

RECTANGLE OF DOOM 2020

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1 Problem Formulation

1.1 Intro

In the following document, information and background on this project will be provided. This document also contains a draft document outline, an objective statement, as well as a black box diagram (figure 1-1).

1.2 Background

In this project, The *Three Amigos* are working with Zane Middle School located in Eureka, CA. This middle school is a STEAM school, (science, technology, engineering, art, and math). The school and the Environmental Resources Engineering (ERE) program at Humboldt State University have a history of partnering on engineering projects concerning Zane Middle School. The current issue with the Rectangle of Doom is the landscaping that is too delicate and has been continually trampled by the school children. The Engineering 215 group that designed the layout of the Rectangle of Doom did a great job on the Aesthetic look of it but failed the test of time in regard to durability. As The *Three Amigos* apart of the Engineering 215 spring 2020 class, it is in our interests to increase the durability of the landscaping of the Rectangle of Doom so that it may handle a large number of passing students, while also keeping it pleasant to look at. Our project design will hopefully satisfy the guidelines set by our client Joan Crandell and Trevor Hammons, as well as leave a lasting impact on Zane Middle School.

1.3 Objective Statement

The objective of this project is to create a detailed design that will be able to be followed to improve upon the current situation of the Rectangle of Doom, a section of landscaping in front of the school. We wish to create multiple in-depth AutoCAD drawings that once the shelter in place is lifted, they can be used to better equip the Rectangle of Doom for pedestrian traffic whilst maintaining a pleasing aesthetic look. The Black Box model below (Figure 1-1) describes the current situation and desired outcome for this project.

1.4 Black box model



Figure 1-1 Black Box model

2 Problem Analysis and Literature Review

2.1 Introduction to the Problem Analysis

The Problem Analysis further analyzes the problem for it to be better understood and provides the constraints to the solution. Included in the Problem Analysis are specifications, considerations, criteria, usage, and production volume.

2.1.1 Specifications

The specifications of the project include all required aspects that must be incorporated into the design of the project. The following specifications will be taken into consideration during the course of the project: must be completed on online via Auto CAD; the area of construction cannot be all concrete; the project has a realistic completion time of six weeks; any plants included do not limit mobility for anybody using the space.

2.1.2 Considerations

One consideration for this project is whether the students of Zane middle school will use the games that we will install in the space and whether they will know how to play the games that we choose to install.

2.1.3 Criteria and Constraints

Criteria	Constraints	Weight
Durability	Withstand middle schoolers	10
Appearance	better than it is now	7
Cost	\$100-\$325	9
Interactivity	# of times used per day	6
Safety	better than it was before	8
Environmentally Friendly	less than half concrete	4
Maintenance needed	less or equal to the amount needed now	5

Figure 2-1 Criteria, Constraints, and Weights

2.1.4 Usage

The proposed design will be used by the students of Zane Middle School as part of a new interactive walkway which will replace the current rectangle composed of dirt and wood chips.

2.1.5 Production Volume

At least one rectangle will be redesigned and built. It will consist of at least one gameboard and plants or trees.

2.1.6 Client Criteria

The primary client, Joan Crandell wanted the Rectangle of Doom to be a combination space in which the students could both play games on the concrete as well as provide a path for students to walk across. It was also requested that the space contain plants and trees that would be durable and safe from the threat of middle school children. The client stressed the importance of having games the students would be interested in participating in. The secondary clients, parents, and other teachers of Zane Middle School expressed similar ideas in a group meeting. They requested that the space be subtle and provide some games for the students to play with as well as contain scattered landscaping to prevent the entire area from becoming concrete.

2.2 Introduction to the Literature Review

The purpose of this literature review is to provide useful information on The Rectangle of Doom and landscaping options. This section contains topics related to wayfinding (the study of orienting and helping navigate humans from place to place), pathing materials, types of landscape trees and plants, as well as large scale board games children can play on concrete.

2.2.1 Wayfinding

This section contains information on different wayfinding techniques and how they are being utilized in this project

2.2.2 Paths

A wayfinding system is a system that guides people along a predetermined path. The first element of a well-built wayfinding system is a well-defined path. If a path is not well defined, the wayfinding system fails to work. For example, in the earlier design of the Rectangle of Doom, the path through the system was a small square of concrete. This path was not well designed to handle a heavy load of foot traffic

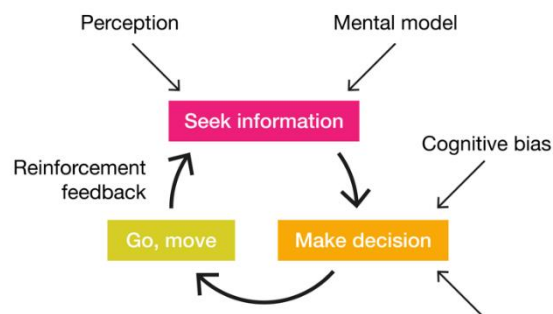


Figure 2- 1 Mental map (Girling 2016)

and did not provide a concrete guide on what directions the students were or were not allowed to take. This lack of a clear path structure resulted in the students walking across the woodchips and over the plants, which led to other students following their example. Good examples of pathing include well defined walkways lined with barriers, clear distinction on what should and shouldn't be walked on, and signs of human interaction along the path. This helps people build a mental map of a clear and unobtrusive route from point A to B. A mental map is a mental picture created of an area from memory, mental maps remind people of what path they should travel along from personal experience (Girling 2016).



Figure 2- 2 Rectangle of Doom (Babcock 2020)

2.2.3 Edges

Related to paths are what Kevin Lynch describes as “edges”. Edges are objects along a road that help define boundaries. Well defined boundaries are what helps maintain a good wayfinding system. They help maintain the condition of the central path by limiting human interaction with areas not along the path. As discussed in the previous section, the lack of a well-defined boundary resulted in the landscaping around the central path to be destroyed. Useful tools to establish a good edge include fences, walls and columns. A good path system should fulfill as many of the four types of social wayfinding as possible (Figure 2-3). The four main identified forms of social wayfinding are Synchronous Weak, Synchronous Strong, Asynchronous Weak, and Asynchronous Strong. Synchronous social wayfinding is influenced and defined by the group using a wayfinding system. Asynchronous wayfinding can be easily defined by the objects in and around a space. For example, building a fence to inform people not to cross a threshold is a form of easy to identify asynchronous strong wayfinding (Dalton et al. 2019).

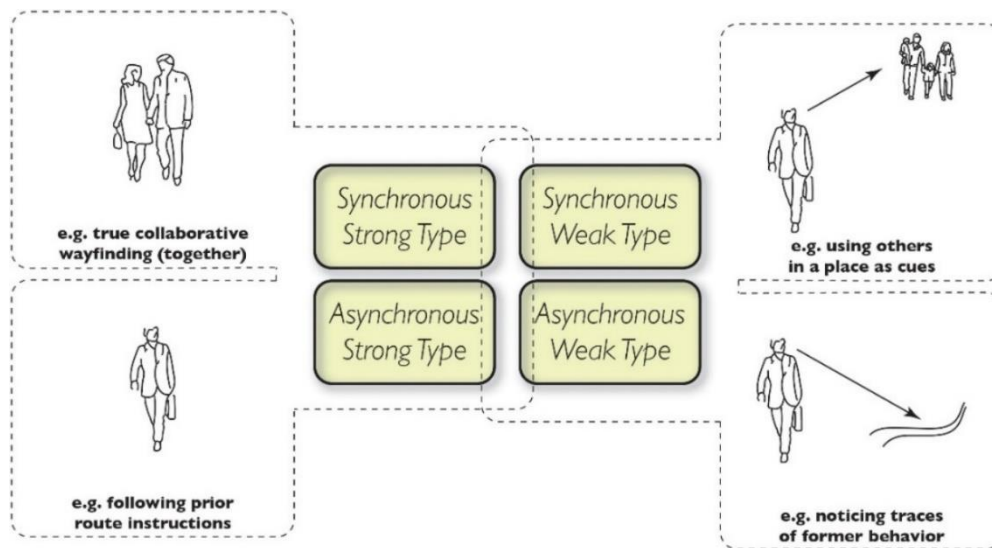


Figure 2- 3 Social Wayfinding (Dalton et al. 2019)

2.2.4 Nodes

Nodes act as intersection points between well-defined boundaries. The Rectangle of Doom's function is to act as a node between the parking lot and the central square where the middle schoolers eat lunch. Currently it is not fulfilling its function as the area has no clearly defined borders except for the division between concrete and dirt. The Rectangle's failure to function as a node is apparent as the middle schoolers walk directly through the Rectangle as if it were a part of the concrete walkway. A well-defined node can serve to enhance the appearance of the landscape as well as serve to control the chaos created by a mob of middle school children (Lynch 1960).

