

The Green Dream Team

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1 Problem Formulation

Zane Middle School has both a large rectangular and triangular area filled with mulch that is right in front of the school. These two mulch filled sections are separate from one another, but both are seen while directly looking at the school.

1.1 Introduction

Section I of this document gives an overview of the background of the site and information that leads to how the objective is created.

1.2 Background

The Green Dream Team chose the groundwork project for the 2017 Spring semester of Engineering 215 intro to design at Humboldt State University, instructed by Lonny Grafman. Humboldt State University and Zane Middle School have had a partnership for the last five years in which students from the class collaborate to solve a problem at the middle school. Therefore, Zane Middle School is the client of this project. The two areas mentioned in the Problem Formulation are areas that will be discussed in this document. Trevor Hammons is the client representative, whom assigned those two sections to the team. These two sections are plain and just have a few plants added to them. The client representative asked for The Green Dream Team to find a way to beautify these sections and create a sense of order to it.

1.3 Objective

The objective of this project is to design a pathway constructed of individual concrete stepping stones and add biotic element to establish a designated walkway while also making it aesthetically pleasing. Incorporated into the stepping stones will be a design of a tessellated falcon, which is the mascot of the middle school, in order to include school spirit and educational value for the students at Zane Middle School.

1.4 Black Box Diagram

Input: Dull mulch area with few plants

Output: designated areas to walk through sections with biotic appeal

Given problem

Figure 1: Black Box Diagram

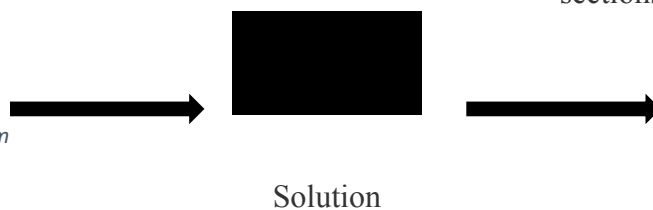


Figure 2: Black Box Diagram

2 Problem Analysis and Literature Review

2.1 Introduction to the Problem Analysis

Section II of this document goes over each criterion from the client and the constraints that go in hand with each of them. Specifications along with considerations, usage, and production will be described in this section.

2.1.1 Criteria and Constraints

Criteria	Constraints
Aesthetics	This must exceed the permeable path created the previous year, which ended up leading to the breaking of the path, leading to the gravel being spread out. This pathway is expected to be uniform and held in place.
Ease of maintenance	The only maintenance that should be needed, is that of the sprinklers which are already set automatically.
Ease of navigation	Meets or exceeds the current state as a dirt lot: both in terms of the difficulties of mud in the wet seasons and as well as the prevention of child stagnation
Safety	Meets or exceeds current government regulations by ensuring that a tripping hazard is kept in mind so that while students walk across, they do not get hurt.
Level of sustainability	This must exceed the current amount of biotic life, in order to create a more environmental aspect into the two areas.
Durability	lasts indefinitely without any major maintenance or replacements/fixes
Educational Value	Exceeds projects that promote sustainable design and incorporates a topic that could be used in lesson plans for the students
Level of Inspiration	Exceeds or meets projects that promote sustainable design, but also include more directed school pride

Figure 3: Criteria/Constraints

2.1.2 Specifications

The specifications for this project are qualities that should be taken into account during the design process. Specifications such as: Plants that are to be incorporated can be no more than 3-3.5 feet high, bench structures should allow the visibility of people sitting from every angle, and the current mulch groundcover is to be replaced by grass.

General Site

- (a) Ten feet on one side of the rectangle, the site location, has been paved.
- (b) Inside of the paved section, on both ends – approximately nineteen feet (19.0333') has been reserved for the other grounds work team, resulting in a total of approximately 38 feet in reservation (38.0666'). The site within the rectangle that has been designated to the ward of the Green Dream Team is assumed to be seventy feet in length.
- (c) Therefore, the site location that is being built upon has assumed measurements of seventy feet in length.

These dimensional assumptions are merely for the sake of the validity of the alternative solutions and can be modified at a later date upon further conference with the client and other grounds work teams.

2.1.3 Considerations

Considerations that need to be recognized for this project are the toxicity and chemicals that are incorporated in the materials being used, omitting the use of wood due to students potentially carving into the wood, and native plants being implemented for educational purposes.

2.1.4 Usage

This area of land will be used to improve the aesthetic value of the school. In order to do so, native plants and pathways will be placed. Not only would this help beautify the school but also inspire the students with educational and school spirit value. This area is expected to last for a long period of time so there should be an ease of navigation and be maintainable.

2.1.5 Production

Production includes over 30 stepping stones for one site facility.

2.2 Literature Review

Introduction to the Literature Review

Components of what will be incorporated into the sections are contained in this literature review. A variety of research from a multitude of sources are within this section and include the information of ways to make pathways, the ergonomics of benches, and native planting.

2.2.1 Materials

The current materials found within schoolyard design, such as plastics, concrete, rubbers, and asphalt, have become incorporated due to the fact that they are dependable, affordable, and easily produced on a mass scale (Danks p.101).

1. *Concrete*

In taking into account factors of longevity and durability within concrete bench construction, supports should be considered. Supports that are wooden and within soil, to maintain the stability of the concrete bench, need to be treated to prevent rot and decay (Ostrovsky). However, these chemicals, especially those found in pressure-treated wood, are extremely dangerous for designs meant for school yards. The preservatives within the wood are hazardous when it comes to human contact and therefore child interaction with them in particular (Danks p. 103)

Concrete is an immensely prevalent material within the global waste stream, as it is affordable, sturdy and requires minimal upkeep post-installation (Danks p. 101). Despite this it requires immense resource to produce on such a scale as it currently is and is quite harmful to the environment. It's manufacture results in substantial emissions of carbon dioxide (Danks p. 114).

There are many factors to consider when incorporating concrete into landscape or bench design. These factors are dependable upon the conditions of the site, such as climate and other such matters related to location. Porous concrete could be considered if the region received large amounts of annual precipitation. This type of concrete allows for proper flow of water and

prevents stagnation or pooling as a result of rainfall. This is due to the fact that no fine aggregate, or sand, is mixed in with the concrete prior to the introduction of the mix to the site. Porous concrete, additionally, can withstand great amounts of pressure and force when it is appropriately mixed (Schnelle).

The mixing of concrete is a critical process that, if performed incorrectly, may lead to segregation of the concrete. This segregation lessens the integrity of the material, therefore decreasing the lifespan of the design and posing risks to those that use and interact with the final design. Refer to figure 1.1 for a visual reference of the segregation of concrete (“Integrated Materials...”). The mix can be comprised of different materials and some researchers have explored alternatives to the fine aggregates generally found within concrete mixtures, generally sand. Using alternatives to sand within the mix is a useful method of the mitigation of environmental pollution. These alternatives, such as plastics, glass, and fiberglass, are materials that are substantially prevalent within the global waste stream. It has been proven that the use of glass as an alternative to the fine aggregate of sand within concrete mixes does not harm the structural integrity of the final product (“The Use of Solid Waste Materials...”). Concrete is the most common building material found upon the planet and the incorporation of sustainable thought into its composition is a method that is growing increasingly popular.



Figure 4: Segregation of Concrete (“Integrated Materials...”)

An important factor to take into account during the mixing process of concrete production is that of water ratios. Oversaturation may result in shrinkage of the end result. Refer

to figure 1.2 for a visual of this shrinkage in terms of the water concentration's relation to the eventual shrinkage (“Integrated Materials...”).

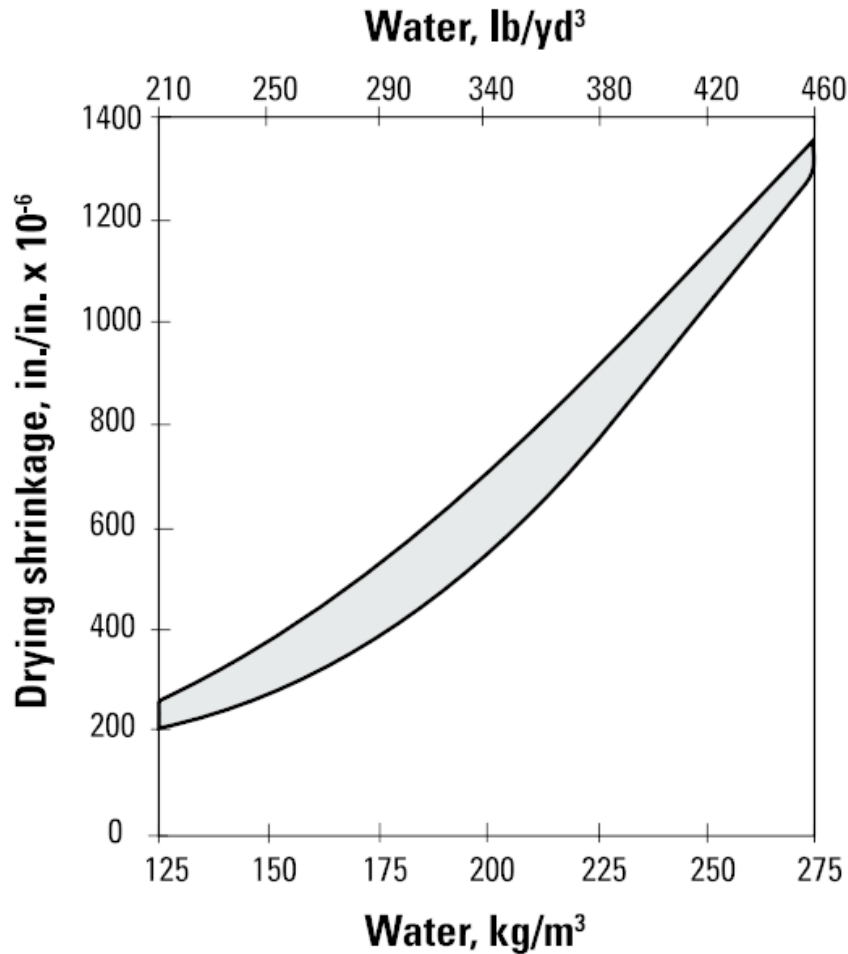


Figure 5: Relationship between water saturation in concrete mixes to the shrinkage of the concrete (“Integrated Materials...”)

2.2.2 Wood

In searching for alternatives to chemically treated wood, due to its hazardous nature, redwood and cedar are viable options. These types of wood are adapted to their environments in order to be resistant to forms of rot (Danks p.103). Additionally, salvaged woods could be considered for design incorporation. Wood that has been freshly cut typically has a looser grain than older, salvaged wood. The repurposing of such materials would therefore be beneficial to a design that values durability of the finished product. Salvaged wood should be obtained in such a way that chemical treatments are avoided. Wood from telephone poles and railroads are sources of salvaged wood to avoid, as they are treated heavily. Furthermore, plywood tends to be processed with preservatives such as formaldehyde (Danks p.103). This prevents decay and increases longevity of the product, but should be avoided in design that encourages human design and proximity.

