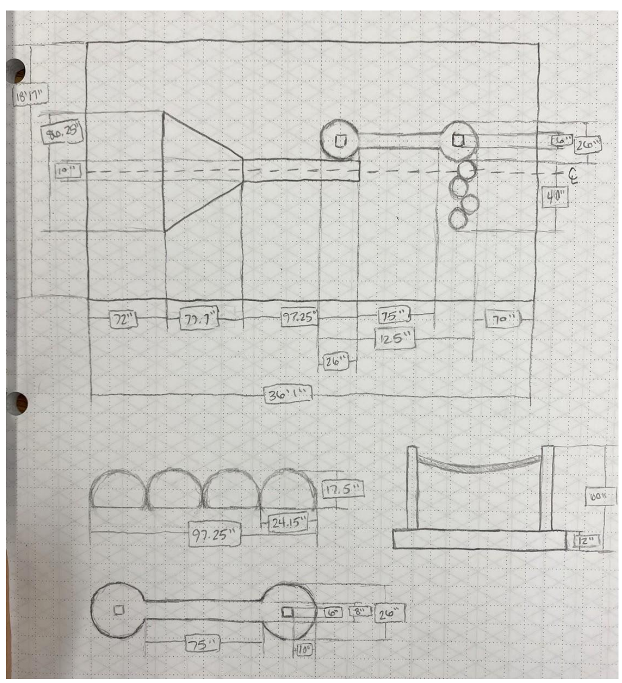
The images provided above are the playground design models. Most of the parts were 3D printed: the planter boxes, the pots and pans, both tire mountains, the tire swing, the tire pathways, the balance beam, and the log path.

Engineering

One of the two main practices we demonstrated was the development and use of the playground design models. The other main practice included were the weekly group meetings where we did things such as ask questions, define problems, and plan our next moves.

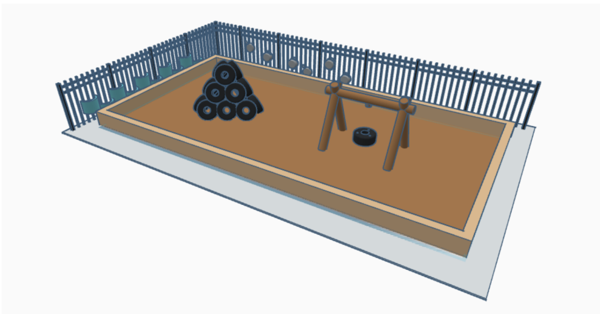
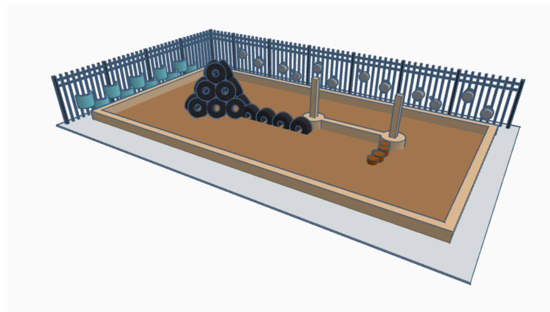
The playground models were designed both on paper and online. The detailed sketch was drawn in an engineering notebook and displays the real world measurements of the playground designs as well each piece of equipment separately.





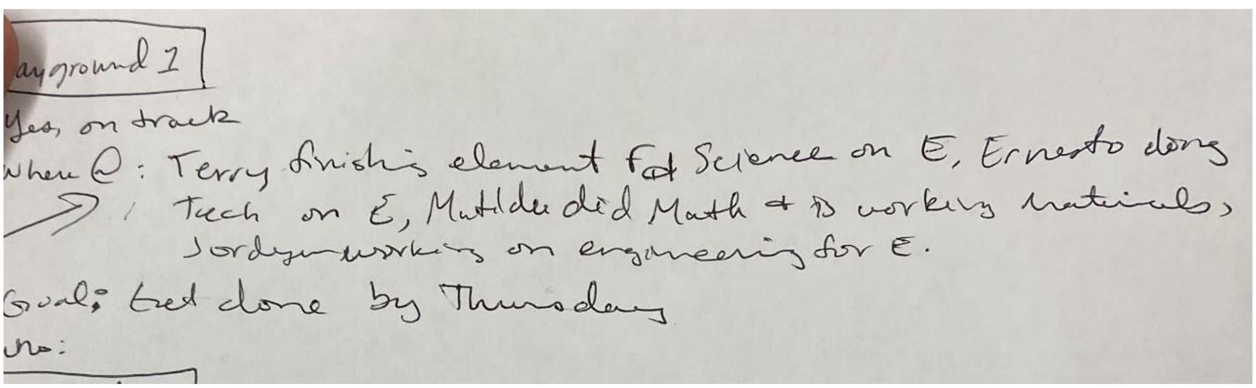
Detailed Sketches of the Playground and it’s Equipment

The online models were created in the online software *Tinkercad*. This software allows the user to build a 3D object using basic 3D shapes. This model was then exported to a 3D printer and was able to construct our physical models.

Models Constructed Using *Tinkercad*

The other principle we met was having weekly meetings. In these meetings we discussed our goals for the week and what we were going to do to reach them. We broke each goal up and assigned each group member roles to achieve them.

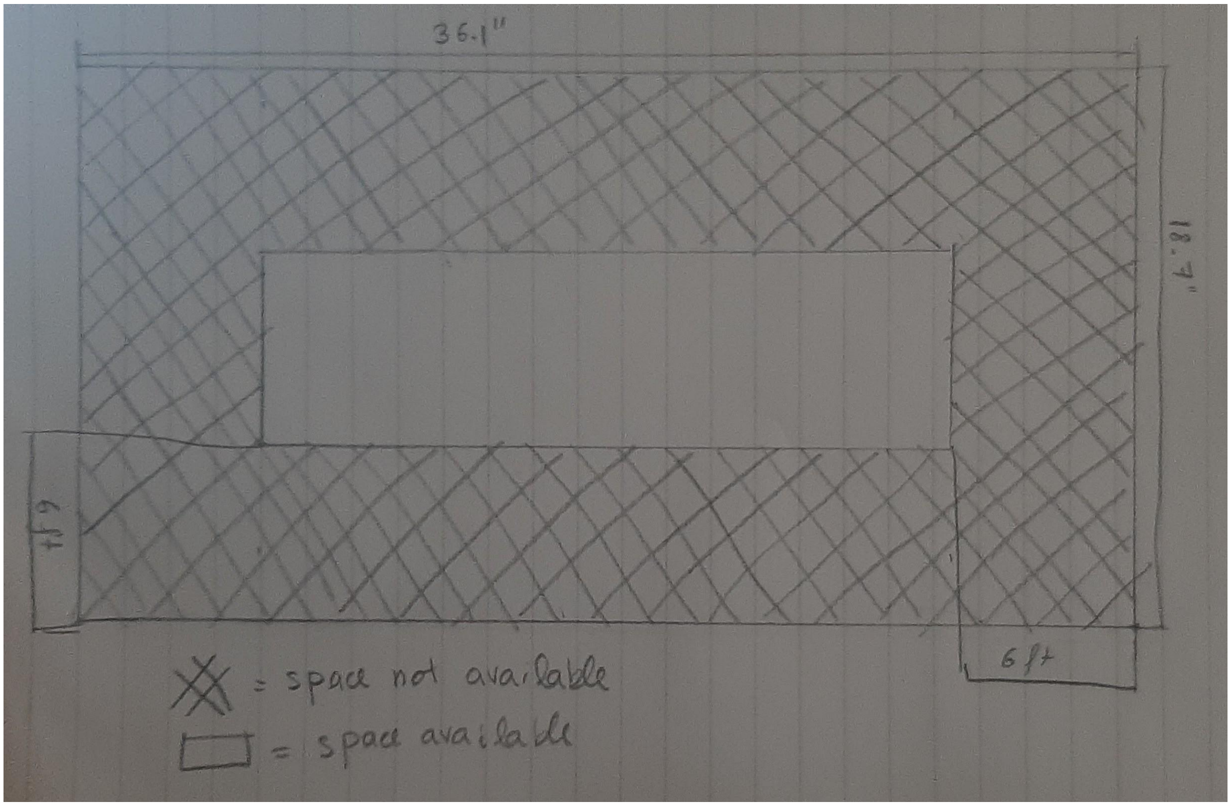


ayground 1
Yes, on track
Where @: Terry finishing element for Science on E, Ernesto doing
Tech on E, Matilde did Math + is working materials,
Jordyn working on engineering for E.
Goal: Get done by Thursday
No:

