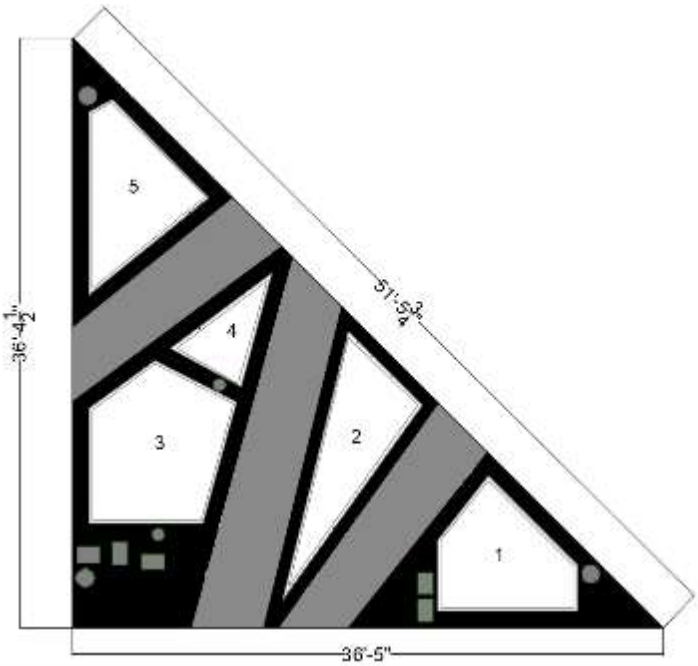

TRIANGLE OF DEATH

By The Cowboys of the Season

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Spring 2020
ENGR 215: Intro To Design

Table of Contents

Table of Figures

Table of Tables

1 Problem Formulation

1.1 Introduction

The following is the Section One problem formulation for the 'Triangle of Death', post COVID-19 outbreak. In this section, the Cowboys of the Season give background on the Triangle of Death, outline an objective statement, and conceptualize by using a black box diagram shown in Figure 1-1.

1.2 Background

The project originally takes place during the spring 2020 semester at Zane Middle School in Eureka, CA, but after the COVID-19 pandemic suspended physical construction, it has taken a digital route. Zane Middle School focuses their curriculum around science, technology, engineering, art, and math (STEAM), and has a student population of 760. Our project, the 'Triangle of Death', is a piece of land that has had aesthetic and functional problems. The Triangle of Death's issues arise from its awkward placement between classrooms, causing it to suffer heavy foot traffic. Previously, another Engineering 215 group attempted to remedy the issue by adding urbanite foot paths, mulch, and small local plants. Their design's failures were associated with the plants' survival and the foot paths' quality. As the Cowboys of the Season, it is our goal to create a plan for 'apocalypse-proof' landscaping that is sustainable, functional, and beautiful, as requested by our client, Zane Middle School counselor Trevor Hammons, as well as DIY videos for those stuck at home.

1.3 Objective Statement

The objective is to provide Zane Middle School a detailed AutoCAD document that provides directions for construction of a landscaped pathway in the Triangle of Death area. A satellite project will be creating DIY videos that have some relevance to landscape design.

1.4 Black Box Model

The following Figure 1-1 is a black box diagram that conceptualizes the state of the project before and after the solution.

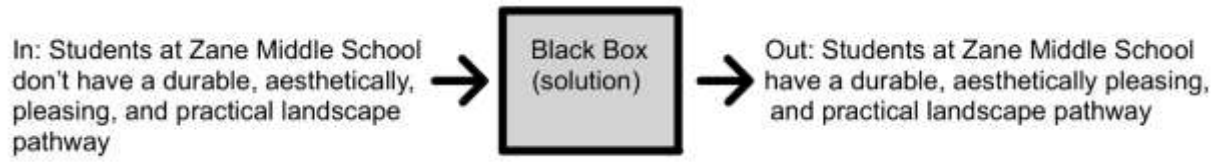

Figure 1-1: Black Box Model Diagram for Design Process

2 Problem Analysis and Literature Review

2.1 Problem Analysis Introduction

This problem analysis provides a detailed summary of the specifications, considerations, criteria, constraints, and product volume for the Triangle of Death, which will be considered during the creation of the plans and DIY videos. The section containing criteria and constraints will have qualitative and quantitative information to help decide the best solution for the Triangle.

2.1.1 Specifications

The Triangle of Death is a walkway area at Catherine L. Zane Middle School. The planning for the landscaped pathway and videos must follow several specifications to be a proper and adequate solution. The following lists those specifications.

- Must be located at Zane Middle School
- The landscaping must withstand and/or defer foot traffic from middle school students
- The project must follow all ADA school safety regulations
- The project must follow all school safety regulations
- The project must be contained within the area of the 36’ x 36’ x 51’ triangle
- The landscaping must be low-maintenance and simple to construct
- The videos must be educational, kid-friendly, and easy to share in a quarantine situation

2.1.2 Considerations

The considerations listed in this section have been gathered from interviews with the client as well as others educated on the project. The main consideration is that the plan is easy enough to follow so that the school follows through with construction. The design is in a high-traffic walkway of a middle school. Additionally, the maintenance of the finished project must be considered. Maintenance consists of ensuring that the vegetation is watered for their first three months after planting, and if they are non-local species, that they will continue to be watered after these first three months. For the videos we must consider that might be shown in a classroom to middle schoolers at Zane.

2.1.3 Criteria and Constraints

To quantify the success of the project and satisfy client needs, criteria and constraints need to be established. These criteria and constraints were formulated through interviews with the client, students, and staff at Zane Middle School, along with personal research. Each criterion and their constrain is rated on a scale of importance with ten being highest importance and zero being lowest importance. Tables 2-1 and 2-2 provide the criteria and constraints for the project.

Table 2-1:Criteria and Constraints for the Landscape Design

Criteria	Constraints	Importance 0-10
Safety	Comply with all school safety regulations. Must be safe for kids to be around and pose no threat to their physical health.	10
Ease of Construction	Can be constructed in 200 human-hours.	10
Durability of Material	Design must last more than six years.	9
Aesthetics	Must be more appealing than the previous landscaping before.	7
Cost	Materials must be under $2000.	6
Environmental Justification	Materials should be sustainably produced and locally sourced to minimize their carbon footprint.	4

Table 2-2:Criteria and Constraints for Construction Document and DIY Videos

Criteria	Constraints
Ability to Replicate	The AutoCAD design document must contain enough information that people with little to no construction experience could replicate it.
Virality	The videos must be shareable over multiple devices through social media.
Enjoyable to Watch	Videos must be enjoyable for a younger audience to enjoy with their family. Editing must be professional and clean.
Educational	The videos must have educational purposes for families and students to learn from.
Relevance to Landscape Design	The plan and videos must have connections to the original landscaping construction project.

2.1.4 Product Volume and Usage

One landscape construction plan will be designed, and three DIY videos will be created. The construction document will be used by the school staff or a future engineering group to create the landscape design at Zane Middle School. The DIY videos will be used during and after the pandemic by those interested in at home projects.

2.2 Literature Review Introduction

The purpose of this literature review is to provide necessary background information to create a foundation for the beginning of the design process for the Triangle of Death. The following topics that will be discussed are materials, structures, ecology, mulching techniques, math education curriculum, student safety, school pride, and mosaics.

2.3 Client Interview Information

Trevor Hammons, Zane Middle School's counseling services director, is our client. During his interview he gave information regarding expectations and ideas for the design project. His main objective for us is to create "indestructible landscaping" for a high-traffic area at Zane Middle School, coined the Triangle of Death (Hammons 2020). Multiple Engineering 215 groups attempted this project, but none have succeeded. The first project was a design with recycled concrete pathways that were placed in a ray design around a central point, shown in Figure 2-1. The placement of the paths did not work, as the students for the most part ignored them (Hammons 2020). The second project involved the removal of the previous paths and the implementation of new paths. They also used the concrete from the previous project to build planter boxes, but the planters never received plants and were determined a safety hazard and removed (Hammons 2020). The current condition of the triangle is shown in Figure 2-2. The area does not have access to water, so resilient (preferably native) plants are required. The main design parameters are beauty and durability to withstand heavy foot traffic.

Figure 2-1: Triangle of Life Final Design Spring 2015 (Caminiti 2015)

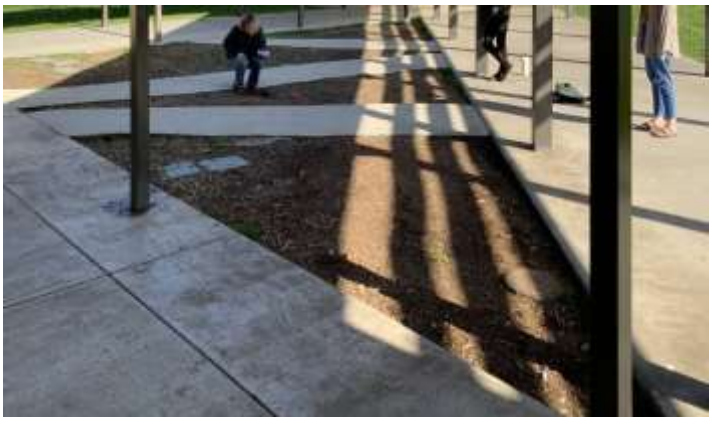

Figure 2-2: Triangle of Rebirth Beginning of Spring 2020 (Taylor 2020)

2.4 Materials

To successfully implement the design, durable materials are necessary. Previous designs have failed at the Triangle of Death because the vegetation or materials have not been able to survive the vigorous use of hundreds of middle schoolers. In this section we will outline a variety of materials that could be used such as pavement, planters, and ground cover.

2.4.1 Planter Materials

This section discusses the benefits of using brick versus stone planters and cement versus mortar as a binding agent. Brick incorporates with the 1980's Southern California architecture of Zane. Stone blends better with the color palette and existing structures of the school. Mortar is the most common binding agent used for building planter boxes. Cement can be used as an effective replacement in order to reduce expenses, as it serves the same purpose as an adhesive (SF Gate 2016).

2.4.1.1 Brick and Stone Planter Boxes

The benefit of having raised, trample proof planter boxes integrated into the design is they incorporate nature while maintaining the fortitude necessary in building at a middle school. As described by SFGate, the process of creating a planter box is simple for people with limited time and masonry skills. To start the process, a trench must be dug that is 6 inches deep and the ground must be flattened. Next, the cement must be mixed using a wheelbarrow and garden

hose and poured four inches deep to create the base of the planter. This concrete should be set to dry for 48 hours, upon which time the process of laying bricks or stones can begin. To place stones, mortar mix or concrete can be used to stick the bricks to each other and the base. Put bricks next to each other and adhere them to the ground until you have a perimeter, then begin stacking them to form a small wall. This rough process can be followed for both brick planters and stone planters (Lougee 2020).

Figure 2-3:Brick Planter (Pinterest n.d.)