The figure below is an example of the incorporation of salvaged wood into schoolyard landscape to promote sustainable design. It is of a bench design at the Rosa Parks School, located

in Berkeley, California. The design was featured in Sharon Gamson Danks' "Asphalt to Ecosystems: Design Ideas for Schoolyard Transformation".



Figure 6: Wooden Bench Design at Rosa Parks School in Berkeley, California (Danks)

2.2.3 Metal

Metal is a material that is valued for its longevity and resistance to wear. Despite the increased cost of both the substance and its installation, relative to concrete and other such solutions, or, in some cases, stone, it would generally be a more financially viable option. This is due to the fact that it requires less upkeep than alternatives such as wood or clay-based solutions (Schnelle). Its incorporation into bench design, either as the sole material put to use within the assembly or use as structural supports, could be financially beneficial to the client and/or engineer.

The figure below gives an example of a repurposed metal design that the Montgomery High School of the city of San Diego utilized to promote the education of its students. This education was achieved through the native plants incorporated into the design and the art and metal work that the students managed (Danks). The fences surrounding the garden are made from repurposed metal. The design of the fences was synthesized by students of the San Diego high school and was cut within their classes.



Figure 7: Example of Repurposed Metal Design (Danks)

2.2.4 Bamboo

Bamboo is a material that grows relatively quickly within its natural habitat and is thus a renewable resource (Danks). It is suited for a wide variety of climates and can withstand numerous circumstances pertaining to weather. It is desirable within construction due to its durability and renewability. It is a sturdy material that

2.2.5 Rammed Earth

Rammed Earth is a method of construction that involves the mixing of sand and/or soil into concrete compositions, resulting in a product that is then forcibly molded into the designer's desired shape. The end result is a solid form that has structural integrity and holds up under decent amounts of pressure. This method of construction is desirable because it is natural and can withstand weathering (Danks).

2.2.6 Stone

Stone is a greatly prevalent material that is utilized in landscaping due to the durability and longevity of the substance. Many landscape designs incorporate repurposed stone in order to promote sustainability. Due to the fact that the material is quite dense and heavy, a substantial amount of energy, generally in the form of fossil fuels, is required for its transportation to

construction sites or distributors. It's use in construction is therefore responsible for substantial pollution and toxic emissions (Danks p.111).



Figure 8: Lorenskog Steiner School in Oslo Norway – Wall of Stone with Water Design that Leads to Fountain (Danks)

2.2.7 Wattle and Daub

Wattle and Daub is a method of construction that utilizes interlaced pieces of wood as a frame for supports. The name ‘daub’ refers to the mix that encases the interlaced pieces of wood and seeps into crevices, providing insulation and leaving little room for defects. The mixture typically is comprised of biotic materials such as animal excrement and soil. It may also contain sand and fibers.

2.2.8 Cob

Cob is a very tactile and adherent mixture that is composed of straw, sand, and clay. Forms and structures are constructed from it typically by the addition of the material by hand, essentially forming mounds out of the building material. The properties of the composition change depending upon the ratios of the fundamental materials of cob. Increasing the amount of sand within the mixture, relative to the ratios of the other, aforementioned, materials, will increase the density and therefore the weight of the material as well. Addition of straw improves the insulation of the final product (Danks p. 109).

2.2.9 Earthbag

Earthbag is a method of construction that involves filled sand bags and the placement of the sandbags in such a way that they are sturdily set. After they are set, they are kept in place by metal attachments such as rebar and wire. Sometimes builders and construction workers utilize methods of deterioration-prevention such as a coating of concrete over the chicken wire that is wrapped around the sandbags. This can inhibit weathering from the elements and human interference(Danks). Laurel Tree Charter School utilized such a material in the construction of one of their benches in the collection entitled “Three Scoops Three Flavors Benches” (Laurel Tree...).



Figure 9 Three Scoops Three Flavors Benches at Laurel Tree Charter School – Earthbag, Urbanite, and Ecoladrillo (“Laurel Tree Charter Schools...”)

2.2.10 Ergonomics of Benches

1. *Supports*

Bench supports can be made of varying materials such as certain types of metals or wood as the most common solution to support design. Benches can be made entirely of one material, such as concrete, without factoring in supports. This works relatively well and can contribute to simplicity of the design and therefore decrease potential financial expense in relation to the construction of benches. It is important to understand the properties of the supports – in terms of decay

The figure below, ‘Image of Basic Bench Structure’, shows braces and joints of a simple construction. The brace stretches diagonally within the internal section of the construction. The joints used at the corners of the bench are ‘lap joints’. As the figure shows, lap joints are an interlocking design that increases stability of the bench.

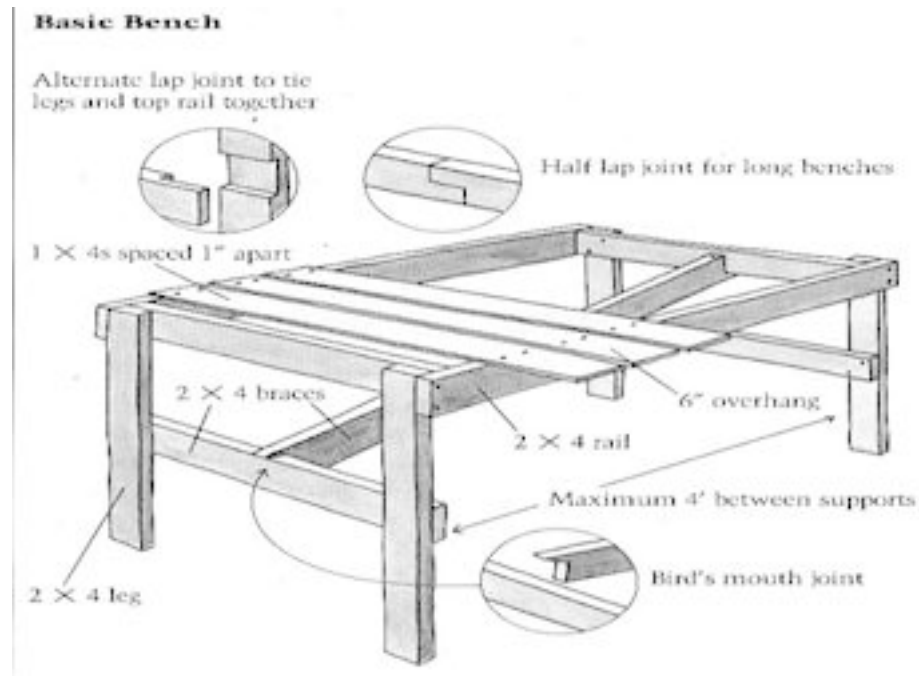


Figure 10 Image of Basic Bench Structure (Ostrovsky)

2.2.11 Permeable ground covering

Permeable pavements allow for water to go through the pavement by holes which are connected in the substance. These pavements are made up of a variety of different components. Permeability is the measurement of how much water seeps through a substance (“Chapter 4 Permeability,” 2000). This is ideal for an environment with high levels of rainfall due to the fact that it soaks through, leaving a dry surface and not creating puddles (“Guidance on the permeable surfacing of front gardens,” 2008). A benefit from using permeable pavement is that the water going through the holes infiltrating into the native soil, reduces and filters stormwater before reaching other bodies of water (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”).

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2.2.12 Structure

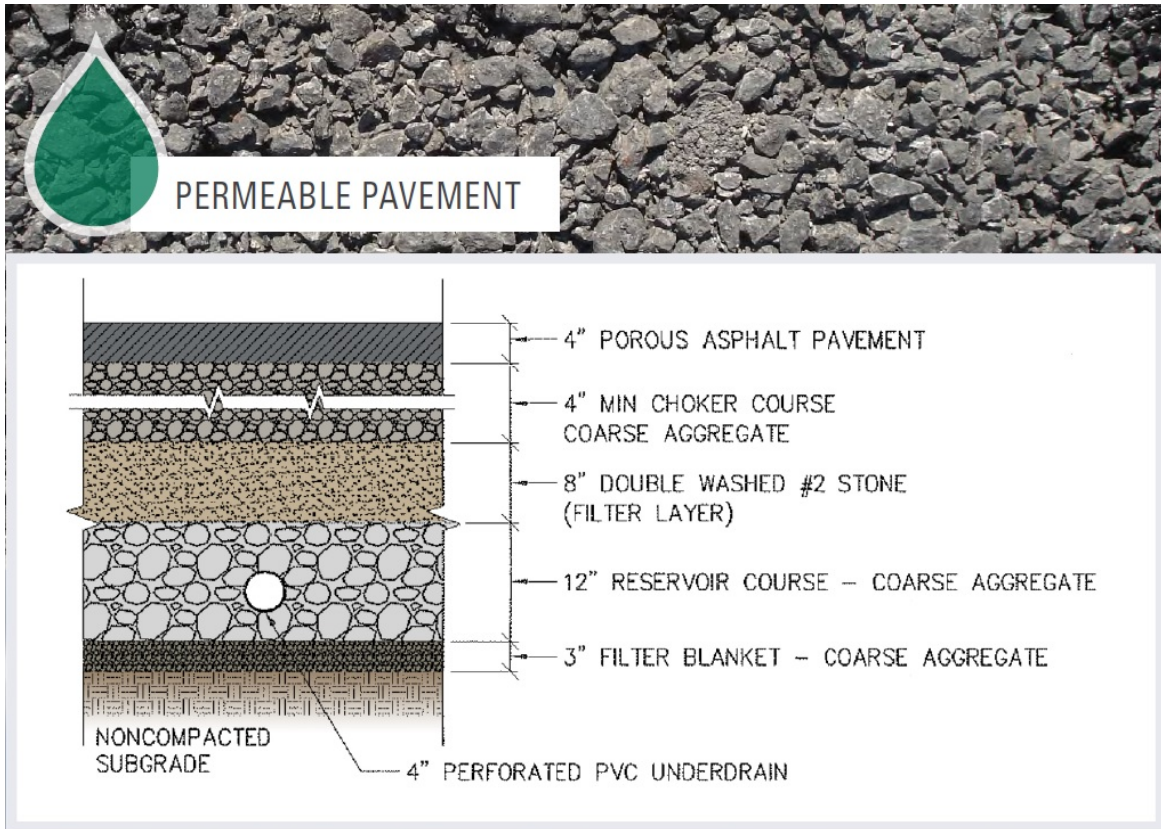


Figure 11: Example of pavement having asphalt as the surface layer with its subsections
<https://sites.newpaltz.edu/sustainability/view-programs-and-progress/green-infrastructure/permeable-pavement-parking-lot/>

1. Surface Layer

The surface layer, also known as the cover, is the top layer in permeable pavement. The surface layer is the one that is visible and allows the identification of the type of pavement used (“Permeable Pavement: Research Update and Design Implications,” 2006). The top layer is the determinant of what the name of the pavement is, as seen in Figure 9 which has the top layer as asphalt, therefore that component being the identifying factor of the pavement. Some types of permeable materials used at the top layer include porous concrete, asphalt, and pavers (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”). Depending on what is wanted for the pavement, the top layer consists of different options and can alternate what is included in its mix. (“Permeable Pavement: Research Update and Design Implications,” 2006). The top layer is the determinant of what the name of the pavement is, as seen in Figure 9 which has the top layer as asphalt, therefore that component being the identifying factor of the pavement. Some types of permeable materials used at the top layer include porous concrete, asphalt, and pavers (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”). Depending on what is wanted for the pavement, the top layer consists of different options and can alternate what is included in its mix.