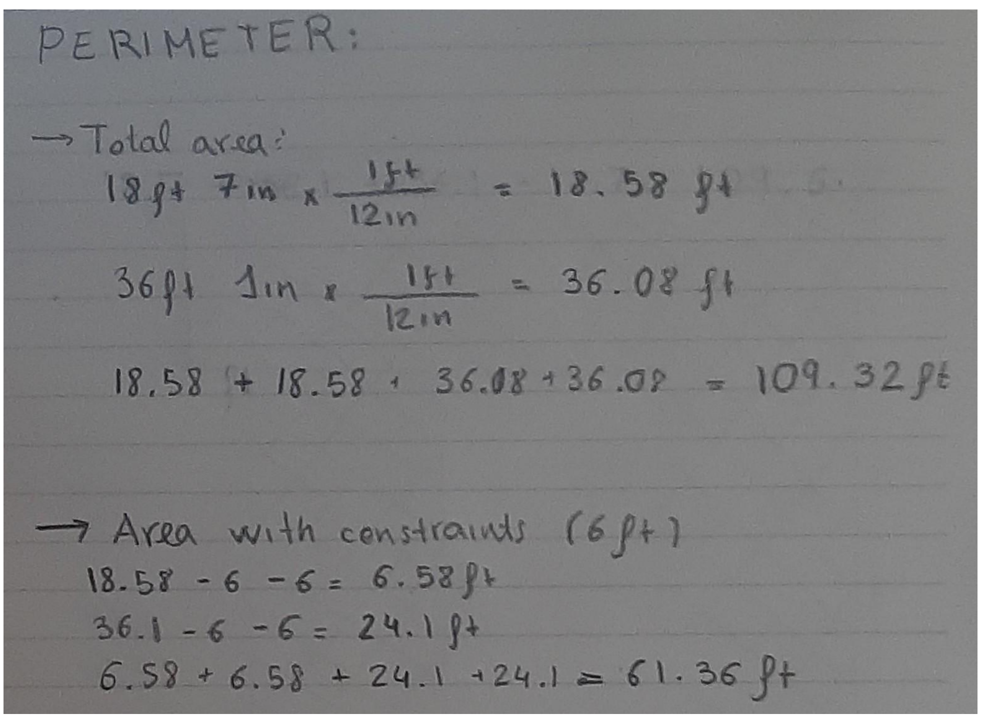
Example of Notes From Weekly Meetings

Math

While we were designing the playground we had to take different mathematical concepts and principles into consideration.
One of the most important was related to space: the perimeter of the area allowed to be built in, taking into account the six feet distance between the edge and the playground equipment.



In this image the space of the playground with dimensions is drawn. The original dimensions are shown, as well as the ones after the 6 feet distance constraint.


PERIMETER:

→ Total area:

$18\,ft\ 7\,in \times \frac{1\,ft}{12\,in} = 18.58\,ft$

$36\,ft\ 1\,in \times \frac{1\,ft}{12\,in} = 36.08\,ft$

$18.58 + 18.58 + 36.08 + 36.08 = 109.32\,ft$

→ Area with constraints (6 ft)

$18.58 - 6 - 6 = 6.58\,ft$

$36.1 - 6 - 6 = 24.1\,ft$

$6.58 + 6.58 + 24.1 + 24.1 = 61.36\,ft$

The calculations about the perimeter of the area for the playground. The ones at the top are of the total area, the unavailable and the available part. The ones at the bottom are of the available part.

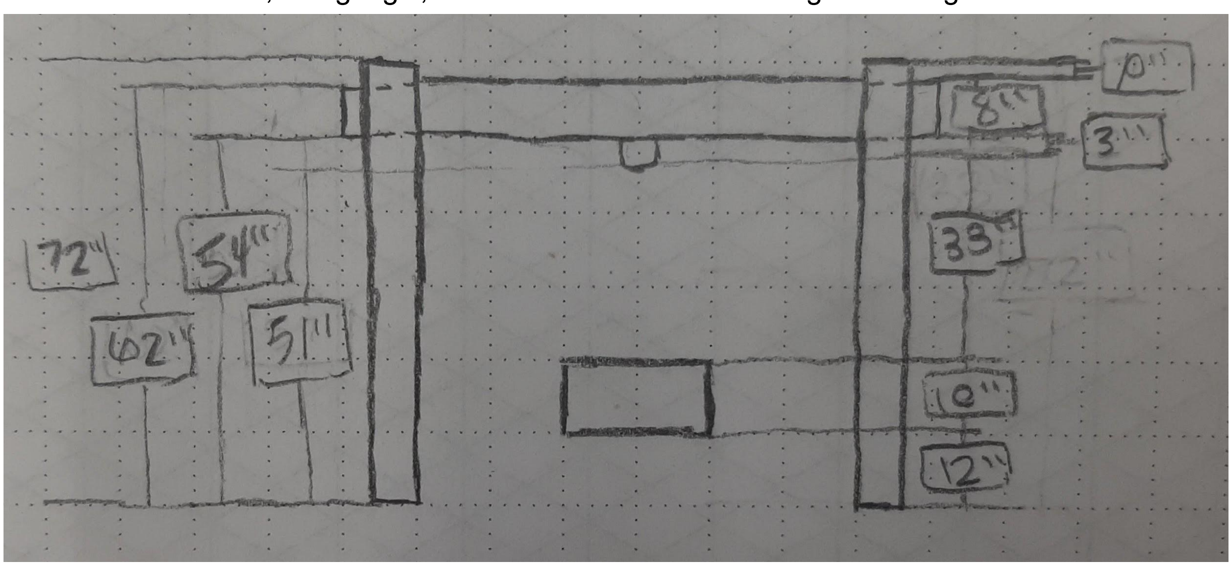
Another mathematical problem to be solved was the height of the tire swing.

Age	Height - Females	Height - Males	Weight - Females	Weight - Males
1	27 to 31 inches	28 to 32 inches	15 to 20 pounds	17 to 21 pounds
2	31.5 to 36 inches	32 to 37 inches	22 to 32 pounds	24 to 34 pounds
3	34.5 to 40 inches	35.5 to 40.5 inches	26 to 38 pounds	26 to 38 pounds
4	37 to 42.5 inches	37.5 to 43 inches	28 to 44 pounds	30 to 44 pounds
6	42 to 49 inches	42 to 49 inches	36 to 60 pounds	36 to 60 pounds
8	47 to 54 inches	47 to 54 inches	44 to 80 pounds	46 to 78 pounds

[8]

This table shows the average height of a 4 year old, needed for the calculations. It was created based on statistics,

With this information, using logic, we made the calculations to get the height.



c

We set the tire to be 12 in off the ground, the top of it being 22 in high. We can also observe all the other measurements of the tire swing.

[8] *Normal growth*. Normal growth rates for kids | Children's Wisconsin. (n.d.). Retrieved from https://childrenswi.org/medical-care/adolescent-health-and-medicine/issues-and-concerns/adolescent-growth-and-development/normal-growth

Materials

To design the playground, we had to analyze the pros and cons of the materials used:

TIRES	
PROS	CONS
Recyclable material (cheap) Provide different sensory stimuli (different temperature, different textures) Durable	They get heated by the sun Need to be buried in concrete or be held with a structure They can be slippery when wet

TREATED LUMBER[9]	
PROS	CONS
Natural Durable Cheaper than other types of wood Easy to work with Able to paint easily Easily to repair Insect repellent	Chemical risk (if not handled correctly) Color fading of the wood because of the solar rays (can be avoided if painted) Splinters and checking

CONCRETE[10]	
PROS	CONS
Durable Strong Flexible Fire-resistant	Expensive It requires constant reinforcement to avoid cracks Low tensile strength

[9] Moylan, J. (n.d.). *What are the advantages and disadvantages of pressure-treated wood?* Full-service remodeling and decking contractor in MD, VA, and DC. Retrieved from https://www.designbuildersmd.com/blog/what-are-the-advantages-and-disadvantages-of-pressure-treated-wood-decks

[10] Johnston, B. (2020, January 15). *The Pros and cons on concrete*. Tomahawk Power. Retrieved from https://tomahawk-power.com/blogs/articles/the-pros-and-cons-on-concrete

Validation

The utilization of STEM emphasizes the fact that our approach took into account a wide range of practices and disciplines. It emphasizes how we used science, technology, engineering, and math to validate our final design throughout the design and development process. We used the STEM principles to ensure the constraints and safety regulations were followed, such as the 6 feet apart or the height allowed for the tire swing. We also used it to help us, mostly with technology, by building a website and printing 3D models. We also used engineering organization skills with the weekly meets and with the playground models.