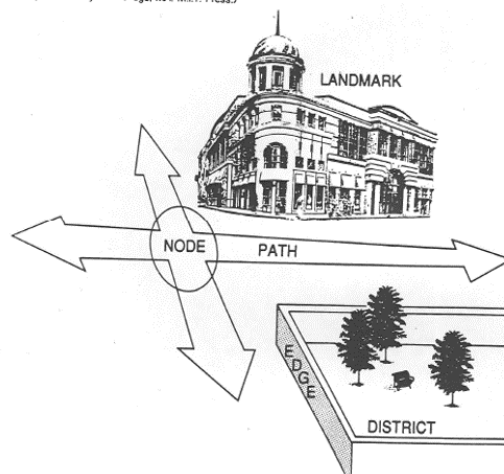


Figure 2- 4: Wayfinding System 1 (Wilson-Doenges 2017)

2.2.5 Landmarks

Another useful tool for developing a well-built wayfinding system are landmarks, easily identifiable objects that act as a reference point. For example, an excellent landmark used almost extensively in hotels is the front desk. The front desk serves as an easily recognizable destination to anyone who's new to the area. The Rectangle of Doom has the potential to become a landmark. It's located at the very front of the school and covers a substantial area. However, as of now, the Rectangle only consists of loose wood chips and a single slab of concrete.

2.3. Path material

2.3.1 Brick

A small rectangular block made of sundried or fired clay. Bricks have been used as a building material for centuries. The average cost per square foot of brick path (figure 2-5) is \$5 to \$10 and has an average life span of about 25 years.

The benefits of using brick as a paving material is that it is a relatively inexpensive pathway material. It looks nice, and it stands up to normal usage in moderate weather. Bricks can be easily removed or replaced if necessary. If used with sand or gravel as a filler, the pathway will be permeable to water.

The drawbacks of using bricks are that over time the bricks can become unstable and may start to shift around possibly becoming a tripping hazard. It can also be labor intensive process and may require a skilled laborer to create a brick pathway due to the cutting of bricks. They are less durable than other options. They have a moderate environmental impact due to the heating in energy intensive kilns. When laid using mortar or grout the pathway will be impervious to water causing runoff (Bortz).



Figure 2-5: Brick pathway (Tanja 2018)

2.3.2 Gravel

Gravel consists of crushed or sorted rocks of a small size. A gravel path is a simple and inexpensive way to create a walkway (figure 2-6). The average cost per square foot is approximately \$1 to \$3 and gravel has a predicted life span of about 100 years (depending on weather conditions)

The benefits of using gravel is that it is the most inexpensive option and it takes the least amount of labor and laborer skills. Gravel pathways easily conform to uneven terrain. Gravel paths maintain great waterflow causing little to no runoff or pooling. Gravel is also moderately environmentally friendly and can be sourced locally (Bortz 2019).

The drawback to using gravel as a pathway material is that it may have a life span of 100 years, but it can be easily spread to the local areas by heavy foot traffic, causing the need for more gravel to be placed and spread in future years.



Figure 2-6: Gravel pathway (shelterness 2020)

2.3.3 Paver stones

Paver stones are made up of natural rock (often granite or flagstone) combined with either a cement, gravel, or sand-based filler. A path made of paver stones cost approximately \$15 to \$30 per square foot and has a life span of 100 years.

The benefits of using paving stones to create a pathway are that they have a long-life span. Paths made of paver stones look very appealing and require little maintenance. They are ecofriendly, and they can be reused and sourced locally.

The drawbacks of using paver stones are that they are an expensive paving option. They also require a large amount of labor-intensive work and laborer skills (depending on filler options). Paver stones are impervious to water (if cement filler is used). If filled with sand or gravel, stones may shift and cause a potential tripping hazard (Bortz 2019).



Figure 2- 5: Paver Stone Pathway (Jc landscape 2018)

2.3.4 Concrete

Concrete is made up of three main components: water, aggregate, and cement. Once these components are mixed, poured and hardened, a solid durable material will be formed. The average cost of concrete is \$5 to \$6 per square foot (dependent on thickness) and the life span is 25 to 50 years.

The benefits of concrete is that it is extremely durable and versatile, and once the foundation is set it can hold up well in any climate. It provides a smooth durable surface that can be formed to a variety of contours. Concrete paths require little to no maintenance and can be painted upon.

There are many drawbacks that are associated with concrete. It is not very visually appealing. It is not eco-friendly; large amounts of CO₂ are produced in the creation process. Concrete is also impervious to water often causing runoff issues in big cities. Concrete can be difficult to remove if the path is deemed unnecessary. (Bortz 2019). During pouring and setting, initial temperature changes can cause the

cement to crack curing its curing process, fortunately the local environment does not have drastic temperature changes (Emmons 1992).

2.4 Games

2.4.1 Chess

Chess is one of the oldest and well-known board games. It is played on a square checkered board with 64 squares arranged in an 8x8 fashion with two opposing players. The object of the game is to get the opposing player's king into a position where is unable to avoid being captured, which is known as a checkmate (Neugarten 2015).

The benefits of installing a chess game board are that chess is a well-known game so that most students know the basic rules; and a standard checkered game board should not be too difficult to create.

The drawbacks of installing a chess board are that large scale game pieces could be difficult to produce, or expensive to buy. Chess is a time-consuming game so children might not have time or an attention span long enough to stay interested in the game.



Figure 2- 6: Chess Board (Bhaduri 2019)

2.4.2 Arimaa

Arimaa is a board game that is played on an 8x8 grid with 32 animal pieces. This game consists of stronger animals like elephants and camels and weaker animals such as rabbits. The larger animals can push the smaller ones into "traps" to remove them from the game. The goal of the game is to get one of your rabbits to the opposing team's side. Each player gets an elephant, a camel, 2 horses, 2 dogs, 2 cats, and 8 rabbits, and each animal can push any other animal that is smaller than it. The game was invented by an Indian American computer engineer who wanted to produce a game that was difficult for a computer program to play, and win (Syed 2002).

The benefits of installing an Arimaa game board is that it is played on a slightly altered checkered game board that should not be too difficult to create. Also, the game is more unique than others so it may create interest among new players.

The drawbacks of installing an Arimaa game board are similar to those of chess, in that large-scale game pieces could be difficult to produce and to buy due to the low popularity of the game. Arimaa is a less popular game, therefore less students will know the rules of the game and may be discouraged from playing.

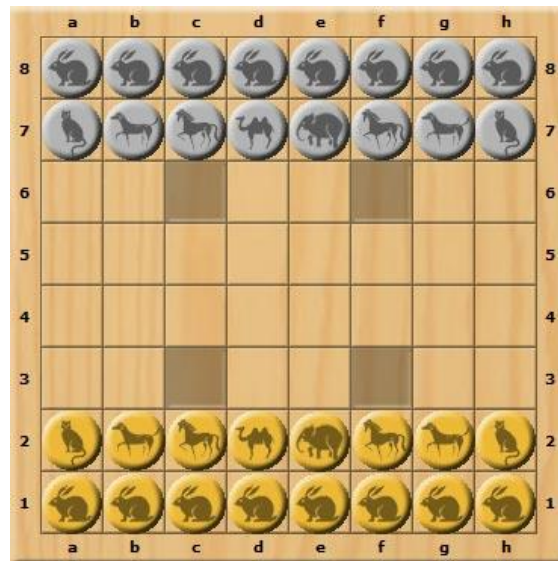


Figure 2- 7: Arimaa Game Board (iggame)

2.5 Native Trees

2.5.1 Blue Elderberry (*Sambucus Cerulea*)

The Blue Elderberry is a deciduous shrub that grows from 6 to 24 feet tall, it is native along the West coast from Oregon to Baja California. Blue Elderberry is signified by the yellow flowers that occur during bloom and the berries it produces in the fall. It is important to note that the berries on the Blue Elderberry are an important source of food for birds. This tree grows fast and is durable, which is responsible for its spread across the west coast in different climates. Blue Elderberry is most commonly found at elevations between sea level and 10,000 feet and can handle a variety of soil types. They can grow well in dry soil but will likely become deciduous if soil is dry. The Blue Elderberry also does better in sunny areas or partly shaded (Vaghti 2008).

The Blue Elderberry would be suitable for the project because of its durability. It can grow in relatively dry soil and in sun which it will be exposed to. It also has a size that is large enough to not get trampled by middle schoolers yet not too large as to look out of place. Another benefit is the cost which is

between 10 and 20 dollars for the plant (Wilson 2014). A potential con is the location, which could potentially not have enough sun. This would not kill the plant, but rather alter the shape of it.



Figure 2-7 Blue Elderberry

2.5.2 Bigleaf Maple (*Acer Macrophyllum*)

The Bigleaf Maple is a deciduous tree native to the West Coastal Regions spanning from southern Alaska to Southern California. It has a green coloring and has flowers that can be yellow and pink and is usually around 50 to 60 feet tall but can be anywhere from 30 to over 100 feet tall. The Big Leaf Maple has generally short, dense trunks and large round crowns. It grows quite fast and flowers in the spring. The Bigleaf Maple grows at low to middle elevations up to about 3000 feet from sea level. Can grow in multiple types of soil but mostly in alluvial soil which is loose soil or sediment that has been shaped by water. The Bigleaf Maple also does well in the sun (Johnson 1932).