2. Gravel/Aggregate Base

The gravel or aggregate base, is the one that is right beneath the surface layer. The gravel base is also referred to as the bedding or “choker” source. Aggregates are small grainy material such as

sand and gravel (“Aggregates”, 2017). The pieces of gravel are small and are compact as can be seen in the choker source in Figure 9. Shape of this layer matters because it affects the way the water flows through. In this level small pieces are not meant for the storage aspect of the section (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”, 2006). An example of what is meant by the meaning of the shape is that if the aggregates are rough, long and sharp shaped, then those particles need more water “to produce workable concrete (“Aggregates,” 2017) .” Providing stability for the top and allowing for a level surface is the purpose of this layer (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”, 2006). All permeable pavements except for concrete need this layer when it comes to supporting vehicles. Although sometimes the gravel base is not needed in permeable concrete structures, it can still be added to allow more storing of the rainfall water (“Permeable Pavement: Research Update and Design Implications”, 2006). Overall this section creates a sturdier leveled layer for the top surface and contributes to how the water transmits through the top through the bottom. 2006). An example of what is meant by the meaning of the shape is that if the aggregates are rough, long and sharp shaped, then those particles need more water “to produce workable concrete (“Aggregates,” 2017) .” Providing stability for the top and allowing for a level surface is the purpose of this layer (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”, 2006). All permeable pavements except for concrete need this layer when it comes to supporting vehicles. Although sometimes the gravel base is not needed in permeable concrete structures, it can still be added to allow more storing of the rainfall water (“Permeable Pavement: Research Update and Design Implications”, 2006). Overall this section creates a sturdier leveled layer for the top surface and contributes to how the water transmits through the top through the bottom.

3. Reservoir Layer

The reservoir layer is either made up of larger pieces of gravel or aggregates compared to that of the previous layer. The purpose of this layer is to create gaps large enough to create storage for the rainwater that falls and structural support with each piece (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”, 2006). Opposed to the choker source, which consists of finer and smaller pieces, Figure 9 displays how the reservoir layer has larger pieces. The cleanliness for this layer and the one above this layer are very important because they could contain harmful substances such as absorbed chemicals that would degrade the state of the permeable pavement being used (“Aggregates,” 2017). The existing soil subgrade permeability distinguishes how thick the reservoir should be (Eisenberg, Bethany, Lindow, Kelly Collins, Smith, David R., 13), this layer and the one above this layer are very important because they could contain harmful substances such as absorbed chemicals that would degrade the state of the permeable pavement being used (“Aggregates,” 2017). The existing soil subgrade permeability distinguishes how thick the reservoir should be (Eisenberg, Bethany, Lindow, Kelly Collins, Smith, David R., 13),

4. Sub-Base

The sub-base consist of “exposed native sub-soil” that is right below the reservoir layer (“Article: Permeable Pavements - Reduce Runoff thru Pervious Layers”, 2006). This is the soil in which the water infiltrates through. Pouring water over a permeable subbase will soak more quickly and in a smaller area compared to how impermeable hardcore spreads over the surface (Guidance on the permeable surfacing of front gardens, 2008).

5. *Underdrains*

Underdrains are located at the bottom of the sub-base in order to collect the stormwater and bring it to the sewer (“Permeable Pavement: Research Update and Design Implications”, 2006). Their location is important because the bottom is where all of the water from rainfall eventually goes after passing through each component in the levels of the structure of permeable pavements.

Another reason for the specification to the placement of underdrains is that their impermeability is beneficial at that spot because it prevents the water to seep into other soils, which may be contaminated(Eisenberg, Bethany, Lindow, Kelly Collins, Smith, David R., 13).stormwater and bring it to the sewer (“Permeable Pavement: Research Update and Design Implications”, 2006). Their location is important because the bottom is where all of the water from rainfall eventually goes after passing through each component in the levels of the structure of permeable pavements. Another reason for the specification to the placement of underdrains is that their impermeability is beneficial at that spot because it prevents the water to seep into other soils, which may be contaminated(Eisenberg, Bethany, Lindow, Kelly Collins, Smith, David R., 13).

6. *Ground cover*

Plants that spread across the ground but that don't grow tall. This makes it a maintainable lawn alternative that requires no cutting. These ground alternatives are typically chosen for its aesthetic value such as texture, density, and the choking of weeds. This is beneficial to the soil in the sense that it acts as a mulch. Typically, groundcover lawns require a lot maintenance the first year, but once established, they need little attention. maintenance the first year, but once established, they need little attention.



Figure 12: (RealTimes)

7. *Mulch*

This matter benefits plants by reducing moisture loss through evaporation. Different types of mulch are used for different purposes. For example, mulch that consists of bark are greatly used around trees, shrubs, and other garden beds. This type of mulch consists of large woody pieces which doesn't mix too well with soil; however, it does last longer than finer organic mulch. Another type of mulch is one that consists compost and compost manure. This mulch can essentially be used anywhere as long as it is well composted and weed free. There are many other organic matters that can be incorporated such as grass clippings, newspaper, shredded leaves, and straw.



Figure 13 Different types of Mulch (Mulch Makes a Difference)

8. *Grass*

Grass is the most common type of lawn coverage. It consists of short plants that long narrow leaves that inhabits large areas. There are multiple components that need to be taken into account when maintaining a grass lawn. Components such as the soil, fertilizer, water, seeds, air, etc. -Soil:

Preparing your soil is key. Banishing weeds and making sure the soil won't crust over or compact into lumps. Testing the pH of the soil is also incredibly important. Soil pH consists of the measurement of acidity and alkalinity in soils. An online source states, "The optimal pH range for most plants is between 5.5 and 7.0; however, many plants have adapted to thrive at pH values outside this range" (Soil pH 1). Once tested, its best to get rid of any weeds and rototill to a certain depth that allows one to improve drainage. Adding loam is the best type of soil to use when planting. Loam is a soil that consists of equal portions of clay, sand, and silt.

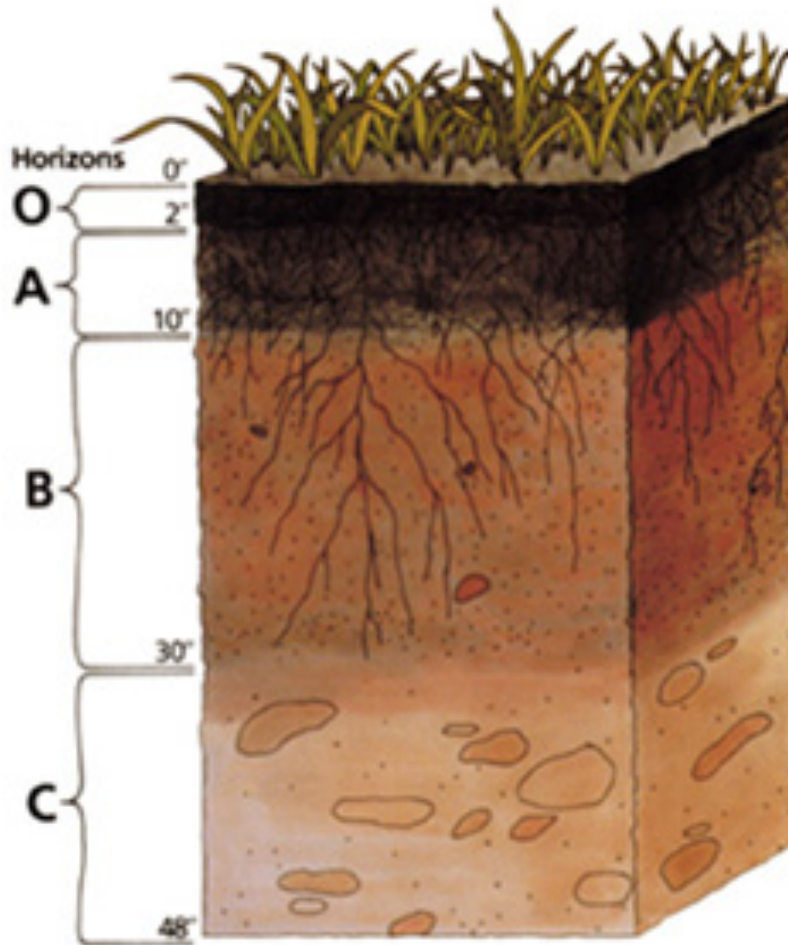


Figure 14 Soil Profile (Natural Resources Conservation Service Soils)

Fertilizer:

It is recommended to use fertilizer about twice a year, during spring and fall. An expert says, “beware the common N-P-K (nitrogen-phosphate-potassium) fertilizers popular with most gardeners, says Gary; they don't provide everything your hungry grass needs. Instead, he recommends a complete fertilizer that includes micronutrients such as sulfur, copper and iron” (Haiken 1). Depending on the location, adding these different minerals may not be necessary, which is another reason why it is important to test the soil's pH.

-Water:

Watering the grass is massively important, but too much water can also be harming. Watering about once a week and watering deep into the roots is ideal. Watering deep can also prevent pesticides. Certain bugs that attach to dried out lawns and with the use of deep watering, minimizes the amount of these bugs. Also depending on the type of soil determines the amount of water that is needed. Different soils tend to dry out quicker than others. For example, sand based soils compared to clay based require more water due to the porous characteristics.

-Air:

Aeration is important in the sense that there needs to be a circulation of oxygen in order for the nutrients to penetrate properly. Poking holes in the lawn is a way for this to occur. This way, the

air, water, and nutrients run through the soil and into the roots and grow deeply to produce a stronger lawn.

9. *Concrete*

The most basic ingredient for concrete would be Portland cement which is a synthetic inorganic polymer. It is the most common, most widely used, and least expensive. The insoluble atoms that are present in the mixture allows it to harden. The way in which concrete is handled should be carefully conducted. An article states, "Concrete should not be deposited more rapidly than it can be spread, struck off, consolidated, and bull floated and deposited continuously as near as possible to its final position" (Placing and Finishing 1). With that said, concrete is a sensitive component that requires a lot of start up, but little to no maintenance once it is placed.

2.2.13 Environmental Gardening

This is the process where one desires to create a setting that appeals to the eye and provides a recreational area for others. Environmental gardening helps save native plants and encourages native ecosystems by removing invasive species that destroy those native species.