2.4.1.2 Wooden Planter Boxes

Creating wooden planter boxes is a simple and cheap process but requires a lot of specialized equipment that may be difficult to acquire. An example of a wooden planter box is shown in figure 2-4. The materials include nine 5'8" cedar pickets, one 2x4, some screws, and a table saw, and drill will be required for construction ($23 DIY Planter Box 2017). Cedar wood is a good option for a wetter climate because it has natural oils that protect from mold and mildew. Cedar oils dry out when meeting direct sunlight, and after one year the color of the wood tends to fade. This issue can be addressed by applying a waterproof varnish to the wood before construction. Although it is advisable to add a coat of varnish to the wood every year, it is not necessary because of the properties of cedar wood (Is it Necessary to Waterproof a Cedar Fence? 2014).

Figure 2-4:Wooden Planter Box ($23 DIY Planter Box 2017)

2.4.2 Laying Cement

Most pre-made cement products, including Portland Cement and Fly Ash Cement, can be found at local hardware stores, including Hensel's Ace in Arcata. Creating a cemented area takes a lot of prep work that may take multiple days for unexperienced builders. The first step to laying cement in a large area is to clean and level the area using a shovel. The ground must be level so that the cement, when dry, will not have a slant. The designated area must be outlined using 4x4 boards or special plastic cement molding materials so that the edges of the cement are clean. Molding materials are then braced using stakes so that when the cement is poured in the molds will not warp. Next, rebar or large hole steel wire mesh is pinned to the ground in order to form a lattice. The purpose of this step is to ensure that the cement will remain firmly in place and unliftable once dry. Next the cement must be mixed, which requires the addition of water until the cement powder becomes a thin paste. A cement mixer, or realistically a wheelbarrow and shovel, will be used to incorporate the ingredients. These will be poured into the mold and smoothed using pieces of wood and cement smoothers (Day 2019).

2.4.2.1 Portland Cement

Portland Cement is considered one of the strongest and popular building materials on because of its incredible durability and versatility. Portland Cement is present in buildings, sidewalks, roads, etc. To create this material, a powdery substance made up of hydrated lime, sand, gravel, crushed limestone or crushed rock, is mixed with water and poured or applied to a location as a binding agent (Bye 1983). When it dries it creates a grey rock-like material that lasts from 20-150 years (Pate 2015). Although it is incredibly durable and long lasting, Portland Cement creates an excess of CO_2, SO_2, CO, and SiO_2 during manufacture and is not easily reused in buildings, making it not ecologically less friendly than other options (Hasan). In a study by the International Journal of Pharmaceutical, Chemical and Biological Sciences (2014), researchers found that dust from the mining and manufacturing of virgin cement contaminates air, waterways, soil, and drinking wells with particulate matter containing salts. These salts make the groundwater harder and cause gastrointestinal diseases. The contamination of soil with cement particles decreases biodiversity and profitability of land through the formation of salt deposits. Cement dust is present at most stages in the manufacturing process and has been known to cause stress reactions in plants and frequently death (Ramesh 2014).

2.4.2.2 Fly Ash Concrete or Ashcrete

Ashcrete is a sustainable alternative to traditional Portland Cement because it is made of fly ash, a byproduct of coal combustion. In the past, fly ash would be collected and disposed of in landfills, but now fly ash is converted into cement that can be used in a variety of building projects. Using fly ash as an alternative to sand and gravel means a reduction in mining and in the generation of CO_2 and other gases. Fly ash concrete takes less energy to produce, making it a more sustainable option than Portland Cement. Fly ash is mosaic compatible and is most used in pathways and roads (Rodriguez 2019)

2.4.2.3 Slag Cement

Slag is the stone waste material separated from ores during smelting. Slag Cement is a material made from slag that can be used in combination with Portland cement as a partial replacement. Using slag cement is an environmentally friendly alternative variety of cement (What is Slag Cement 2014).

2.5 Ecology

Ecology is the relationship between living organisms and their surrounding environments. The study of ecology is important to consider when landscaping the Triangle of Death, because the implementation of plants and vegetation is a primary concern of the project. To successfully integrate plants into the Triangle of Death, the plants must be resilient and able to withstand the environment (esa.org n.d.).

2.5.1 Best Soil for Plants

As defined by the article “Soil”, “Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life"(Sposito 2020). The best soil for plant growth is sandy loam: an even mix of sand, silt, and clay. An ideal growing soil has a pH of 6-7, which allows for both plants and important soil-dwelling organisms to do well. A high calcium level is important because it allows for soil to retain more water and creates a looser, more airy loam that allows for more oxygen to reach roots (Patterson 2015). Since Eureka is in a rainy climate, the rain will add acidity to the soil which will need to be considered. Local plants are adapted to thrive in 5.5-6.0 pH (Sawyer, J. O., Keeler-Wolf, T., and Evens, J. 2009).

2.5.2 Plant Options

Evergreen Huckleberry vaccinium ovatum, shown in Figure 2-5, is an adaptable shrub native to Northern Coastal California. Its colors change throughout the seasons, bringing variety to landscape designs. A unique property of the evergreen huckleberry is its response to different light conditions. In a dark forest, the shrub grows tall, but in sunnier conditions, the shrub reaches a reasonable five feet in height. The Evergreen huckleberries also bare an edible berry (Mann, B. 2017).

Figure 2-5: Evergreen Huckleberry (flowerinspiration.co 2017)

The Western Sword Fern, polystichum munitum, shown in Figure 2-6, is an evergreen fern native to a wide variety of climates along the Pacific coast of the United States. Western sword ferns prefer “well-drained acidic soil of rich humus and small stones”. These ferns can survive occasional droughts, and do best with consistent moisture, moderate sunlight, and cool temperatures (Polystichum munitum n.d.).

Figure 2-6: Western Sword Fern (Tennessee Whole Sale Nursery 2019)

Encore Azaleas, rhododendron oldhamii, shown in Figure 2-7, are hybridized to be the most sun tolerant azaleas (Yee 2010). They bloom twice per year, in the summer and fall. Azaleas prefer acidic soil dense with organic matter. They require regular watering and good drainage to combat drought and heat related stresses. Encore azaleas tolerate sunny to partial shade. Ideally, they should receive 4-6 hours of direct sunlight per day along with afternoon shade, particularly for hotter areas. If planted in shady areas, it is likely they will not bloom (Foose 2017).

Figure 2-7: Encore Azaleas (The Tree Center 2019)

Hardiness refers to the temperatures a plant can withstand. Hardiness zones, shown in Figure 2-8, are assigned to different regions based on their temperature extremes. (Hardiness zone 2020). The Encore Azaleas are hardy in zones 7 through 9 with certain varieties hardy to zone 6 (Foose 2017).

Figure 2-8: Plant Hardiness Zone of Northern California (USDA 2017)

2.6 Weather

Eureka sees average rainfall of 40.3 inches over its 127.5-day rainy season and sees on average 6.7 sunshine hours per day. However, these numbers vary significantly throughout the year which is shown in Figure 2-9 (Yu Media Group 2019).

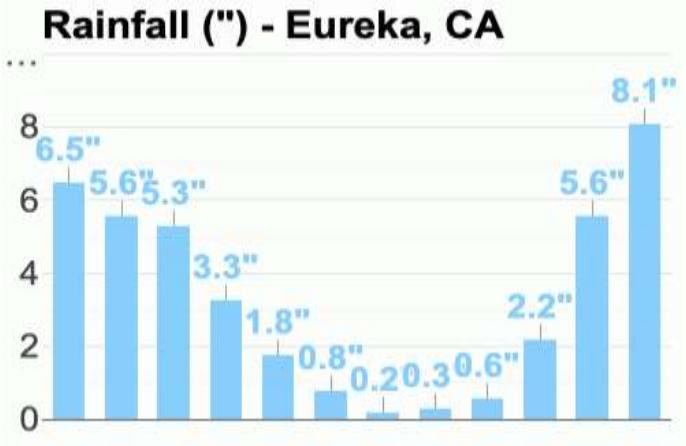

Figure 2-9: Average Rainfall Eureka, CA (X axis in Months), (Weather Atlas 2019)

2.7 Mulching

Mulch is applied over the top layer of soil as a covering to retain moisture, suppress weeds, keep the soil cool, and make the garden bed more attractive, shown in figure 2-10 (All Around Soil and Stone 2017). Mulch also helps the problem of water shortages caused by rainfall fluctuations (Gao et al. 2019). Mulch reduces loss of soil moisture from evaporation by 10 to 25 percent (Evans 2000). Use of mulch at Zane would create better soil to improve plant survival, and

control weeds to lower maintenance requirements. It is also an improvement to overall aesthetic as raw soil is unattractive. Because mulch blocks sunlight, it prevents some seeds from germinating. This is good for keeping weeds away, but not for the seeds of plants trying to grow. For landscaping, saplings are needed instead of seeds. Another problem with mulch is that it attracts pests that like cool, dark, and moist places. To minimize this, a thin layer of mulch kept several inches away from plant bases is necessary. Lastly, because mulch is moisture absorbent, when heavy rains come the ground can be over-saturated for several days. In Eureka, the possibility of heavy rain is high, so the possibility of the mulch turning the soil to mud is likely (Iannotti 2019).

Figure 2-10:Mulch (Iannotti 2019)

2.7.1 Bark

One of the more affordable forms of mulching is using bark. Experts suggest that a layer of up to four inches of wood chip is necessary to provide the correct level of protection (Chief 2019). Bark mulches are best used around trees, shrubs, and in garden beds where there won't be a lot of digging. These woody mulches don't mix well into the soil and moving them can become a hassle to make way for new plants. They will, however, last longer than finer organic mulches. This option would be ideal at Zane since no one will have to dig or maintain the area, but it will be a problem for the future if they do choose to plant new saplings in the same space (Iannotti 2019).

2.7.2 Composting

Composting is considered a form of mulching as it can help keep the soil moist and enrich the soil with nutrients. Compost and composted manure can be used essentially anywhere, if the soil is well-composted. Composting can be used as either a mulch coating or as a side dress to plants during the growing season to insulate and give a nutrient boost. Compost is made by combining organic materials and placing them in specialized bins or tumblers (Iannotti 2019). A composter was a previous ENGR 215 project at Zane, so there is an on-campus site that makes compost. Therefore, it is a possibility to use this compost for our project. A drawback to compost is that when it becomes wet it can develop an unpleasant odor (Blue, J 2016).

2.8 Education

Students regularly see the Triangle of Death, so it would be opportune to incorporate their math curriculum into our design project, exposing sixth- and seventh graders to geometry that they will learn about in their near future. All students would be able to apply what they are learning in class to the geometry they see in the Triangle of Death. Bringing math outside the classroom has the potential to bring excitement to the topics being covered as well as more involvement from the students, resulting in a higher level of student motivation (Larson and Keiper 2012).