Element F: Consideration of Design Viability

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

This element will discuss the safety and ethical responsibilities we must follow when we construct a design. Some of these are legal responsibilities we must follow, some are ethical. We have to ensure the construction and lifetime of our design is environmentally friendly and worthwhile. The design must be able to withstand the wear done by children's regular play.

Engineering Design Considerations

There are a multitude of restrictions that must be considered when designing the play structure. Their main purpose is to ensure the safety of the children while playing. We must look into different handbooks for safety to ensure we have the whole picture. We must also make sure that the playground is a fun environment for the children to play. We also will use only recyclable or natural materials, as the customer asked for a green playground; but at the same time those materials need to be safe for the children.

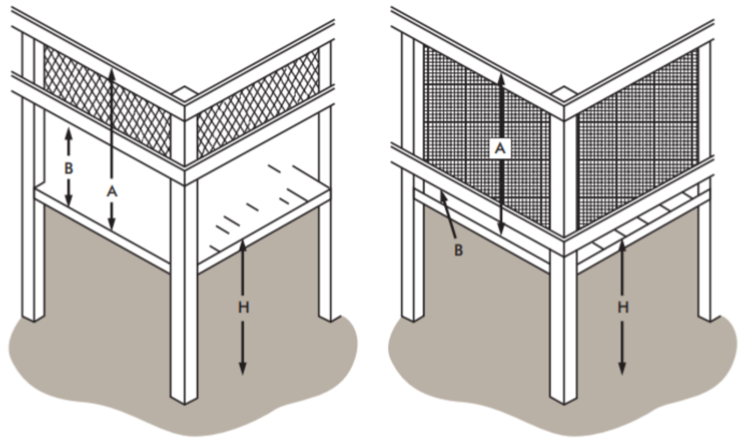
Ethical Responsibility[11]

The following constraint were provided by the Consumer Product Safety Commision:
-Consider the travel patterns children take
-Make sure any metal or tires are not able to overheat in the sun
-Put drainage in all elements of the structure
-Wood must be rot and insect resistant (either naturally or with a finish)
-No creosote-, pentachlorophenol-, or tributyl tin oxide-treated wood
-Be careful of:

[11] U.S. Consumer Product Safety Commission. (n.d.). *Public Playground Safety - cpsc.gov*. Retrieved from https://www.cpsc.gov/s3fs-public/325.pdf

-Crush and shearing points
-Entanglement and impalement points
-Diameter of projection should not increase when further from the surface Toward the exposed end
-Bolts should not have more than 2 exposed threads beyond the end of the nut
-All hooks must be closed (no gap or space larger than 0.04 in.)
-Entrapment points
-No gaps between 3.5 and 9 inches
-Sharp points, corners, and edges
-Corners must be rounded
-Suspended hazards
-Suspended components should be fastened at both ends unless it is 7 in. or less long or attached to a swing seat
-Tripping hazards
-Change in elevation should be obvious
-Tires shouldn't be able to collect water or debris
-Platforms should be within 2° of horizontal
-Platforms should minimize collection of debris
-Stepped platforms shouldn't be taller than 12 in. (access component such as a ladder is needed if taller)
-Guardrails or protective bars should line elevated platforms greater than 12 in. tall
-Guardrails should be no more than 15 in. away from platform outside of entrances and exits

Table 4. Guardrails and Barriers



	Guardrail	Barrier
Protects against accidental falls from platform	Yes	Yes
Discourages climbing over	No	Yes
Protects against climbing through	No	Yes
Toddlers		
A Top edge distance from platform	Not recommended	A = 24″ or higher
B Bottom edge distance from platform	Not recommended	B < 3″
H Recommended when platform fall height is:	Not recommended	H = 18″ or higher
Preschool-age		
A Top edge distance from platform	A = 29″ or higher	A = 29″ or higher
B Bottom edge distance from platform	9″ < B ≤ 23″	B < 3.5″
H Recommended when platform fall height is:	20″ < H ≤ 30″	H > 30″

-Climbing methods should be able to be used to ascend as well as descend
-Provide an easy way out at all points of the structure

	AGE OF INTENDED USER	
Type of Access	**Toddler**	**Preschool-age**
Ramps (not intended to meet ADA/ABA specifications)		
Slope (vertical:horizontal)	< 1:8	≤ 1:8
Width (single)	≥ 19″	≥ 12″
Width (double)	≥ 30″	≥ 30″
Stairways		
Slope	≤ 35°	< 50°
Tread width (single)	12-21″	≥ 12″
Tread width (double)	≥ 30″	≥ 30″
Tread depth (open riser)	Not appropriate	≥ 7″
Tread depth (closed riser)	≥ 8″	≥ 7″
Vertical rise	≤ 7″	≤ 9″
Step ladders		
Slope	35≤65°	50-75°
Tread width (single)	12-21″	12-21″
Tread width (double)	Not appropriate	Not appropriate
Tread depth (open riser)	Not appropriate	≥ 7″
Tread depth (closed riser)	8″	≥ 7″
Vertical rise	> 5″and ≤ 7″	≤ 9″
Rung ladders		
Slope	Not appropriate	75-90°
Rung width	Not appropriate	≥ 12″
Vertical rise	Not appropriate	≤ 12″
Rung diameter	Not appropriate	0.95-1.55″

-Rungs should be round and easy to grip
-Hand grips shouldn't be able to turn
-Hand support for hanging should have a diameter between 0.95 and 1.55 in. (1.25 in. is recommended)
-The vertical distance between the top front edge of a platform and the top of a handrail should be between 22 and 26 in.
-Balance beams should be no taller than 12 in.
-Swings should be suspended from a structure that discourages climbing
-A-frame supports for swings should not have horizontal cross-bars

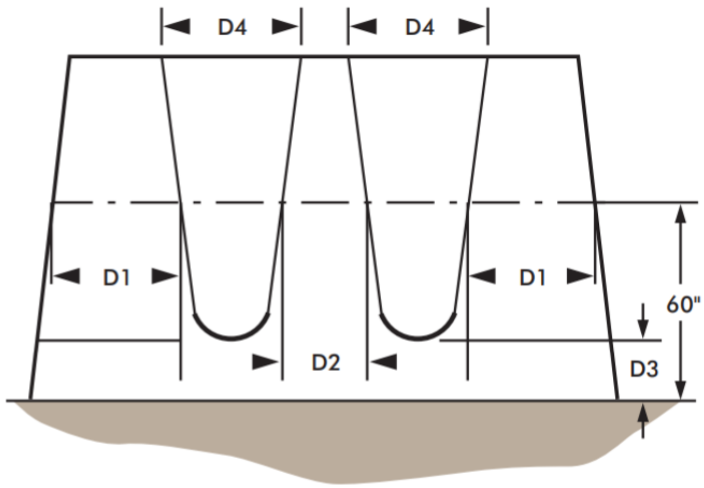


Figure 23. Minimum Clearances for Single-Axis Swings

Table 7. Minimum clearance dimensions for swings

Reason	Dimension	Toddler Full bucket	Preschool-age Belt	School-age Belt
Minimizes collisions between a swing and the supporting structure	D1	20 inches	30 inches	30 inches
Minimizes collisions between swings	D2	20 inches	24 inches	24 inches
Allows access	D3	24 inches	12 inches	12 inches
Reduces side-to-side motion	D4	20 inches	20 inches	20 inches

-Swings should not be designed to accommodate multiple users
-No heavy tires for swings (such as tractor tires)
-The minimum clearance between the bottom of a swing and the ground should not be less than 12 in.

