

Children's Center Playground Renovation: A Capstone Project to Benefit Our Community

Abstract

The Young Women's Christian Association, known globally as the YWCA, offers many services and programs to the local community, including programs aimed at improving children's lives. The local YWCA Children's Center is a licensed four-star learning center that hosts children aged six weeks to around six years old daily. Following a philosophy that each child develops at their own rate, the Children's Center seeks to include age-appropriate and culturally diverse playground experiences that correlate with each child's specific needs and skills. However, the local YWCA's existing outdoor play area was worn and outdated, lacking opportunities to support children's learning and growth or to provide interesting play activities. An interdisciplinary capstone senior project team followed the engineering design process from problem definition, through research and brainstorming, to initial design and stakeholder approval, to prototyping, and finally to creating a sustainable, engaging, and appealing children's play and garden area to fulfill the YWCA's needs for many years to come. This student paper will provide findings of extensive research on current children's playground and garden designs as well as study of children's abilities and curriculum by age. The designs of the new equipment, begun as hand sketches and then modeled in AutoCAD, PTC Creo Parametric, or Revit, are provided. The final equipment, playscapes, and playground layouts with nature as a theme will be shown. Of equal value to the project team's professional development, the team's interactions with their stakeholders – the YWCA administrators, teachers, children, and project funders – will be described. The student authors also discuss the significance of service learning as a valuable contribution to their engineering education.

Introduction

Senior capstone design projects provide engineering and technology students the opportunity to demonstrate and apply their learned skills and abilities to solve a problem. Ideally, this problem is genuine, rather than theoretical, as today's students seek to make a difference in the real world. When given a choice between working on a corporate sponsored project or a problem brought by a non-profit community entity, students may feel the former has greater status, will be more "real world" in nature, and will better prepare them for their engineering careers. This paper discusses a senior engineering design capstone project undertaken for a local, not-for-profit organization, and suggests that this service learning project was, in fact, ideal for building the student team's professional skills while allowing them to make a genuine contribution to their community.

The overall goal of this project was to design and renovate an educational playground and garden for children ages six months to six years at the local Young Women's Club of America (YWCA). The YWCA is a non-profit organization that strives to uphold their mission to "eliminate racism, empower women, promote peace, justice, freedom, and dignity for all." They provide several services and programs to the community, including a four-star child care center. The children's center playground and garden area was outdated and did not fit the needs of the children or teachers using it. The redesign of the playground will encourage a higher rate of educational development and will better suit the curriculum currently used in the classrooms.

Following the engineering design process to achieve project goals

The engineering design process was used from the start, adapting it as necessary for the particular needs of this project. The broad steps the YWCA project team took were as follows:

- Identify the project need (problem statement), criteria (requirements), constraints (limits), and – particularly important in this project – identify the multiple stakeholders and their needs.
- Undertake thorough and relevant research to provide needed background and support project activities.
- Brainstorm and imagine a wide variety of outcomes, and generate possible solutions.
- Select best options for each established need, and develop them (in this case, through CAD drawings and layouts). Evaluate for strengths and weaknesses, and adjust as necessary.
- Following communication with clients and funders, complete design and build of final products.
- Test built solutions for satisfaction of design criteria as well as meeting all stakeholders' identified needs.
- Implement the solution, follow up as necessary, and provide thorough documentation throughout.

Stakeholders' needs assessed

Project deliverables were to provide the client (YWCA) with a safe, exciting, and innovative children's play area that enhances youth learning. In addition to the playground, the YWCA requested a solution for the children's garden and "drop-off corral" area. To better understand the requirements of these deliverables, meetings with the YWCA stakeholders were held. At these meetings, the student project team interacted with the Education Coordinator, teachers, and young children to learn their needs and hopes for the play area. Because the budget for the project would come from outside funders, the team was asked to provide two unique design options that significantly differed in cost and complexity. These design options would then be presented to boosters, teachers, and parents at the YWCA, where they would compare options and choose which design to fund.

Deliverables, criteria, and constraints

Specific criteria and constraints for the final playground redesign were identified early on, and these drove subsequent project activities. First, better, and more, learning opportunities in the play area, based on the YWCA's creative curriculum and to support the young students' classroom learning, were required. The new equipment and playground designs had to be designed for children ages six months to six years, and the new playground must support a maximum number of 25 students on the playground at once. Materials used needed to be mostly natural based materials, like wood, or sustainable materials, like recycled plastic.

In addition to these criteria, project constraints included Michigan weather and the codes and regulations required for children's center playgrounds. Because the project began in September and requires an outdoor implementation, and given the unknowns of Michigan winters, there was a narrow window for implementation of the completed design and equipment. Furthermore,

safety and mandated codes and regulations needed to be constantly referred to during the design process to ensure 100% safety for the children and adults engaging in the playground. The project budget, as mentioned earlier, was to be determined based on YWCA supporters' response to the team's high-end and moderate design options, presented mid-way through the project.

Extensive research to support project choices and design

Any capstone design project using the design process to structure activities will undertake research to support design choices and identify tools for completing the project. In the case of the YWCA children's play area redesign, such research was not only useful, but was mandated by concerns for the eventual playground users' learning and safety. To better understand the project's priorities and needs, research was first carried out on the YWCA itself. This was followed by investigation of children's learning styles, including age-appropriate activities and abilities, and how children's learning can be supported by outdoor play and activity. Understanding children's abilities and children's curriculum by age was especially important, as the YWCA is looking to incorporate their curriculum into children's outdoor play times.

Existing children's playgrounds, especially those designed for learning and educational support, were examined. Numerous codes and regulations had to be researched before actual design of the play area and equipment could begin. And materials for all areas and equipment of the planned play area had to be researched for appropriateness to this application

Background and mission of the YWCA

The Young Women's Christian Association, known globally as the YWCA, has many services and programs available to the community, including, but not limited to community education, women's empowerment programs, sexual assault programs, a crisis hotline, and programs aimed at improving children's lives. These programs support their mission statement that the "YWCA is dedicated to eliminating racism, empowering women, and promoting peace, justice, freedom, and dignity for all."¹ The YWCA Children's Center is a licensed four-star learning center that hosts children ages six weeks to around age six. They follow a philosophy that each child develops at their own rate. Therefore, they try to focus on using age-appropriate and culturally diverse equipment that correlates with each child's specific needs and skills.² Although the local YWCA has had an outdoor area for children for several years, it was outdated and worn, and it did not meet teachers' desires to support their classroom curriculum with enjoyable, safe, and age-appropriate activities. The photos below show this previous play area.