Students will recognize concepts they are learning in class when they walk past the Triangle of Death; Engaging students will help them retain information, so applying geometry outside of the classroom would increase involvement, which would improve their overall knowledge on the subject (washington.edu n.d.). Despite the education the Triangle of Death could provide, turning the Triangle of Death into a geometrical educational area could lead to the removal landscaping in the area.

2.8.1 Middle School Curriculum

California enforces the use of common core in teaching math in grade schools. Grades six through eight are introduced to geometry. The common core curriculum for grades six through eight introduces concepts such as the number system, geometry, statistics and probability, expressions and equations, ratios and proportional relationships, and functions (corestandards.org n.d.). Common Core was initiated to ensure that all schools are meeting the same standards (cde.ca.gov n.d.).

2.8.2 Geometry

Geometry is a prevalent topic in the math curriculum covered in grades six through eight. The geometry sections that are covered incorporate topics regarding triangles, polygons, rectangles, and prisms (corestandards.org n.d.). Traditional, basic geometry is introduced in elementary school such as identifying different shapes both two dimensional and three dimensional. Middle schoolers take it steps further by covering topics including relations between angles, congruence, symmetry, and the Pythagorean theorem (Bailey 1968). However, our project is concerned with the geometry of triangles specifically. General knowledge about triangles are that all angles of a triangle add up to 180 degrees and the different types of angles are called right, acute, and obtuse angles. Students should know how to identify complementary and supplementary angles. Students should or will know what the Pythagorean Theorem is. They should know that isosceles triangles, right triangles, and equilateral triangles are the three different types of triangles. Students should know how to classify them based off the angles or sides given. Lastly, students should also know how to find the area of a triangle (oercommons.org n.d.). All these different properties of triangles are topics that students have either covered or will cover in the next two years.

2.9 Student safety

The safety of students while at school is of the utmost importance. Our improvements to the Triangle of Death will have to abide by a set of rules in order to ensure the safety of students. Student safety can be compromised by things such as tripping hazards throughout campus and other students throwing objects they find on campus. Additionally, students are more likely to learn in an environment in which they are not worried about their personal safety (safesupportivelearning.edu n.d.). Any safety concerns that the materials being used may pose must be considered.

2.9.1 Tripping Hazards

Common tripping hazards present in schools include wet or slippery surfaces, environmental conditions like an icy ground or rain, insufficient lighting, changes in elevation like curbs or cracks in sidewalks, climbing or descending stairways, and maintenance issues in walkways (occutec.com 2017). In an area with vegetation and soil that kids continue to walk over , it could become a potential tripping hazard during the rainy season. Mud puddles could easily form with enough rain and kids decide to walk through the puddles resulting in a tripping hazard

from the wet ground. Another potential tripping hazard in the Triangle of Death would arise with the implementation of a mosaic on the ground. Depending on the materials used to make the mosaic, rainfall might make the mosaic a slippery area.

2.9.2 Throwable Objects

Plants that bare removable, rotund, weighty, 'throwable' objects will be avoided. Examples of such objects are fruits, acorns, pinecones, etc. Any plants that produce throwable objects whether it be fruit or pinecones present the possibility of students using them for purposes that could compromise either their own or other students' safety. Some students may find it hard to leave these objects alone and will attempt to play games with these objects or use them as ammunition. Rocks are also throwable objects.

2.10 School Spirit

School spirit is a way to improve student achievement. Studies have shown that students with higher levels of school spirit have better academic performance, are more engaged, and are happier than their less-spirited peers. The research found that students with higher levels of school spirit have higher average Grade Point Averages and are more likely to plan to further their education than students with lower school spirit. Additionally, most principals feel that it's important to build school spirit at their school and four in five agree that school spirit is a key measure of an effective school administration. (Varsity Brands 2020)

2.10.1 Campus Pride

A school's facilities play a major role in student learning and achievement. This is because of their involvement in creating a stimulating and inspiring environment. As the appearance of a school's facilities degrades or improves so does the students' achievement. Studies show that pride in a facility can help to lower absence levels and increase student morale. This creates improvements in both student performance and teacher retention and makes aesthetic landscaping essential to students' academics. An important aesthetic component for a school would be colors on campus. Incorporating school colors throughout facilities create a strong sense of identity and inspire a sense of community in students. Colored walls in communal areas or student pride art pieces are a way to increase the prominence of school colors within the school's facilities. (Brown, M. n.d.)

2.11 Mosaics

Mosaics are the orderly arrangement of parts composed into a permanent unified whole. An example of a mosaic is shown in Figure 2-11. They are made up of materials such as stone, glass, or tile set in cements or adhesives. (Jenkins et al. 1957). Mosaic Craft items are used as home decor. Cities often decorate public places such as parks with mosaic murals and sculptures. Traditional mosaics are made of small, flat, and roughly square, pieces of stone or glass of different colors, known as tesserae, and some floor mosaics are made of small rounded pieces of stone and called pebble mosaics. Mosaic skinning, which is covering objects with mosaic glass, is done with thin enameled glass and opaque stained glass. Modern mosaic art is made from any material in any size ranging from carved stone, and bottle caps. (Dunbabin, K. 2012)

Figure 2-11: Mosaic of a Tiger (Mosaico 2020)

3 Alternative Solutions

3.1 Introduction

Alternative Solutions is composed of the brainstorming process and alternative solutions to be created at Zane Middle School. The solutions are described in relation to the criteria and specifications that were described in Problem Analysis.

3.2 Brainstorming Process

The brainstorming process began as soon as we knew what project we would be doing but became more focused and constrained once we started contacting our client. The first call with Mr. Hammond revealed a variety of possibilities for the triangle but an in person meeting, interviews of staff and students, and a tour of the triangle further expanded the possible ideas, while also helping us narrow down to the best design. Our formal brainstorming process lasted for around an hour, which we started by doing some constrained categorization, shout-out idea generation, for various aspects of the design. We then followed the force fitting brainstorming by taking specifications from each of our categories to make possible designs, creating 12 total ideas. After this we went around in a circle and each picked what we thought were the top few picks that were realistic. The results of the brainstorming can be seen in Appendix A in Figures A-2 through A-7.

The names of the top designs are as follows:

- The Pepperoni Pizza
- Pepperoni Strawberry Pizza
- Wood'nt it be Nice
- Will you be my Cementine?
- Mushroom and Sausage Pizza
- Mushroom and Spicy Sausage Pizza
- Mosaic Pathways

3.3 The Pepperoni Pizza

The Pepperoni Pizza design consists of three main components: circular planters made of brick and mortar, bark surrounding the planters, and plants inside the planters. The design can be seen in Figure 3-1. The circular planters are two feet tall with a 6 to 13-foot diameter. The bark surrounding the planters covers the dirt, so it is purely aesthetic. The planters are filled with soil and topped with mulch. The brick planters are very durable, having a lifespan like concrete, with an asymmetrical design. The bricks are painted every other brick to be yellow to match the school colors. The brick is the most expensive portion of the project with brick costing $6 – 10.50 per square foot installed. The budget for 1,000 bricks can run as little as $340 to as much as $850. The mulch, soil and plants all have the possibility of being donated. The laying of the bricks and mortar is a time-consuming process with lots of manual labor but still most likely takes less than the 200-man hour time constraint listed in the criteria and constraints. This design also follows all specifications listed in Problem Analysis.

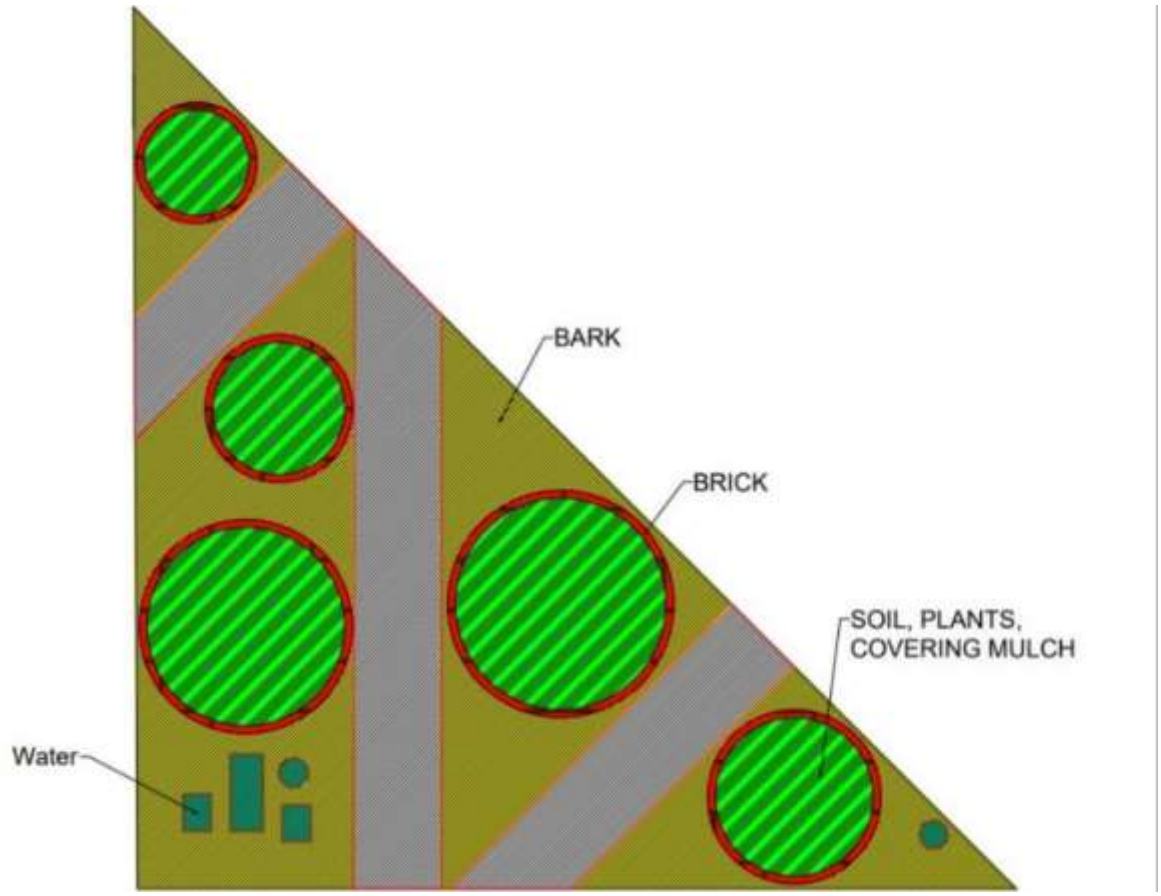

Figure 3-1:Pepperoni Pizza Design (drawn 3/11/20)

3.4 Strawberry Pepperoni Pizza

The Strawberry Pepperoni Pizza design consists of three main components: the circular planters made from brick and mortar, the strawberry plants surrounding the planters, and the plants inside the planters. The design can be seen in Figure 3-2. The circular planters are 2 feet tall with a diameter that varies from about 13 feet to 6 feet. The strawberry plants surrounding the planters are to cover up the dirt and add edible landscaping. The planters are filled with soil,

which is topped with mulch. The brick planters are very durable with brick planters having a life like concrete. The aesthetic of the design is not symmetrical but has a sort of random design to it which makes it look less boring. The brick is also painted every other brick to be yellow to match the school colors. The brick is the most expensive portion of the project with brick costing $6 – 10.50 per square foot installed. The budget for 1,000 bricks can run as little as $340 to as much as $850. The mulch, soil and plants all have the possibility of being donated. The laying of the bricks and mortar is a time-consuming process with lots of manual labor but still most likely takes less than the 200-man hour time constraint listed in the criteria and constraints. This design also follows all specifications listed in Problem Analysis.