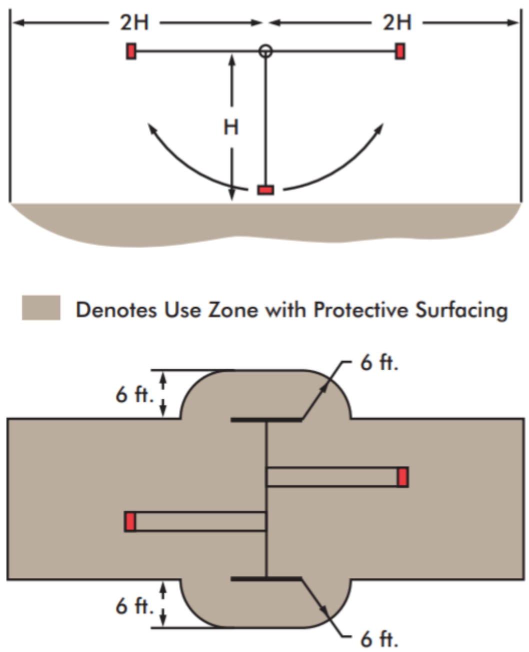


Figure 25. Use Zone for Single-Axis Belt Swings

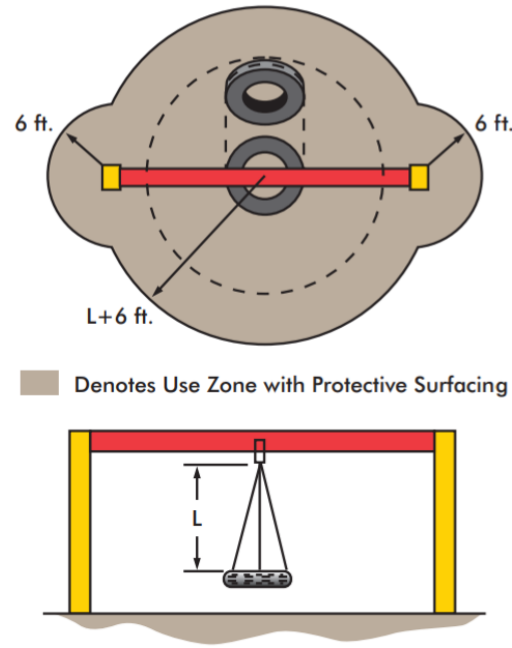


Figure 27. Use Zone for Multi-Axis Swings

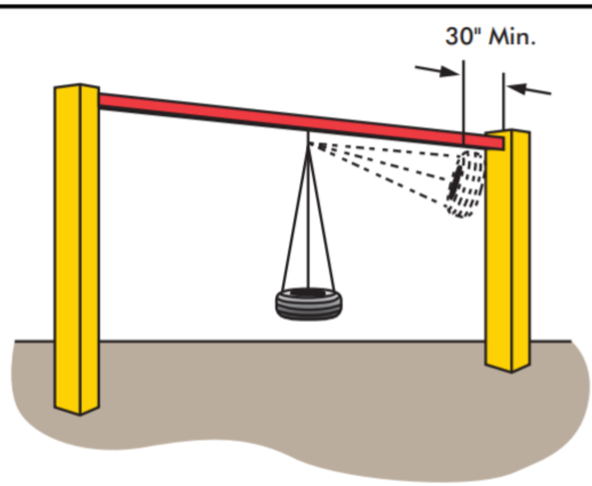


Figure 26. Multi-Axis Swing Clearance

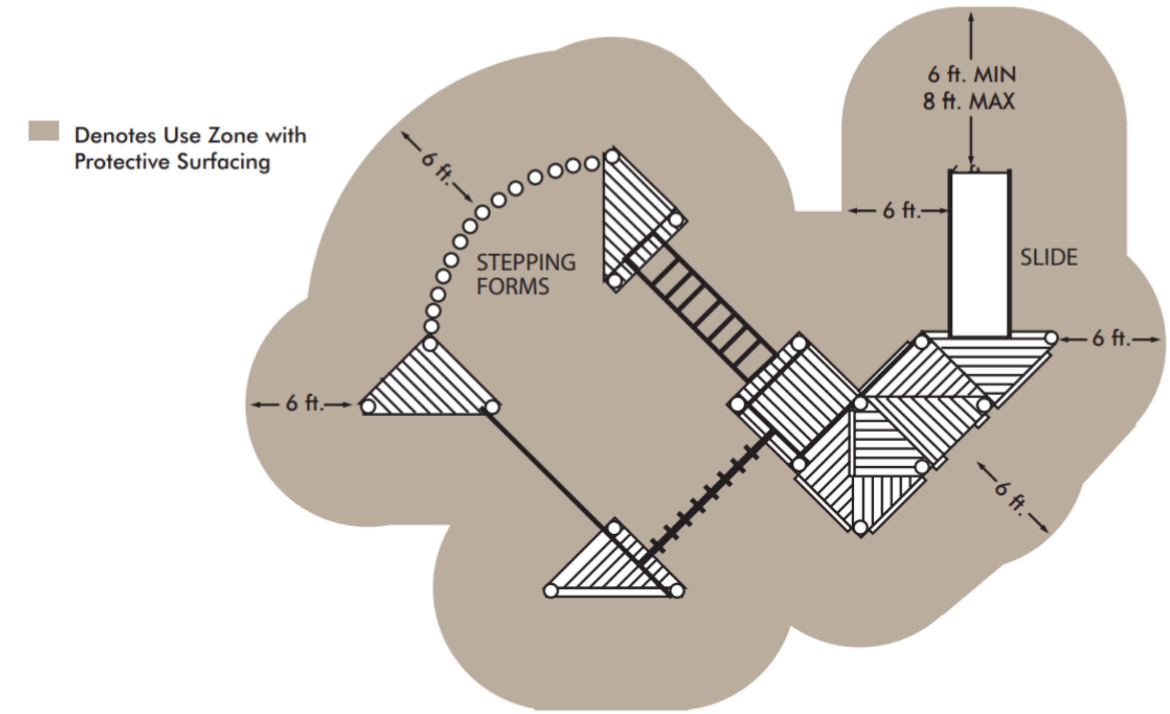


Figure 28. Use Zones for Composite Structure

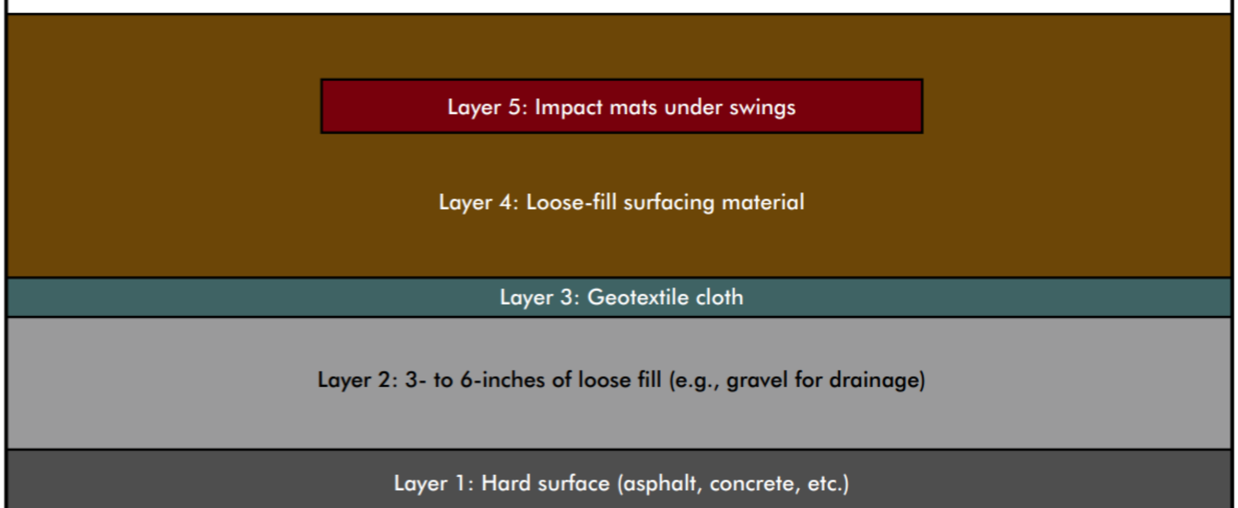


Figure 1. Installation layers for loose-fill over a hard surface

Table 2. Minimum compressed loose-fill surfacing depths				
Inches	**Of**	**(Loose-Fill Material)**	**Protects to**	**Fall Height (feet)**
6*		Shredded/recycled rubber		10
9		Sand		4
9		Pea Gravel		5
9		Wood mulch (non-CCA)		7
9		Wood chips		10

* Shredded/recycled rubber loose-fill surfacing does not compress in the same manner as other loose-fill materials. However, care should be taken to maintain a constant depth as displacement may still occur.