Figure 1. Existing YWCA play area



Figure 2. Existing playscape

Children's learning abilities

Playground equipment must be created around each age group's physical and cognitive abilities. Within the broad abilities for children six weeks to six years, the team researched the most important physical and cognitive abilities of children in their perspective ranges. This information was broken into specific skill groups: fine motor skills, gross motor skills, and cognitive and sensory abilities. Fine motor skills are the ability to manipulate tools and objects with coordination between the eyes and the muscles in the hands, fingers, and wrist.³ Gross motor skills require the movement of the entire body or at very least large muscle groups such as the legs and core muscles. The cognitive and sensory abilities involve the children's ability to learn, communicate, and understand commands while learning through their five senses.

The information from the sources led us to believe that most children in their early years learn better from visual and sensory aids that support understanding of basic concepts such as size, weight, speed, and other physical properties of everyday materials. The playground should include many different aids to be suitable for all children. Mastery of fine and gross motor skills are essential in a child's development.⁴ The playground should challenge and reinforce skills such as balance and climbing, and should test their analytical skills. Learning specific milestones for each age provided better understanding of what each child is capable of and how designs might best correspond to their development.⁵

The Creative Curriculum for Preschool

A project criterion was that the playground be an extension of the YWCA classroom. Lesson plans from YWCA teachers and research regarding the Creative Curriculum program were used to evaluate the effectiveness of possible designs. Research on learning styles of young children showed that using visual and sensory aids greatly increases the educational understanding of many children. The sources used to evaluate this curriculum were received directly from the YWCA. Their curriculum has been meticulously analyzed and tested for effectiveness. With this in mind, these sources should be accepted as reliable and worth examining.

The education provided by the YWCA is directly drawn from The Creative Curriculum for Preschool. This is a teaching strategy widely used to educate children from birth to age eight. The primary goal is "to prepare children to live in the global age by learning how to solve problems, think creatively and flexibly, use technology, work collaboratively and constructively with others, be respectful of differences, care for the environment, have good communication skills, and be lifelong learners."⁶ This strategy believes that these skills are best developed at an early age and the education a child receives when they are young provides the foundation for which all other skills are built.

Importance of outdoor play

The Creative Curriculum places great emphasis on the importance of outdoor play, going so far as stating that outdoor play is just as important to how a child learns as their time in the classroom. An outdoor space can allow children to do activities they enjoy such as running, jumping, and climbing. It was deemed important to the success of this project to reduce restrictions or barriers to play when that could be done safely. An outdoor space can aid teachers with lesson incorporation in a new and exciting way. Children tend to stay focused longer and participate easier with a hands-on activity in the fresh air. The development and learning of young children that teachers should focus on can be broken down into several categories

including social and emotional, physical, language and literacy, and cognitive. Each of these categories can be incorporated and combined in the outdoor play area.

Social and emotional learning

Playgrounds support the social and emotional development of children when they gain a sense of achievement and capability during outdoor activities. This can be seen when a child catches a ball, scores a goal, or climbs to the top of a structure. Playground equipment design should ideally involve multiple children growing their social skills. These skills teach sharing, working together, respectfulness, empathy, and nurturing. The design should be able to bring out these social and emotional skills through normal play. It is suggested that most builds should be in a style that multiple children use it and possibly are required to problem solve together.⁵

Physical learning

Obviously, a playground's primary purpose is to get kids active. Obesity in children is increasing, but a well-designed playground can motivate children to get the correct amount of activity. In a technology-driven world, many children would rather stay stagnant for most of the day. As they age, this habit may become engrained. A way to boost motivation is by creating fun ways to play outdoors. These activities develop gross and fine motor skills.⁴ Designs should be exciting enough that children prefer to play outdoors and should encourage them to be as active as possible. Children should be able to run, jump, swing, slide, and climb. Excitement can come from taking risks and testing the capabilities of their bodies. The challenges they face will motivate them to continue to grow the physical skills needed later in life.

Learning through literacy

One of the most valuable skills needed for a successful life are language and literacy. The Creative Curriculum suggests using nature and real-world examples for learning words.⁷ Starting with words that children are familiar with and experience daily, the playground design can help create a literal connection between a word and what it represents. For example, a teacher could use a water feature to describe the words wet, slippery, cold, etc. Children can play in the water and experience the actual meanings of these words.

Cognitive learning

Cognitive skills are those that the brain uses to think, focus, make decisions, work together, and help the body achieve most other functions. The smell of a flower, hardness of concrete, time it takes for a flower to grow, and number of leaves on a plant all teach these mental skills. These skills can be broken down even further into areas such as mathematics, science and technology, social studies, and art. Every one of these was deemed imperative to the design and should make learning fun.

Tactics to separate age groups

One challenge when designing for the children's learning needs are the age range separation. All children will need activities for each listed skill, but complexity and use will vary greatly between groups. The youngest groups are infants and toddlers, and the main educational focus for them is movement, communication, and sensory skills. It is also important to create a daily routine for children at this age. While any education at the infant level is very basic and broad, it is the start of this educational foundation and could be argued that it leaves the strongest impact on the child. For example, an infant's literacy skills could focus on discovering the sounds they can create and not forming actual words with meanings.⁷ The client requested that there should

be a clear separation between the smallest children's area and the rest of the playground, while still being open enough to pass through it. These youngest children will still experience the environment that the older kids do, but their safety is paramount.

The older children, to whom the majority of the physical area in the space is dedicated, can be given more advanced activities. These children have fewer restrictions on what they can accomplish and there must be a greater variety of experiences open to them. It is very beneficial from a learning and design efficiency standpoint if multiple skills are used at one time.⁶

“Best practice” children’s playground designs

Once the team had fully researched and understood children's learning needs and stages, it became useful to examine existing play areas that supported such learning. The concept of a play area that is focused on early learning is not necessarily a new concept, but one that is becoming more popular as creative curriculum becomes more essential to childhood development. It is valuable to learn from other designs and adapt best practices to the YWCA project. There are currently several non-profit organizations dedicated to building educational and safe play areas for children, like Kaboom, Carter's Kids, and Play360. There are also commercial playground equipment manufacturers, like GameTime and Playcore, that focus on sustainability and creating products that are environmentally responsible.⁸ These organizations and companies work with YWCA locations and independent playgrounds around the country to develop and enhance them, and the team was asked to look into these designs.

The first step to playground design once the user demographic is understood is determining what zones would be most viable. Zoning on a playground refers to the process of placing different types of equipment into specific zones based on type of play and physical activity level. This can be crucial when designing a playground for a wider range of ages, because each age has different sensory and motor skills and will participate in play differently. A recent (2017) case study required focused zoning at an elementary school playground, because the design had to be accessible to children in wheelchairs while also being challenging and offering the potential for high physical activity levels for able-bodied children.⁹ The elementary school in the case study, similar to YWCA, also wanted a way to incorporate their curriculum into their playground equipment. The major zones determined for this playground included a transition zone (1) between the indoor and outdoor areas, a sand play zone (2), a dramatic play zone (3) including a wooden stage, and a natural zone (8) with planters and an open field, among other zones. Choosing where to place the zones was determined heavily by noise level, taking into account noisy versus quiet zones and the ability to keep children engaged in their chosen activity without being distracted by high noise levels from adjacent zones (2017).⁹ Figure 3 shows the placement of the different zones based on their noise level and physical activity level.

