Triangle of Life

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3 Problem Formulation

3.1 Introduction

Section 3 consists of an objective statement and a black box model. The current problem is to take an unutilized piece of land and convert it into a utilized area. The black box model shown below in figure 1-1 displays the current problem, the solution, and the world after the solution has been implemented.

The client is Zane Middle School, located in Eureka California. Zane Middle School is a "STEAM" (science, technology, engineering, art, mathematics) school, and features sustainable projects such as a recycling program and a rainwater catchment system. For this project, Zane Middle School has requested that a patch of land nicknamed "The Triangle of Death" be converted into a hub of activity for the students. After the area is converted, the project will be the Triangle of Life.

3.2 Objective

The objective of this project is to design a social and friendly environment in a currently unused piece of land. The design will consist of a way to cross the patch of land and an aesthetically pleasing landscape to complement existing landscapes around the campus.

3.3 Black Box Model

The black box model shown in Figure 1.1 describes the initial state of the Triangle of Death, the solution, and the final stage after solution implementation.

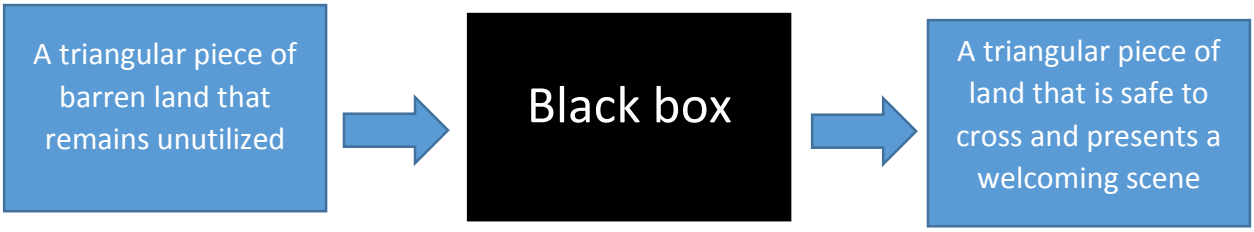

Figure 3-1 ***Black Box Model*** *shows the current state, solution, and subsequent state of the triangle of death*

4 Problem Analysis

4.1 Introduction

Section 4 identifies the criteria and constraints that the client has in vision for the Triangle of Death. The problem analysis describes specifications, considerations, criteria and constraints for the project. The problem analysis also describes the usage and production volume for the project.

4.2 Specifications and Considerations

Specifications are the known facts and details about the project. Considerations consist of factors that must be taken into account when working on the project.

4.2.1 Specifications

Listed below are the specifications of the Triangle of Life, which are the assessment of requirements, dimensions, and materials that are implemented in the final design.

- The workspace is a right triangle with side lengths of 36 feet and a hypotenuse with a length of approximately 51 feet.
- The existing maintenance structures cannot be altered, including the sprinkling system.
- The students must be able to walk across the patch of land on a constructed path.

4.2.2 Considerations

The considerations are carefully thought out and deliberated thoroughly in designing the Triangle of Life. The deliberations are listed below:

- The project is being designed for use by middles school students
- The design will be one of the first things seen on campus

4.3 Criteria

Criteria are standards that are based on a scaled system rather than a yes or no answer. Constraints are specific limitations on each of the criterion. The criteria and constraints are displayed in Table 4-1 below.

Table 4-1 Criteria and Constraints of design

Criteria	**Constraints**
Aesthetics	Must be visually appealing providing a welcoming view.
Sustainability	Most of the materials for the pathway should be reused or recycled
Functionality	Students, faculty, staff, and other individuals are able to walk and cross the area at ease.
Low Maintenance	Maintenance staff must approve designs. Must not require major upkeep
Durability	All materials can withstand wear and tear as well as weather conditions.
Safety	No materials utilized in the final design can cause harm or be used to cause harm.
Cost	Must not exceed $400.

4.4 Usage

The Triangle of Life is designed to provide an aesthetically pleasing landscape that allows students to walk across the area instead of walking around it. The area provides low maintenance plants, a pathway, and aesthetically pleasing scenery presented in front of the school. This is a permanent landscape that will last many years if the plants and the pathway are maintained. The Triangle of Life is near the front of the school and will provide a welcoming scene to students and visitors.

4.5 Production Volume

The Triangle of Life is only produced once, but can be replicated to fit most shapes and sizes of different projects.

4.6 Literature Review

4.7 Introduction

The literature review contains all of the research and findings on the development of a pathway design for the "Triangle of Death." Topics included are the client interview, regulations, low maintenance plants, landscaping, way-finding, different materials for pathways and benches, and the local weather of Humboldt County.