The Bigleaf Maple would be suitable for the project because it is native to the location and the elevation and soil will be adequate for its growth. Its size is beneficial to keep it from getting destroyed as it is too large of an obstacle to trample. Also, it goes for an entry level price below 20 dollars (Wilson 2012). A

Figure 2- 8: Bigleaf Maple

potential downside could be the size as they become quite wide, but it would provide good shading. The soil at Zane is not ideal the looser alluvial soil that Bigleaf Maples thrive in but would likely be adequate.

2.5.3 Creek Dogwood (Cornus Sericea)

The Creek Dogwood is a deciduous tree native that is native throughout North America where it better suited to damp soil such as wetlands. This is a large shrub which grows at a moderate speed to roughly 5 to 15 feet tall and can be as wide as it is tall. For the most part the branches of the plant are a dark red and the leaves are a dark green during the summer months and turn red to purple in the fall. The flowers of the Creek Dogwood are small and a white color clustered at the end of the branches where the globose white berry sprouts. The elevation range for the Creek Dogwood is under 9000 feet (California Native Plant Society).

The Creek Dogwood would be suitable for the project because it has ideal size for a tree in the location of the project and it is in the elevation zone. The cost is under 10 dollars for one gallon. The cons to the Creek Dogwood are that it requires moist soil and partial shade. Woodland settings are ideal for the Creek Dogwood and so it would be totally exposed to the sun in the location of the project.

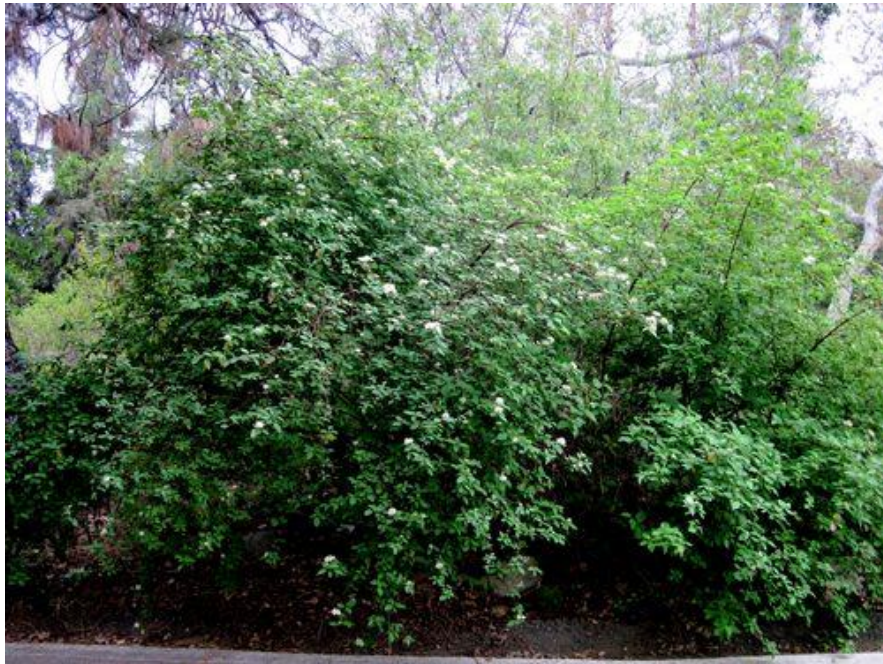


Figure 2-11: Creek Dogwood

2.5.4 Arroyo Willow (*Salix lasiolepis*)

The Arroyo Willow is a winter deciduous tree native to all parts of California. It grows best in marshes and wet areas in general and at elevations below 7000 feet. The Arroyo Willow grows fast and in many habitats such as in woodlands, forests, and coastal. To grow, the Arroyo Willow needs constantly moist soil. It has a yellow flower color and can reach around 35 feet but can be as low as seven feet. This tree is common in restoration projects and is important for many animals (California Native Plant Society).

The Arroyo Willow would be suitable for the project mainly for its size. The one-gallon Arroyo Willow can be found for under 10 dollars (Wilson 2012). The cons of the Arroyo Willow at the project location outweigh the pros as the soil is not damp enough for the Arroyo Willow to grow well.



Figure 2-12: Arroyo Willow

2.5.5 California Laurel (*Umbellularia Californica*)

The California Laurel is an evergreen tree that is native to the coast of California and thrives at elevations below 5000 feet. It is native to the Humboldt area. The California Laurel has a large size spread- from 6 to 80 feet- but mainly between 20 and 45 feet. The growth rate of the California Laurel is moderate and depends on the conditions. The tree flowers in the spring and the colors can be yellow, white, and green. The bark varies in color from blonde to brown. The tree releases terpenes to kill competing plants and doesn't need an understory which is a positive. It has a pleasant smell and turns a golden color in the autumn. The tree grows a round green berry and can tolerate clay soil (California Native Plant Society). The cost is under 10 dollars for the one gallon (Annie's Annuals).

The California Laurel would be suitable for the project because it is native to the Humboldt area and it does not require wet soil. It also grows in the elevation range of the project. The downsides to the California Laurel are the terpenes which could potentially kill other plant life in the project space. The size could be a problem if it gets to the extreme tall end of the spectrum but likely not.



Figure 2-13: California Laurel

2.5.6 Mu-Lan (Magnolia Lilliflora ‘Nigra’)

The Magnolia Lilliflora is a deciduous shrub from the Magnoliaceae family that can grow around 8 to 12 feet high and around 8-12 feet wide. It blooms from April to May. This shrub grows best in moist, fertile, rich and well- drained loams in full sun to light shade. Intolerant of poor soils (Missouri Botanical Garden). It also needs consistent moisture throughout the year. The shrub is native to China and has lily shaped purple/pink flowers during its bloom time. Can bear cone-like fruit. The Lilliflora does best in full sun to part shade and with a medium amount of water.

This shrub would be mildly suitable for Humboldt because of its ability to take rain and would be good for the Rectangle of Doom because the size of it is large enough to not get trampled. It can be bought for around 10 dollars but for that cost need care to reach full size.



Figure 2-8 Magnolia Lilliflora

2.6 Native Plants/Shrubs

2.6.1 Deer Fern (*Blechnum Spicant*)

The Deer Fern is a species of fern native to Europe and western North America and specifically can be found in the Humboldt area. It in damp areas covered in shade such as Redwood or Evergreen forests and at an elevation of below 3000 feet. The Deer Fern grows at a moderate rate and, due to it being a fern, grows up to roughly 3 feet. It has two types of leaves: sterile and fertile leaves. Because the Deer Fern is deciduous, it does not have its leaves in winter. The key to successful growth is shade, water, and not excessive heat. Although they grow best in moist soil and shade, they are fairly drought tolerant plants that can grow in most conditions besides in the sun in a hot climate (Thegardenhelper). The price range for the Deer Fern is between 10 and 15 dollars on the cheap end (Annie's Annuals).

The Deer Fern would not be a suitable plant for the project because it is too small to survive middle schoolers and can be easily destroyed. It would also not be in a satisfactory location because of the direct exposure to sunlight, but as stated above it would likely be able to survive as the climate is mild. Although the climate and region are suitable for the Deer Fern to grow successfully, there are many other aspects which make the Deer Fern unsuitable for the project.



Figure 2-15: Deer Fern

2.6.2 Coyote Bush (*Baccharis Pilularis*)

The Coyote Bush is a common shrub that is native to the west coast from Oregon to Baja California. There are two species, of which the *Consanguinea* is the one found along the coast Coastal mountains and would therefore be the one considered for the project. The height of the shrubs can be up to ten feet tall or as short as 1.5 feet. The Coyote Bush is evergreen which means it would maintain its leaves year-round and grows at a fast rate. It also blooms white or yellow flowers in early winters with a sticky texture to the stem. It is very easy to grow in landscape and is fire resistant and overall quite durable (California Native Plant Society). It also hosts a wide variety of insects and can be acquired for around 10 dollars (Nyunt, Penny and Wilson 2014).

The Coyote Bush would be suitable for the project because of its durability. It would be difficult to trample and would be able to withstand the conditions and soil. The only potential downside is if the specific ones selected were extremely small.



Figure 2-16: Coyote Bush

2.6.3 Blueblossom (*Ceanothus Thyrsiflorus*)

The Blueblossom is a large shrub that has a huge variance in size from up to 30 feet to only 2 feet tall with small oval leaves. The Blueblossom has a short trunk and many branches with flower plumes that can be white, blue or purple in coloring. The Blueblossom is evergreen and has green leaves. Their flowers attract insects and the seeds attracts birds and small mammals. The Blueblossom grows fast and does best in sun or part shade. The preferred elevation of the Blueblossom is below 2000 feet and is easy to care for. The Blueblossom best in well-drained soil but can tolerate clay and sand (California Native Plant Society). Also, the one-gallon size of this shrub/tree can be found for only 10 dollars (Native Foods Nursery).

The Blueblossom would be suitable for the project because it has an ideal size and has pretty coloring. It can also survive in exposure to the sun and a variety of soil types and is native to the Humboldt area. The Blueblossom would also attract birds and mammals which could be considered a pro and a con. Therefore, the Blueblossom is a serious contender for the project as it does not really have any drawbacks.