Product Lifecycle

STEEL ZINC-PLATED[12] (HEX NUTS, BOLTS & FLAT WASHERS)					
Lifecycle	**Premanufacture**	**Manufacture**	**Product Delivery**	**Use**	**End Life/ Disposal**
Energy **Water** **Fossil Fuels**	Electrical energy Fuels Water	Electric energy Water	Diesel fuel	Energy	Coal Natural gas Electricity

[12] *Steel Production & Environmental Impact*. Greenspec. (n.d.). Retrieved from https://www.greenspec.co.uk/building-design/steel-products-and-environmental-impact/
How bolts are made? Here is the manufacturing process. Nord. (n.d.). Retrieved from https://www.nord-lock.com/en-us/insights/knowledge/2018/the-making-of-bolts/
Steel life cycle. SSAB. Retrieved from https://www.https://www.ssab.com/company/sustainability/sustainable-offering/steel-life-cycle
Steel recycling: Processes, benefits, and Business Solutions. Rubicon. (2021, July 21). Retrieved from https://www.rubicon.com/blog/steel-recycling/

Chemicals Solvents Biological agents	Fluxes Oxygen Silicon Manganese Phosphorus	Chlorine dioxide Phenol Alkaline Cyanide Ammonia Sulfur dioxide Chromate	None	None	None
Raw materials Parts Components	Iron ore Coke Limestone	Steel wire rod Zinc	Cardboard box Zinc-plated flat washers / hex nuts / bolts	Zinc-plated flat washers / hex nuts / bolts	Scrap steel
Finished components Finished parts	Steel wire rod	Zinc-plated flat washers / hex nuts / bolts	Cardboard box Zinc-plated flat washers / hex nuts / bolts	Zinc-plated flat washers / hex nuts / bolts	Steel sheets
Non-hazardous outputs	Iron scrap Limestone scrap Coke scrap	Steel scrap	None	Cardboard box	None
Hazardous materials outputs	CO_2 Emissions to air Emissions to water	CO_2	Nitrogen oxide Carbon monoxide Sulfur dioxide	None	CO_2

TREATED WOOD[13]					
Lifecycle	**Premanufacture**	**Manufacture**	**Product Delivery**	**Use**	**End Life/ Disposal**
Energy Water Fossil Fuels	Water needed for growth	Biomass and fossil fuel Energy provided by by-product	Diesel fuel	None	Reused for energy
Chemicals Solvents Biological agents	Herbicide Fertilizer	Copper based preservative including ACQ[14] and CA[15]	None	None	None
Raw materials Parts Components	Saplings	Sawn softwood lumber	Treated Lumber	Treated Lumber	Wood
Finished components Finished parts	Lumber	Treated Lumber	Treated Lumber	Play equipment	Wood pulp, wood chips, etc.
Non-hazardous outputs	Carbon dioxide removed from atmosphere	None	None	Possible decay	Reuse Decay
Hazardous materials outputs	None	CO_2	CO_2	Possible CO_2	CO_2 Methane

[13] *End-of-life management of preserved wood ... - woodpoles.org*. (n.d.). Retrieved from https://woodpoles.org/portals/2/documents/ReusePreservedWood.pdf
[14] Alkaline Copper Quaternary
[15] Copper Azole

CONCRETE					
Lifecycle	**Premanufacture**	**Manufacture**	**Product Delivery**	**Use**	**End Life / Disposal**
Energy Water Fossil Fuels	Water	Water, Fossil fuel energy	Fluid	Recycle resource	Timed decompose
Chemicals Solvents Biological Agents	Tricalcium silicate, Tricalcium aluminate, Tetracalcium aluminoferrite, Gypsum	Calcium, Silicon, Aluminum, Iron, biogenic sulfuric acid	None	None	None
Raw Materials Parts Components	Rock, Sand, Gravel, Aggregate	Lime, Iron Oxide, Alumina, Silica	Bulk storage	Basic Foundations	Cement paste
Finished Components Finished Parts	Gravel	Fluid cement	Bulk storage	Basic Foundations	Fine coarse aggregate
Non - Hazardous Outputs	Antifreeze,Wood, Paper, Cardboard	Paper, Iron, Steel scraps	None	Automotive parts	Repeat decompose,
Hazardous Material Outputs	Asbestos, lead, mercury, PCB	Calcium oxide, Crystalline silica, Chromium	CO	B.C.P	CO

TIRES					
Lifecycle	**Premanufacture**	**Manufacture**	**Product Delivery**	**Use**	**End Life/ Disposal**
Energy Water Fossil Fuels	Electricity none Fuels	Reducing scrap tires into rubber.	Coal	Tropical rubber Trees	Acid oil
Chemicals Solvents Biological agents	Carbon black Liquid nitrogen rubber	sulfur	none	isoprene	Methane gas
Raw materials Parts Components	Sulfur	Natural rubber, synthetic rubber, carbon black and oil	Natural rubber, synthetic rubber, carbon black and oil.	rubber	Waste water
Finished components Finished parts	Tread ,side wall, belts	Steel or aluminum	steel	Steel cord, tread, layers of rubber.	None
Non-hazardous outputs	Steel, aluminum, iron.	Steel, aluminum, iron.	Steel, aluminum, iron.	none	None
Hazardous materials outputs	Gasses, heavy metals and oil.	Gasses, heavy metals and oil.	None	none	None

Conclusion

The construction of our playground is very environmentally friendly. We plan on using a majority of recycled materials that we will have donated. The structure will also be in place for a long time and can be unkempt with regular maintenance. Once the structure is at the end of its lifecycle, it can be dismantled and salvaged for parts. The equipment will serve its purpose for a long period of time and will service many children.

Element G: Creation of a Testable Prototype

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

We have two different final designs for the playground. Both of them follow the constraints and regulations imposed by the state, six feet distance between all equipment and the edge being the most important. We also kept in mind our customer's desire of having a green playground, just using recyclable and natural materials. Furthermore, thinking about what the student would like and taking into account their survey. With all these we designed our playground.

With the ideas from the research –from existing green playgrounds, mostly in Europe and from the favorite options of the students– we started brainstorming. We picked the kids' favorites (the tire mountain, balance beam and tire swing) and tried to place them on the space available. As we could not fit all three in one, we decided to do two different designs.

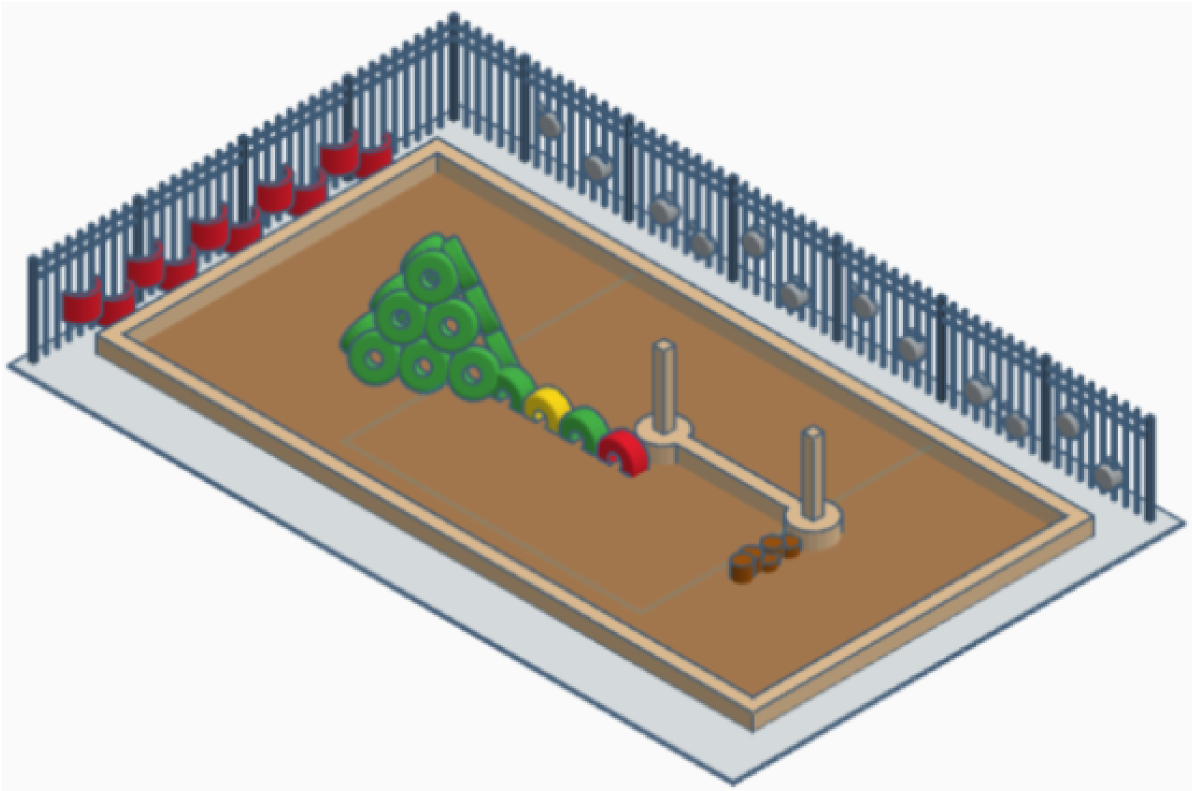
During all the process we kept in mind their safety, but we also wanted to ensure that it will help them develop their sensory development. We made sure the playground included different textures (from all the different materials), different temperatures (as the tires heat with the sun and cool with the cold), different colors (as the tires will be painted in many different ways, that the students can choose), different smells (from the plants) and different sounds (from the musical pots and pans).