In a 2006 study, Cosco tested three separate activity center designs, providing diagrams as shown in Fig. 4. She concluded that a design with wide and curvy pathways, low shrubbery for effective adult supervision, and smaller, compact play areas located off the pathway, supported the highest activity levels and positive social interactions between children.¹⁰ According to further research done on activity levels of children ages three to five in an outdoor learning environment by Smith, Moore, and Cosco, children were more likely to have a higher level of activity when playground designs included curvy paths, open areas, and naturalization, which

refers to the equipment and nature elements being integrated together.¹¹ This research was influential in the team's playground designs, which also incorporate a focus on zones devoted to specific activities, pathways, and integrating equipment and natural elements together.

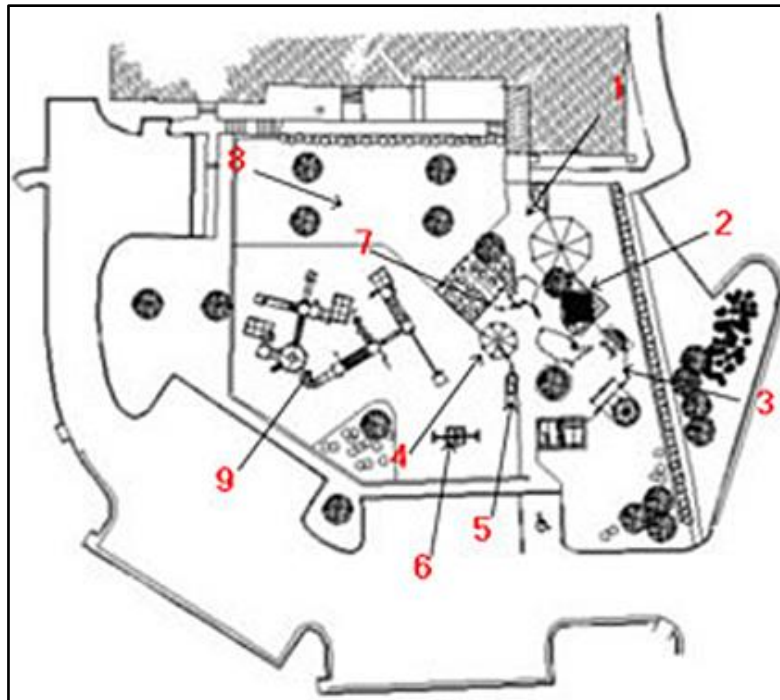


Figure 3. Playground design by zone.⁹

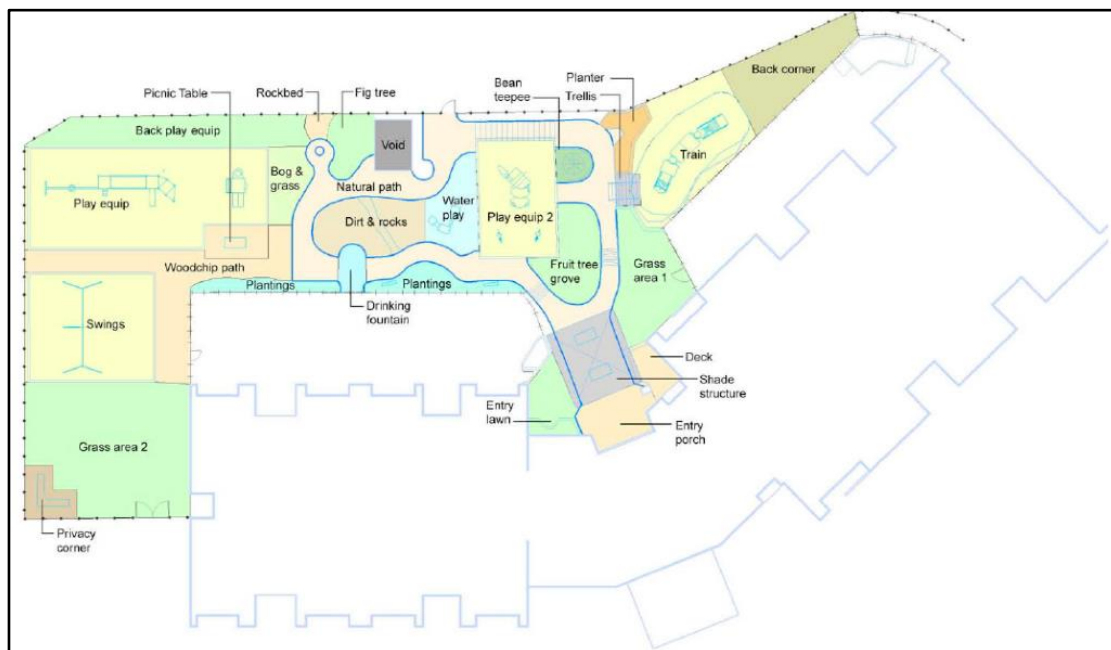


Figure 4. Behavior settings for activity center ¹⁰

Gardening Ideas

The scope of this project also included the redesign of the current garden space at the YWCA. Two potential garden areas exist surrounding the children’s play area: a long strip that runs outside of the long fence, and an area by the drop-off (from buses) zone. The physical nature of gardening and play around plants has long been known to support children’s learning. Sensory gardens – planting and planted areas that appeal to the five senses of sight, sound, touch, smell, and taste – are increasingly common. These sensory gardens provide opportunities for children to get dirty, to learn about the natural world, and to share responsibility and love for nature.¹²

The YWCA clients shared their interest in adding potted herbs and easy-to-maintain flower beds as part of a sensory garden for the children. Research was conducted into gardening ideas, including types of plants, and the designs that would implement these plants into the work area. The pros and cons of planting and maintaining an open garden area vs. more controlled planting in pots and planters were researched, and input was sought from the YWCA clients. Based on ease of maintenance by staff, ability to keep young gardeners focused, and costs, it was decided by all to design and provide pots and planters.