When planning an environmental garden, one should designate the piece of land that will be used and it is important to take the amount of abuse the planting will take into account. It is important to visualize the garden and try to make those images real. This type of gardening could be beneficial because it encourages the idea of sustainability by going about certain situations in a "greener" manner. For example, instead of profusely watering the garden, in an area that does not receive a lot of precipitation, it would be best to plant a species that does well in dry areas with little to no water. Another example would be instead of using chemicals to get rid of pesticides, environmental gardeners would use a natural component to rid of species such as covering the plant with plastic to prevent bugs from eating them or putting a species of bugs to eat the invasive bug but not the plant.

Overall, environmental gardening is the process where gardeners work with the environment and attempt to establish a sustainable ecosystem. This leads to the enactment of native species and the removal of invasive species. This also reinforces the idea of composting and recycling as well as taking care of wildlife such as native birds, butterflies, reptiles, etc.

3 Search for Alternative Solutions

3.1 Introduction

This section, the Search for Alternative Solutions, includes the nine alternative solutions that the Green Dream Team has formulated, as proposed solution for grounds work at Catherine L. Zane Middle School, in two methods of brainstorming conveyed below. The nine designs outline in this section follow the criteria stated in Section 2.1, the Problem Analysis.

3.2 Brainstorming

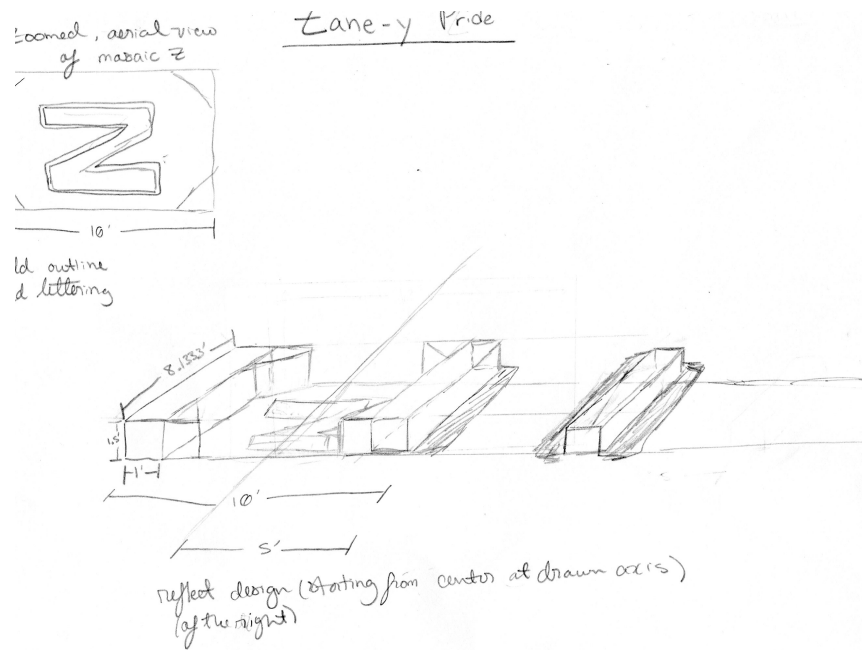
In order to develop alternatives for the proposed grounds work at Zane Middle School in Eureka, California, there were two methods utilized to brainstorm for the final design: an unstructured session and a structured session. The unstructured brainstorming session occurred on March 2, 2017 during the Green Dream Team's Engineering 215 lab. This session was developed in order to problem solve as creatively as possible by designing solutions outside of human limitations and/or client specifications. Members of the Green Dream Team came up with a multitude of creative solutions. The first solution outlined at this session was beyond cost and safety criteria: ornate wrought iron benches lined pathways of permeable concrete and curved around the center of the design. Trellises are above the pathways and have vines of passion flowers. Raspberry bushes are on the outer edges of the design. The second design proposed in the unstructured session was dependent upon at least one member of the Green Dream Team possessing omnipotence over plant life. In the possession of this power, the individual could make any and all flora flourish. This second solution of the unstructured brainstorming session proposed a veritable fruit jungle: an orchard of fruit trees dense with vines. The third and final proposed solution of this session was dependent upon the construction of the design one thousand years into the future. The design is enclosed by an airtight half sphere container to keep out toxic and polluted airs. Solar panels cover the top of this container. The last tree and the last squirrel of Earth lie within. Members of the Green Dream Team assumed themselves to be capable of designing and constructing this project on the expectation that their minds have been implanted in the bodies of robots. However, due to human limitation and the constraints of the project, these designs are not realistic. The second brainstorming session took the exact opposite approach to the first – designing with respect to constraints. At this session, the proposed alternative solutions of the Green Dream Team were formulated. The notes pertaining to the brainstorming sessions and the solutions which they outlined are contained within Appendix B.

3.3 Alternative Solutions

3.3.1 Zane-y Pride

Within the solution 'Zane-y Pride' the criteria is met through an inspirational design that is structurally safe. The site location is seventy feet in length and approximately 8.1333 feet in width. Within this alternative, concrete benches, as approved by the school district, are placed around a centered section with dimensions of 10'x8.1333'. The benches are 'curved' in so that the benches themselves are rectangular prisms with trigonal prisms attached. Between the benches is poured concrete and a mosaic of the school letter – Z, as is shown within the diagram.

The mosaic is red with gold outlines and be made from upcycled tiling. On the sides of the center benches of dimensions 1'x1.5'x8.1333', are flower beds. On the other side of the flower beds is a path of paved concrete of five feet in length with benches on the side and on both sides of these additional two benches are flower beds of the same type as previously mentioned. This results in a total of six flower beds, four benches, and one large 'Zane-y' Z. The paths are interlocking falcon head stepping stones. A diagonal path of falcon head stepping stones cuts across the triangle. There is a tree to the side of this path. Grass seed is placed in un-/under-developed portions of the design.



note: sketches are not to scale

Figure 15 'Zane-y Pride' before alterations; Sketch by: Katelyn Rose Brady

3.3.2 Sunny-dial Days

Within the design of 'Sunny-dial days', the client's criteria is met through a safe and aesthetically-pleasing design. The space in between the center benches is reserved for a sundial. The dimensions are the same as that of the first listed alternative 'Zane-y Pride', with the center in between the benches being of a length of ten feet. Aside from the incorporation of the sundial, this alternative differs from the first in that flower planters are placed upon the East and West sides of the benches, as opposed to the North and South sides. These planters are made from upcycled red brick, in line with school colors. The outer benches are district-issue. The pathways are interlocking falcon head stepping stones. The triangle contains a falcon head stepping stone path and a tree next to it, as well as grass seed within the undeveloped space. The pathways extend diagonally to the rectangle, but do not form Z's.

"Sunny-dial Days"

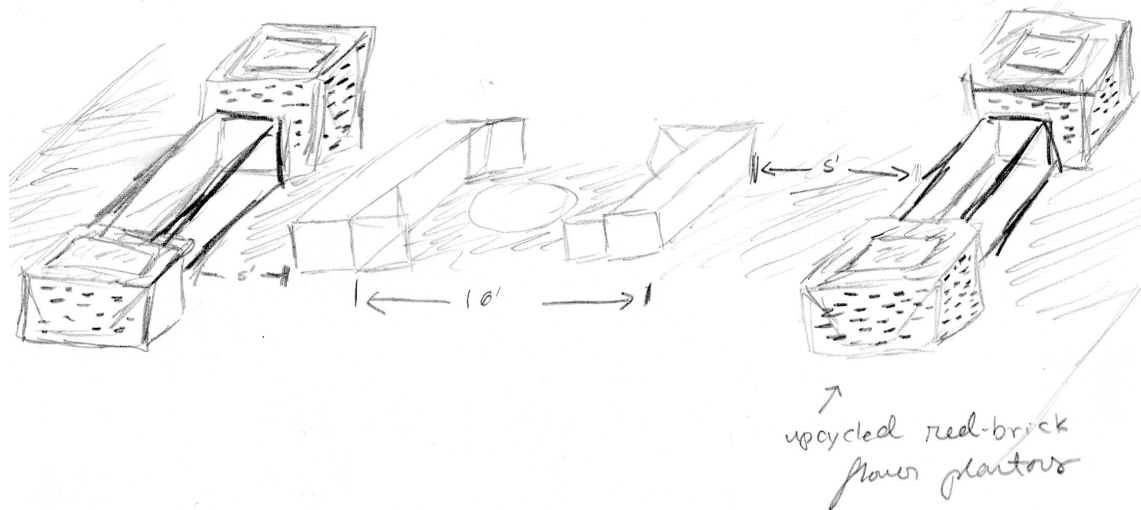


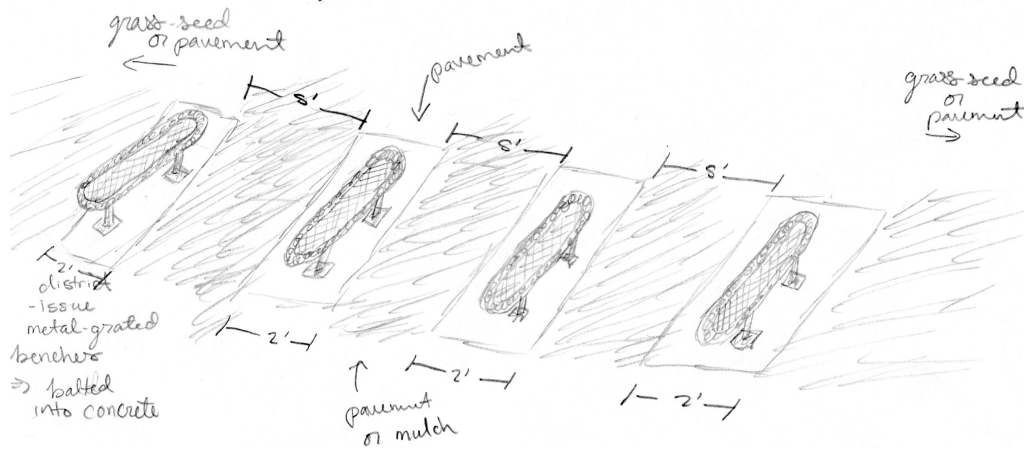
Figure 16 'Sunny-dial Days' before alteration; Sketch by: Katelyn Rose Brady

3.3.3 Concrete Blazing

Within the design solution 'Concrete Blazing', the client's criteria is met through a safe, aesthetically-pleasing, and inspirational design. This solution involves the incorporation of a total of three pathways and four benches. The pathways are centered such that the second, or middle, rests approximately $51.5333'$ in from the paved edges (of $10'$ in length) on the North and South sides of the rectangle. Flower planters, made from upcycled red brick are placed on the West and East sides of the benches. The benches are in style with the metal-grated district-issue found upon the school campus. The three pathways are all $5'$ in width and approximately $8.1333'$ in length. The areas outside of the approximately $19'$ (length) segment, incorporate more pavement, if need be for proper navigation and direction of student flow, or grass seed and white clover ground covering, if need not be. The white clover added to the grass seed will result in green lawns year-round for Zane. Interlocking falcon head stepping stones extend from the triangle to the rectangle and vertical paths of the same design connect to form Z's on either side of the center of the rectangle. The metal district-issue benches line the sides of the length of the

rectangle as opposed to cutting across the width. The triangle incorporates a tree next to the path. The Z's are surrounded by grass seed and white clover.