Figure 2-17: Blueblossom

2.6.4 Tobacco Brush (*Ceanothus Velutinus*)

The Tobacco Brush is a shrub that has several names including Red Root and Snowbrush *Ceanothus*. It is native to the western United States where it grows in many types of habitat including forest and woodland. The height of the Tobacco Brush ranges from 6 to 13 feet tall and about just as wide. It grows at a moderate speed and is an evergreen plant. It flowers in the winter, summer, and spring giving way to white and green flowers. The Tobacco brush tends to cluster and form thickets that are tangled together. The leaves are green and have an oval shape with teeth around the edges. The Tobacco Brush also grows a small fruit and supports many types of insects. Fortunately for the project, the Tobacco Brush does not need very much water and can be in direct sunlight (California Native Plant Society).

The Tobacco Brush would be suitable for the project for pretty much all aspects of the shrub. It is a good size, durable and native to the area. The only potential downside is that the climate could be too wet which seems unlikely due to its nativity to the area. Also, the cost was unable to be located.

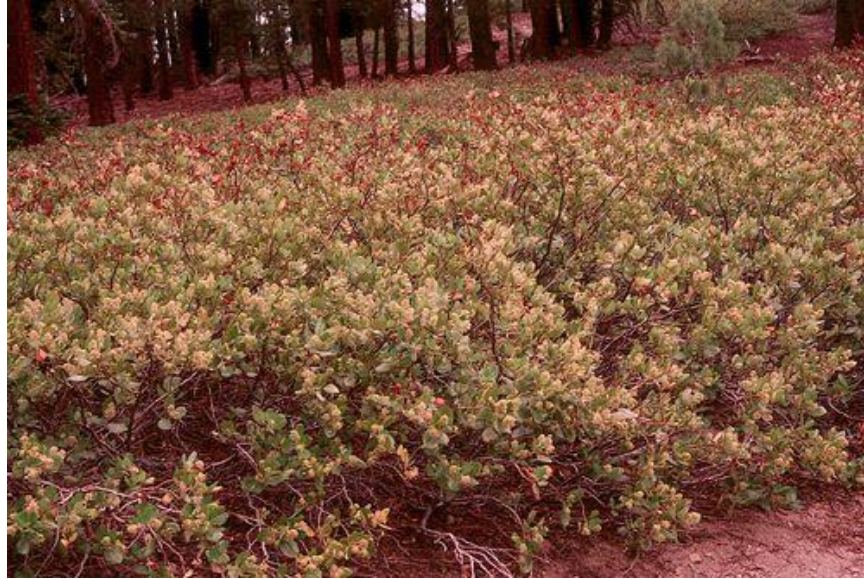


Figure 2-18: Tobacco Brush

2.6.5 Salal (Gaultheria Shallon)

Salal is a shrub related to the Madrone. It is found in western North America and specifically on the coast of California. It has dark green leaves and grows from one to seven feet tall. Salal also has white and pink flowers with an edible dark blue fruit and can survive in both sunny and shady conditions. The growth rate is moderate to fast and it is an evergreen shrub. Because of the size variance, Salal can be ground cover or a decently sized shrub that can form thickets. It is relatively durable and can tolerate low temperatures. Salal grows best at elevations below 5000 feet (California Native Plant Society). The cost for Salal is between 10 and 15 dollars for the one-gallon size (Fabulous Florals 2018).

Salal would be suitable for the project because of its durability, affordable cost and nativity to the project's location. The only potential downside is that it could be not quite tall enough to withstand trampling though this can likely be avoided by picking a shrub that is already grown to a decent size.



3 Alternative Solutions

3.1 Introduction

During a one-hour brainstorming session, nine alternative solutions were eventually created. The following alternative solutions fit within design constraints and criteria. Each of the alternative solutions satisfied the clients requirement to transform the space into either an attractive and/or usable space for the children to enjoy.

3.2 Brainstorming

This section introduces our many alternative solutions to the Rectangle of Doom. Many different solutions to the Rectangle of Doom were discussed, such as fully paved, a picket fence, all grass, all landscaping, several game boards, one game board and more. Visuals of brainstorming can be found in Appendix A.

3.3 Alternative Solutions

Below are eight of the alternative solutions conceptualized during the brainstorming process which we decided were the most promising. Each alternative solution contains a in depth description of the solution along with a drawing to give a visual representation of each solution. We will weigh theses solution against each other to decide on the most appropriate solution for the Rectangle of Doom.

3.3.1 100% Landscape

The 100% Landscape alternative that would focus more on the attractive aspect is a rectangle which would be composed entirely of two to three medium sized tree and some surrounding bushes enclosed in a very small wooden picket fence. The picket fence would deter the middle school children from running across the area and allowing for the plants and trees to grow unchallenged. The picket fence would be constructed out of pine or cedar wood and would line the entirety of the rectangle. The tree would be a relatively unobtrusive and beautiful tree such as an Eastern Redbud. The shrubs around the

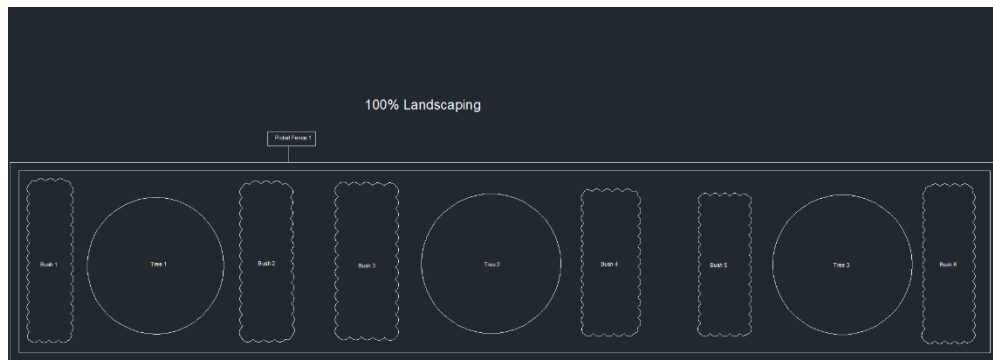


Figure 3-1: 100 % Landscaping Alternative which includes a surrounding picket fence, three trees, and six bushes

tree would be a low maintenance and durable plant such as northern blue-eyed grass or twinflower bush.

3.3.2 75% Landscape

The 75% Landscape option, like the 100% Landscape option, is more focused on being attractive but also improves upon the efficiency of walking around and through the rectangle by including a small brick or concrete pathway splitting the rectangle into two halves. Each half will be lined with identical pine or cedar picket fences allowing the students to walk across the rectangle and leave the landscaping untouched. Each of the rectangular halves will contain a medium sized tree surrounded with small low-maintenance shrubs.

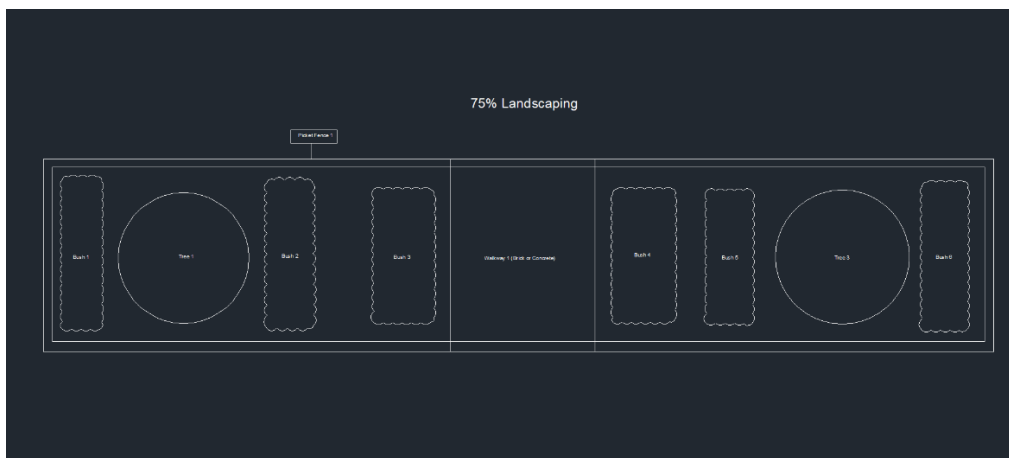


Figure 3-2: 75% Landscaping Alternative containing two trees, six bushes, and a concrete walkway

3.3.3 Bocce Ball Court

The Bocce Ball Court solution involves turning one of the two rectangles into a Bocce Ball court for the students to utilize. To install the bocce ball court the wood chips must be removed, and the area must be leveled. Once the wood chips are removed, wooden boarder walls that run the entire circumference of the rectangle can be built. Lastly the space will be filled with sand for the game to be played on. The bocce balls will be stored inside a nearby building and will be accessible for students to use during break.