Several designs including instructions on how to build, as well as a bill of materials required, are available through Kaboom, a national non-profit that is “dedicated to giving all kids, great, safe places to play.”^{13, 14} Figures 5 and 6 show planter boxes that are classified as easy-to-medium difficulty projects that can be completed in less than five hours. The materials are minimal and require only four volunteers. Kaboom notes that incorporating these planters into a play space is a simple way to get children involved in sensory learning and provides opportunities for them to tend to plants while also enhancing the space for adults utilizing it.¹³



Figure 5. Raised planter box.¹⁴

BigToys, a subsidiary of Playcore, is a playground equipment manufacturer that makes environmentally sustainable products that promote the development of sensory skills and encourage social interaction between children. They create products for a wide variety of skill sets for children ages 6 months to 12 years. They incorporate their sustainability philosophy in their gardening products.^{15, 16} Figure 7 shows an example of one of their planters for ages two to five. It includes their conditioned wood that protects against termites and decay, and recycled metal and plastic that provide slip resistant decks in any condition.



Figure 6. Planter box.¹³



Figure 7. Green thumb planter box.¹⁵

Playground Specifications and Regulations

The YWCA Children’s Center play area design and build must comply with governmental codes and regulations. This is a legal and ethical obligation accepted by all involved. Compliance ensures the playground is safe and minimizes injuries.

Background

When building a playground structure and renovating an outdoor area, many regulations are set by multiple sources, including the U.S. Consumer Product Safety Commission (CPSC), the American Society for Testing and Materials (ASTM), and the 2015 Michigan Building Code. “Laws in Michigan require all new playground equipment to satisfy both CPSC and ASTM specifications.”¹⁷ Although there are the only two sets of specifications required by Michigan’s Department of Licensing and Regulatory Affairs,¹⁸ many other resources were consulted to help guide the design process with constraints relating to the size and strength of all new equipment and structures, appropriate materials, and safety.

Consumer Product and Safety Commission

The CPSC is a regulatory agency created to “protect the public against unreasonable risks of injuries and deaths associated with consumer products.”¹⁹ This group’s 2010 handbook on public playground safety is still relevant today, and its standards and recommendations apply to the YWCA project. These topics include playground guidelines, injuries, considerations, hazards, maintenance, and constraints for all the different parts of the playground. In particular, the constraints chapter was beneficial in helping determine appropriate sizing for all equipment, rope features, water features, sand features, and structures.²⁰

The major characteristics of the playground will be the play structure, the layout, and the equipment. The play structure is a main attraction of most playgrounds. The team’s design is a composite structure, which is “two or more play structures attached or functionally linked, to create one integral unit that provides more than one play activity.”²⁰ Beside the play structure, an effective layout of the playground is crucial to success. Six key factors in the layout are “accessibility, age separation, conflicting activities, sight lines, signage and/or labeling, and supervision.”²⁰ The CPSC handbook lists all ASTM specifications that apply to playgrounds and the equipment while also giving providing safety information on rope climbing openings, guardrail heights, balance beam heights, and much more.

American Society for Testing and Materials

American Society for Testing and Materials (ASTM) works independently to create technical standards.²⁰ The sections that pertain to playgrounds are paraphrased below:

- F1148 - Safety performance of home playground equipment
- F1292 - Appropriate surfacing materials
- F1487 - Safety performance of public playground equipment
- F1816 - Children's drawstring strangulation hazards
- F1918 - Safety performance of the equipment in an enclosed playground with materials such as plastic and padding.
- F1951 - Accessibility around playground equipment
- F2049 - Safety performance of fences enclosing a playground
- F2075 - Engineered wood fiber used in a playground
- F2223 - Playground surfacing
- F2373 - Safety performance of equipment used by children from 6 to 23 months old
- F2479 - Cast in place playground surfacing

Trying to achieve safety and longevity from the playground design required that the team meet these specifications.

2015 Michigan Building Code

The 2015 MI Building Code is an additional set of specifications that guide the building of all types of structures and buildings.²¹ Only a small part of the code applies to playgrounds and equipment; these helpful sections were:

- 305 - The classification of the renovation work as group E, educational.
- 424 - Children's play structures
- 1004.5 - Egress for outdoor areas
- 1010.2 - Gate requirements

Materials

The playground's materials and equipment must be carefully selected based on safety and value for educational learning. In accordance with CPSC and ASTM regulations, a surface material must be appropriate for the age group, desired critical height, and equipment.²⁰ Research was conducted to aid in material selection for any potential ground and flooring changes to be made to the existing play area, as well as the structural materials used to build new playground equipment.

Ground and flooring

One of the hardest decisions to make was the selection for material of the ground. Some of the most popular surfacing materials are "solid rubber surfacing, artificial grass, wood chips, rubber mulch, and engineered wood fiber."²² A loose-fitting material, such as pea gravel, sand, rubber mulch, wood mulch, and wood chips, would be more difficult to keep up as it requires proper maintenance. The other option is unitary materials, which have shock absorbing capabilities and can be colored to help with sun exposure. A unitary material would be more expensive to start, but any maintenance would be minor.

According to the CPSC, appropriate playground surfacing is “any material tested to ASTM F1292, including unitary surfaces, engineered wood fiber, etc.”²⁰ However, section 2.4.2 of the CPSC playground handbook suggests not using loose-fitting material for playgrounds for toddlers, and it was decided a unitary (solid) material is better.

After selecting a material, the critical height can be determined. The critical height of the existing rubber material on the current playground is about 4'-0", so replacing something with the same ASTM F1292 rating or better is ideal. One other thing to consider about surfacing the ground with a unitary material is whether the product requires the material to be installed over another surface such as concrete or asphalt. If it requires a layer underneath the flooring material, costs will increase.

If loose-filling materials are used in any area of the playground, several factors to be considered are critical height, minimum depth, toxicity, accessibility, gradual compaction depth, containment, and drainage.

Structural materials

There were many factors taken into account when choosing the correct material for playground equipment. Some of these factors included sustainability to the environment, durability, costs, and safety regarding the children using the equipment. Finishes and preservatives had to be considered when choosing materials. Because the use of natural materials was requested, the team focused on wood and recycled materials in developing the playground equipment.

Although pressure-treated wood was formerly used in playgrounds, in 2002, the U.S. Consumer Product Safety Commission recommended against its use in playground equipment, as it can pose a health risk to children.²³ The use of CCA-treated wood in commercial playgrounds nationally stopped in 2004. Any wood that is used in playground equipment should be naturally rot and insect resistant or be treated to reduce deterioration. The CPSC recommends avoiding latex and oil based stains due to peeling and flaking, and to stay away from creosote, pentachlorophenol, and tributyl tin oxide due to its toxicity.²⁴

A material growing in popularity for use in playground equipment because of its eco-friendly properties is recycled plastics. GameTime, another subsidiary of PlayCore, currently credits their manufactured equipment as being made of 93% recycled content while their products are also 100% recyclable. By using recycled plastics, they were able to reduce their carbon footprint in the environment while also reducing their water consumption and eliminating waste.⁸ The YWCA project team sought advice and materials from a local manufacturer of lawn and garden equipment that also has a commitment to sustainability and natural and recycled products.