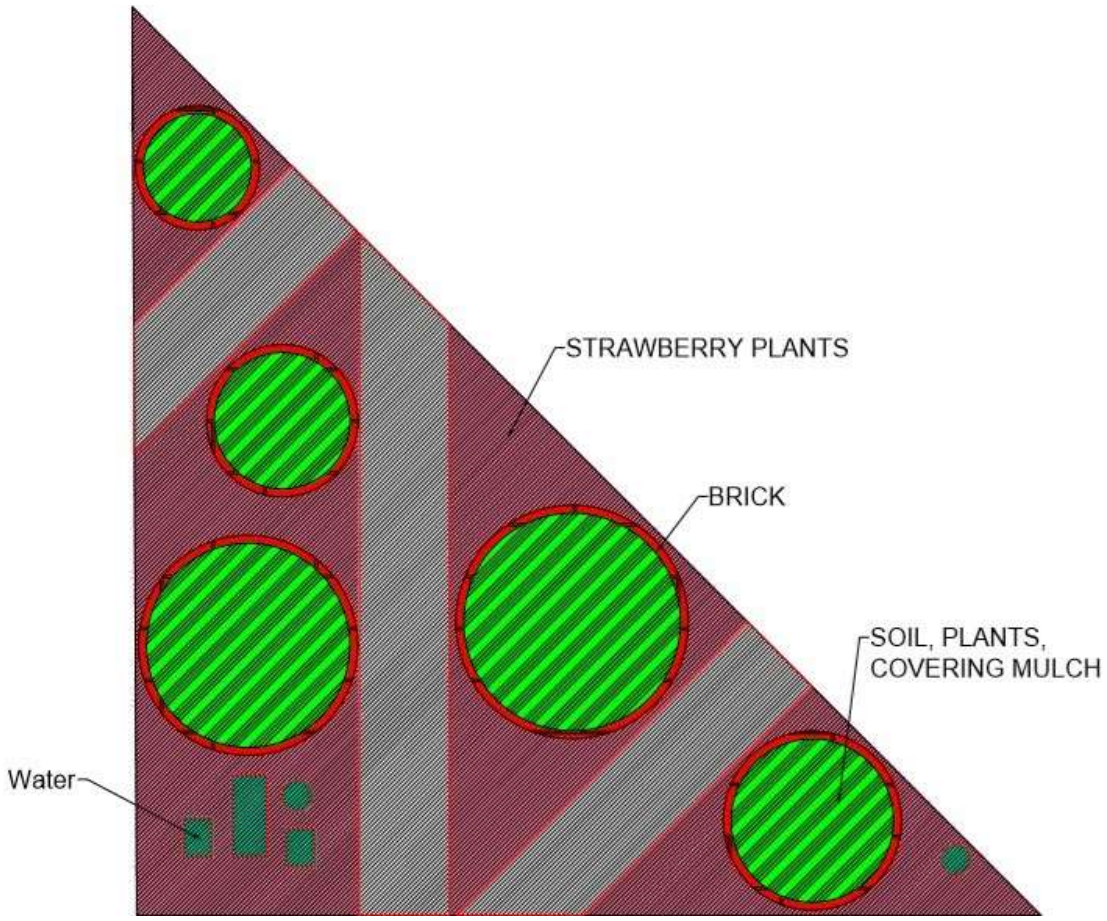

Figure 3-2: Strawberry Pepperoni Pizza Design (drawn 3/11/20)

3.5 Woodn't it be Nice

The Woodn't it be Nice design allows student passage through a nicely landscaped planter area, while forcing students to only walk on designated walkways. The design can be seen in Figure 3-3. Planter boxes are strategically placed between pathways in order to fill all the currently empty space, while avoiding the sprinkler and sewer utility boxes. Planters are triangular or quadrilateral and follow the edges of the paths. This design ensures protection against trampling because the planters serve as separation between the kids and the plants. The planter boxes are constructed out of cedar that has been treated with lacquer, ensuring that the wood lasts a long time. Planter boxes are 2 feet high, and 1 foot away from the paths. Cedar wood is $4.63/board foot and has an estimated cost of $100/planter. The space between paths and the raised boxes are filled with strawberry plants as a ground cover. Planted boxes are filled with dirt and

compost as fertilizer and grow a variety of plants including encore azaleas, roses, huckleberry ferns, and sword ferns. We expect to receive donations of the plant and dirt materials. The pathways are be the easiest part of executing this design because we are keeping the same “Z”-shaped path that is already present. This design is a very safe option because it keeps the students a significant distance away from the roses and other potentially scratchy plants. Additionally, the planters are high enough off the ground to keep the plants safe but not too high that when kids jumped off it, they are okay.

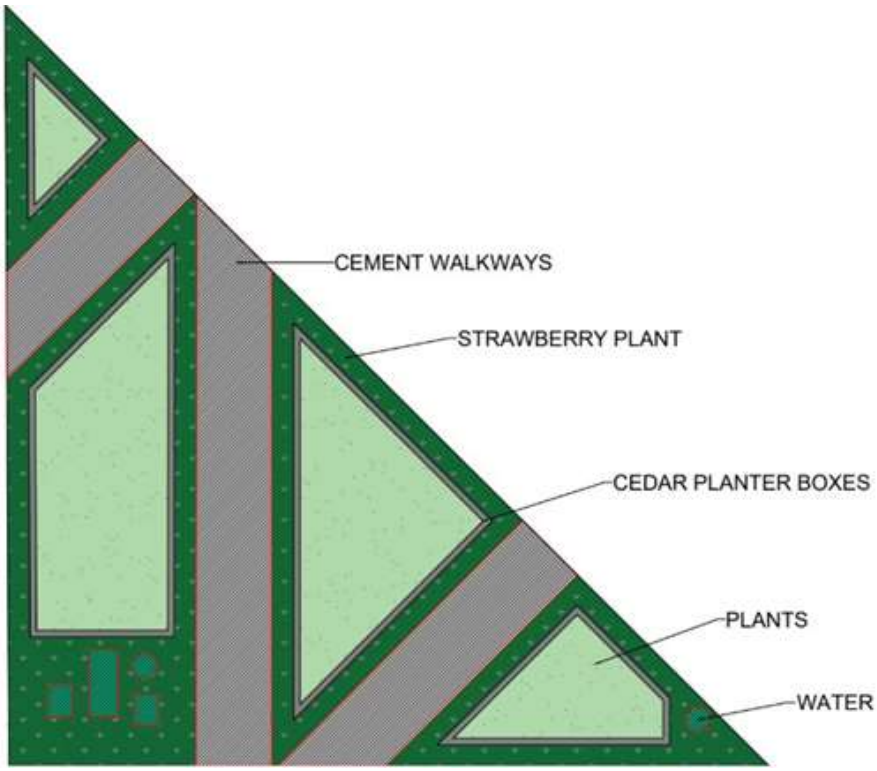

Figure 3-3: Woodn't it be Nice Design (drawn 3/11/20)

3.6 Will you be my Cementine?

The Will you be my Cementine design allows student passage through a nicely landscaped planter area, while forcing students to only walk on designated walkways. The design can be seen in Figure 3-4. Planter boxes are strategically placed between pathways to fill all the currently empty space, while avoiding the sprinkler and sewer utility boxes. Planters are triangular or quadrilateral and follow the edges of the paths. This design ensures protection against trampling because the planters serve as separation between the kids and the plants. The planter boxes are constructed out of fly ash cement ensuring the planters last multiple decades. Planter boxes are 2 feet high, and 1 foot away from the paths. Hiring a cement mason typically costs around 50-100 dollar an hour, but this aspect of the project is hopefully be donated. The space between paths and the raised boxes are filled with strawberry plants as a ground cover. Planted boxes are filled with dirt and compost as fertilizer and grow a variety of plants including encore azaleas, roses, huckleberry ferns, and sword ferns. We expect to receive donations of the plant and dirt materials. The pathways are the easiest part of executing this design because we are keeping the same “Z”-shaped path that is already present. This design is a very safe option because it keeps the students a significant distance away from the roses and other potentially

scratchy plants. Additionally, the planters are high enough off the ground to keep the plants safe but not too high that when kids jumped off it, they are okay.

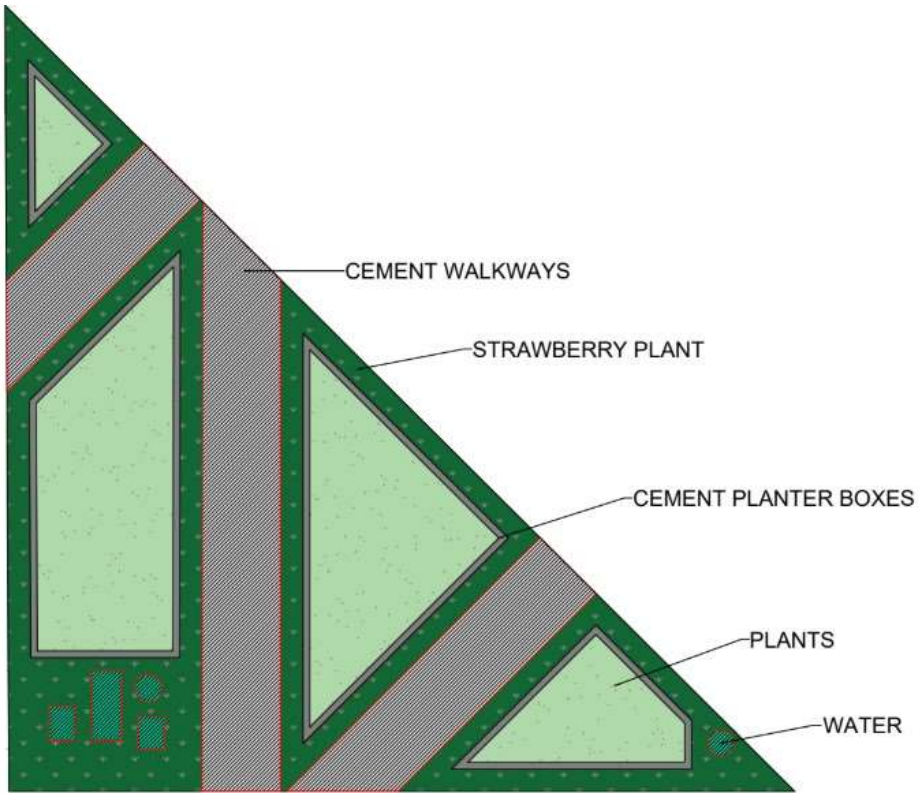

Figure 3-4: Will you be my Cementine? Design (drawn 3/11/20)

3.7 Mushroom & Sausage Pizza

This design consists of grass, wood planters, and concrete disks covering the areas without paths. The design can be seen in Figure 3-5. To protect the grass from foot traffic, there are concrete disks placed in critical areas, with stone inlays. The planters are circular, two feet tall with a diameter of six to twelve feet and made from cedar wood. Cedar wood is $4.63/board foot and has an estimated cost of $100/planter. The mulch, soil and plants all have the possibility of being donated. The planters are placed in the three primary grass zones, one foot away from the paths. The planters are filled with soil, which is topped with mulch. Inside the planters, there are huckleberry ferns and encore azaleas which are drought resistant. This design also follows all specifications listed in Problem Analysis.