Regarding the materials used in a green playground they all had to be natural or recyclable, except from the bolts used to join the tires and the concrete. We also made sure that the materials were able to provide different sensory experiences. One example is tires: they have different colors, textures, heights and temperatures.

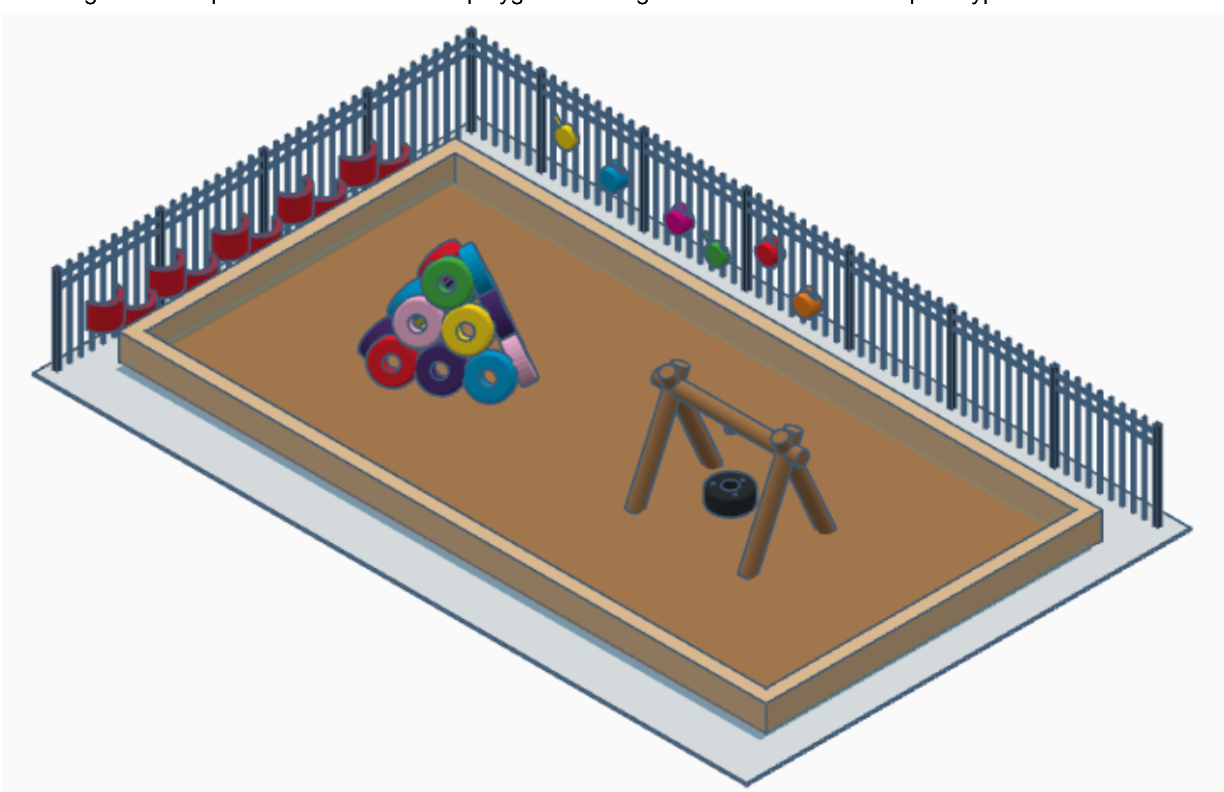
Prototype Fabrication

The first step to fabricate the prototype was brainstorming. This plays a key role in fabricating the prototype, a time when questions are asked and resolved; we asked ourselves how we could make the prototype. We first thought of the size and area of the prototype, and we tried to fit the chosen playground equipment - the students' favorites (the tire mountain, balance beam and tire swing), from the survey results- on the design. We weren't able to fit those three in the same design so we decided to do two different ones. Both designs have a tire mountain, as the tires are going to be donated, so it would be the cheapest option. In the first design we only added one big piece of equipment: the tire swing, as we did not have more space. In the second one, we added the balance beam, and as we had more space available, we added a tire path to connect the balance beam to the tire mountain and a log path before the balance beam. To use the space as wisely as possible we added pots and pans hanging on the fence, to be used as musical instruments. We also added planter boxes to the other part of the fence.

The second step was to translate our ideas on paper, or in this case on a 3D modeling program. We decided to do it as realistic as possible by setting the floor as it would look like wood chips -the same chips that will be used in the future playground afterwards-, by having the fence, by giving color to the equipment, and by, of course, having the right dimensions.



The image above represents one of the two playground designs we used to make the prototypes.



The image above represents one of the two playground designs we used to make the prototypes.

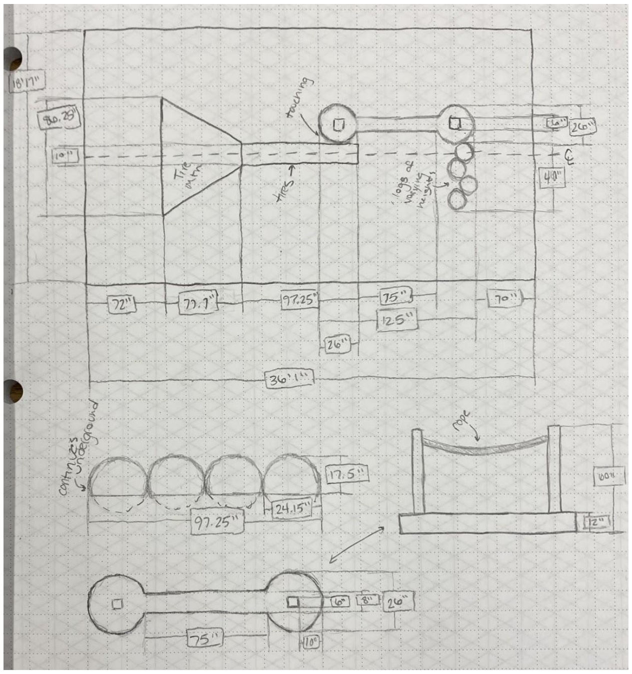
After doing the designs, we had a meeting with a worker of the buildings and grounds office to check if our design fulfilled all the requirements, and be able to move one to create the 3D model.

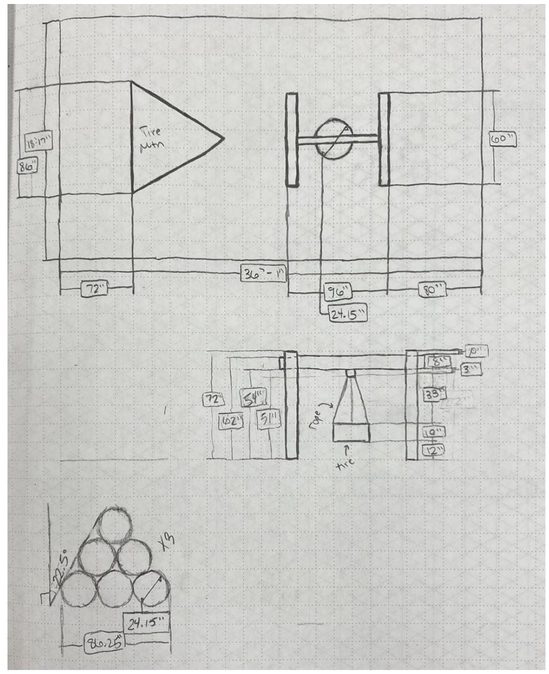
For the 3D model we 3D printed the pieces from the playground equipment (the tire mountains, the tire swing, the balance beam, the tire path and the log path, the pots and pans, the planters), we did it to scale so the 3D model would be realistic. Once we had them we painted them. For the ground, we cut a foamboard piece to scale, to represent the playground area, and we glued a picture of wood chips to simulate the wood chips that we find on the playground. We cut pieces of wood and glued them around the edge of the foamboard to simulate the border. After that we created the fence (painting toothpicks black and gluing all them to a perpendicular thin piece of wood, so they would stay together) and glued it to the foamboard, leaving some distance between it and the edge. The next step was adding the playground equipment to the foamboard: we glued them, measuring so they will be on the right spot.