4.8 Client Interview

When meeting the client, Ron Perry and Trevor Hammons from Zane Middle School, they had certain idea already in mind for the area. The criteria of the design is to match the pre-existing structures, have upcycled materials implemented, and the design to be aesthetically pleasing. The client is most concerned with converting an unused patch of land into a hub of activity for the students, without causing any significant increase in work for the maintenance staff. The client indicated that there are maintenance pipes must be avoided. The client emphasized that materials used in final design cannot be used as harmful substances by middle school students. Both Ron and Trevor mentioned that the area is near the office so all plants and structures must be low to the ground (Perry 2015).

4.9 Regulations

Any recycled or upcycled materials will be tested for lead and asbestos by a local lab. All plants that are chosen must be approved by maintenance and the client. The plants are inspected for any branches or thorns that may cause potential harm. In addition, the design cannot increase the total maintenance hours for the maintenance staff.

4.10 Low Maintenance Plants

The three low maintenance plants researched and discussed are Azaleas, Ferns, and Lithodoras.

4.10.1 Azaleas

Azaleas are evergreen plants that have vibrant colors that have aesthetic please in the Triangle of Life. An Azalea is displayed below in Figure 4-1. Azaleas were first planted in Charleston, South Carolina in 1848 when they came from England (Bruno 1997-2010). In order for plants to grow successfully, they need to be planted in acidic soil (Bender 2015). Azaleas flourish best in areas with mild climate (Bender 2015).

Figure 4-1 an image of Azaleas
Retrieved from: https://davermfarm.wordpress.com/tag/encore-azaleas/

4.10.2 Ferns

These plants have a vibrant green color, as displayed in Figure 4-2, and thrive in areas where there is shade and moisture. After planting a fern, the fern needs to be watered consistently to get accustomed to an area (Beardshaw 2008).

Figure 4-2 Image of sword ferns
Retrieved from: http://www.galvestongardening.com/GGTropicals.htm

4.10.3 Lithodora

Lithodora is a ground cover that provides an area with vibrant colors. As portrayed in Figure 4-3 below, Lithodoras spread out across the ground while maintaining a low profile. Sunlight is essential for a Lithodora to bloom. Lithodoras require only a minimal amount of water in order to survive (Ipatenco).

Figure 4-3 Image of Lithodora
Retrieved from: http://www.greenerearthnursery.com/lithodora-grace-ward.html

4.11 Redwood Mulch

Redwood mulch is shredded redwood that is used as a layer that sits over soil. Mulch serves for different purposes depending on the location. It can be used to conserve moisture, to improve the fertility and health of soil, reduce weed growth, and enhance the visual appeal of an area. Mulch may be applied around plants, trees, and pathways to help prevent soil erosion on slopes. However, mulch may also be harmful if it is applied too thickly around the plants, preventing sunlight and water from reaching the soil (Genevieve 2009).

Figure 4-4 Image of Redwood Mulch
Retrieved from: http://www.rockymountainlawn.com/Mulch.shtml

4.12 Water Regulation and Drainage

Water regulation can be more easily controlled with a sloped garden bed, shown in Figure 4-5. This allows for a raised slope for the water to run down preventing water from pooling up and drowning out the plants (Schmidt and Greenberg 2012).

Figure 4-5 Image of a sloped garden bed
Retrieved from: https://www.pinterest.com/nicoleford5/backyard-dreams/

4.13 Methods of Weed Prevention

A weed barrier cloth, like the one below in Figure 4-6, can be placed down with holes cut out around the plants for them to grow. If implemented correctly, the weeds will not penetrate the cloth and will only grow out from its outer edges (Schmidt and Greenberg 2012).

Figure 4-6 An image of a piece of weed barrier cloth in place surrounding a growing plant. Retrieved from: (http://www.groundforcegardening.co.uk/ekmps/shops/lawnsuncut/resources/Design/98362-weed-control-fabric.jpg)

4.14 Way-finding

Way-finding are sets of principles that provide the navigator an informative area of space to reach their final destination (Aimitt 2015). When navigating through an area, people are faced with decisions when choosing and following different paths to reach a destination. Way-finding is a strategy that helps define certain patterns to navigators, which helps with reaching a destination point (Gibson 2009). Sequence of signs and understandable messages allow for anyone to successfully reach their destination point they are seeking. Colors are used as well to help navigators connect to a place and identify. Colors may indicate a message that is universally recognizable, such as traffic signals (Gibson 2009).

4.15 Pathway Materials

Potential pathway materials researched are broken flagstone, fireclay tile, classic brick, and urbanite.

4.15.1 Broken Flagstone

Flagstone materials, such as the ones in the pathway in Figure 4-7, are those such as bluestone, quartzite, and granite that are considered to be denser in comparison to other natural stones

(JJmaterials 2014). These are usually found in the northeastern United States because they can resist in freezing moist temperatures (JJmaterials 2014).