(Concrete) Trail-Blazing



note not to scale (in any conceivable way)

Figure 17 'Concrete Trail-Blazing' before alteration; Sketch by: Katelyn Rose Brady

3.3.4 Structural aesthetics

The design alternative 'Structural Aesthetics' meets the client's criteria of a safe and easily-navigable layout. 'Structural Aesthetics' consists of grass with white clover seeds, that allow the grass to stay green all year round with little irrigation. Along with the grass, other biotic factors are taken into account. There are native plants that stay in bloom all year long, and avoid the growth of invasive plants. In addition, three pathways placed along the section of the rectangle. These pathways are made of permeable pavers in order to add structure and stability. On each side of the pathways are placed concrete benches, resulting in a total of four benches.

Structural Aesthetics

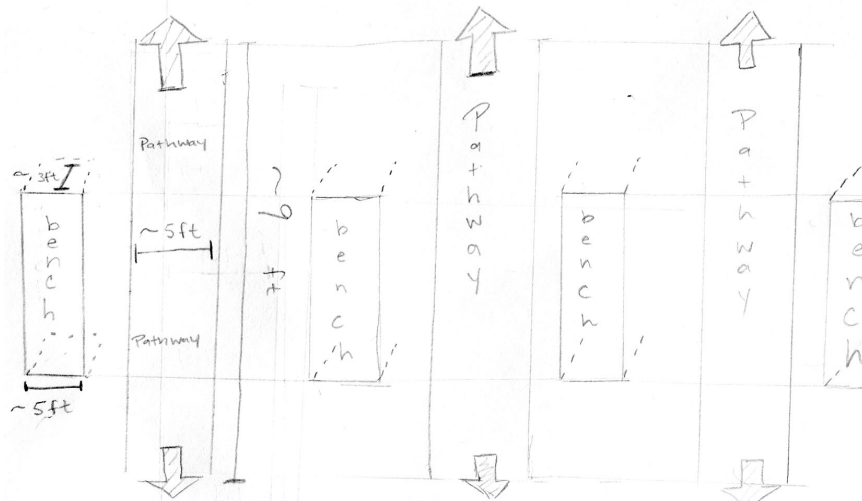


Figure 18 'Structural Aesthetics' before alteration; Sketch by: Kathleen Madrid

3.3.5 Flowery blossoms

The alternative solution 'Flowery Blossoms' meets the client's criteria through a safe and visually-pleasing design. 'Flowery blossoms' is almost identical to the previous option, titled "structural aesthetics". There is grass, with white clover seeds, concrete four benches, and three pathways. The difference is that there is an addition of flower boxes on the east and west sides of each of the benches. These flower boxes are made of concrete, with some coloring to add to the aesthetics. With these flower boxes, the other biotic aspects are eliminated. The concrete planters for the flowers optimize design space by keeping the live elements of the solution contained.



Figure 19 'Flowery Blossoms' before alteration; Sketch by: Kathleen Madrid

3.3.6 Less is more

The alternative solution 'Less is More' meets the client's criteria through a safe, visually-pleasing, and easily-navigable design. 'Less is More' is an alternative that excludes the concrete benches and only includes one permeable pathway through the middle of the rectangle. Similar to the previous options, there is grass with white clover seeds and more biotic aspects. In contrast to the two previous options, more plants are incorporated within the design. Four concrete benches provide seating areas and the paved pathways provide a clean and easily-navigated layout.

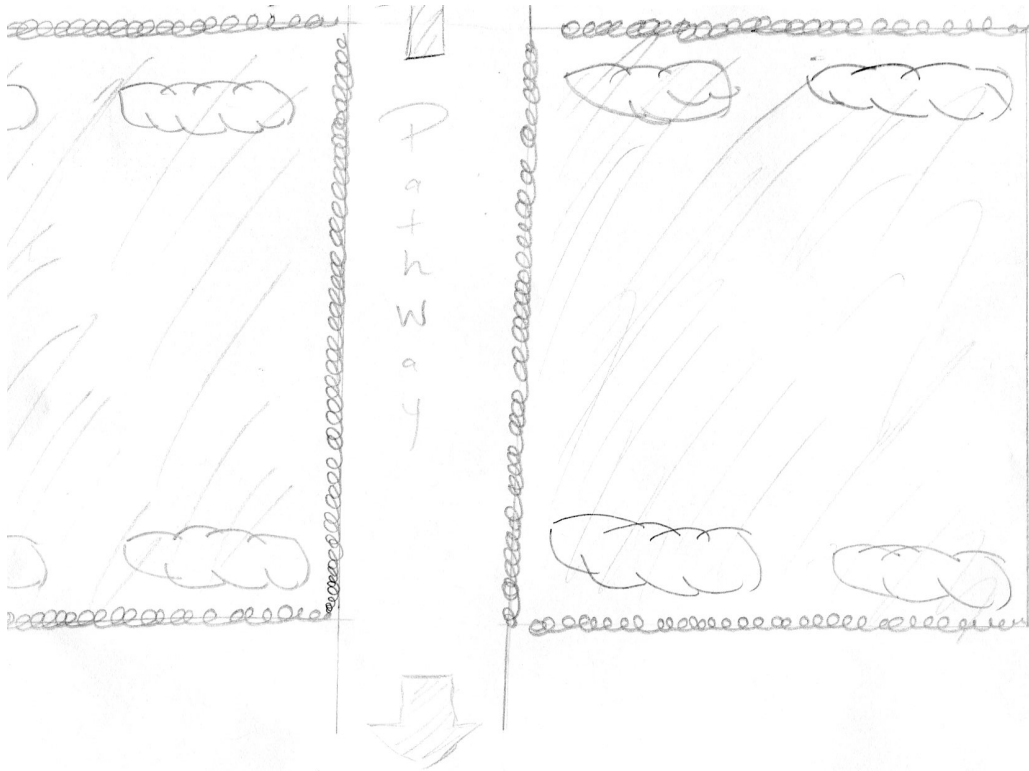


Figure 20 'Less is More' before alteration; Sketch by: Kathleen Madrid

3.3.7 Math Path

The design solution 'Math Path' is probable alternative because it meets the client's criteria of a safe and visually-pleasing design. 'Math Path' includes the implementation of the M.C Escher concept into the diagonal pathway through the triangle. The placement of the pathway diagonally allows for the flow of traffic to go more smoothly when kids are walking to class and parking lot. This pathway is made up by pavers which are created and designed specifically to the design of the school mascot which is a falcon. Falcon heads are created by making a mold to match that of the schools to keep consistency of how the mascot looks. Interlocking falcon heads show school spirit and could be incorporated into the lessons for classes such as math and art in an aesthetically pleasing manner. Surrounding the pathway is the same combination of grass seed

and white clover described in the 'Concrete Blazing' alternative in order to keep the grass looking nice around the designed pathway.

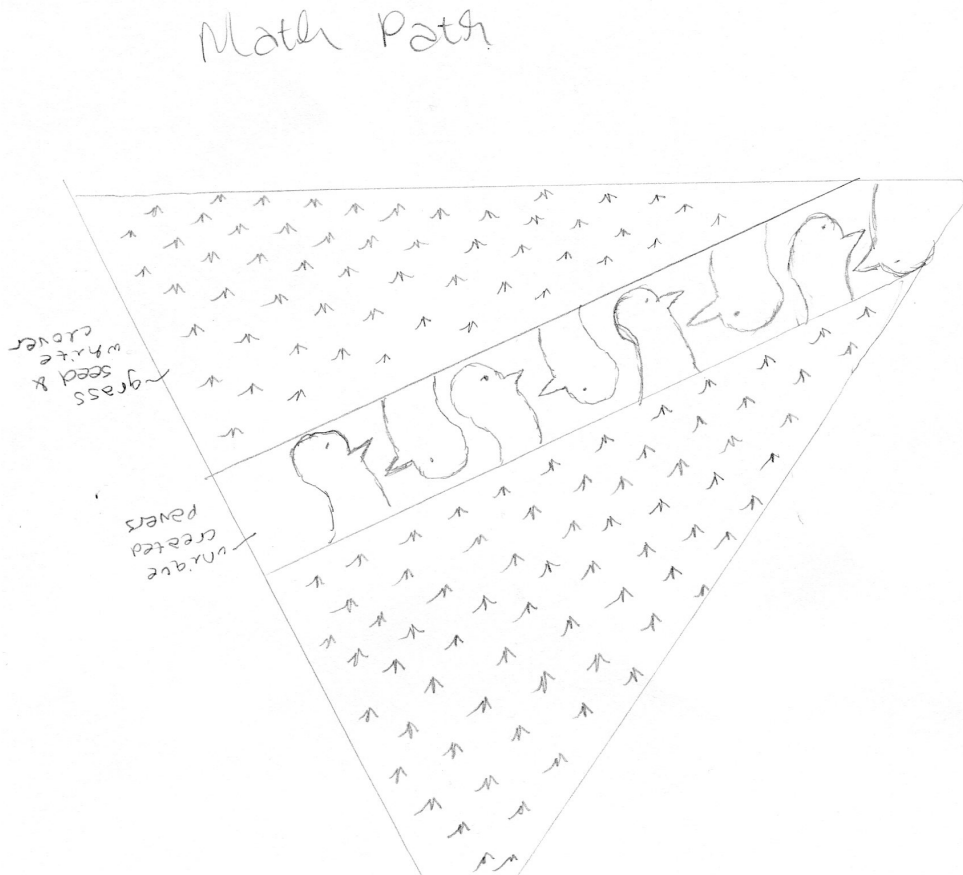


Figure 21 'Math Path' before alteration; Sketch by: Sabrina Rios Romero

3.3.8 I Z Greatness

The design alternative "I Z Greatness" is a conceivable solution because the client's desired criteria of safety and aesthetics have been met. 'I Z Greatness' has some of the same aspects of 'Zane-y Pride' in that one large Z is placed in the middle of the rectangle. The difference in this design is that the Z is made up of upcycled red bricks instead of upcycled red and gold mosaic tiles. Right at the center the Z is placed in a 3'x3' square outline. As opposed to having plants integrated, the area surrounding the Z is permeable concrete. The whole 10'x10' area will all be one big pathway for the students to walk through and this will create more of an opportunity for more students to cross at once.