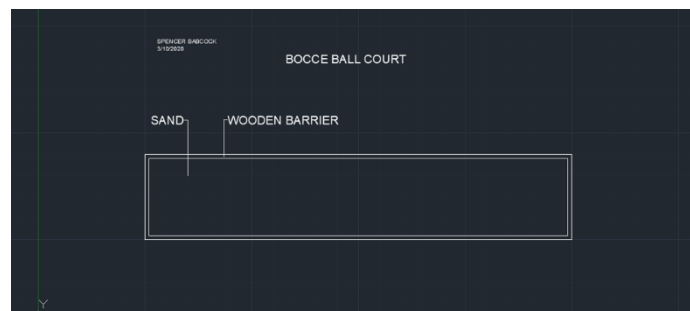


Figure 3-3: Bocce Ball Court Alternative containing only sand and a wooden barrier

3.3.4 Bowling Alley

This solution involves turning one of the two rectangles into an outdoor Sand Bowling alley for students. This solution involves many of the same steps as Bocce Ball court option. The first step is to remove the existing wood chips and install a wooden boarder that spans the entire circumference of the rectangle, and filling with sand. The plastic or wooden bowling ball and pins will be stored inside a nearby building and will be accessible for students to use during break.

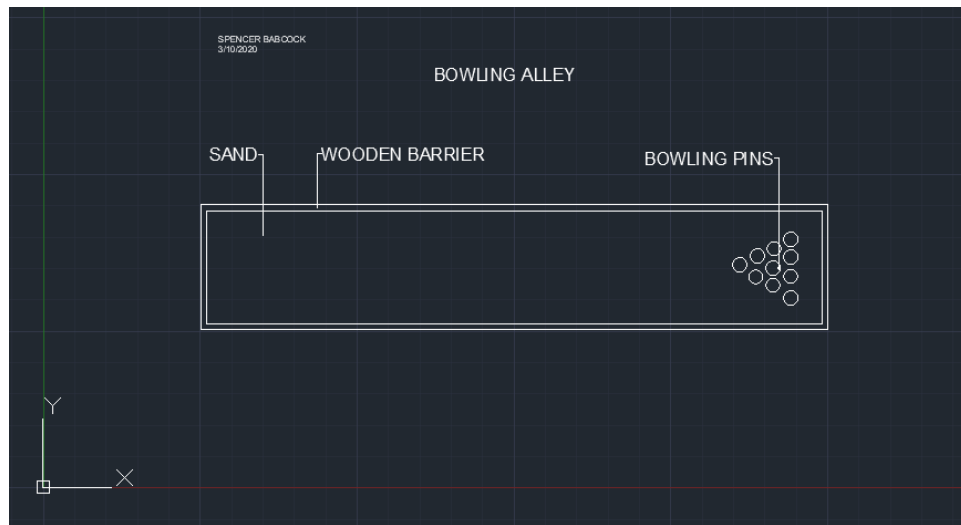


Figure 3-4: Bowling Alley

3.3.5 2 Game boards

there will be 2 concrete game boards surrounded by landscaping installed. The two games boards symmetrically placed and will be located at the 1/3 and 2/3 mark on the rectangle. . These concrete game boards will be constructed by removing woodchips from the area of the board and leveling the group. One the woodchips are removed, and the ground is flattened. Temporary wooden retaining walls will be installed for the pouring of concrete. Once the concrete has been poured, set, and smoothed the checkered game board will be painted on the concrete.

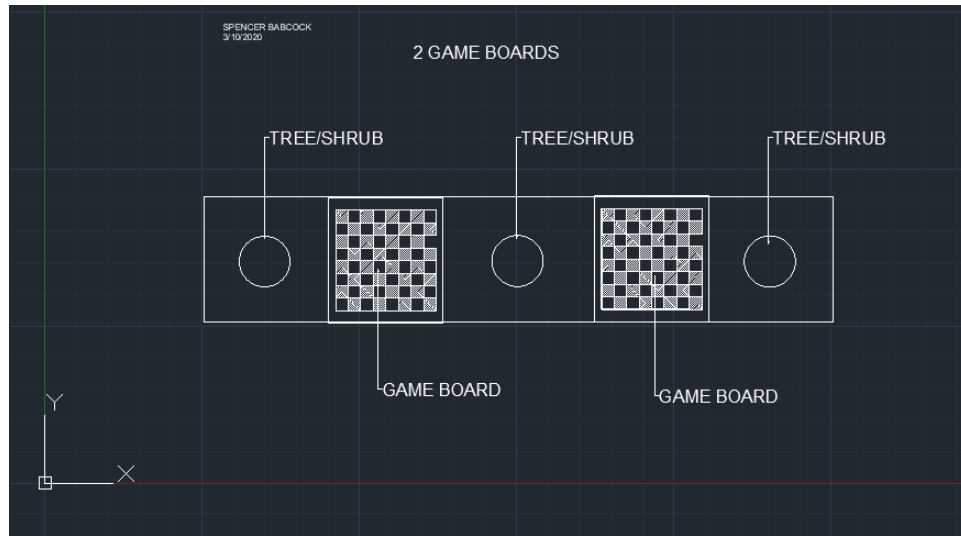


Figure 3-6: 2 Game Boards

3.3.6 100 % Grass

This solution consists of 100% grass to fill in all parts of the Rectangle of Doom. A picture can be seen in figure.... There will be short to medium length grass of even length across all parts of the rectangle. The grass can be easily maintained and fits in with the overall campus design which is mostly filled with grass between walking paths. This alternative relies on simplicity and practicality in its durability.

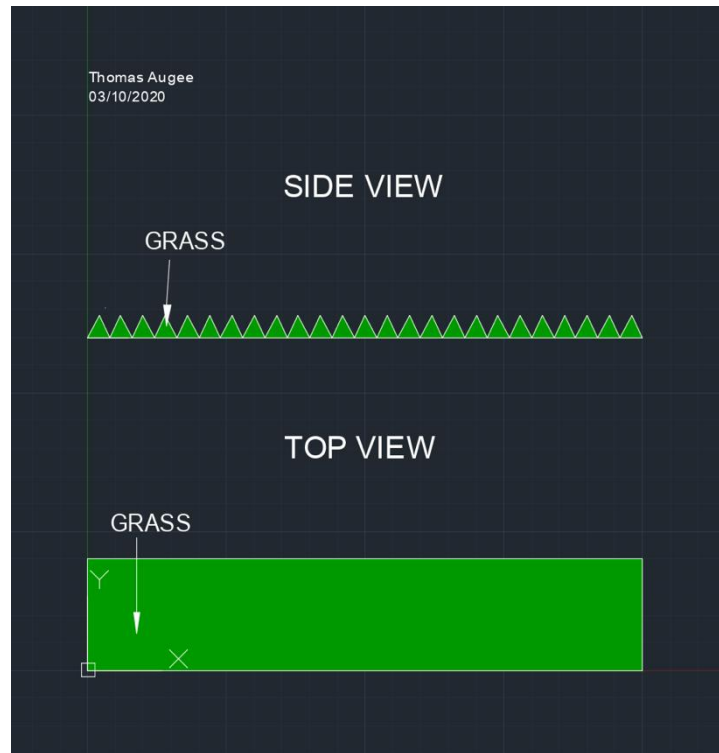


Figure 3-7: AutoCAD of 100% Grass

3.3.7 Gameboard and Two Trees

The Gameboard and two Trees is an alternative solution that combines a concrete surface with a bark chip surface which will contain two trees (Magnolia Lilliflora). There will be a gameboard from concrete put in the middle of the rectangle. This will take roughly half of the space available. On either side of the concrete gameboard will be soil until the edges of the property, and in the middle of the soil will be a Magnolia Lilliflora as shown in figure 3-8. The Magnolia Lilliflora can provide shade to the children using the gameboard and are large enough to not be trampled. The concrete game board will be constructed by digging 8 inches into the ground in the 10 by 10-foot middle and laying down 4 inches of subbase- with sand and gravel and concrete on top. In between the concrete about 2 inches deep will be a steel reinforcement beam or rebar to keep the concrete from cracking. Because this site is not expected to see heavy loads, wire mesh will suffice. Temporary wooden retaining walls will be installed for the pouring of concrete. Once the concrete has been poured, set, and smoothed the checkered game board will be painted on the concrete using masonry paint.

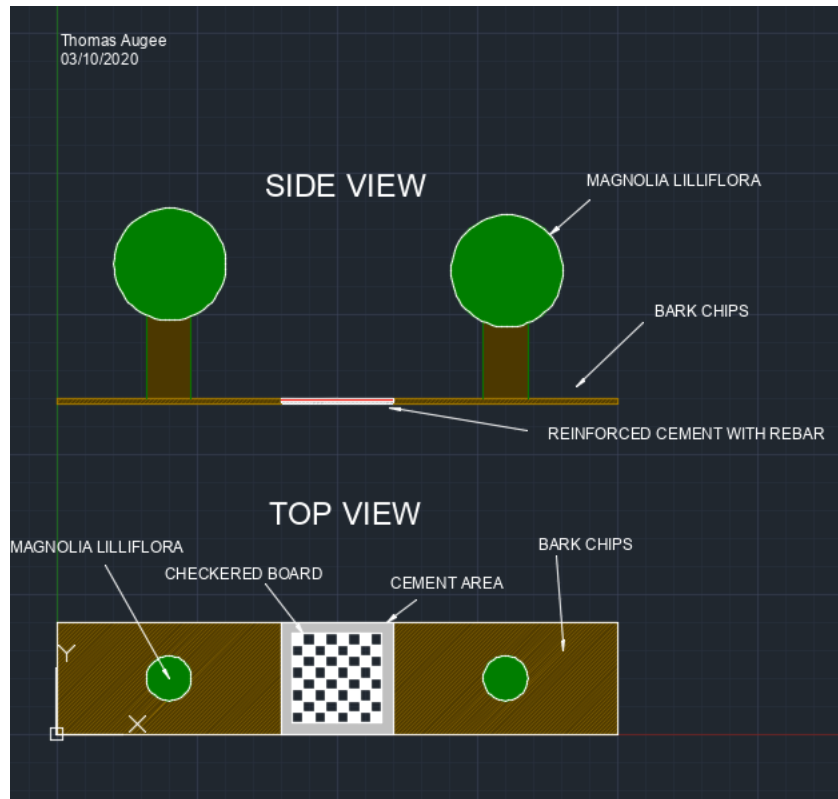


Figure 3-8: Autocad of Gameboard and Two Trees

3.3.8 Gameboard and Two Shrubs

The Gameboard and two shrubs, as in 3.3.9, combines a concrete surface with a soil surface on either side. The concrete surface would contain a built-in gameboard for use by the schoolchildren. The gameboard will take up half of the space in the middle of the rectangle. In this design however, Salal would be planted on either side of the concrete gameboard in place of Blue Elderberry (see figure.....). The Salal is planted for aesthetic beauty and to provide volume to the design.