Figure 4-7 A broken flagstone pathway
Retrieved from: myhomeredux.com

4.15.2 Fireclay Tile

Fireclay tile are tiles made from recycled materials from windows and solar industries. Fireclay Tile is a company that makes tiles, similar to the ones shown in Figure 4-8, from locally gathered materials, using natural color pigments. (Fireclay Tile 2014).

Figure 4-8 An example of Fireclay tile
Retrieved from: (st. houzz.com)

4.15.3 Classic Brick

Brick is classified as low maintenance, durable and sustainable (Parker, 2014). Bricks are utilized for structures such as buildings or landscaping. Bricks are made out of cement, sand and water, and require a minimal upkeep and are long lasting. Natural clay minerals such as kaolin and shale are the majority substances found in brick (Trends in brick plant operations 1992). Brick may withstand corrosion, retain heat and is fire resistant. Brick is often considered in projects due to the low maintenance and longevity of the material, potentially saving time and money from minimal upkeep on the materials (Trends in brick plant operations 1992).

Figure 4-9 A brick pathway
Retrieved from: Faceslandscape.blogspot

4.15.4 Urbanite

Urbanite is reused concrete that can be utilized to make a number of landscape designs. Urbanite resembles a flagstone pathway once it is completed. Materials such as concrete contain embodied energy, or the energy it took to make and transport these materials. By reusing the concrete for an Urbanite pathway, the embodied energy of the overall landscape is reduced (Bay Friendly Landscaping 2009.)

Figure 4-10 Example of an urbanite pathway.
Retrieved from: http://fairyyardmother.blogspot.com/2014/10/broken-concreteurbanite.html

4.16 Bench Materials

4.16.1 Upcycled

The process known as upcycling is finding a use for waste products instead of sending them to a landfill. Upcycled materials differ from recycled materials because recycled material requires energy to break down, while upcycling uses existing products. Upcycling promotes sustainability by reusing products for purposes that differ from their original use. This prompts creativity in the process of reusing materials for functional purposes (Ali 2013).

Figure 4-11: Upcycled benches made from reclaimed wood.
Retrieved from: http://www.alternativeconsumer.com/2012/03/07/upcycled-benches-from-hipcycle/

4.16.2 Recycled

Benches can be made from recycled materials such as steel, aluminum, and plastics. One example of recycled plastics comes from a company named Green Tree Plastics that takes plastic bottle caps and converts them into recycled benches. This process removes approximately four hundred pounds of plastic from the waste stream and coverts it into a useful product (O'Nan 2014).

Figure 4-12: Bench made with 100% recycled plastic
Retrieved from: http://www.plasticrecycling.us/recycled_plastic_benches_malibu.shtml

4.16.3 Concrete

Concrete is a mixture of sand, gravel and cement. The strength of the concrete depends greatly on the proportions of the mixture. The proportions for a general mix of concrete are one unit of cement to two units of sand to four units of gravel, 1:2:4. To mix the components for small scale use, first mix the dry elements in a wheelbarrow or mixing pan until the mix has a uniform consistency. Then make a divot in the middle of the mix and add water slowly, while dragging the dry components into the divot and mixing with the water. To test the mixture, smooth out a small section and make grooves with your finger. If the mixture is too wet, the grooves won't hold their shape. In this case, add more dry ingredients with the same 1:2:4 proportions. If the mixture is too dry, then the grooves will be clumpy and gritty, and more water is required. When the mixture is just right, the grooves will be smooth and will hold their shape. This mixture will then need to be poured into the form desired, which can be created with scrap boards one inch thick that are leveled with each other. Fill the form to the top with the concrete mixture to ensure that the finished product is level (Litchfield 1997).

Figure 4-13: Solid concrete bench
Retrieved from: http://www.langleydesign.co.uk/products/benches/pewsham-bench-pbn408/

4.16.4 Wood

While softwoods such as redwood are easier to work with for outdoor applications, a hardwood such as white oak is best suitable for benches. Wood-based projects should be designed to shed water to reduce the chances of damage such as rot. This will limit the amount of time the wood has to soak up any water. Also, seal any joints or end grain very well. These spots tend to soak up the most water and must be treated with extra care (Wood Magazine 2006).

Table 4-2 Comparing various types of lumber
Retrieved from: http://msatterw.public.iastate.edu/ENG%20250%20Readings/OutdoorFinishes%5B1%5D.pdf