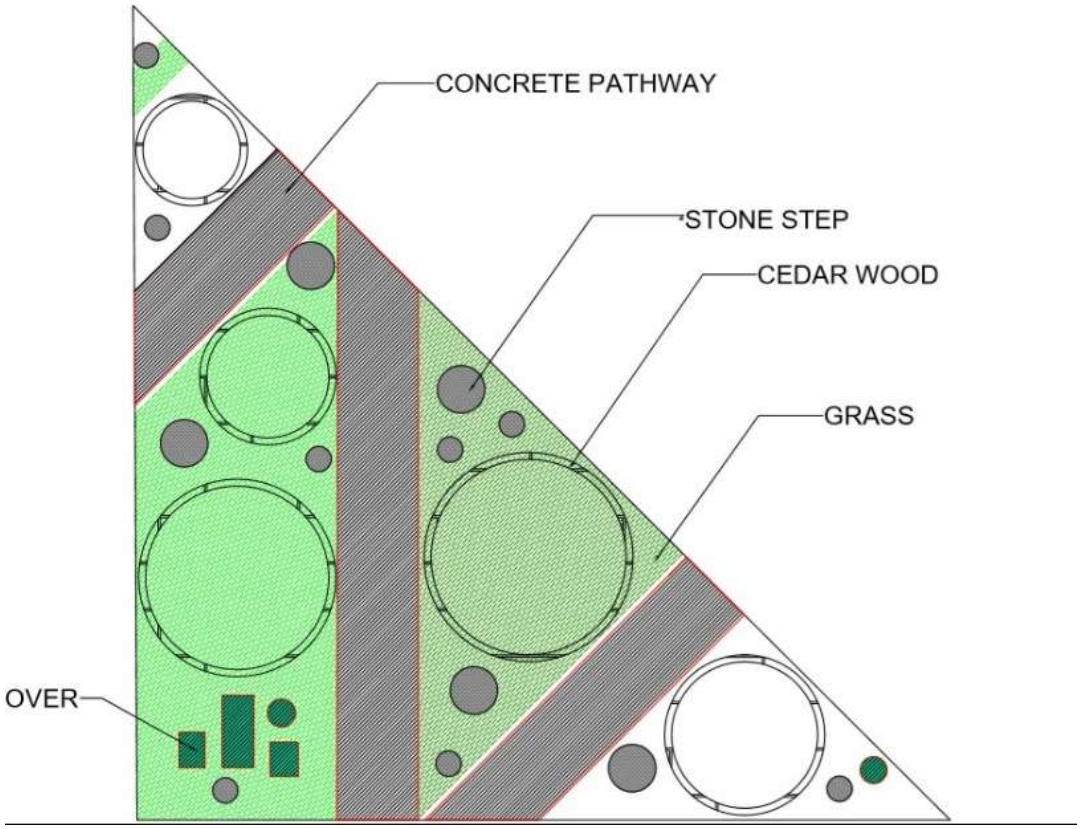

Figure 3-5: Mushroom & Sausage Pizza Design (drawn 3/11/20)

3.8 Mushroom & Spicy Sausage Pizza

This design consists of grass, wood planters, and concrete disks covering the areas without paths. The design can be seen in Figure 3-6. To protect the grass from foot traffic, there are concrete disks placed in critical areas, with mosaic inlays, designed by the students, for decoration. The planters are circular, two feet tall with a diameter of six to twelve feet and made from cedar wood. Cedar wood is $4.63/board foot and has an estimated cost of $100/planter. The mulch, soil and plants all have the possibility of being donated. The planters are placed in the three primary grass zones, one foot away from the paths. The planters are filled with soil, which is topped with mulch. Inside the planters, there are huckleberry ferns and encore azaleas which are drought resistant. This design also follows all specifications listed in Problem Analysis.

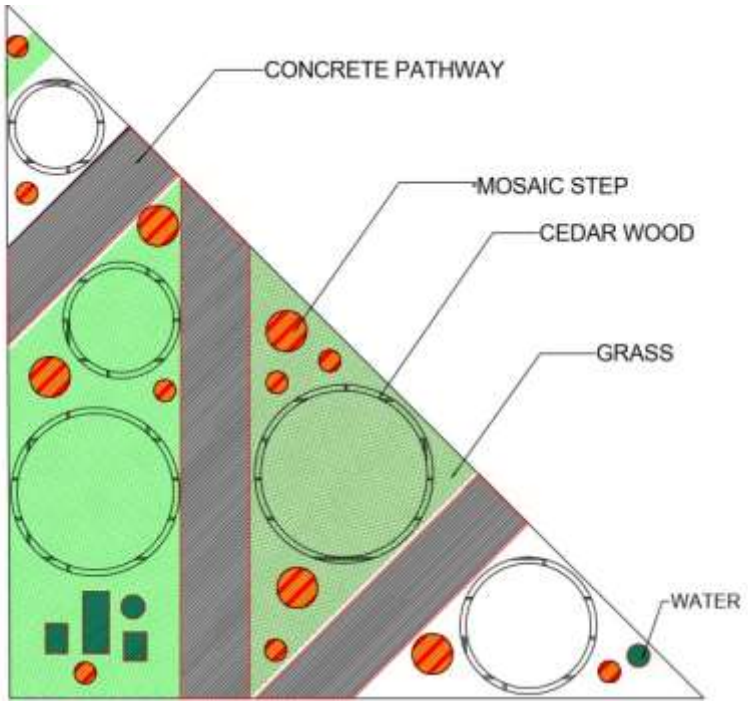

Figure 3-6: Mushroom & Spicy Sausage Pizza Design (drawn 3/11/20)

3.9 Mosaic Pathways

In this design, wood planters are used, pathways are covered with mosaics, and exposed dirt areas are covered with strawberry plants. The design can be seen in Figure 3-7. The current pathways are improved with triangle-shaped mosaics placed over them. There is potential for student involvement from the middle schoolers if each student from Student Leadership is given a space to design a mosaic. Additionally, 4 wood planters are placed in the dirt areas around the cement pathways. The planters are, quadrilaterals, placed 1 foot away from the pathways, and are 2 feet high. The planters are made from cedar wood, which costs $4.63 per board foot. There are azaleas in each planter, and the dirt not covered by planters is covered with strawberry plants. Each planter's cost ranges from $75 to $150, so this design is a more expensive option; however, it makes up for the higher cost with its beauty and potential for student involvement. This design does not pose tripping hazards, nor does it give students access to throwable objects.

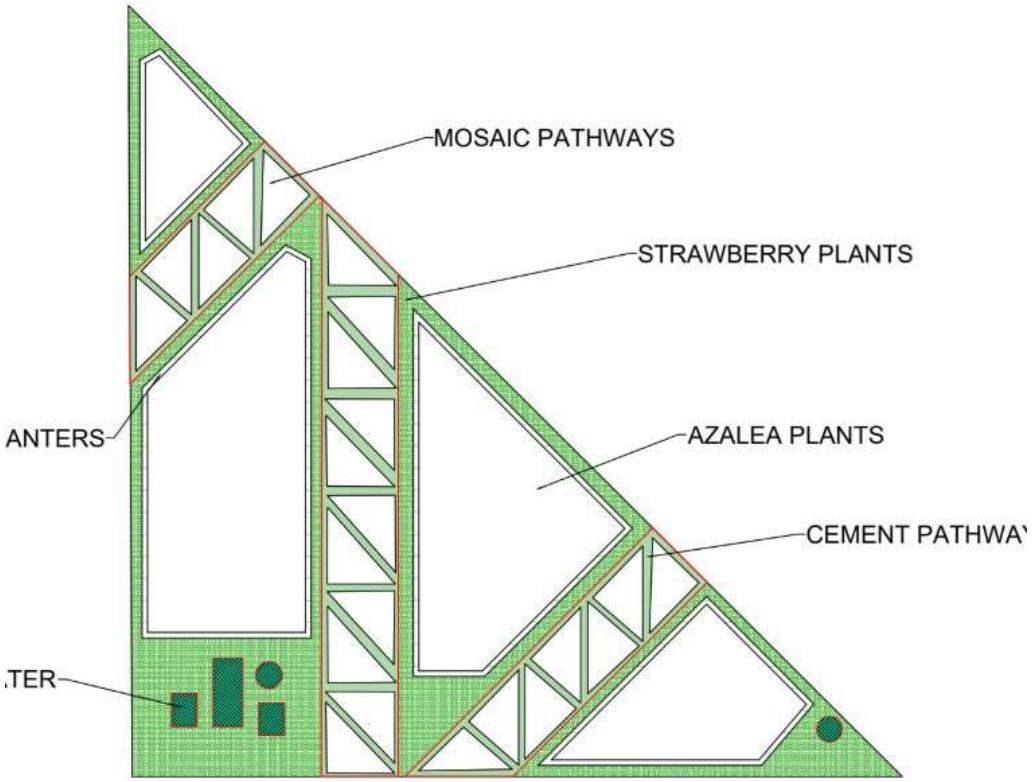

Figure 3-7: Mosaic Pathways Design (drawn 3/11/20)

4 Decision

4.1 Introduction

This section focuses on the analysis of the alternative solutions to decide which one is the most compatible for the final design. To properly analyze the solutions, a Delphi Matrix, shown in Section 4.3, will be used to analyze the list of criteria and the importance of each component. After the Delphi matrix is complete, each alternative solution will have a value which will determine its suitability. The solution with the highest value will be chosen as the final design.

4.2 Criteria

Safety: Complies with Americans with Disabilities Act and school regulations.

Durability of Materials: Pathways/planters last more than 6 years, and plants are tougher than daylilies.

Aesthetics: More appealing than the previous landscaping.