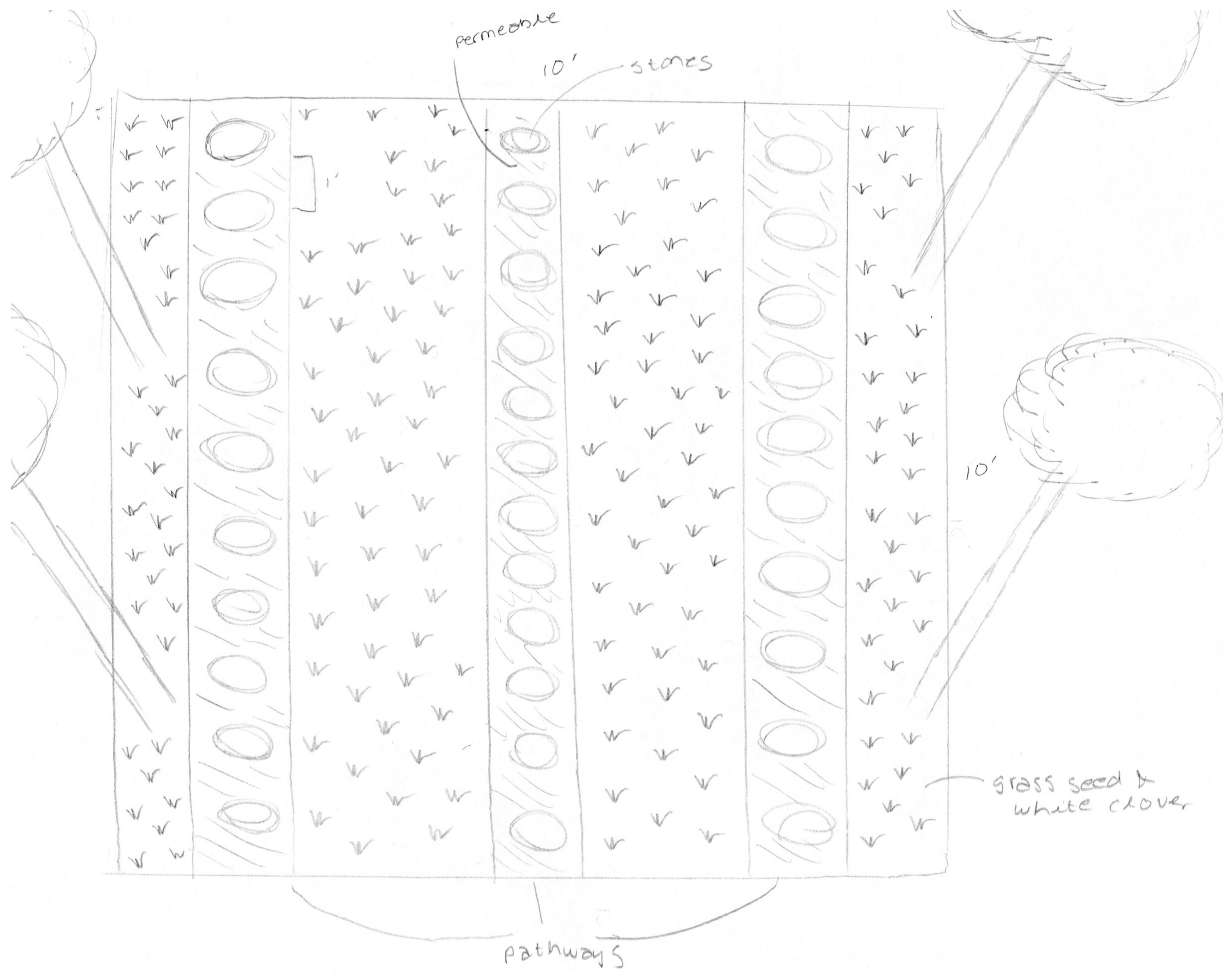


Figure 23 'Tree Pathways' before alteration; Sketch by: Sabrina Rios Romero

4 Decision Phase

4.1 Introduction

Section four includes the decision processes of the Green Dream Team as the final design is determined. The processes utilize client feedback and the Delphi Matrix, in order to determine the best possible design solution through a system of weights.

4.2 Criteria Definition

This section provides definitions of the criteria that was established for this design project. These factors detail qualitative reasoning behind the critique and analysis of designs.

Ease of Navigation: establishes an ease of traffic amongst the student population.

Aesthetics: This is a design that is directly in front of the school and will be the first thing people see when they drive up. It is important to provide an eye pleasing design that will give people a great first impression of the school.

Safety: Children will be around this site at all times; therefore, the toxicity of the materials and hazardous aspects had to be taken into account to provide a safe establishment for the students to enjoy.

Durability: This is going to be used every day so it is important to have this last a few years as opposed to a few months.

Ease of Maintenance: No extra maintenance efforts wanted to be put into this design project, especially if the resources to do so weren't available.

Level of Sustainability: The degree to which the project had an impact on the environment and the impact should be as little as possible.

Education and Inspiration: This is established to provide a uniqueness and authenticity to the design for the students and school.

4.3 Decision Process

The decision process is justified in two parts: the incorporation of client feedback into the design alternatives and the use of the Delphi Matrix to determine the best possible solution.

(a) Client Feedback

The challenges that the Green Dream Team faced within the decision process included the requirement of working inside of and around two other grounds work teams. Thus,

the feedback from the client to the Green Dream Team frequently concerned the cohesiveness of design in relation to the other two grounds work team.

(b) **The Delphi Matrix**

In order to complete the Delphi matrix, a weighted system of criteria must be established, which is shown in Table 1. With these criteria and their weights, the Delphi Matrix is performed.

Table 1 Weighted Criteria

Criteria	
Criteria List	Weight (0-10)
Ease of navigation	10
Aesthetics	9
Safety	8
Durability	8
Ease of maintenance	7
Level of Sustainability	3
Education	2
Inspiration	2

4.4 Final Decision Justification

With the utilization of the Delphi Matrix, a system of weighted criteria, as well as the analysis and application of client feedback, a decision has been reached. The weights came into the favor of “Zaney-Pride”, which includes the tessellated falcon head stepping stones in the form two “Z”s mirroring each other on either side of the rectangle.

5 Specification of Solution

5.1 Introduction

Section five consists of the specifications and details of the final design that was determined in the previous section. Analysis of each component of the whole design is broken up then explained in depth. Instruction on how to use the final product is to also be reviewed. An examination of these elements that are composed within the project will be outlined.

5.2 Solution Description

Zaney-pride is a walkway system designated for the students of Zane Middle School to walk through with ease of navigation while also implementing school pride. The walkways are made up of individual stepping stones, which are then placed directly in front of the other to create the direction of the path. Falcon head tessellations are engraved in each stone and the overall placement of the stones forms the letter “Z”.

5.2.1 The Z shaped path

5.3 Cost Analysis

The Cost Analysis section consists of the estimated costs of the design process, materials, and maintenance.

5.4 Design Costs

Figure 5-1 presents the number of hours The Green Dream Team has spent on the design process. The Green Dream Team has spent a total of 169 hours on the design process. The majority of the work was spent on sections two and five.

5.5 Materials Costs

Table 2 presents the materials costs as The Green Dream Team constructed the groundwork project. The total of money spent on the project was approximately \$100.00. The most expensive item The Green Dream Team spent on the project was the bender board, which projected to be about \$20.00.

Table 2 The cost of materials spent on this project

Itemized Costs of Materials				
Materials	Use	Quantity	Cost (\$)	Total Cost (\$)
94 lb bag Portland Cement	Concrete mix	1	12.95	12.95
70 lb bag All purpose sand	Concrete mix	1	7.95	7.95
Cala Lily	General grounds	3	14.99	44.97
Bucket	Concrete mix	2	4.99	9.98
Wooden Spoon	Concrete mix	1	2.95	2.95
12' Bender Board	Concrete form	1	20.00	20.00
Total				98.80

5.6 Maintenance

The groundwork design was made to have minimal maintenance costs. The stepping stones described in the previous section was implemented to have a durable structure that would last with little to no maintenance.

5.7 Implementation Instructions

In order to utilize the grounds work project to the full extent of its design it would be recommended to start by walking along one of the constructed paths. Once the initial difficulty of this task has been overcome, the user should attempt to apply these directions to the other paths.

5.8 Prototype Performance and Results

For the prototyping process, there were a number of different factors in regards to the stepping stones that were tested. First, stones were tested with pre-mixed concrete and determining the proper ratio of water to concrete.



Figure 24 Mixing Concrete



Figure 25 Pour of Pre-mix

Then the falcon head stamp synthesized from the ACAD design was tested upon the surface of the almost dry pour of pre-mixed concrete. It was determined that there was too much gravel in the pre-mix for the stamp to work. Next ratios of cement to sand to water were tested to determine that the values were 5:10:5, relatively. Gravel was left out entirely as the relative small size of the concrete form did not require it in any way. Once this ratio was determined, it was tested with red concrete dye. It was determined that the dye was not aesthetically pleasing and did not fit into the budget. Therefore, the dye was left out of the design. During the dye trial, the performance of the stamp was tested simultaneously. It succeeded with the proposed ratios for the mix. The issue with the stamp was that its strict structure did not allow for the design to go to the edges of the mold.

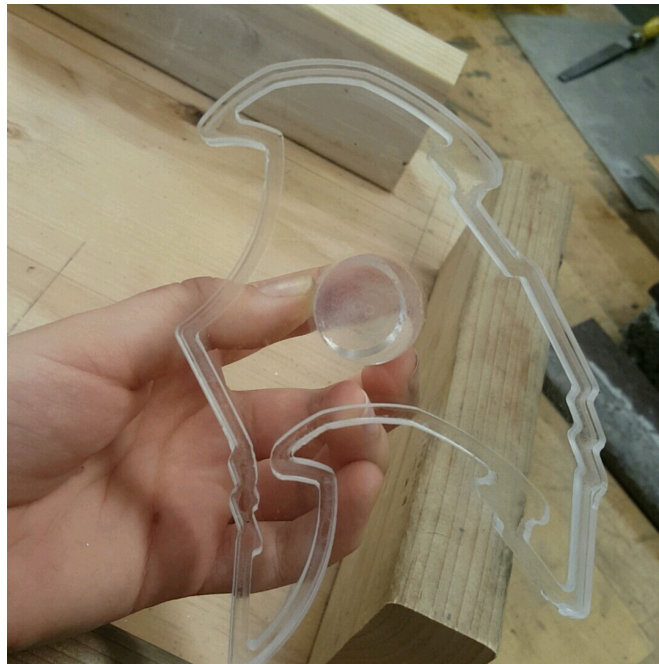


Figure 26 Plastic stamp synthesized from CAD design

An plastic addition to the mold was then synthesized from a CAD design that would rest on the base of the mold.



Figure 27 Finalized Concrete Pouring Form

Within the finalized concrete pouring form is placed a plastic mold. The plastic mold is synthesized from an AutoCAD drawing. This is done so that the tessellated design can be imprinted on the concrete stepping stone when the mix is poured.



Figure 28 Finalized Form with Plastic Mold Addition

Images of the final grounds work design are in Appendix C.