Non-structural and non-ground material considerations

Many more materials can be used in a playground that do not relate to the ground or play structures. Play equipment materials can range from wood, steel, rubber, or plastic, or a combination. Wood and steel require more maintenance and weather sealing, and wood must also be insect resistant in order to prevent its deterioration. Rubber used in tires must be ground down and stripped of all sharp edges and points. Other rubber equipment must also be sealed in order to prevent deterioration. Commercial grade plastic is one of the most common materials seen in a playground, because it is less likely to cause severe injuries, is relatively inexpensive, and is easy to apply colored finishes in order to make it more appealing.

YWCA Children’s Center project activities

The renovation of the YWCA project, like most capstone design projects, had numerous steps and activities. Because the budget for the project was dependent on the YWCA’s philanthropic supporters, it was early on determined that the team would present at least two overall playground revision plans to the YWCA director, board, and other affiliates, to solicit their approval (and funds!) for the builds. The YWCA stakeholders called these prospective plans “Oldsmobile” – for a lower-cost change to the existing playground, with fewer features – and “Cadillac” – for a fully renovated, unlimited budget renovation.

Thus, the team envisioned and designed several individual pieces of equipment, play area zones, and overall improvements, from which to draw for the two proposed plans. In planning these presentations, the team needed to complete graphics to fully convey what they were proposing, and they needed to have accurate costs of each layout. They also had to have initial recommendations on general material selection, based on their research and YWCA input. Following approval of which option to pursue, or combination of both, the team developed that layout fully and made final material selections. They then built the individual equipment pieces, testing them as necessary, and getting frequent input from multiple stakeholders in regularly scheduled meetings. Once weather permitted, the newly built equipment was installed and user tested. The garden area was also installed.

Design of individual equipment pieces

Once research was completed, design of the individual pieces of equipment, the playscape, the garden, and, finally, the overall YWCA Children’s Center area began. Individual brainstorming by each team member resulted in numerous options. These options were brought back to the team and discussed for their fit to stakeholders’ needs; the thorough review of playground “best practices,” regulations, and child development provide significant input into designs chosen. A Pugh matrix was used to rate the design options against project criteria, and it was decided to pursue six different items.

Hand-drawn sketches were completed, and again, discussed at length. The types of equipment discussed are storage and play equipment, as well as the playscape structure. Some of these sketches have been modeled in Autodesk Revit, PTC Creo Parametric, and/or AutoCad and can be seen in the following sections.

Storage equipment

The existing children’s playground had no structure for storing small play items, like balls, or the bikes the children use in the area. These items would typically end up scattered around, getting dirty and causing a tripping hazard. During stakeholder interviews, teachers requested an area and means to organize items and keep them handy and safe. The team designed a structure dedicated to ball and bike storage, to be placed near the door from the building. Children can grab these items as they enter the playground, and be reminded to put them back before leaving. Figure 8a shows the design of the requested bike and ball combination storage structure. The left side is a rack for ball storage. It will include elastic straps that allow for balls to be easily slid in and pulled out. As a ball is pulled out, the rest drop to the bottom, keeping them in reach for small children. The right bottom side is tricycle storage. Areas to still be decided include a

potential mass lock and best utilization of space above bike storage. The bill of materials and estimated costs are also shown.

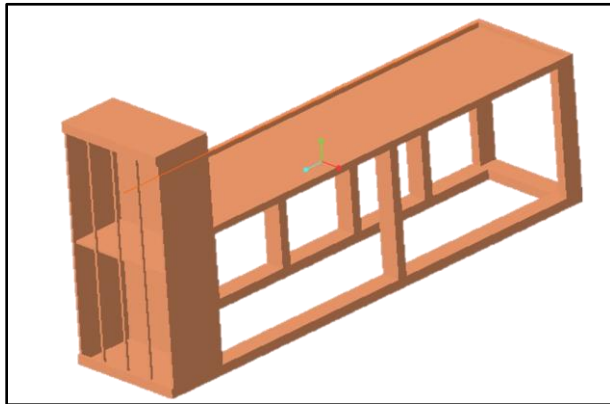


Figure 8a: Bike / ball rack

Material	Size	Qty	\$ per	Total
Wood boards	2x4x8	8	8.50	68.00
Plywood sheet	4x8x1/2	3	20.50	61.50
Screws	1-5/8	1 lb. box	8.47	8.47
Bungie cords	1/4" diam.	4	3.00	12.00
Total				149.97

Figure 8b: Bike / ball rack bill of materials

Play equipment: Seesaw / balance beam

In a somewhat restricted space, a best practice is to have equipment serve more than one purpose and demographic. Teachers indicated that younger children can safely enjoy a seesaw proportioned for their size, while older children will embrace the challenge of a balance beam. Thus, a combination seesaw / balance beam was designed. A key characteristic of this piece is that it can be easily adapted from one use to the other. Figure 9 shows the initial concept sketches.