Outdoor woods: how they stack up

Type		Density (1)	Unfinished rot resistance	Rigidity	Finishability (2)	Ease of use (3)	Stability	Stain acceptance	Cracking tendencies	Warping tendencies	Availability (4)	Cost per 1x6 lin. ft. (5)	Best use
American softwoods	Western red cedar	L	B-	B-	C	A	B	A	B-	B-	A*	$1	All purposes
	Redwood	L	B	B	C	A	B	A	B-	B	C	$2–$7*	All purposes
	Cypress	M	B	B	C	A	B	A	B	B	B-*	$2	All purposes
	Pressure-treated pine	L	A	B	B	A	B	B	C	C	A	$1	Deck frame, decking, ramps
Hardwoods	White oak	H	A	A	A	C	B	A	B	B	C	$2	Benches, arbors, chairs
	Ipe	VH	A	A	B	D	A	D-	A	A	C	$3	All purposes
	Teak	H	A	A	C*	C+	A	D	A	A	D	$15	Small items
	Mahogany (African/Honduran)	H	A	B	A	A	A	A	A	B	B	$5–$7	Furniture projects
Composites	Solid	VH	A	D	D-	D	A	D	A	A	A	$2–$3	Decking, ramps, railings
	Hollow core	VH	A	C+	D-	C	A	D	A	A	A	$2–$3	Decking, ramps

1. L-Low, M-medium, H-high, VH-very high
2. Must remove waxy resin with acetone
3. Includes difficulty of driving fasteners, cutting, weight
4. Depends on region
5. Price depends on grade

A excellent B good C fair D poor

4.17 Climate of Coastal Humboldt County

Humboldt County experiences much precipitation throughout the year and a mild climate. The annual temperature in coastal Humboldt County ranges from highs around 70 degrees Fahrenheit to lows around 30-40 degrees Fahrenheit. The average rainfall per year is between 40 inches in dry areas and 100 inches in wet areas (County of Humboldt).

Figure 4-14: Humboldt County (http://www.redwoods.info)

5 Alternative Solutions

5.1 Introduction

Section 5 consists of the different alternative designs for the Triangle of Life that came up during the brainstorming process.

5.2 Brainstorming

Team Triangle of Life conducted many brainstorming sessions after lecture in SH 110. These brainstorming sessions are documented in Appendix A. During these sessions, many alternative designs were created. Any designs that came out of the brainstorm sessions had to meet the criteria and constraints for the project. A total of eleven different designs came about due to these sessions.

5.3 Alternative Solutions

The following are the alternative solutions produced during the brainstorming sessions:

- Falcon Triangle
- U-Shape Triangle
- Mosaic Style Falcon Logos
- Urbanite Triangle of Life
- Circular Triangle of Life
- Thunder Z Triangle
- Triangle within Triangle
- The Z plus the Triangle
- The Z Triangle
- Triangle Paths

- Semicircle Bench Triangle
- Logical Triangle

5.3.1 Falcon Triangle

The Falcon Triangle is an alternative solution displayed in Figure 5-1 that features three walkways surrounding a circular centerpiece. Each walkway is tangent on three points of the center circle. The walkways cut across including entrance and exit points. These pathways consist of urbanite in order to increase the sustainability of the design. The circular centerpiece consists of a concrete base with a mosaic style image of Zane Middle School's logo, a falcon. Along the top of the center circle there is a curved concrete bench for students to have a place to stop and rest on their way to their destination. In each corner of the Falcon Triangle, there are low lying evergreen plants such as groundcover. These plants promote the aesthetics of the overall design.