Appendices:

A. References

- Schnelle, Michael A. "Greenhouse Floors and Benches." *Oklahoma Cooperative Extension Service*, < pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1287/HLA-6703web.pdf > (Feb. 19, 2017).
- "Why Concrete?" *MIT Concrete Sustainability Hub*, <https://cshub.mit.edu/why-concrete> > (Feb. 18, 2017).
- "The Use of Solid Waste Materials as Fine Aggregate Substitutes in Cementitious Concrete Composites," *Center for Transportation Research and Education*, < www.ctre.iastate.edu/PUBS/semisesq/session2/shehata/index.htm > (Feb. 19, 2017).
- Danks, Sharon Gamson (2010). *Asphalt to Ecosystems: Design Ideas for Schoolyard Transformation*. New Village Press. Oakland, California.
- "Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual." (2007). *U.S. Department of Transportation – Federal Highway Administration*, < https://localroads.wisc.edu/sites/default/files/imcp_manual_october2007.pdf > (Feb. 19, 2017).
- Ostrovsky, Nick. "Greenhouse Benches." < depts.washington.edu/propplnt/Chapters/Greenhouse_benches.htm > (Feb. 19, 2017).
- "Laurel Tree Charter School three scoops three benches," Appropedia, last modified October 28, 2014. < www.appropedia.org/LaurelTree_Charter_School_three_scoops_three_flavors_benches > (Feb. 20, 2017).
- "Aggregates." *Aggregates*. N.p., n.d. Web. 23 Feb. 2017.
- "Chapter 4 Permeability." *Developments in Petroleum Science Integrated Flow Modeling* (2000): 41-56. Web.
- Designing Circulation Areas*. Gütersloh: Birkhäuser Verlag GmbH, 2013. Web.
- Guidance on the Permeable Surfacing of Front Gardens*. Wetherby: Dept. for Communities and Local Government, 2008. Web.
- "Guide for Maintaining Pedestrian Facilities for Enhanced Safety Research Report - Safety | Federal Highway Administration." *Guide for Maintaining Pedestrian Facilities for Enhanced Safety Research Report - Safety | Federal Highway Administration*. N.p., n.d. Web. 23 Feb. 2017.
- In 2006 And 2007, The Division Of Water Qual-, Ity, North Carolina Department Of Environment, Implemented And Natural Resources (Ncdenvr), and Design Guidance And A Design Requirement That. *Permeable Pavement: Research Update and Design Implications* (n.d.): n. pag. Web.
- "Permeable Pavement Parking Lot." *Office of Campus Sustainability*. N.p., n.d. Web. 23 Feb. 2017.
- Quality, Department Of Ecology Water. *Article: Permeable Pavements - Reduce Runoff Thru Pervious Layers* (n.d.): n. pag. Web.
- "Table 3.3 Angel Capital Statistics from CVR." (n.d.): n. pag. Web.
- "Zane Middle School Native Memorial Garden." *Zane Middle School Native Memorial Garden - Appropedia: The Sustainability Wiki*. N.p., n.d. Web. 23 Feb. 2017.
- Permeable Pavements*. Reston: American Society of Civil Engineers, 2015.
- Kim, Yail, Adel Gaddafi, and Isamu Yoshitake. "Permeable Concrete Mixed with Various Admixtures." *Materials & Design*, 100 (2016): 110-119.
- Arms, Karen. "Environmental Gardening". Halfmoon Publishing. 1992. Print.

Brady, Nyle. "The Nature and Properties of Soils". Macmillian Publishing Company, New York. 1990. Print.

Charles E. Carraher Jr., John P. Droske
Journal of Chemical Education 2006 83 (10), 1428

Concrete : Design, Construction, Examples. Basel : Munich: Birkhäuser ; Edition Detail, 2006.

Haiken, Melanie. "Basic Lawn Care Tips". *Hgtv.com*. 2017. Web.

Hansen, Beth. "Mulch and Soil Fertility". *Rodalesorganiclife.com*. 26 August 2013. Web. 20 February 2017.

Iannotti, Marie. "Mulch - What Is It and Which Mulch Should You Use Where?".
Thespruce.com. 19 January 2017. Web. 20 February 2017.

Kaiser, Laura. "Low Maintenance Lawn Alternatives: Ground Cover". *Houselogic.com*. 2017. Web.

"Lawn Alternatives". *Eartheasy.com*. 2014. Web.
http://eartheasy.com/grow_lawn_alternatives.htm

Pratt, Chris. "Environmental Gardening". *eagantigua.org*. The Environmental Awareness Group of Antigua and Barbuda. 28 November 2010. Web. 20 February 2017.

"Soil pH". *Cropnutrition.com*. 2016. Web. <http://www.cropnutrition.com/efu-soil-ph>

"What's the ideal fertilizer ratio for turfgrass?". *Turf.unl.edu*. University of Nebraska. 2012.
<http://turf.unl.edu/turfinfo/Ideal%20Fertilizer%20Ratio.pdf>

B. Brainstorms

unstructured March 2, 2017
all members
(in lab)

DREAM BIG

raspberry trellis ⇒ passionflower permeable concrete raspberries

ornate wrought iron benches w/ armrest + curved around bench

⇒ SUPERPOWERS

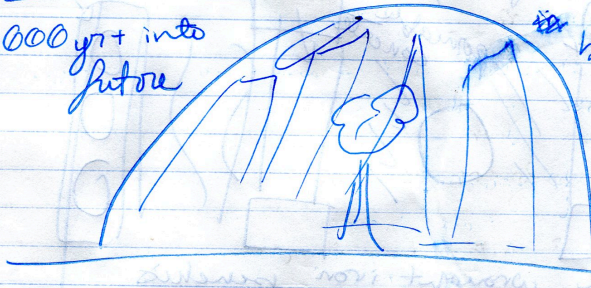
girl from sky high

- ⇒ incorporate every single plant species from "Fruits of Humboldt Bay"
- ⇒ make a fruit jungle
- ⇒ orchard with vines ⇒ so children can get lost w/in this 10x10 ft (ish) space, but w/in the height limit (3 ft)

Figure 29: Unstructured Brainstorm 03/02/17

TIMETRAVEL

1000 yr+ into
future



last apple tree w/ last
on earth squirrel on earth

Solar panels on
encased
bubble (atmospheric
conditions on
earth are no
longer viable)

⇒ we can still design this project b/c
our brains have been implanted into
the bodies of robots #cyborgengineers

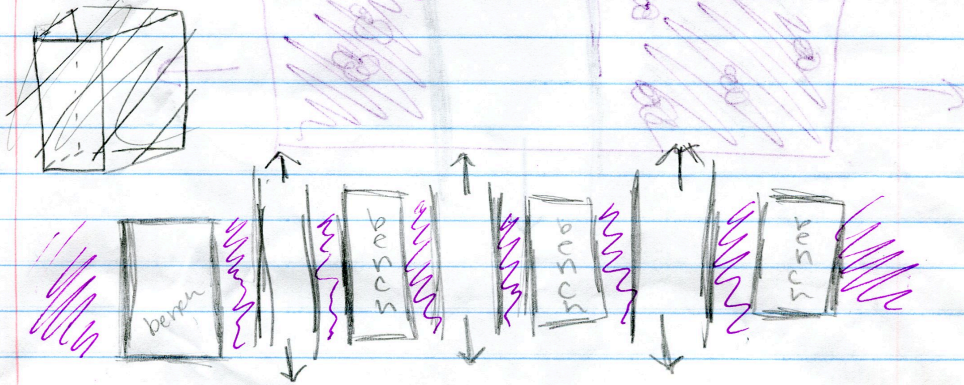
~~WAS A SCENARIO~~

Figure 30: Unstructured Brainstorm 03/02/17 cont.

Library (all members)

3-8-17

Alternative #6 - Grass seed and pathways (3) with benches on both sides of all 3 pathways. (4 benches)
This all depends on the location of the sundial.
The sundial not being in the rectangle.



Alternative #7 - Alternative #6; but with flower boxes on either side of bench.

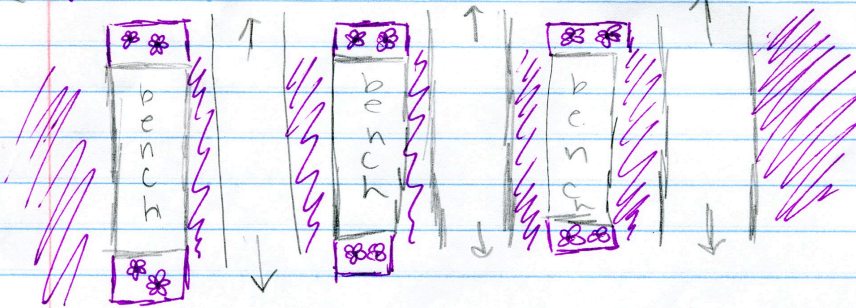


Figure 31: Structured Brainstorm 03/08/17

Library
(all members)
3-8-17

W ≈ 97.667 inches
L ≈ 128.67 ft
~~26-17~~
~~7-19-17~~

Alternative #6

Grass seed & pathways w/ benches on both sides of all 3 pathways (4 benches in total) (dependent on location of sundial).

Alternative #7

Same as #6 but with flower boxes on each side of the benches.

Alternative #8

No benches with one pathway through the middle and grass w/ other biotic aspects.

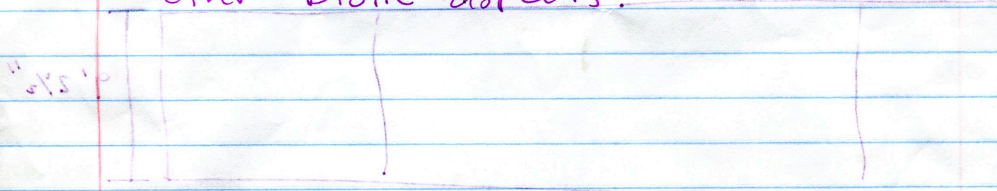
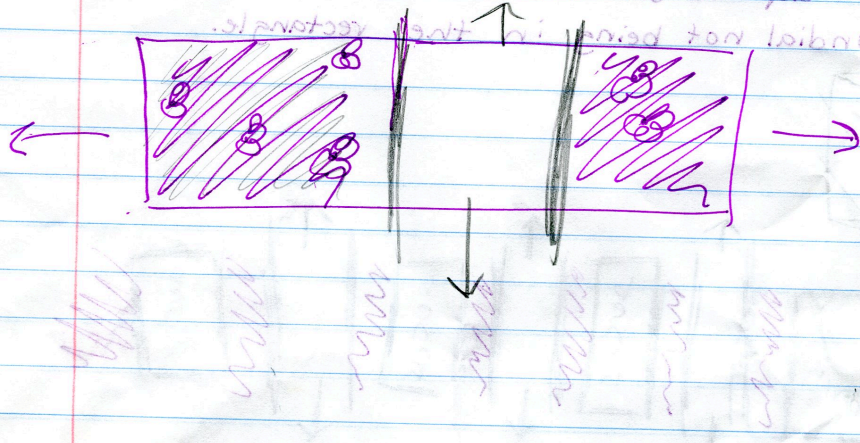


Figure 32: Structured Brainstorm 03/08/17 cont.