The image above represents one of the two playground designs we used to make the prototypes.

The image above represents one of the two playground 3D models.

Detailed Drawings





Conclusion

The prototype is helpful when solidifying our design because we are able to have physical models to easily move around. This helps to visualize the placements and restraints to optimize our final design. This is just a scaled down replica of our final design and will need to be upsized in the building of the final playground. These models, however, allow the students, parents, and staff of Goodland Montessori to see what the final design will look like.

Element H: Prototype Testing and Data Collection Plan

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

Our group has done research on the concepts we would like to use in our playground design. First, we started looking for organizations and individuals that we believe represent Goodland Montessori School's values regarding childhood learning and nature interaction (creating a bond with nature, hand-on activities and collaborative play). We also did some research in natural play spaces, in what ways they benefit children (health benefits, sensory stimulation and community engagement). We researched basic ideas based on existing European playgrounds, as the principal suggested in an interview we had with her. This research is presented along with a survey extended to the students of Goodland Montessori school who will be using the playground.

Our group looked at different design requirements that need to be tested to ensure the safety of the children that will be using the playground. Our safety requirements tested were: the load bearing capacity for the tire mountain, the stability of the balance beam, the drainage of the planters, and the stability of the tire mountain.

TEST #1: Stability Tire mountain

<u>Names</u>: Ernesto and Matilde

<u>Incremental Testing Summary</u>:
Starting with one person and ending with three, in an increasing amount of force, those people will push the tie mountain to check its stability.

<u>Testing Date</u>: 05/23/2022

Testing Location:
Goodland Montessori School (4800 Graceland Blvd, Racine, WI 53406)

Purpose:
The purpose of the test is to insure the stability of the tire mountain in the event of excess force.

Pass/Fail Criteria:
Pass: If when the tires are applied with an excess force, they do not fall over, move excessively, come apart, or become otherwise unsafe in any way.
Fail: If when the tires are applied with an excess force, they fall over, move excessively, come apart, and/or become otherwise unsafe in any way.

Materials:
1. Tire mountain
    a. 18 tires
    b. 36 bolts
    c. 72 washers
    d. 36 hex nuts

Initial Conditions:
The tire mountain is set above the ground, with the bottom row planned to be half buried in the ground. The mountain consists of 3 faces that form a pyramid shape; each of them has 6 tires: 3 on the bottom row, 2 on the middle one and one on the top one. There is an additional tire connecting the bottommost point of the top layer to improve stability.

Safety Concerns:
If the tire mountain is not stable enough it would not be able to be used by the children that will play on the playground due to the possibility of a piece injuring a student.

Test Termination:
The test is terminated once the final test force is removed.

Data:

Body Weight Pressure	Hard Stomp

Light Push	Pulling
Hard Push	Jumping
Light Kick	Climbing

Stepwise Procedure:

1. Pushing the tire mountain with a lower amount of force (one person)
2. If the tire mountain does not fall, push it with a higher amount of force (two people)
3. If the tire mountain does not fall, push it with a higher amount of force (three people)
4. Conclude if the tire mountain is stable, not just by the risk of falling, if not as well the movement or balancing it has.

TEST #2: Stability Balance Beam

Names: Ernesto and Matilde

Incremental Testing Summary:

The balance beam should be sturdy enough to hold the weight of several children standing on it.

Testing Date: 05/23/2022

Testing Location:

Goodland Montessori School (4800 Graceland Blvd, Racine, WI 53406)

Purpose:

The purpose of the test is to insure the stability of the balance beam in the event of excess force.

Pass/Fail Criteria:

Pass: If when the balance beam is applied with an excess force, it does not fall over, move excessively, come apart, or become otherwise unsafe in any way.
Fail: If when the balance beam is applied with an excess force, it falls over, moves excessively, comes apart, and/or becomes otherwise unsafe in any way.

Materials:

1. Balance Beam
    a. Treated lumber (2 of 4inx4inx10ft)
    b. Rope
    c. 4 in Bolts (100)
    d. ⅜ in flat washer (100)
    e. Corner hex socket
    f. ⅜ in hex nuts (100)

Initial Conditions:

The horizontal beam is attached to two vertical beams which are partially buried in the ground.

Safety Concerns:

If the balance beam is not stable enough it would not be able to be used by the children that will play on the playground due to the possibility of a piece injuring a student.

Test Termination:

The test is terminated once the final test force is removed.

Data:

Walk	Moves / Does not move
Jump	Moves / Does not move

Stepwise Procedure:

1. Step onto the balance beam
2. Walk along the balance beam for 30 seconds
3. Record data
4. Jump on top of the balance beam 5 times
5. Record data

TEST #3: Drainage of the Planters

Names: Erik, Gavin, Tyler, Maximus

Incremental Testing Summary:
The planters should be able to release extra water caught.

Testing Date: 05/23/2022

Testing Location:
Goodland Montessori School (4800 Graceland Blvd, Racine, WI 53406)

Purpose:
To test if the planters will drain properly.

Pass/Fail Criteria:
Pass: The planters released water through drainage holes.
Fail: The planters did not release water through drainage holes.

Materials:
1. Planters (wood)
2. Water

Initial Conditions:
The planters are on the fence gathering water.

Safety Concerns:
Water that is sitting for long periods of time can produce bacteria and other undesirable biolife. It can also damage the plants if the water is not properly drained.

Test Termination:
The test is terminated when the water drains out of the planter.

Data:
Drains/Does not drain

Stepwise Procedure:
1. Observe the amount of water in planter
2. Observe if the water is draining through the bottom or not.

TEST #4: Load Bearing Capacity of the Tire Mountain

Names: Tyler, Erik, Gavin, Maximus

Incremental Testing Summary:
The tires should be able to withstand the force being applied to it.

Testing Date: 04/27/22

Testing Location:
Goodland Montessori School (4800 Graceland Blvd, Racine, WI 53406)

Purpose:
To determine how much weight the tires can support.

Pass/Fail Criteria:
Pass: If when the tire mountain is applied with an excess force, it does not fall over, move excessively, come apart, or become otherwise unsafe in any way.
Fail: If when the tire mountain is applied with an excess force, it falls over, moves excessively, comes apart, and/or becomes otherwise unsafe in any way.

Materials:
1. Tire mountain
    a. 18 tires
    b. 36 bolts
    c. 72 washers
    d. 36 hex nuts

Initial Conditions:
The mountain is sitting there.

Safety Concerns:
Overloading the tires

Test Termination:
The test is terminated when the tire mountain can withstand the force being applied.

Data:
Stays structurally sound / falls over/breaks.

Stepwise Procedure:
1. Observe the force being applied
2. Observe if it topples over or not.

Conclusion

Our tests successfully address our design goals of safety, quick and accurate feedback, universality and time taken to secure the product. The passing or failing of these tests will indicate if the final design is safe or not.

Element I: Testing, Data Collection and Analysis

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

For testing the playground equipment we focused on the stability of the tire mountain and the balance beam, the load bearing of the tire mountain, and the drainage of the planters. All those tests ensured the safety of the children. They were done after the playground was built, but at a point when we could still modify it.

TEST #1: Stability Tire mountain

The purpose of this test was to insure the stability of the tire mountain in the event of excess force. To see if the students using the playground would be safe on the tire mountain, and that I wouldn't fall or excessively move.

<u>Pass/Fail Criteria:</u>
Pass: If when the tire mountain is applied with an excess force, it does not fall over, move excessively, come apart, or become otherwise unsafe in any way.
Fail: If when the tire mountain is applied with an excess force, it falls over, moves excessively, comes apart, and/or becomes otherwise unsafe in any way.

The procedure of the test consisted of pushing the tire mountain, with an increasing amount of force. First, one person pushed, later, two, and finally, three.

The tire mountain did not pass the test as when the first person pushed, the tire mountain started moving. The tire mountain did not fall, not even when the three people were pushing at the same time. The conclusion of the first test is that the tire mountain was not stable, so it had to be redesigned.

The decision was to change the bottom row of tires for truck tires that are more resistant. As well as burying the bottom row with concrete, to gain stability. After those changes were done, the tire mountain was tested a second time, passing the test confirming its stability.

The first version of the tire mountain that failed the test (left) & the second version with truck tires that past the test (righ)

The tire mountain being tested (the first design)

TEST #2: Stability Balance Beam

Purpose:

The purpose of the test is to insure the stability of the balance beam in the event of excess force.