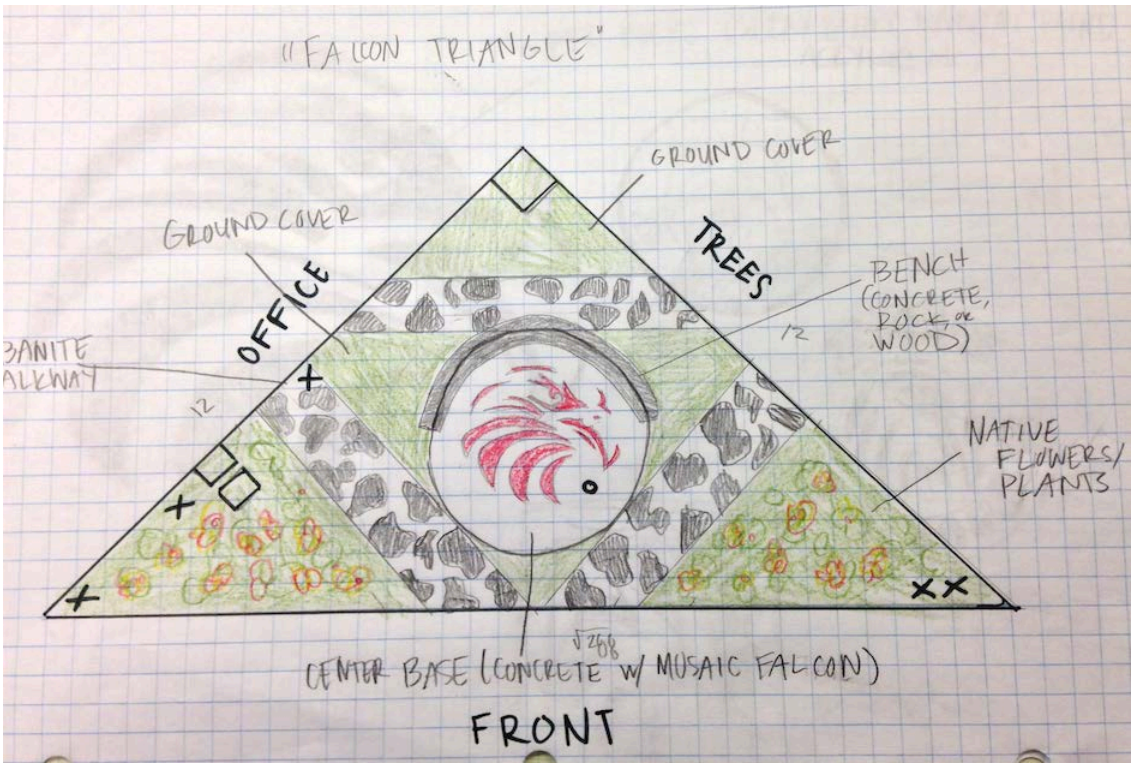

Figure 5-1 The Falcon Triangle featuring three Urbanite pathways, evergreen plants, and a circular mosaic centerpiece (Photo by Amani Adams)

5.3.2 U-Shape Triangle

The U-Shape Triangle is an alternative design that features a u-shaped pathway around a mosaic centerpiece that is surrounded by evergreen plants. The pathway pictured in Figure 5-2 is made from urbanite to fulfill the sustainability criteria. Inside the path is a square shaped concrete base with a mosaic styled Falcon with the words "Zane est. 1965" in red and yellow. This encourages school spirit and the aesthetic value of the design. In each corner of the U-

Shape Triangle there are evergreen plants that require low maintenance such as ferns and Azaleas.

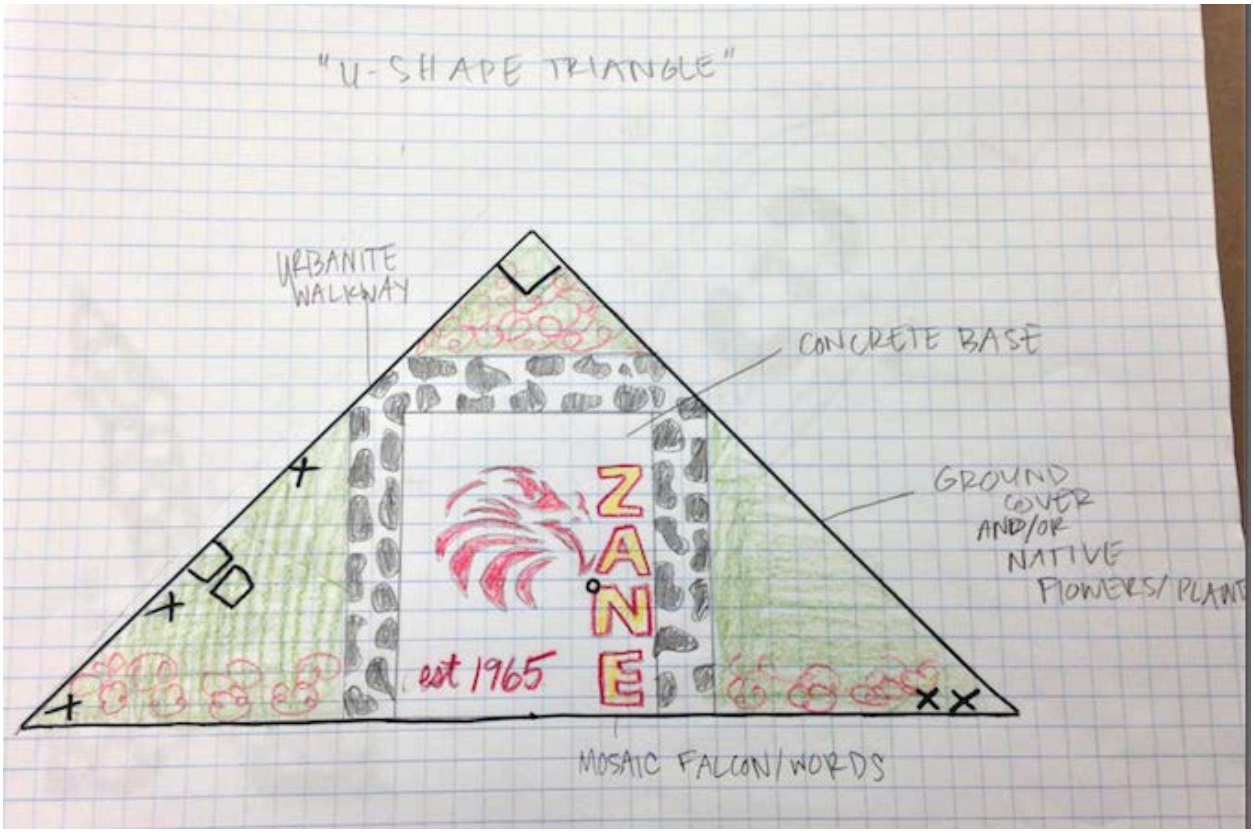

Figure 5-2 The U-Shape Triangle featuring a square logo for Zane Middle School, urbanite pathways, and evergreen plants (Photo by Amani Adams)