Cost: Materials and plants are the lowest cost possible, and preferably donated. Combined materials are under $2000.

Environmental Justice: Materials should be sustainably produced and locally sourced to minimize their carbon footprint.

Ease of Construction: Must be constructible in 200 man-hours

4.3 List of Alternative Solutions

- Will You Be My Cementine?
- The Pepperoni Pizza
- The Pepperoni and Strawberry Pizza
- Mushroom and Sausage Pizza
- Mushroom and Spicy Sausage Pizza
- Mosaic Pathways
- Woodn't it be Nice

4.4 Decision Process

The decision process consisted of brainstorming alternative solutions, giving our criteria and constraints to the client, taking his feedback, and placing each criterion on a scale of 1-10, 10 being the most important. The weighted criteria are shown in table 4-1.

Table 4-1: Criteria and Respective Weights of Importance

Criterion	Weight 1-10
Safety	10
Hardiness/Durability of Materials	9
Aesthetics	7
Cost	6
Environmental Justification	4
Ease of Construction	8

A Delphi matrix was used to assess the ability of each alternative solution to meet the criteria. The scale used was 1-50, where 1 was associated with the design being extremely unlikely to meet the criterion, and 50 was used when the design was extremely likely to satisfy the criterion. The values for each design were added at the bottom of each column, with higher numbers signifying designs that were more likely to satisfy the design criteria. The completed Delphi matrix is shown in Table 4-2.

Table 4-2: Delphi Matrix

Criteria	Weight (0-10 High)	Alternative Solutions (0-50 High)					
		The Pepperoni Pizza	Pepperoni Strawberry Pizzza	Woodn't it be Nice	Will you be my Cementine?	Mushroom & Sausage Pizza	Mushroom & Spicy Sausage
Safety	**10**	35 / **350**	30 / **300**	40 / **400**	45 / **450**	35 / **350**	35 / **350**
Durability of Materials	**9**	45 / **405**	40 / **360**	25 / **225**	45 / **405**	45 / **405**	45 / **405**
Aesthetics	**7**	30 / **210**	35 / **245**	35 / **245**	30 / **210**	40 / **280**	45 / **315**
Cost	**6**	30 / **180**	28 / **168**	35 / **210**	35 / **210**	30 / **180**	30 / **180**
Environmental Justification	**4**	25 / **100**	30 / **120**	40 / **160**	30 / **120**	25 / **100**	25 / **100**
Ease of Construction	**8**	20 / **160**	15 / **120**	45 / **360**	15 / **120**	17 / **136**	15 / **120**
	Total	**1405**	**1313**	**1600**	**1515**	**1451**	**1470**

4.5 Final Decision

The design that scores the highest on the Delphi Chart is Woodn't It Be Nice. Woodn't It Be Nice scores second highest in the safety category behind Will You be my Cementine. The major safety concerns with the Woodn't it be Nice design involve splinters and issues that may arise when the planters begin to decay. This design receives its lowest score in the section of durability for the possibility of future decay. The cost for all the wood is $613.50. The cost for the soil is approximately $150. The cost for the plants is approximately $100. In total, the costs meet our criterion. With the weather in Humboldt County, it can be expected that there will be additional weathering. Overall, the Woodn't It Be Nice design scores a higher-middle score most of the time, but does not have any categories that it lacks in. In terms of simplicity, this design is easy to implement, and requires little maintenance. Our client determined that the watering of plants could be assigned to a class, which promotes student involvement. This design is environmentally friendly because it uses materials that are either compostable or reused.

4.6 Spring 2020 COVID-19 Decision Justification

The new project objective comes in two parts. Firstly, we will switch to full on design work utilizing AutoCAD to create a document that Zane staff can follow to recreate the Woodn't It Be Nice design at the Triangle of Death. Secondly, we will create three DIY Videos that are related to our prototyping process, the Woodn't It Be Nice design, and the other alternative landscaping.

5 Specification

5.1 Specification Introduction

Section Five describes in detail the landscaping plan and DIY videos that were sent to Zane Middle School. This section contains a final complete description of the design, along with instructions for implementation. Data on the costs, labor, and the projected costs for maintenance are included in this section as well. The results of the final project can be found at the end of this section.

5.2 Description

As described in Section 4.6, because of COVID-19, the solution to make a construction document for the “Woodn’t” and DIY videos was selected to be our final product. The construction document is a NUMBER page long document which has all the necessary components for any person to recreate what was in mind initially for the project. It includes dimensions, 3D-modeling, and required materials. The three DIY videos are “How to Make Mosaic Concrete Steps”, “How to Make Milk Carton Planters, and “How to Press Flowers”. These videos are for anyone who wants an entertaining project to do at home, especially during the pandemic.

5.3 AutoCAD Construction Document

AutoCAD designs were made that have measurements and give a layout of what the finished project would look like. The AutoCAD’s show all the dimensions of the finished project so Zane will know how to build it in the future. They take into consideration the angles and lengths of everything in the triangle, and account for the plastic sprinkler boxes. Notable measurements are the planter box height, which is eight inches, and the distance between the planters and the pathways, which is one foot. This height measurement is important because they keep the project on-budget, and this distance measurement is important because it allows for the grass to be properly watered and cut to keep it healthy. Examples of dimensions shown in the construction document are shown below in figure 5-1.

Figure 5-1:Planter Box 2 Specification

5.4 Planter Box High Caliber Prototype

The planter box is made to replicate the process that would have been taken to implement planter boxes in the Triangle of Death. This planter box is the shape of a rectangle and is made out of redwood, rather than cedar wood, due to limited resources under the circumstances. Treated wood was used rather than untreated wood for an increased lifespan, while also minimizing the utilization of other materials, such as plastic liners within the box. The planter box has a height one foot, a width of four feet, and a length of eight feet. To build the planter box, gathering materials and cutting them to size was the first step. Seen in figure 5-2, once the pieces were the correct length, they were attached using a drill and screws in figure 5-3. The planter boxes for Zane would be made of cedar wood and would be quadrilateral shapes that fit within the triangle and pathways. Despite the differences in shape and material, the process to make the final planters is similar if not the same.

Figure 5-2:Boards Cut to Length

Figure 5-3:Planter Box Put Together Ready to be Used

5.5 DIY Milk Carton Planter Box Tutorial

This section describes the creation, prototyping and final design implemented in creating the DIY Milk Carton Planter Box Tutorial. This tutorial was created so that students at Zane Middle School have educational activities during the COVID-19 lockdowns. This craft is meant to be easy and kid-friendly enough for middle schoolers to be engaged and entertained. This project is good for the lockdowns because it requires little to no money to complete and is made of things that are found around the house.

5.5.1 Milk Cartoon Planter Box Design

The materials that were used to create the milk carton planter are:

1. A milk Carton
2. A Box Cutter
3. String (Optional)
4. Wire Mesh (Optional)

5. Rope (Optional)
6. Potting Soil
7. Plants

The main inspiration for the design came from a Pinterest post which was easily modifiable and repeatable. The milk carton is the body of the planter box, and it has a large rectangular hole on one of the long sides (see figure 5-4). Holes are cut for drainage and the planter can be hung with rope or placed on a surface for decoration. For more information on the construction refer to the tutorial.

Figure 5-4:Finished Milk Carton Planter

5.5.2 Milk Carton Planter Box Prototyping

The first prototype of the Milk Carton Planter Box was not made of a soda can that had been cut to have an open top. It took a very short amount of time to realize that the project was not suitable for kids due to the sharp edges of the can and the risk of cuts from the tool. After research the milk carton was chosen as an easier and safer alternative to the can. Milk cartons are a good choice because most families have them in their houses, so they would not have to go to a store or spend money to complete this project. The first full prototype of this project was uploaded on YouTube, and after a week an improved version was uploaded, which included information about painting the milk carton. This information was collected through trials on how different paints stick to the waxy surface of the carton as shown in figure 5-5.

Figure 5-5:Swatches of Pain on a Wax Surface

5.5.3 Milk Carton Planter Box Video Creation

The process of creating this video consisted of a six-hour brainstorming, prototyping, filming, and editing session. After coming up with the general milk carton planter premise, the creation of the final product was filmed. The only recording device used was a smartphone camera. The filming process took up most of the total time. Extra-long footage of each step was recorded with fear that there would be a lack of material. A third party did most of the filming while one person did most of the construction. Because the design was well-planned, there were no issues with filming and building. After filming concluded, the video clips were compiled and trimmed. A voice over was written, recorded, and synced to the clips. All of it was then uploaded to the YouTube channel "Ella Moore" which is shown in figure 5-6.

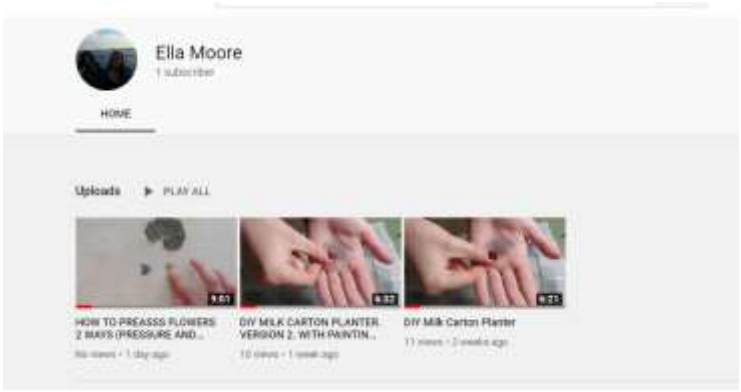

Figure 5-6:Ella Moore YouTube Channel

5.6 DIY Flower Pressing Tutorial

This section describes the design, prototyping, and creation of the flower pressing YouTube tutorial. This tutorial assists students at Zane Middle School in creating their own pressed flowers to keep them entertained during the COVID-19 quarantine. This tutorial was designed to get the kids out into the garden and encourages creativity. Many of the materials are very accessible to families, and many can be found around the home. Two flower pressing methods are explored in this tutorial, and many applications of the flowers are shown.

5.6.1 Flower Pressing Design

The materials that were used to create pressed flower include:

1. Flowers/leaves
2. Parchment Paper
3. Heavy Books
4. Iron
5. Ironing Board

The flower pressing methods are inspired from multiple websites and blogs about pressing flowers. Through prototyping, the methods were revised and refined. The most effective method is the book method. It includes putting flowers between pieces of parchment paper and putting them between the pages of a heavy book. Over 7-10 days, the pressure of the book will squeeze the flowers while drying and preserving them. The less effective method uses an iron to heat and flatten the flowers and leaves. Flowers can be fastened to multiple surfaces, including candles,

stationary, collages, and glass using Mod Podge. The video includes many examples of this which can be seen in figure 5-7, and some tips on picking what to apply flowers and leaves to.