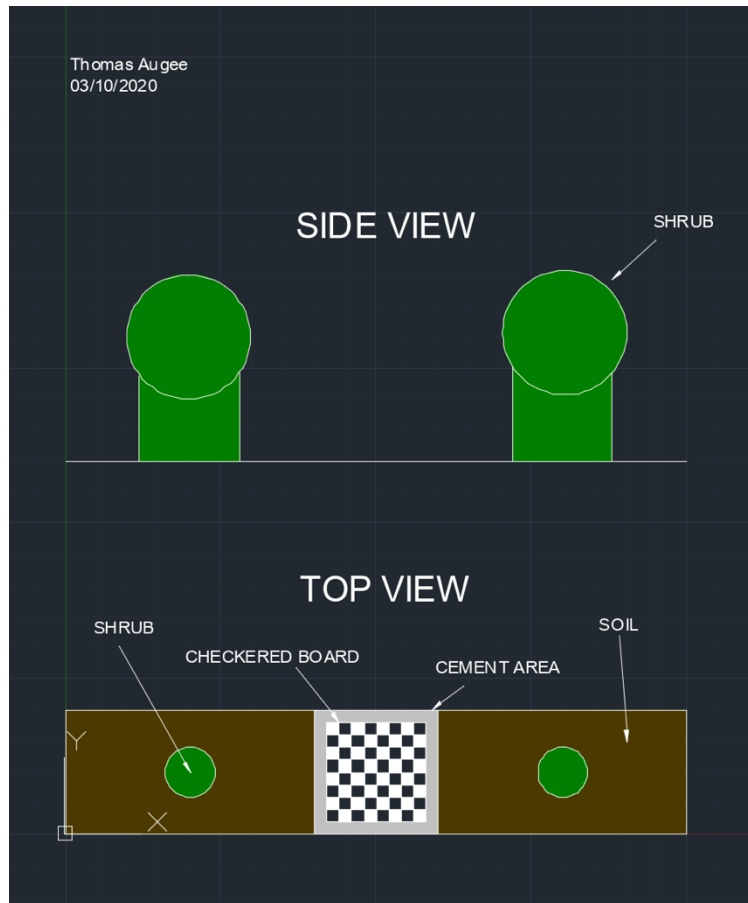


Figure 3-9: AutoCAD of Gameboard and Two Shrubs

4 Decision Process

4.1 Introduction

The decision process is laid out in section 4. The purpose of this section is to evaluate all of our alternative solutions and to pick the best one for the design project. This will be done using the Delphi Method. This method formulates a rating for each of the alternative solutions based on how well each solution fits the criteria of the project.

4.2 Criteria

Listed Below are the following criteria for the project. The criteria are defined to reflect all aspects of the project that are being considered.

4.2.1 Durability

The area should be able to withstand trampling from passing middle school students and wet weather conditions.

4.2.2 Aesthetics

The rectangle should look better than it does now and should satisfy the teachers of Zane middle schools' expectations.

4.2.3 Cost

The entire cost of this project including the cost of construction material, and the cost of prototyping materials should not exceed \$325 US dollars.

4.2.4 Interactivity

The area should be more interactive than previously. Students should be able to interact with the game board.

4.2.5 Safety

The area should not pose any sort of safety risk to staff or students without them violating safety protocol.

4.2.6 Environmentally friendly

Materials used should be selected with environmental impact considered. No greenhouse gases or carbon emissions will come directly from the area and the area is completely sustainable.

4.2.7 Maintenance

Little or no maintenance is required of the area.

4.3 Solutions

The flowing list contains Alternative solution from section 3. More details on each solution can be found in section 3.

- 100% Landscape
- 75% Landscape
- Bocce Ball court
- Sand bowling alley
- 2 Games board
- 100% grass
- Game board with 2 trees
- Game board with 2 shrubs

4.4 Decision Process

The decision process used to determine our solution was the Delphi method. The Delphi method is a method that weighs a list of criteria for each of the solutions to come out with a score that is used to determine the best solution. More specifically, the Delphi method starts with a list of criteria (Table 4-1). Each criterion is assigned a weight based on its importance to the project. This weight was calculated through verbal communication until an agreement was reached. Then we rated each solution out of 50 for each of the criteria in the solutions table (Table 4-2), where 50 was the optimal score and 0 was the least optimal score. The rating was determined using the same method as in the criteria weight. This score out of 50 was then multiplied by the weight for that criterion and these solution scores were summed to get the final score for each solution. The solution with the highest weighted total is the best solution for the design project.

Table 4-1: Weighted Criteria

Criteria	
List	Weight
Durability	10
Aesthetics	7
Cost	9
Interactivity	6
Safety	8
Environmentally Friendly	4
Maintenance	5

Table 4-2: Delphi Matrix

Criteria		Solutions															
List	Weight	100% Landscaping		75% Landscaping		Bocce Ball Court		Bowling Alley		2 Game Boards		100% Grass		Gameboard and Two Trees		Gameboard & Shrubs	
Durability	10	25		35		35		35		35		20		35		25	
			250		350		350		350		350		200		350		250
Aesthetics	7	45		40		15		15		30		25		30		25	
			315		280		105		105		210		175		210		175
Cost	9	30		20		40		40		10		10		20		20	
			270		180		360		360		90		90		180		180
Interactivity	6	0		5		45		45		45		5		35		35	
			0		30		270		270		270		30		210		210
Safety	8	25		30		10		10		40		45		40		40	
			200		240		80		80		320		360		320		320
Environmentalism	4	50		35		35		35		20		40		30		30	
			200		140		140		140		80		160		120		120
Maintenance	5	15		25		35		35		30		20		30		35	
			75		125		175		175		150		100		150		175
Totals		1310		1345		1480		1480		1470		1115		1540		1430	

4.5 Final Decision

According to the Delphi Method, the Gameboard and Two Trees was the best solution for the Rectangle of Doom. This solution scored well on its safety, durability, and interactivity. This solution also did not have any criteria score that was extremely low. Overall, the Gameboard and Two Trees will contribute to the aesthetic beauty at the entrance of Zane Middle School and will enhance the interactivity of the plot of land. The cost will use most of the available budget but will have easy maintenance.

4.6 2020 COVID-19 Decision Justification

Due to the current circumstances of the COVID-19 situation we are unable to physically meet as a group and physically construct our design. Instead we will be producing more in-depth and detailed designs, that the client will be able to easily follow and that can be used to complete the physical building of the project once the quarantine is lifted. To accommodate for potential budget constraints, there will be two different solutions- a Low-Cost version and a High-Cost version. There will also be detailed 3-dimensional and 2-dimensional designs using Auto CAD for each one.

5 Specification

5.1 Introduction

Section 5 of the design project will contain a detailed description of the solution, a layout of the different costs, and instructions for the implementation of the design. Specifically, the description will be broken down into the concrete chessboard area, the pieces, and the area on either side of the concrete with a planted tree on each side. The following will be a breakdown of the costs starting with the design cost. There will also be a materials cost and a maintenance cost to further deconstruct what went into the project. At the end will be instructions on the use of the model which will go over the construction of the design. Section 5 will be concluded by describing the results of our testing including any issues that need to be addressed.

5.2 Description of Solution

The One Gameboard Two Trees solution will consist of designs on AutoCAD with a 2D and 3D model. The solution will clearly layout the design that we have come up with. This will include a model that shows all the dimensions with labels and specified distances from viewpoints of different angles. The

design will be made taking into consideration the available space and will be based off of what we have learned from our prototypes.

5.2.1 The Gameboard and Concrete

5.2.1.1 High-Cost

The concrete and Remesh hog wire are the foundations that the gameboard is going to be constructed on. Remesh hog wire is a 40-gauge welded wire grid that is important to prevent cracks in the concrete. Concrete can be laid without reinforcement; however, the concrete is then more prone to cracking. Concrete can be poured at a minimum of 4 inches. The depth of the concrete will be 6 inches. This was decided because the concrete will not be experiencing heavy loads from cars or trucks. The concrete requires a wooden frame to be set up before it is poured.