5.3.3 Mosaic Style Falcon Logos

Mosaic Style Falcon Logos pictured in Figure 5-3 are several design options for center pieces. The image of the falcon will be made up of red painted rocks. Option 1 is a circular logo with “Zane Falcons” along the top and bottom of the falcon image. Option 2 is a circular logo with “Zane Falcons” along the top and bottom of the falcon image. Option 2 includes the words “EST. 1965” on the right of the falcon image. Option 3 is a square logo with the falcon image in the center. Along the right side of the falcon image is the word “Zane” in capital letters. “Zane” is outlined with red rocks and is filled in with yellow rocks.

Figure 5-3 Diagrams for different Falcon Logos to go in the centerpiece of the pathways (Photo by Amani Adams)

5.3.4 Urbanite Triangle of Life

The urbanite triangle of life shown in figure 5-4 is designed to provide an area where students can gather and pass through with ease. In the Urbanite Triangle of Life there are two pathways made from urbanite. The pathway provides access to cut through this area. In the center of the Urbanite Triangle of Life there is a circular cement piece with a capital 'Z'. The 'Z' for Zane is made of urbanite that is set in the cement. The 'Z' provides school spirit and aesthetic value. Surrounding the 'Z' are round cement benches. The cement benches and cement holding the urbanite together will supply greater durability. The areas that are not taken up with cement are covered in grass to provide a natural aesthetic aspect.