Figure 5-7:Coffee Jar with Pressed Cloves

5.6.2 Flower Pressing Video Creation

The bulk of the video was filmed in one day, but filming was dispersed throughout a few weeks. Flower pressing with the book method took 7 days. When the filming phase finished, the editing process was started immediately and completed within a few hours. The tutorial was uploaded to the same YouTube channel as the milk carton tutorial.

5.7 DIY Mosaic Concrete Steps Tutorial

This section describes the creation, prototyping, and the final design that was implemented in creating the DIY Mosaic Concrete Step Video. This tutorial was created so that students at Zane middle School and others can have activities to do during the COVID-19 lock-down. This craft is meant to be easy and kid-friendly enough for middle schoolers to be engaged and entertained.

5.7.1 Mosaic Concrete Step Design

The materials that were used to create the Mosaic Concrete Step are:

1. Concrete Steps (pre-made)
2. Mortar
3. Acrylic Decorative Pieces
4. Newspaper
5. Mixing Shovel
6. Hand Shovel
7. Bucket

The main inspiration for the design came from the mosaics that are already at Zane Middle School. These steps embody the school spirit by bringing art and color to the campus. The steps are created by taking already-created concrete steps and then using mortar as an adhesive for acrylic decorative pieces. The pieces chosen for the video were red and gold to show Zane Middle School spirit, as their school colors are red and gold. The mortar is spread over the surface of the concrete, and then a design is created by placing the acrylic pieces in the mortar. After this the stone is set to dry for a day. If implemented at Zane middle school this project would have been an excellent opportunity for student involvement. This project leaves a lot of space for creativity, which is why it's excellent for Middle schoolers.

Figure 5-8:Mosaic Steppingstone Complete

5.7.2 Mosaic Concrete Step Prototyping

Prototyping for the mosaic step included prototyping for color and design of the mosaic that should be made in the video. This was done to ensure the video ended up being more interesting and relate it to Zane Middle School with the red and gold color scheme.

5.7.3 Mosaic Concrete Step Video Creation

The entire video was filmed over 2 days, the first day involved the recording of the construction of the steps and the second day involved the recording of the outcome after a day of curing. When the filming was finished, the editing did not begin for a few days afterward but was then finished editing in one day in a few hours. The tutorial was then uploaded to the same YouTube channel as the other tutorials.

5.8 Cost Analysis

This section provides a cost analysis of designing and implementing the construction document and DIY videos. The final cost represents the total time spent researching and designing the document and the videos and prototyping the designs.

5.8.1 Design Cost

The design costs indicate the number of hours that The Cowboys of the Seasons put into this design project. A total of 207 hours was spent on this design project. Most of the design hours were spent in the design and prototyping sections as the final project had no real physical form. Figure 5-9 represents the distribution of hours that went into this project.

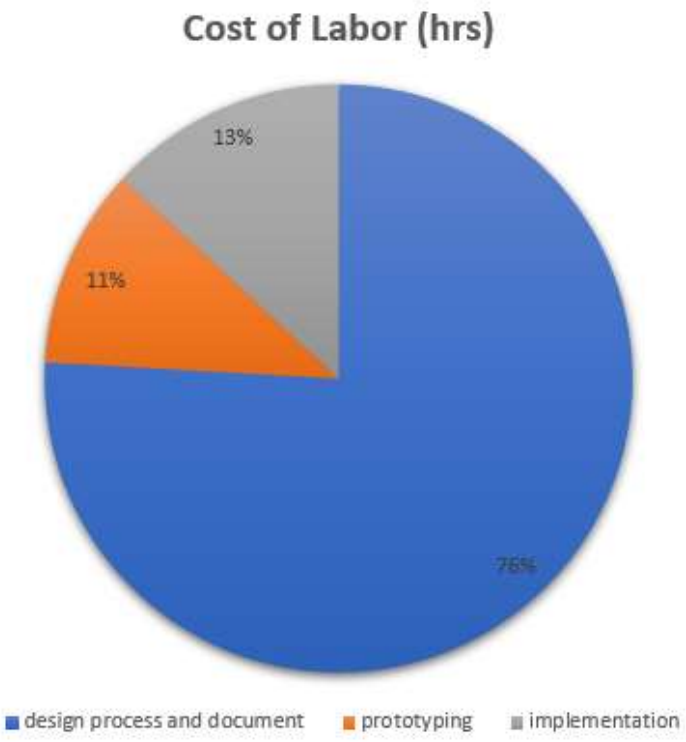

Figure 5-9:Pie Chart of Time Spent on Sections of Project (total hours 207)

5.8.2 Materials Cost

Table 5-1 indicates the costs of materials used in the creation of the DIY Videos and Planter Box Prototype. The total amount spent to construct the project was $147.20. Theoretical cost for the construction document is also included in table 5-2, the total theoretical cost for the construction of the landscape is $1093.56.

Table 5-1:Cost of Creating DIY Videos and Planter Box Prototype

PROJECT COSTS			
Amount	Name	Cost	Total
Mural Stepping Stones			
2	Decorative gems	$ 12.99	$ 25.98
1	Rectangular stepping stone	$ 6.13	$ 6.13
1	Moratr Mix	$ 6.93	$ 6.93
Cost Of Mural Stepping Stones Project:			$ 39.04
Pressed Flowers			
1	Mod Podge	$ 7.99	$ 7.99
Cost of Pressing Flowers Project:			$ 7.99
Wooden Planter Boxes			
6	8 foot long cedar boards	$ 12.37	$ 74.22
1	10 foot long 4x4	$ 15.98	$ 15.98
1	Package of screws	$ 9.97	$ 9.97
Cost of Wooden Planter Boxes Project:			$ 100.17
Total			
			$ 147.20

Table 5-2:Cost of Implementation of Landscape Design (theoretical)

Cost of Materials for Construction of Landscape Design			
Item	Units	Cost/Unit	Cost
2x4x8 Cedar Wood	42	$ 8.18	$ 343.56
Used Potting Soil (square yrd)	5	$ 25.00	$ 125.00
Sod Grass (square foot)	250	$ 0.62	$ 155.00
Sword Fern	10	$ 15.00	$ 150.00
Encore Azalea	8	$ 40.00	$ 320.00
3" Screws (lb box)	2	$ 8.97	$ 17.94
	Total Cost	$	1,093.56

5.9 Results

Although a physical project at Zane Middle School was never executed, a copy of the design document will be sent to Trevor Hammons in hopes someone from the school will complete it. If Zane is not able to construct our design, the next Engineering 215 group will also have access to our documents. Also, the tutorials are available to the public on the Cowboys of the Season YouTube channel, and will be sent to Zane families in hopes of educating and bringing joy to the Zane students during this pandemic.