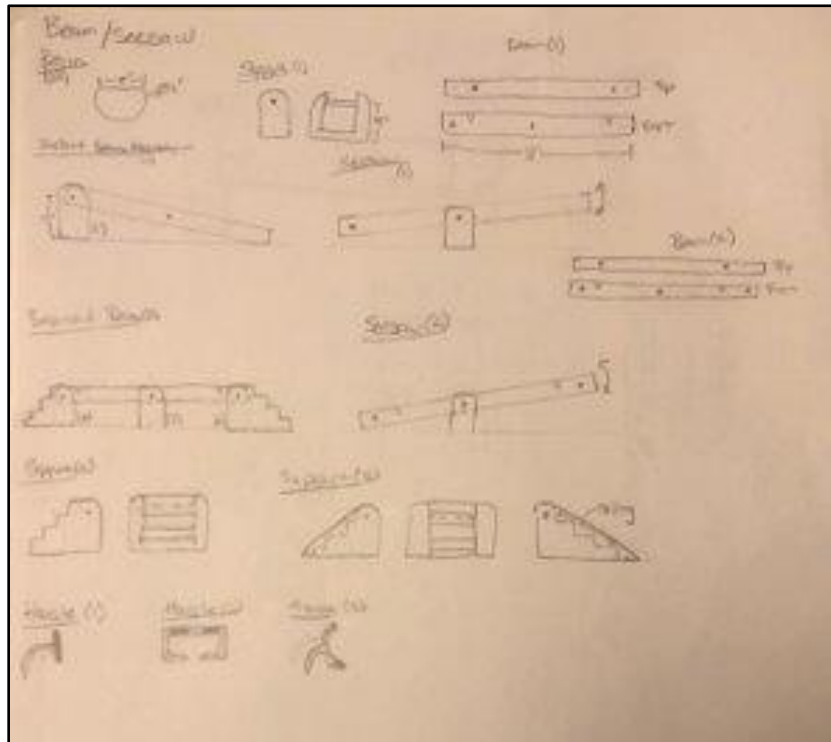


Figure 9a: Initial hand sketches for seesaw / balance beam concept

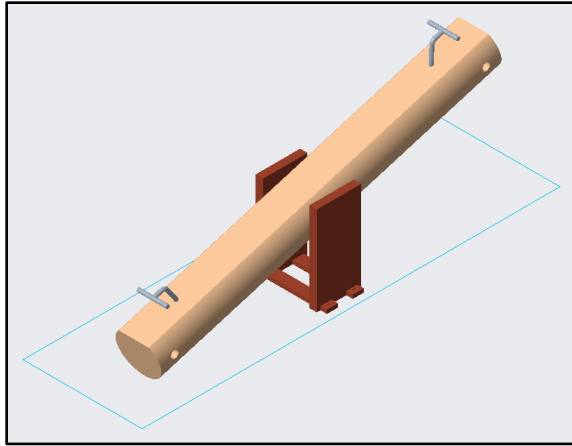


Figure 9b – Seesaw and balance beam: Seesaw

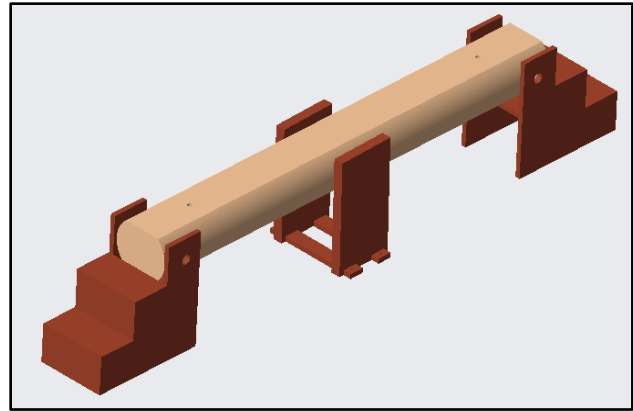


Figure 9c – Seesaw and balance beam: Balance beam

Figures 9b and 9c above show the seesaw and balance beam design, created in PTC Creo Parametric software. Having a permanent post in the middle of the beam while the outer two are removable makes it easy to transition between uses. The easy transition can be seen in Figure 9c. The handles used for the seesaw would be detachable, and removable steps for the balance beam function will be included. Bill of materials and estimated costs are shown below.

Material	Size	Qty	\$ per	Total
Wood boards	1"x4"X8'	4	4.27	17.08
Log	12"x 8'	1	95.99	95.99
Screws	1-5/8	1 lb. box	8.47	8.47
Ball bearings	1"ID/2"OD	2	23.14	46.28
Handles	T-Bar Handle	2	9.50	19.00
Total				\$186.82

Figure 9d – Seesaw and balance beam bill of materials

Play equipment: Sand and water table

Water and sand features were included on the list of specific requests received from the teachers at the YWCA. The team determined that a permanent sand pit in the ground would not have a high longevity; research and teacher feedback suggested sand pits mostly caused mess. Given that a goal was to integrate play and learning, it was decided that a joint water and sand feature would save room and be more effective for sensory development. The table would have different levels, each one appropriate for a different age range. The water would be pumped in through the top and flow through each level, traveling through several obstacles like pegs and wheels. Variations in water flow around the repositionable pegs will stimulate discussion. The outer length of the table would feature slim sand pits that would create minimal amounts of mess. Figure 10a shows the initial hand sketches used to develop the sand and water table. Figures 10b and 10c are the table design and the bill of materials with estimated costs.

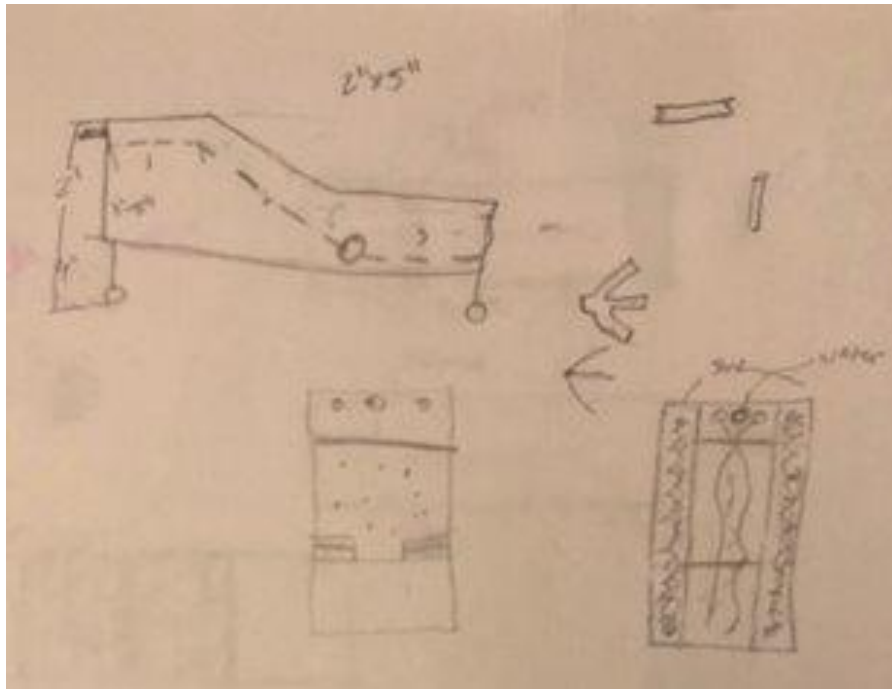


Figure 10a: Initial hand sketches for sand and water table concept

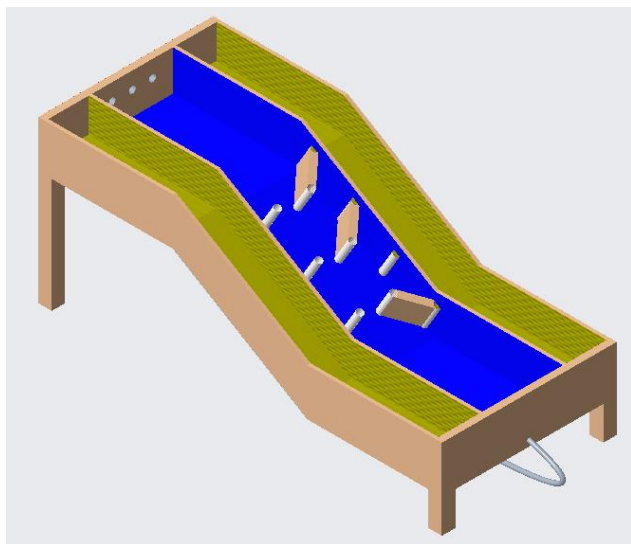


Figure 10b. Sand and water table

Material	Size	Qty	\$ per	Total
Plexiglass	½"X24"X60"	1	149.00	149.00
Wood boards	1"X4"X8'	15	4.27	64.05
Wood slants	1"X4"X12'	1	6.27	6.27
Acrylic rod	¼" - 11 7/8"	6	0.60	3.60
Hose	¾ ID/ 5/8OD	1	8.98	8.98
Pump	9.62in	1	9.97	9.97
Total				\$241.87