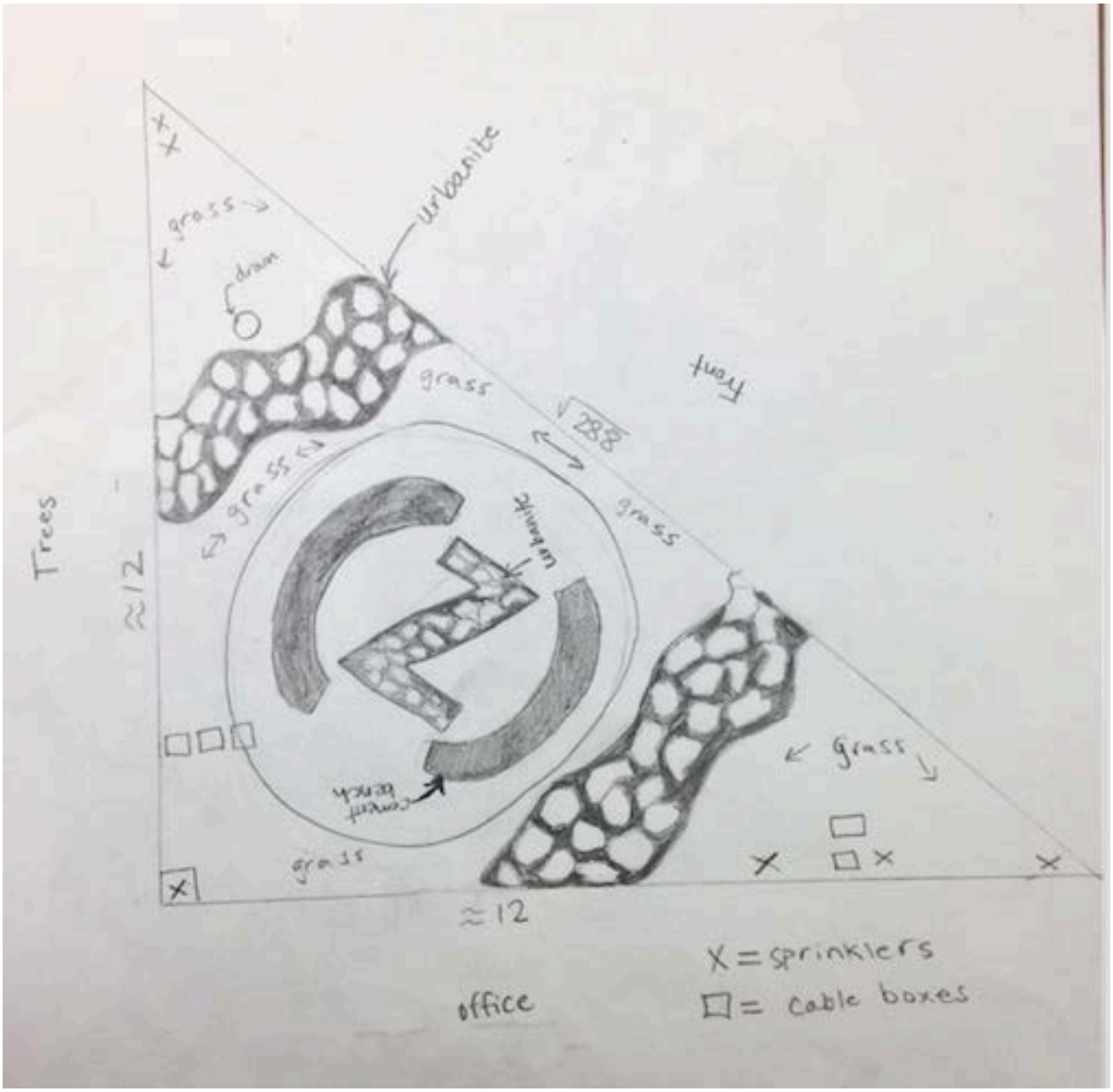

Figure 5-4 The Urbanite Triangle of Life with urbanite set in concrete for pathways and two concrete benches surrounding an urbanite 'Z' (Photo by Kelly Fuentes)

5.3.5 Circular Triangle of Life

The circular triangle of life shown in figure 5-5 features a large concrete walkway surrounding two concrete benches. These benches surround an urbanite 'Z'. The 'Z' displays school spirit and adds to the aesthetic value of the design. The walkways provide many ways to get across the triangle and prove to be very functional. They are also very durable because they are made from concrete. The left over areas are covered with grass to provide aesthetic value and ease of maintenance.