Appendix A

Brainstorming

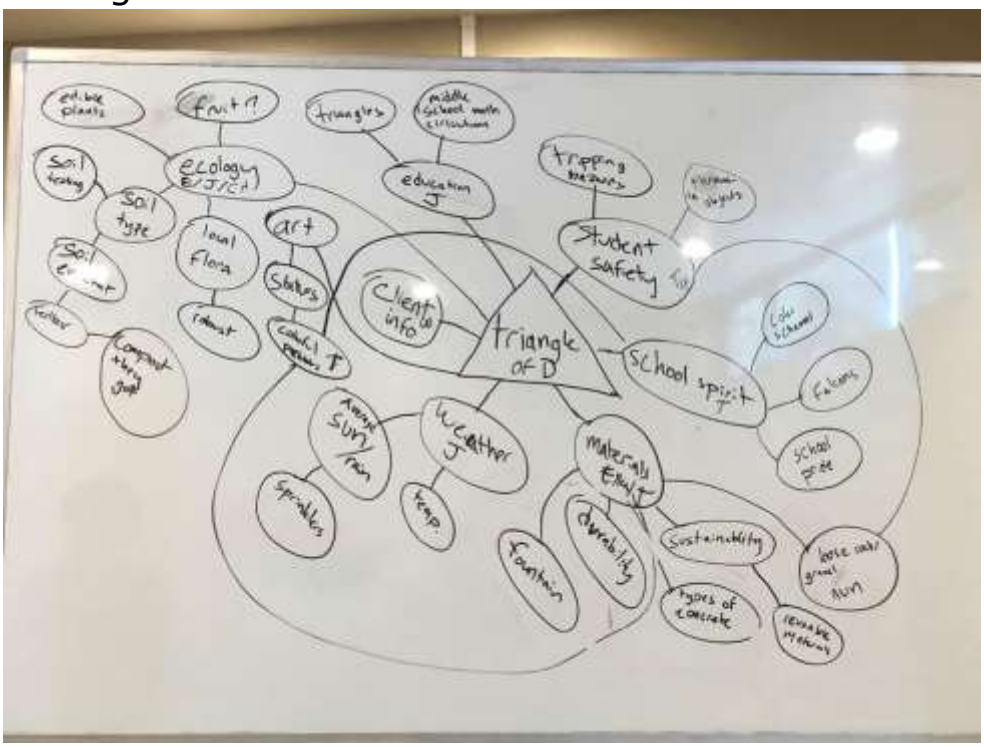

Figure A-1:Literature Review Brainstorming Results

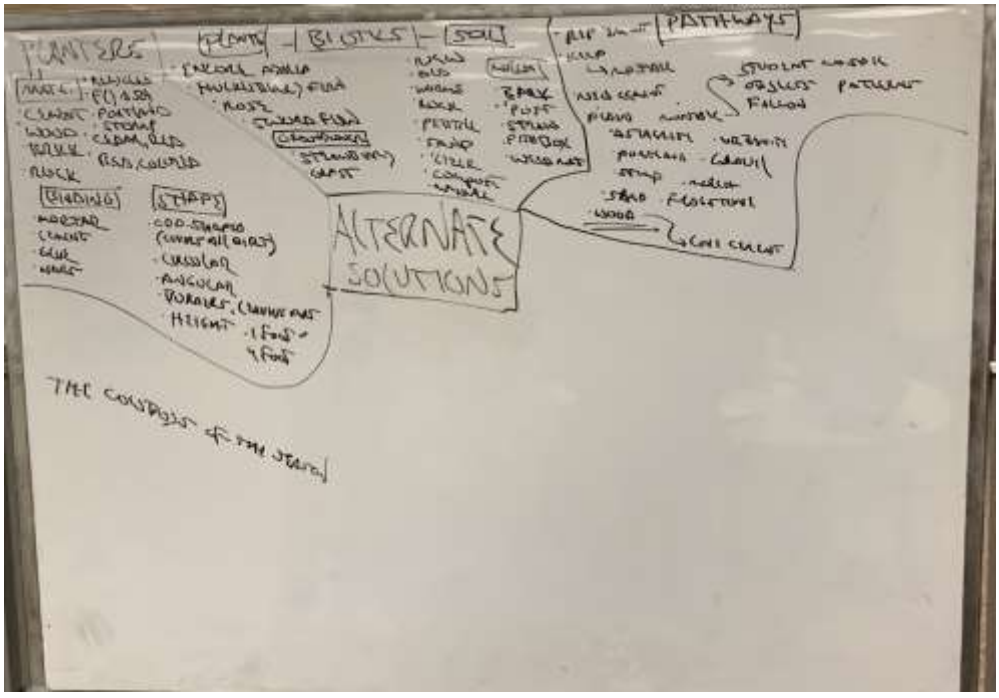

Figure A-2:Alternative Solutions Brainstorming of Overall Materials

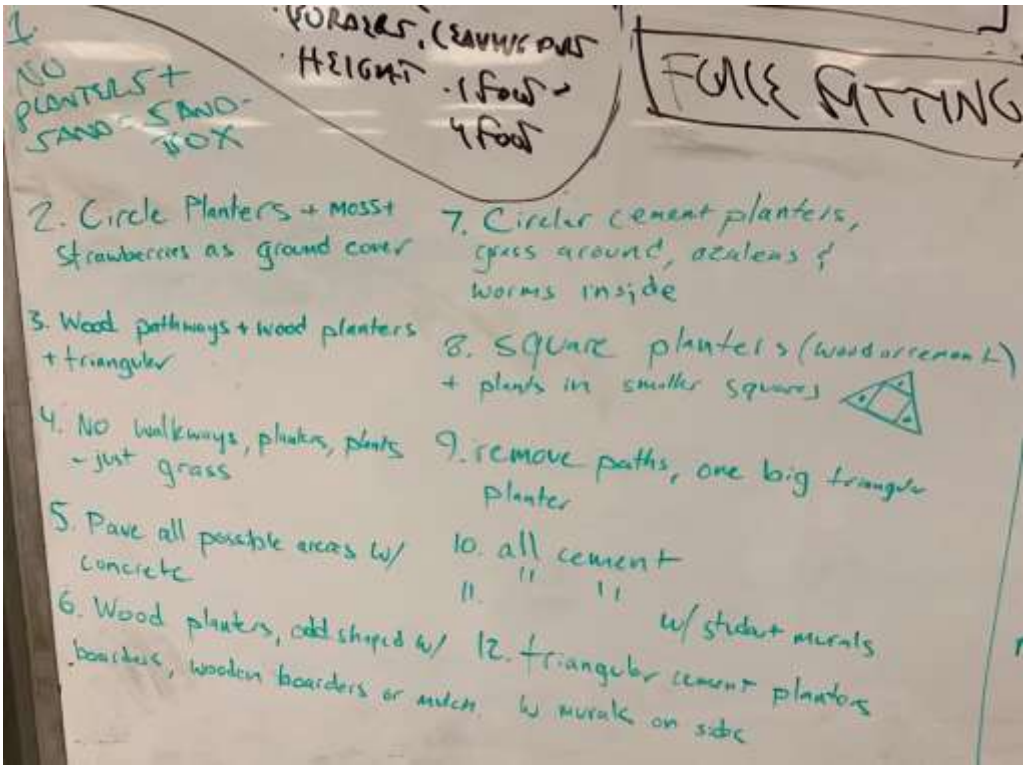

Figure A-3:Alternative Solutions Material Combinations and Designs

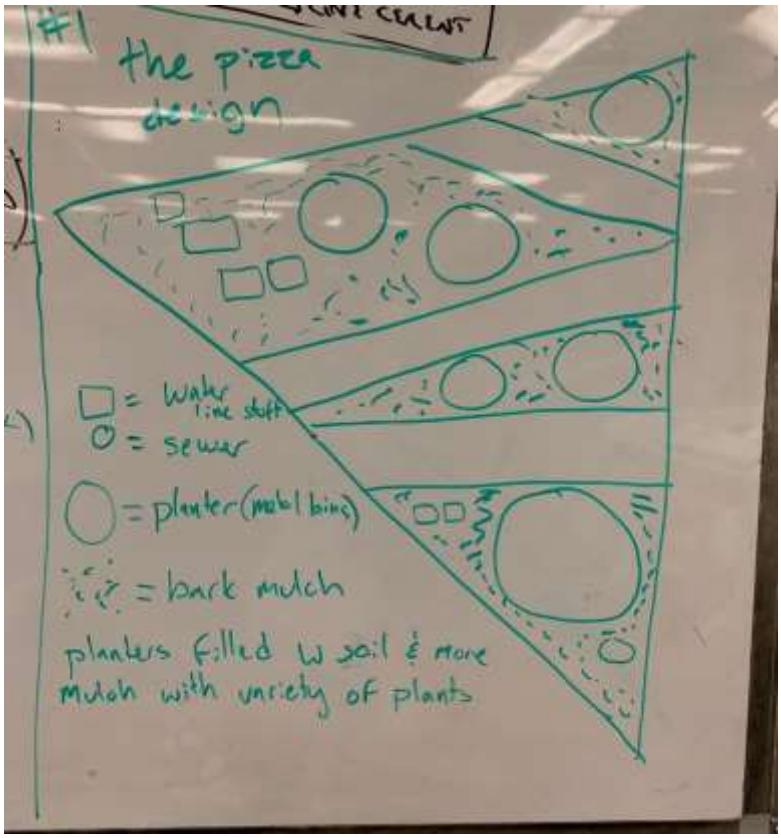

Figure A-4:Alternative Pizza Design Brainstorm Drawing

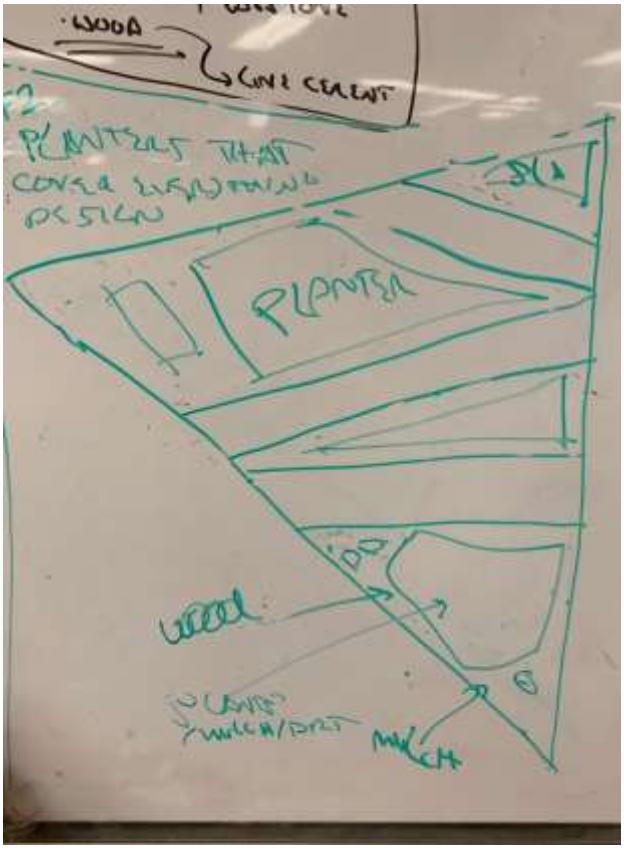

Figure A-5: Alternative Planter Cover Everything Brainstorm Drawing

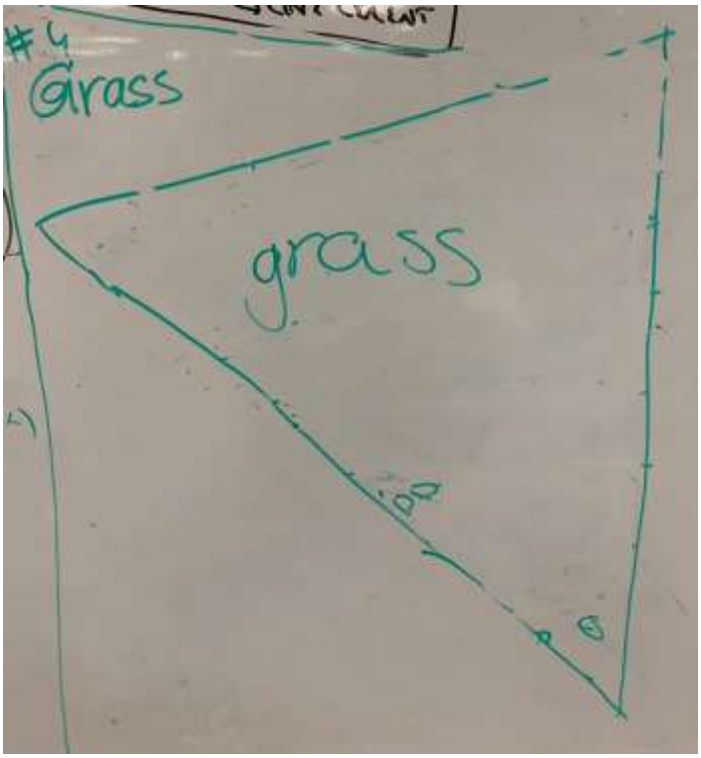

Figure A-6: Alternative Grass Brainstorm Drawing

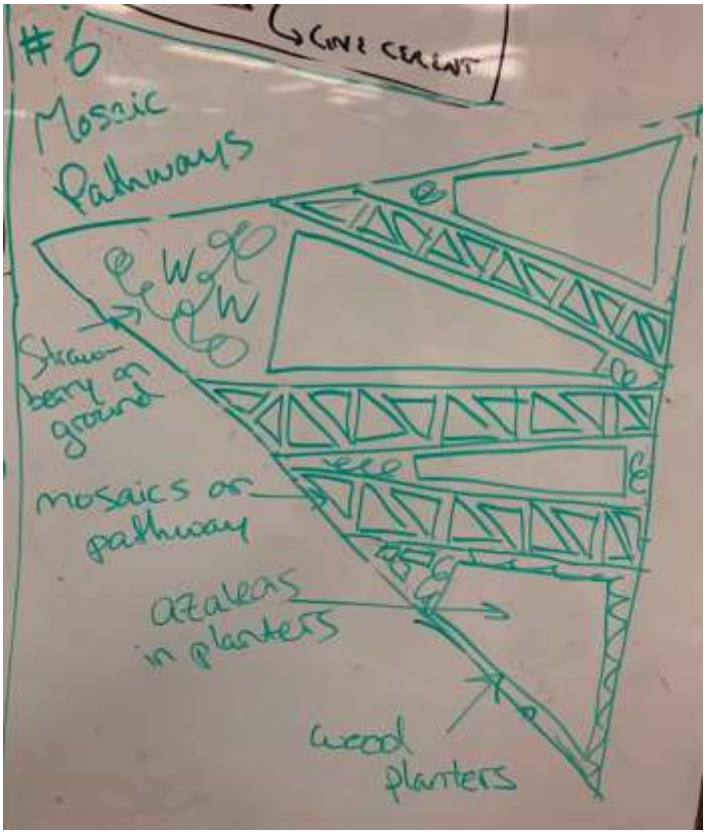

Figure A-7: Alternative Mosaic Pathways Brainstorm Drawing

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