Figure 10c. Sand and water table bill of materials

Play equipment: Playscape with multiple activities

Many children’s playgrounds include a central “playscape”: a larger structure for children to climb, often offering some activities. The existing YWCA playscape was a plastic model with limited appeal and usefulness as a teaching tool, without activity areas appropriate for specific age groups. The YWCA team’s major equipment design was a playscape that would create and keep interest, provide physical challenge and enjoyment, allow children of multiple ages to play at one time, and permit a greater number of children to participate at one time.

Several ideas led to the creation of this playscape. The team wanted to maximize the space available. With a maximum platform height at 4'0", a lower platform at 2'0" was incorporated in order to make the climb easier. Basic steps use a 0'8" riser and 1'0" tread, allowing toddlers to climb to the platform. That platform also helps to split up the playscape, so the users do not all have to move in the same direction following each other. In order to be more versatile, it is a composite structure, using a wooden and rubber belt bridge to connect the larger platform structure described above to the sensory climber for older children, the initial hand sketches of which are shown in figures 11a and 11b.

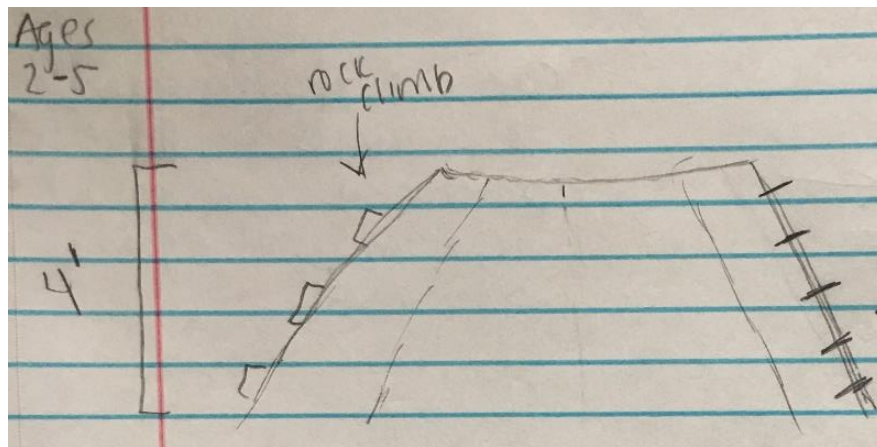


Figure 11a – Sensory climber –side view

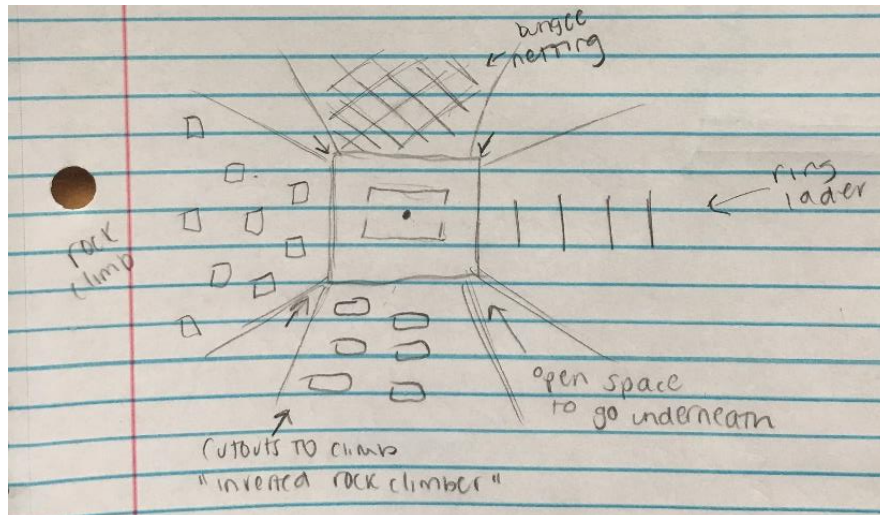


Figure 11b – Sensory climber – top view

The sensory climber is designed for children ages from two to five. The height will be between three and four feet, with slightly angled climbing features reaching the top where there is a flat platform. The original drawing included four different ways for the user to climb up to reach the top platform: a rock climb, a ring ladder, a bungee netting, and oval shaped cutouts described as an inverted rock climb. The different climbing elements can be seen in the top view, Figure 11b. In the middle of the top platform is a short fireman's pole that the children can slide down for

another way to get back to ground level. After consultation, the team decided to connect this design with the large playscape platform and include a rock climb, rope climb, and ladder. The following figures show the combined playscape design.



Fig. 11c – Playscape design (front), REVIT Model – 3D

Figure 11c shows a 3D screenshot of the front side of the playscape, built in the REVIT model. This side's features include a slide, a basketball hoop, and an inclined rock-climbing wall.



Figure 11d – Playscape design (rear), REVIT Model – 3D

Figure 11d shows a 3D screenshot of the back side of the playscape that was built in the REVIT model. The features on this side include a steel bar ladder, rope climb, firepole in the center, and steps for easy access to the middle and top platform.



Figure 11e – Playscape design (plan) REVIT Model

Figure 11e shows a plan view of the playscape that was built in the REVIT model. There are two structures connected by a belt bridge.

Additional playground renovations

The seesaw / balance beam, water and sand feature, and two-part playscape are the major equipment pieces designed for the YWCA Children’s Center renovation. In addition, a new stage to replace the existing rotted wooden structure, and an improved gate latch to replace the existing one, which is not as secure as desired, will be put in place. Garden boxes and planters, as earlier shown, will be built and, with children’s help, filled with plants to support the “five senses” garden. A design for a gazebo has also been included, although it is likely this will be an improvement for future years.

A final improvement will be to renovate and make efficient the small storage area located near the exit gate. This room is used to store miscellaneous equipment, garden and cleaning materials, tools, and general supplies. It has been in a disorganized and inefficient state for years. Given that one of the capstone team members is an engineering management student, it was decided to apply 5S principles to organize the storage room, as a sort of bonus improvement. This activity will be completed following the implementation of new equipment and garden area.