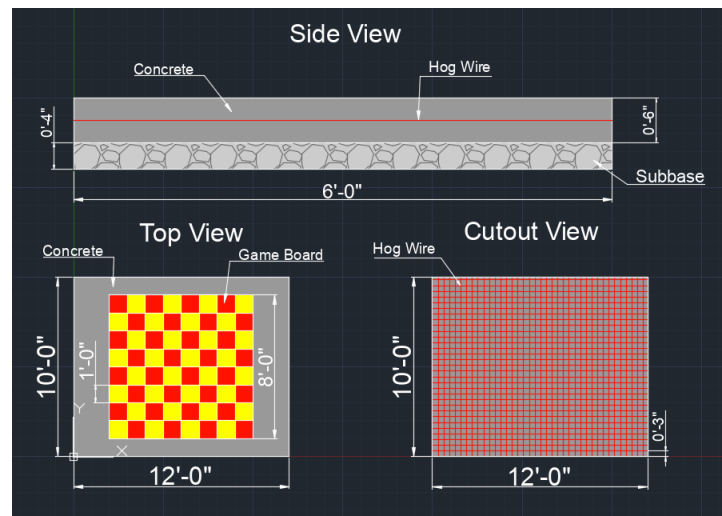


Figure 5-1 High-Cost Concrete Board and Hog Wire (Source: Thomas Augee)

5.2.1.2 Low-Cost

The low-cost model is similar to the High-Cost model. The main difference in the game board is the thickness of concrete and the lack of steel reinforcement. Concrete will be poured at the minimum 4-inch thickness to save cost. The 4-inch thickness should be able to handle day to day foot traffic but will not be strong enough to support a heavy load from something like a car. 40-gauge welded hog wire will also not be used to save cost. This leaves the walkway to be more prone to cracking with use. The concrete requires a wooden frame to be set up before it is poured to maintain desired shape.

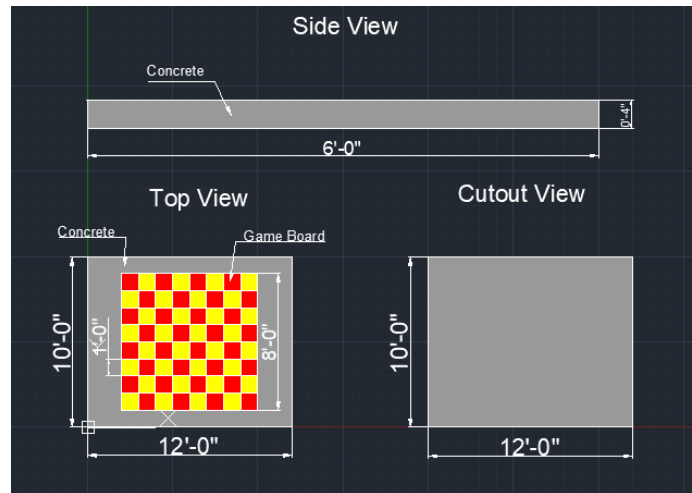


Figure 5-2 Low-Cost concrete

5.2.2 The Wood Chips and Trees

5.2.2.1 High-Cost

The High-Cost model utilizes two Magnolia L. Nigra trees to maintain a more appealing landscape. Two 2-foot tall saplings will be planted to ensure that no ignition trampling will take place. There will also be woodchips spread around the gameboard and trees to add thickness to the already existing woodchips that are sparsely covering the Rectangle of Doom.

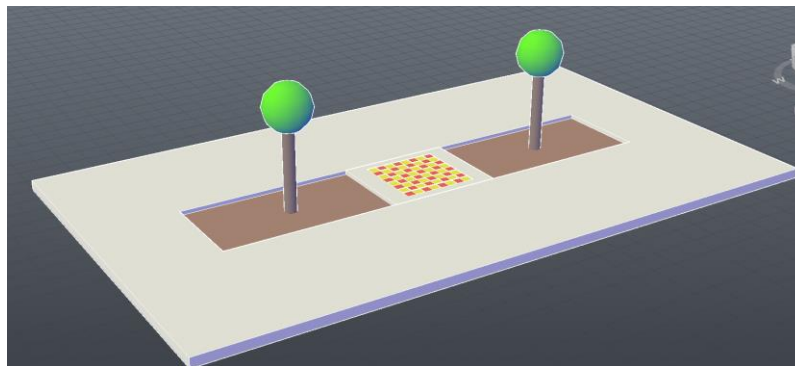


Figure 5-3 High-Cost landscape

5.2.2.2 Low-Cost

The low-cost model will not use any Magnolia L Nigra trees or any extra woodchips to cover the open space in the Rectangle of Doom.

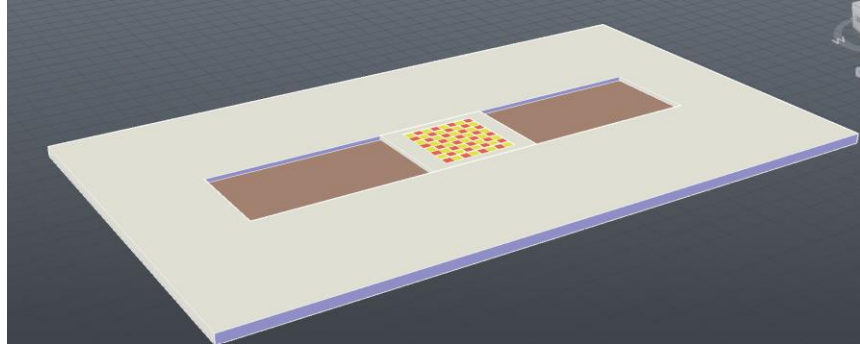


Figure 5-4 Low-Cost landscape

5.3 Cost

5.3.1 Design Cost (hours)

The design cost is displayed by the collective number of hours that The Three Amigos put into the design project. 116.5 hours were spent in total on this design.

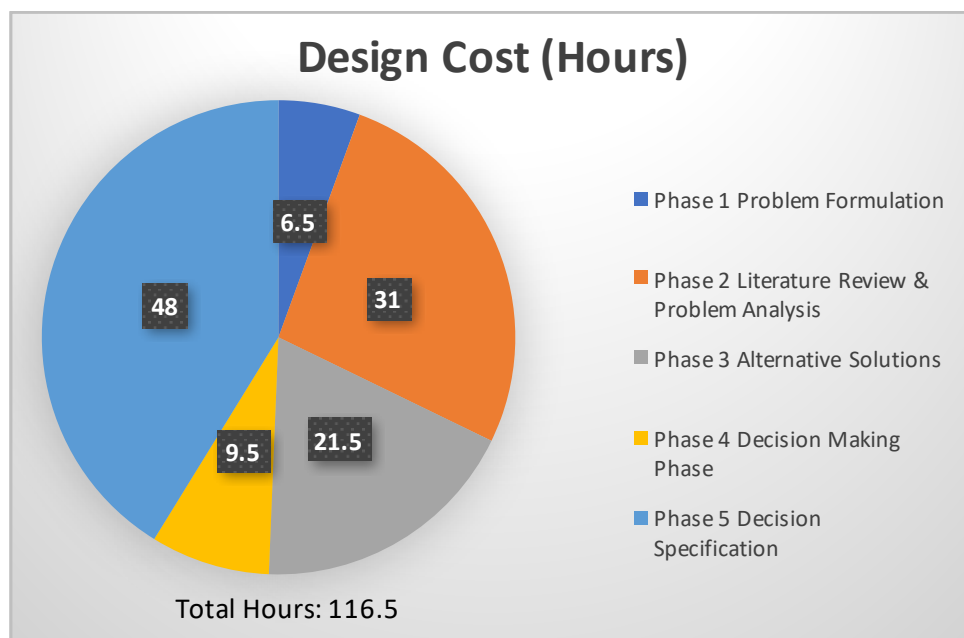


Figure 5-5 Total Team Design Hours

5.3.2 Implementation Cost (\$)

In this section the following table shows the total projected cost of the materials needed for implementation of the design on the Rectangle of Doom. The total cost is \$576.41 for the high-cost

model and \$273.26 for the low-cost model. This number is an estimate and can be reduced with donations and where the materials are acquired.