Alternative # 8: No benches with a central
 pathway through the middle of grass /
 other biotic aspects



Alternative # 1 - Alternative # 2 - Alternative # 3 - Alternative # 4 - Alternative # 5 - Alternative # 6 - Alternative # 7 - Alternative # 8 - Alternative # 9 - Alternative # 10

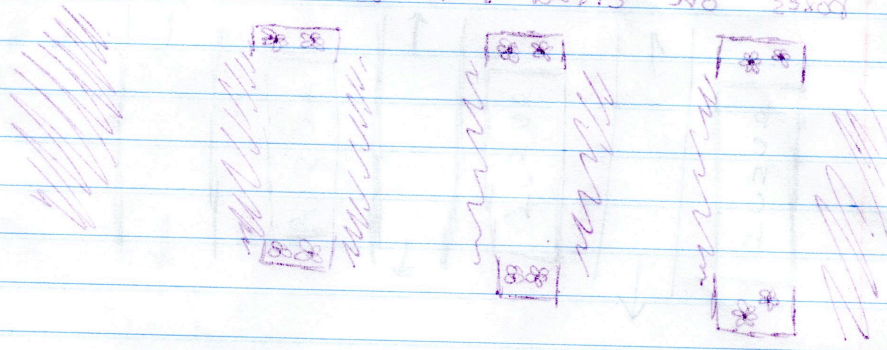


Figure 33: Structured Brainstorm 03/08/17 cont.

notes: front of site faces west with back to school gym (east)

March 1, 2017 all members

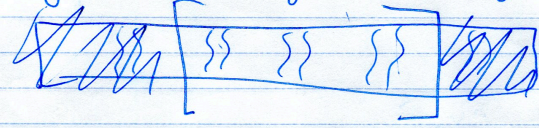
Alternative solutions \Rightarrow Zone Groundwork @ library

1. concrete benches curve around sundial, ground around sundial is paved + perennials + grass covering



WEST CASE SCENARIO

2. pathways in between grass covering/seed



on project
 \downarrow
 []
 } = pathway
] = benches

3. pathways lined by concrete benches, with grass seed



4. same as above, but with flower beds on the west/east sides of the benches (perennials)
5. see alternative 2, but w/ the incorporation of zero irrigation landscape design \Rightarrow fruit trees (?)

triangle \Rightarrow pathway + ^{plants} shrub + perennial

Figure 34: Structured Brainstorm 03/01/17

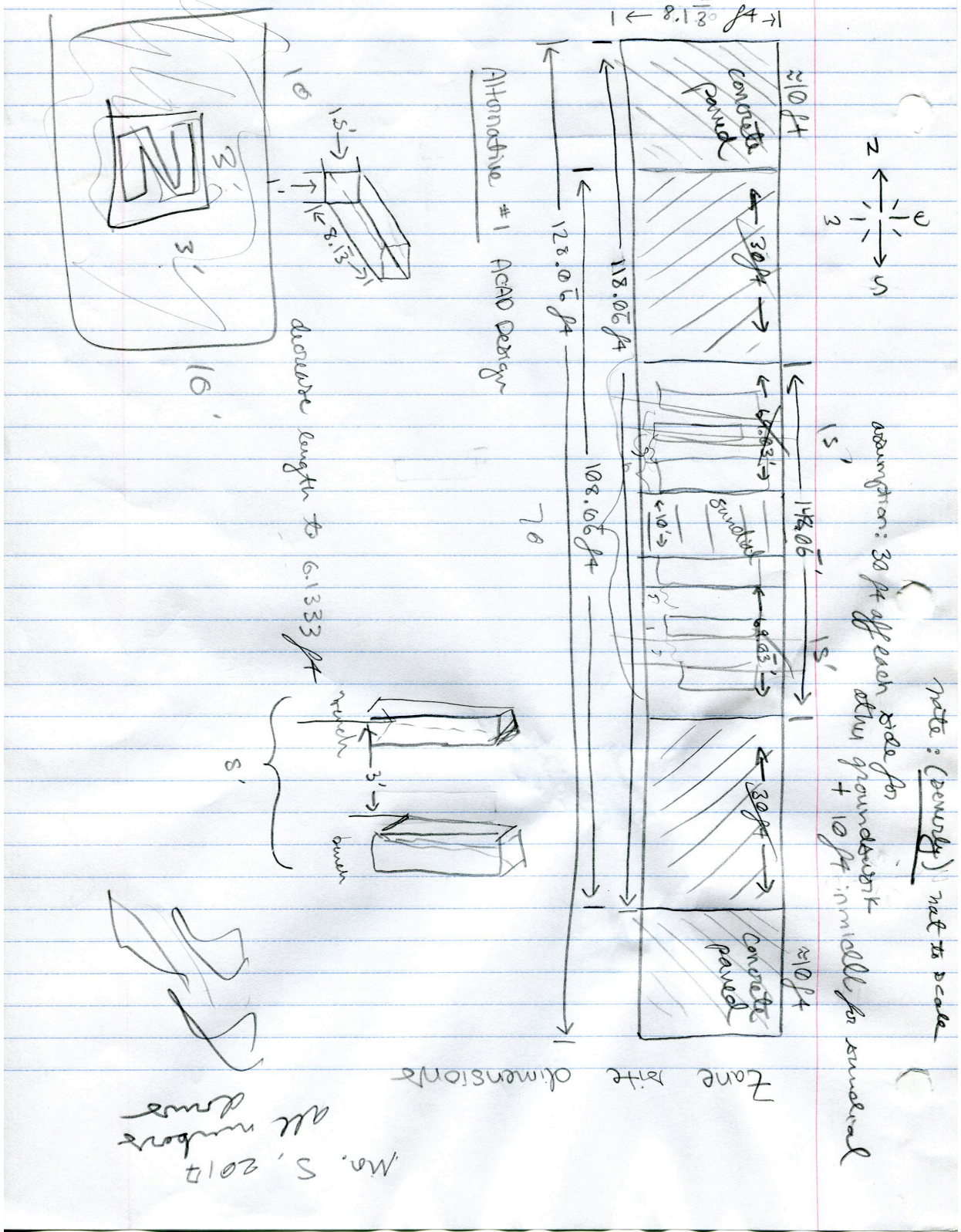
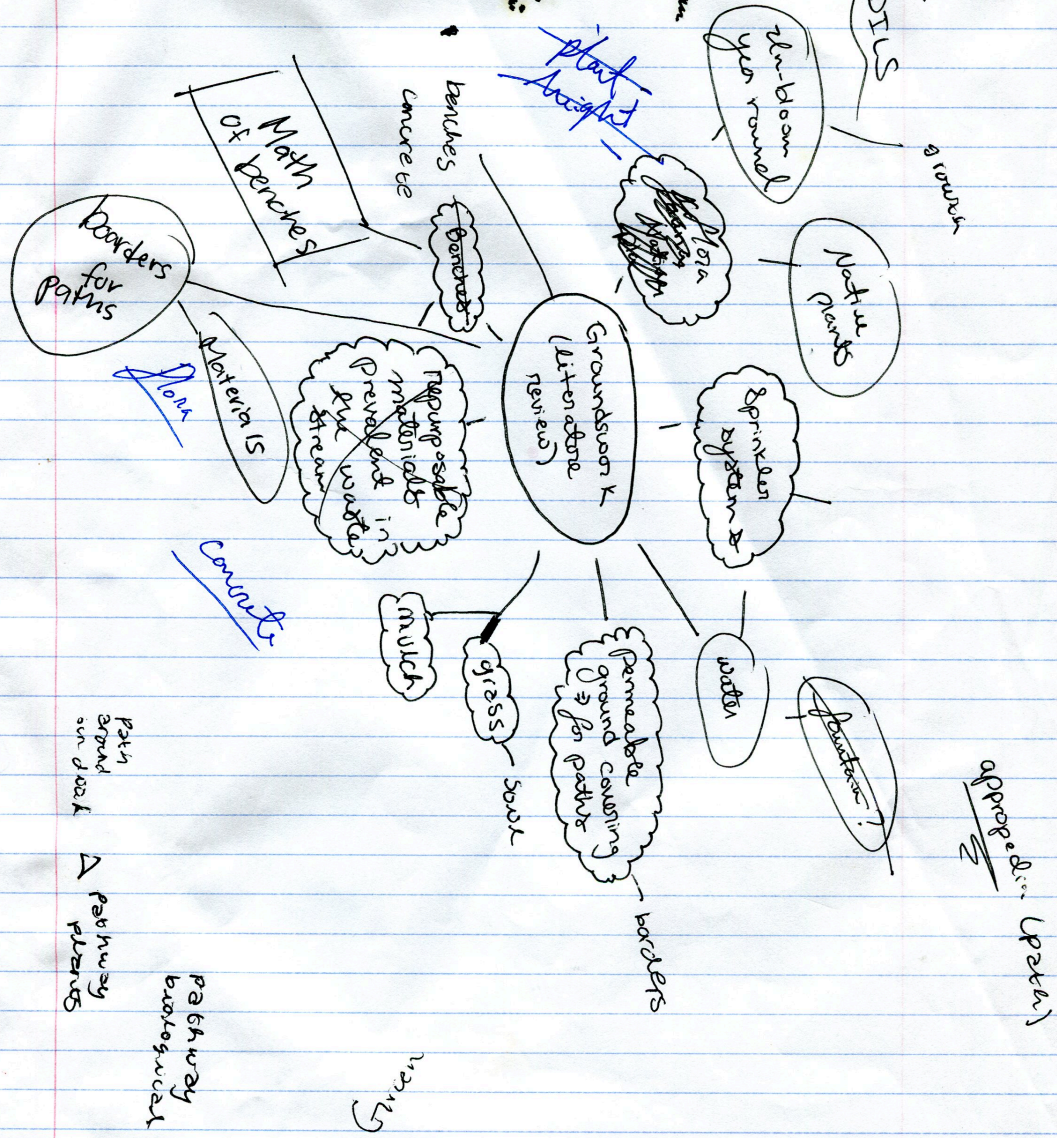


Figure 35: Dimensions Brainstorm 03/05/17

Feb. 16, '17
lab
all members

DAFFODILS



BIO - Kathleen
P&B - Kathleen
B&B - Kathryn

Figure 37: Literature Review Brainstorm 02/16/17

~~no gravel~~ ~~no pavers~~ ~~no~~ ~~rectangle~~ ~~no~~ ~~rectangle~~

- Having both ends of rectangle
- no gravel (tear up gym floor)
- Pavers
- Zero irrigation (want!) * Perfect
- Super flat
- Make own pavers to fit together. * collaborate w/ other teams
- Possibly permeable but w/ pavers or walkers + sundial (make one plan)
- NO broken concrete Possibly → 10 x 10 square
- Trees are okay * no grass...?
- Bushes - line of sight (need to be mature)
- something a * help (possibly 74). lay concrete
 - Hardy * no fruit trees
 - * make it an educational lesson.
- MC-Usher...?
- Falcon heads w/ pavers
- Possible "Z" for kids to hang at (bricks...?)
- Interesting path on triangle.
- Make a design that will ~~be~~ presented * possible

benches
 * benches that Districts provides
 • or other orig. Ideas.

Figure 38: Meeting Notes with Client 03/03/17

C. ...(as needed)