New playground layout proposals

As noted earlier, it was requested at the start that the team would present at least two overall playground revision plans to the YWCA director, board, and other affiliates, to solicit funding for the builds. The team has thus created two prospective plans. The “Oldsmobile” incorporates the ball and bike rack, the seesaw / balance beam, and the water and sand table, along with smaller items, like buried rubber tires, the new stage, and some gardening. The “Cadillac” includes all of those items, along with the large, two-part playscape and curving bike trails and new flooring material. The gazebo design is included in the Cadillac proposal as well.

Following design of the various new equipment pieces, in keeping with best practices and in consultation with YWCA stakeholders, the team has carefully located all new equipment ideas in the Cadillac playground layout. This layout incorporates a curved bike track to weave through much of the playground. Below is a list of all the features included in the layout:

- Playscape with multiple climbing features, a slide, and a belt bridge.
- Basketball hoop with painted lines on the ground.
- Redesigned stage built around the tree and with steps on the corners.
- Water and sand table located near the existing drain.
- Seesaw and balance beam.
- Gazebo with integrated counter interactive boards and two benches for teachers and chaperones (or may be incorporated at a future date).
- Buried tires.
- Bike and ball rack.
- Natural wooden logs on the ground by the path to the gazebo.
- Revised gate corral with new latch, utilizing thick year-round bushes.
- Garden planters filled with “five senses” flowers and herbs.

This final layout offers seamless separation of ages and multiple aspects to encourage learning, risky play, and fun. The layout is efficient in making use of space and filling the needs of the children at the YWCA. Figures 12a and 12b show the overall “Cadillac” playground layout.



Figure 12a – “Cadillac” playground layout – 3D View

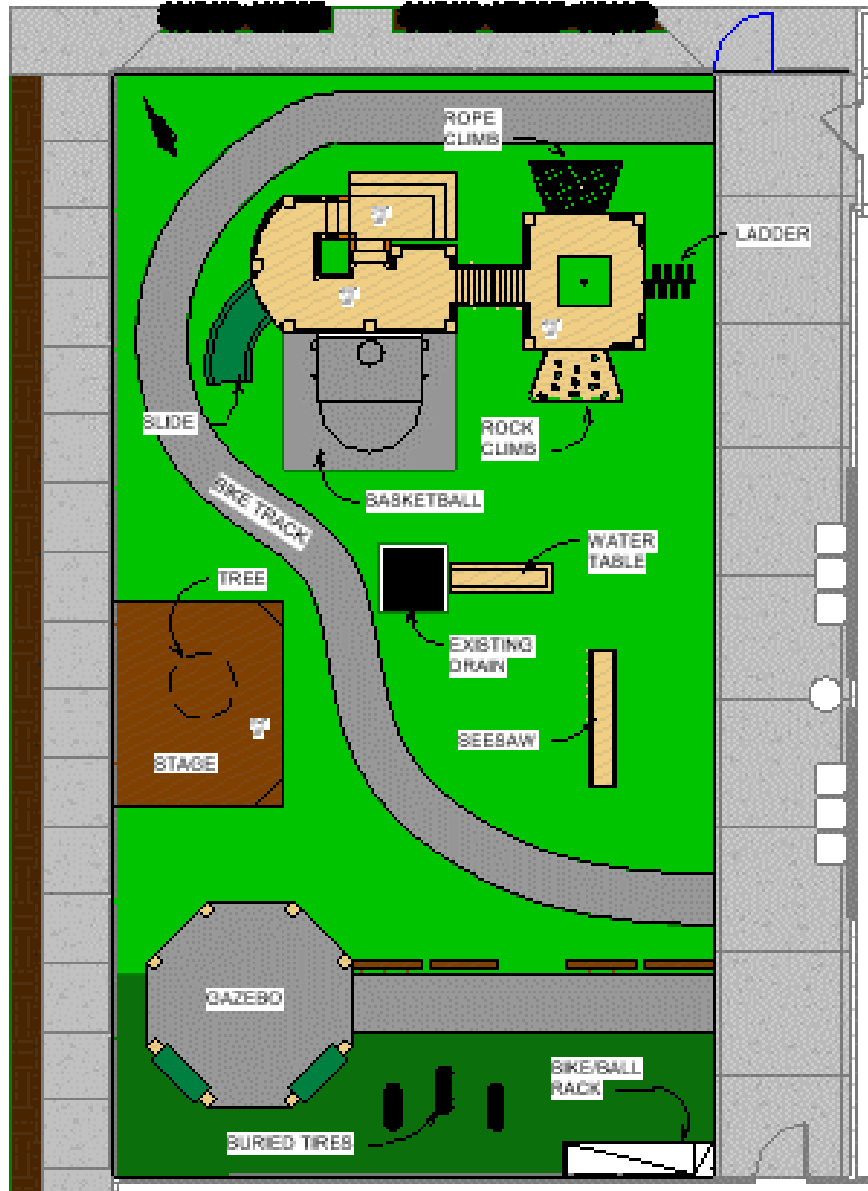


Figure 12a – “Cadillac” playground layout – Plan view

Value and significance of the YWCA Children’s Center renovation

Senior capstone project teams typically take pride in completing their projects to the satisfaction of their clients, and ours is no different. But the YWCA Children’s Center team believes we are gaining benefits our classmates working on corporate-sponsored projects are not. In corporate-sponsored senior projects, students typically have technical backgrounds and focus similar to those of their clients – a sort of shared community. Project deliverables may mirror or directly build on classroom knowledge and activities the students have experienced. However, in this YWCA project, our stakeholders range from six months on up in age; our clients are far more diverse in every possible sense than would be found in the typical engineering workplace. The YWCA strives to uphold their core values of “eliminating racism, empowering women, and

promoting peace, justice, freedom, and dignity for all.” It provides a significant advantage to instill these principles at a young age through learning and knowledge. As the planners, designers, and builders of this playground, the team was keenly aware that whatever is built and used by these children may directly affect their future as they grow educationally, socially, and physically.

At the time of this draft student paper submission, the verdict is still out on which of the Oldsmobile or the Cadillac proposals will be funded. Some smaller equipment builds, such as the garden planters, are underway in the meantime. The team expects to receive funding appropriate to the YWCA stakeholders’ choice very shortly. In the meantime, materials have been located, building space allocated, and guidance with experts, including a local manufacturer of outdoor equipment similar to those proposed here, are in place.

It may be wondered how a team of four students, even with strong guidance and support by advisors, will accomplish the build and implementation of this renovation. One of the greatest benefits of being involved with this project has been the outpouring of support. In our classroom, every progress report elicits offers of help. Fellow students are enthusiastic and keen to contribute their substantial technical skills. Local gardeners are eager to help the YWCA children put in their new sensory gardens. When the funding decision is made and the weather clears, the YWCA Children’s Center play area renovation will move forward swiftly. And we will be excited to share the final results at the ASEE North Central conference.

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