Table 5-1: List of Materials Needed for High-Cost Design

Itemized Cost of Materials (High-Cost)				
Material	Use	Quantity	cost per unit	Project Cost
Concrete	walkway 6'	134 60Lb bags	\$2.21 per bag	\$296.14
wood 2x4	pouring concrete	20 ft	\$2.87 per 8 ft	\$8.61
Welded Wire Grid	Concrete reinforcement	3 3.5' x 7' panels	\$8.90 per panel	\$26.70
Concrete Sealer	seal concrete	6oz bottle	\$21.90 per bottle	\$21.90
Subbase Gravel	pour concrete	1 cubic foot	\$9.36 per cubic foot	\$9.36
Red Paint	game board	32 oz	\$9.98 per can	\$9.98
Yellow Paint	game board	32 oz	\$9.98 per can	\$9.98
Wood Chips	landscaping	10 bags	\$3.48 per bag	\$34.80
Magnolia Trees	landscaping	2 trees	\$50.00 per tree	\$100.00
Large Chess Pieces	playing chess	1 set	\$125.00 per set	\$125.00
Total				\$642.47

Table 5-2: List of Materials Needed for Low-Cost Design

Itemized Cost of Materials (Low-Cost)				
Material	Use	Quantity	cost per unit	Project Cost
Concrete	walkway 4'	89 60Lb bags	\$2.21 per bag	\$196.69
Wood 2x4	pouring concrete	20 ft	\$2.87 per 8 ft	\$8.61
Red Paint	game board	32 oz	\$9.98 per can	\$9.98
Yellow Paint	game board	32 oz	\$9.98 per can	\$9.98
Large checker Pieces	playing checkers	1 set	\$48.00 per set	\$48.00
Total				\$273.26

5.3.3 Maintenance Cost (\$)

With the high cost for the implementation of the design, the short-term maintenance costs should be low. The paint will be expected to last at least 5 years, and potentially longer depending on its use before needing to be re-coated. Similarly, game pieces will vary depending on usage. Bark chips have a

similar lifespan of 5-7 years. If done right the concrete will last for more than 50 years as well as the trees.

Table 5-3: Maintenance Cost of High-Cost Design

Cost of Maintenance (High-Cost)			
Maintenance Task	Frequency	Cost of Action	Projected Cost per year
Repaint (red)	5 years	\$9.98	\$1.99
Repaint (yellow)	5 years	\$9.98	\$1.99
Woodchips	5-7 years	\$34.80	\$5.35
Tree trimming	5 years	\$100.00	\$20.00
Chess Pieces	10 years	\$125.00	\$12.50
Total per year			\$41.83

Table 5-4: Maintenance Cost of Low-Cost Design

Cost of Maintenance (Low-Cost)			
Maintenance Task	Frequency	Cost of Action	Projected Cost per year
Repaint (red)	5 years	\$9.98	\$1.99
Repaint (yellow)	5 years	\$9.98	\$1.99
Woodchips	5-7 years	\$34.80	\$5.35
Checker Pieces	10 years	\$48.00	\$4.80
Total per year			\$14.13

5.4 Prototyping

There were many prototypes that went into the design of the Rectangle of Doom. These prototypes broke down the specific aspects that needed to be addressed and tested and used feedback from others and functional feedback to create the best design. Simplicity was a key aspect in getting results and learning what needed to be improved upon. The following are some of the prototype tests.

5.4.1 Testing of Paint

This purpose of this prototyping was to test the adherence of several different types of paint to concrete. The test was carried out using available paints and analyzing previously painted surfaces. In figure 5-1, the red paint is spray paint and the white paint is latex. They both stuck to the concrete block well, but there was not enough time to analyze the durability. Given the weather conditions at the location of the project, neither paint type was chosen, and Masonry paint was the selected paint.



Figure 5-6 Brick with Latex and Spray paint

5.4.2 Testing desirability

To test the desirability of the Rectangle of Doom, a cardboard prototype was constructed, and people were interviewed about what they thought of it. The goal was to receive feedback that could lead to improvements on the design. What was discovered is that people liked the aesthetic look but questioned the practicality of it. Specifically, whether middle schoolers would display an interest in the game. What needs to be considered is that the area with the gameboard is also a path to walk across the Rectangle of Doom instead of through the bark chips. Another suggestion was to have a box for all the game pieces to be stored inside. This was considered but the cost would be quite high when the pieces could be stored with all the P.E. equipment.



Figure 5-7 Carboard Prototype

5.4.3 Testing Function

The purpose of this prototype was to test the function of the Gameboard at its actual size. To do this, two pieces of wood were placed next to each other and the 8 by 8-foot chessboard was marked with tape (see Figure 5-3). It was discovered that the full 8 by 8-foot gameboard is the best size because it allows people to play and makes good use of the concrete space.



Figure 5-8 Full Size Gameboard

Also, to test function another cardboard prototype of the Rectangle of Doom was constructed. The purpose of this prototype was to build on the 8 by 8-foot chessboard and see what the optimal amount of concrete space not covered by the game board would be. A toy soldier was used to simulate a middle school student. The result was that the concrete path needed to have a couple of feet on each side for students to walk across while other kids were utilizing the game board.



Figure 5-9 Cardboard Prototype for Maneuverability

5.4.4 Testing of Dirt or Wood Chips

The purpose of this prototype was to test whether to use Wood Chips or Dirt on either side of the concrete gameboard. The prototypes were simple, utilizing dirt and bark chips from surrounding areas. As seen in Figure 5-2, the dirt prototype tracked a lot of mud on the wood which is simulating the students walking in the dirt and on the gameboard. The result is that in wet conditions, a lot of mud will be tracked onto concrete and potentially into the classroom.



Figure 5-10 Dirt Prototype

In Figure 5-3, the bark chips are set up on either side of the wood which is the concrete block. On one side the wood chips are wet, and pressure was applied to the wood chips and to the wood to simulate students walking on the wood chips and the concrete. The result is that the wood block is much cleaner than when it was between dirt. The conclusion was to use wood chips. This is convenient as well because the Rectangle of Doom is currently covered by wood chips.



Figure 5-11 Bark Chip Prototype

5.5 Instructions for Implementation and Use

5.5.1 High-Cost

The first part of the construction of the model is preparing to pour the concrete. In order to do this the first step is to dig out the area where the concrete will go and remove everything. The next step is to prepare a wooden form around the area where the concrete is going to be poured and put in the subbase which consists of granular fill. This will give the concrete better stabilization. Make sure that the measurements are precise and build in a slight slope for water runoff. Next place the Remesh hog wire on the inside of the form for support. This gives more structure to the concrete and helps prevent cracks. Before the concrete can be poured, the cement needs to be mixed with sand and gravel in a 1-part cement, 2-part sand and 4-part gravel ratio.

Once the preparations are complete the concrete can be poured from a wheelbarrow. Use shovels and rakes to spread out the concrete. After spreading out the concrete, screed the top using a wood plank to create a flat surface. Split the concrete in half with a control joint using a plank as a straight edge. This helps the concrete withstand cracking. Traction is essential to decrease the slipperiness of the concrete. Sweep across the concrete using a broom in straight lines but make sure the concrete does not stick to the broom. Before the concrete can be left alone cover it with a sealant. This helps cure the concrete and prevent cracks. Remove the wooden frame. Let the concrete cure for 28 days. Now the concrete is dry enough for paint to adhere. Use Masonry paint and mark the dimensions with tape before painting.

While waiting for the concrete to dry the next step in the construction of the model is to plant the two trees on either side of the newly laid concrete. Start by digging a hole that is 2x as wide as the diameter of the root ball and as deep as the bottom of the of the root mass to the flares. Do not make the hole any deeper. Make the edges of the hole gently slope outward. The next step is to place the tree into the

hole using the wire cage on the root ball. Once the tree has been planted place the unaltered backfill around the roots.

To use the model, set up the chess pieces on the gameboard and play the game of chess. When the gameboard is not being used, store chess pieces in a dry place.

The maintenance of the model requires the Magnolia trees to be trimmed every 5 years. The paint needs to be reapplied every 5 years and the woodchips every 5-7 years. Depending on usage, the chess pieces need to be replaced about every 10 years.

5.5.2 Low-Cost

The first part of the construction of the model is preparing to pour the concrete. In order to do this the first step is to dig out the area where the concrete will go and remove everything. Prepare a wooden form around the area where the concrete is going to be poured. Make sure that the measurements are precise and build in a slight slope for water runoff. Before the concrete can be poured, the cement needs to be mixed with sand and gravel in a 1-part cement, 2-part sand and 4-part gravel ratio.

Once the preparations are complete the concrete can be poured from a wheelbarrow. Use shovels and rakes to spread out the concrete. After spreading out the concrete, screed the top using a wood plank to create a flat surface. Split the concrete in half with a control joint using a plank as a straight edge. This helps the concrete withstand cracking. Traction is essential to decrease the slipperiness of the concrete. Sweep across the concrete using a broom in straight lines but make sure the concrete does not stick to the broom. Remove the wooden frame and let the concrete cure for 28 days. Now the concrete is dry enough for paint to adhere. Use Masonry paint and mark the dimensions with tape before painting.

To use the model, set up the checker pieces on the gameboard and play the game of chess. When the gameboard is not being used, store checker pieces in a dry place.

The maintenance of the model requires the paint to be reapplied every 5 years and the woodchips every 5-7 years. Depending on usage, the checker pieces need to be replaced about every 10 years.

5.6 Results

The results of the design model constructed in AutoCAD produces 2 effective ways to improve the Rectangle of Doom. Each design is a cost effective and durable way to produce an interactive solution to replace the empty plot of land in front of Zane Middle School. The designs put forth by this project could also be adapted to fill the second empty rectangle and provide a second game board/walkway. Although a working prototype of the concrete slab or magnolia tree could not be created given the unforeseen circumstances, the designs created through the project seems to be structurally sturdy and viable.

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