Pass/Fail Criteria:

Pass: If when the balance beam is applied with an excess force, it does not fall over, move excessively, come apart, or become otherwise unsafe in any way.
Fail: If when the balance beam is applied with an excess force, it falls over, moves excessively, comes apart, and/or becomes otherwise unsafe in any way.

The test was conducted by walking on the balance beam and, eventually, jumping on the balance beam.

The balance beam was able to hold the weight of a high school student in both trials, passing the test.

The balance beam that was tested, next to the other pieces of playground equipment.

TEST #3: Drainage of the Planters

Purpose:
The purpose of this experiment is to test the planters drainage abilities.

Pass/Fail Criteria:
Pass: The planters are able to adequately drain water
Fail: The planters do not properly drain water

TEST #4: Load Bearing Capacity of the Tire Mountain

Purpose:

The purpose of the test is to determine the tire mountain's load bearing capacity in the event of excess force.

Pass/Fail Criteria:

Pass: The tire mountain is able to withhold structural integrity if an excess amount of force is applied.

Conclusion

Our test results suggest that not all the initial designs were successful. Some of them, like the tire mountain, had to be improved to be safe for the children. But after the improvements were done and the test was repeated, they were successful. Our final design passed all the tests and it is safe for the children to play on it.

Element L: Presentation of Designer's Recommendations

Problem Statement

The Goodland Montessori playground had old, unsafe equipment, only leaving behind a sandpit. Kids can become bored of sandpits easily and it is not fun for everyone. The school is in need of a new playground and play equipment.

Introduction

We had to come up with a design to build a playground for Goodland Montessori School, an elementary school that needed a playground for 3 to 6 year olds. We were given a couple months to come up with ideas and decided to use tires, as their idea of the playground was a green playground (only using natural and recyclable materials) and knowing that materials could be easily donated. We came up with ideas, and after a vote among the students and staff of the school, we had to make a prototype and research the laws on playground regulation to see what the dimensions could be. In addition, planters and pans were adhered to the surrounding fence so students will improve their sensory development. This playground was built with the purpose of the kids having a better engagement with nature, sensory development, and a safe fun time.

Areas needing further development and testing

Our first prototype was different from our final design. We improved different materials, structures and designs. Our initial design consisted of a balance beam built with two railroad ties separated by 4 tires, the balance beam connected on one side to a log path, and on the other to a tire path, which connected to the tire mountain.
The balance beam had to be modified as the railroad tie could not be used due to the chemicals that contained. Instead, a single piece of treated lumber was placed, which made it impossible to place the tires in the middle of the balance beam. Those tires were placed as steps before the balance beam, instead of the log path. To ensure the safety of the kids those tires had to be bolted together so they wouldn't sink or leave a space in between them where the kids' feet could get stuck. The logs were not used as they were replaced for the tires and needed special treatment.

The tire mountain was the piece of equipment that required more changes. The design was accurate, but there was a need for a structure or something that would improve its stability. The decision was to substitute the bottom row of the tire mountain, which were car tires, for truck tires. That improved the load bearing capacity as well as the stability. Concrete was also added to the base, which improved the stability. Another issue found was the hole at the top of the tire mountain, as a kid could fit and get stuck in there. To solve that problem, we built a triangular structure of wood to bolt on top of the mountain.

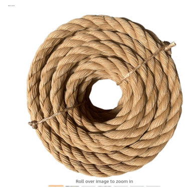
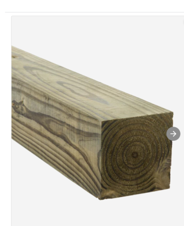
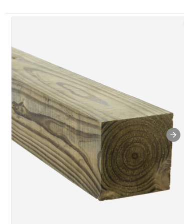
Conclusion

Although our design was initially faulty, we were able to alter the playground to be a safe space for children to play. We are glad that we were able to design and build something that kids will be able to enjoy. If we were to redo the project, there are plenty of improvements that could have been made but we are otherwise satisfied with the work we were able to complete.

Purchase List

Product Name:	Number Needed:	Product Description	Link to Purchase Product:	Picture of Product:	Total Price:
4 in Bolt	4 x 25	3/8 in.-16 x 4 in. Zinc Plated Carriage Bolt Use to bolt the tires together	https://www.homedepot.com/p/Everbilt-3-8-in-16-x-4-in-Zinc-Plated-Carriage-Bolt-25-Pack-800280/204281342		$82.44
Hex Nut	4 x 25	3/8 in.-16 Zinc Plated Hex Nut Use to bolt the tires together	https://www.homedepot.com/p/Everbilt-3-8-in-16-Zinc-Plated-Hex-Nut-25-Pack-802364/204274093		$15.40
Flat Washer	4 x 25	3/8 in. Zinc-Plated Flat Washer Use to bolt the tires together	https://www.homedepot.com/p/Everbilt-3-8-in-Zinc-Plated-Flat-Washer-25-Pack-802324/204276362		$17.24
Spray Oil Paint	3 x green 3 x pink 3 x yellow 3 x purple 3 x blue 3 x red	Professional Enamel Sprays provide a durable protective coating with superior rust prevention and excellent protection from abrasion, fading, chipping, and dulling For use on interior/exterior surfaces including metal, wood, concrete and masonry Applies easily and features a high output	https://www.lowes.com/pd/Rust-Oleum-Professional-Gloss-Hunter-Green-Spray-Paint-Actual-Net-Contents-15-oz/3729789 https://www.lowes.com/pd/Rust-Oleum-Stops-Rust-Gloss-Poppy-Pink-Spray-Paint-Actual-Net-Contents-12-oz/1000760950		$20.94 $17.94 $20.94 $14.94 $20.94 $20.94

		tip that can be sprayed at any angle Used to paint the tires	https://www.lowes.com/pd/Rust-Oleum-Professional-Gloss-Safety-Yellow-Spray-Paint-Actual-Net-Contents-15-oz/3729793 https://www.lowes.com/pd/Krylon-COLORmaxx-Gloss-Gum-Drop-Spray-Paint-and-Primer-In-One-Actual-Net-Contents-12-oz/1000460357 https://www.lowes.com/pd/Rust-Oleum-Professional-Gloss-Safety-Blue-Spray-Paint-Actual-Net-Contents-15-oz/3729851 https://www.lowes.com/pd/Rust-Oleum-SuperMaxx-Gloss-Safety-Red-Spray-Paint-Actual-Net-Contents-15-oz/3729791	    	
Primer spray	3	Bulls Eye 1-2-3 Plus 13 oz. White Interior/Exterior Primer Spray Spray Primer blocks stain and odors on difficult surfaces Resists blistering, peeling and mold and mildew growth High hiding, smooth finish, dries to touch in 30 minutes Used to make the paint of the	https://www.homedepot.com/p/Zinsser-Bulls-Eye-1-2-3-Plus-13-oz-White-Interior-Exterior-Primer-Spray-272479/203985969	 	**$23.94**

		tires attach.			
1 inch rope	1	ATERET Twisted ProManila Rope Cordage I UnManila 3 Strand Synthetic Polypropylene Rope I 1 inch x 50 feet I Multipurpose, Lightweight, Weather-Resistant Cord for Decor, Landscaping & DIY Projects Used as the security rope crossing the balance beam (design 2).	https://www.amazon.com/ATERET-Polypropylene-Multipurpose-Lightweight-Weather-Resistant/dp/B08VRWPFNT/ref=sr_1_1_sspa?keywords=1%2Binch%2Brope&qid=1647366243&sr=8-1-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyOFUySE1ENThOQ0xJJmVuY3J5cHRlZElkPUEwNzk1MDk3MTRHSUdOVVVQWkM4UCZlbmNyeXB0ZWRBZElkPUEwMzAxNDA2MlFBRE1aQ0pVVFUQSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1		$19.90
Treated lumber 6-in x 12-ft	1	Severe Weather 6-in x 12-ft #2 Ground Contact Wood Pressure Treated Lumber Used for the base of the balance beam (design 2).	https://www.lowes.com/pd/Severe-Weather-Common-6-in-x-6-in-x-12-ft-Actual-5-5-in-x-5-5-in-x-12-ft-2-Treated-Lumber/4222523		$71.98
Treated lumber 4-in x 10-ft	2	Severe Weather 4-in x 10-ft #2 Ground Contact Wood Pressure Treated Lumber Used for the post of the balance beam (design 2).	https://www.lowes.com/pd/Severe-Weather-Common-4-in-x-4-in-x-10-ft-Actual-3-5-in-x-3-5-in-x-10-ft-2-Treated-Lumber/4222509		$51.76

					Total (excluding sales taxes); **$ 399.30**