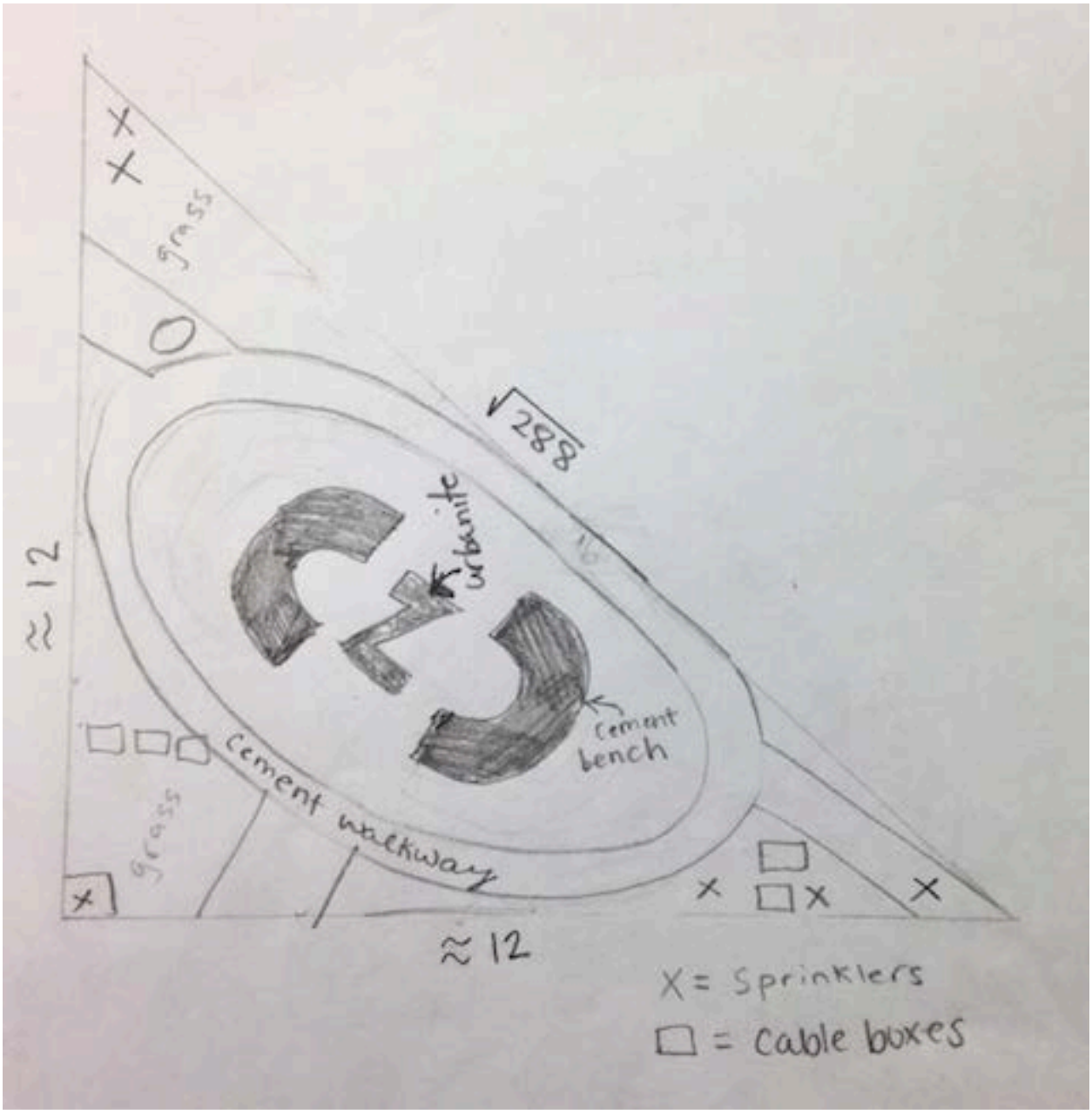

Figure 5-5 The Circular Triangle of Life with durable concrete pathways and benches, grass, and an urbanite 'Z' (Photo by Kelly Fuentes)

5.3.6 Thunder Z Triangle

The Thunder Z Triangle displayed in figure 5-6 is simple with multiple pathways. The triangle has four pathways and a centered urbanite structure in the shape of 'Z'. The 'Z' promotes school spirit and the pathways are made from urbanite while the surrounding areas contain grass. Utilizing urbanite as the main pathway material promotes the overall sustainability of the design. The grass supplies the area with colorful aesthetic value. By having multiple pathways

the students will not be tempted to cut corners and walk in areas where the grass could get torn up. These multiple pathways enhance the functionality of the design as a whole.

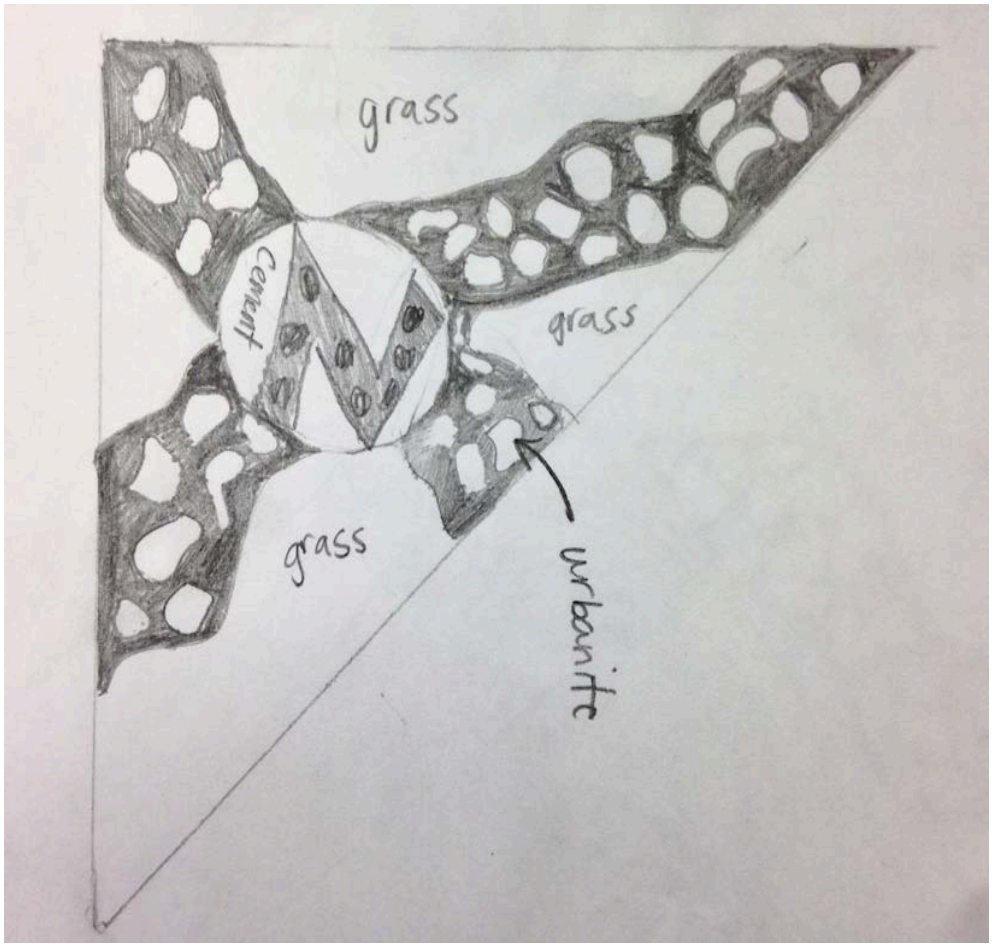

Figure 5-6 The Thunder Z Triangle utilizes multiple pathways made from urbanite and a 'Z' to promote school spirit (Photo by Kelly Fuentes)

5.3.7 Triangle within Triangle

Triangle within Triangle as displayed in figure 5-7 contains a triangle center within the existing triangle. The Triangle within Triangle also contains two more pathways on the side of the inner triangle. The material used for the inner triangle is urbanite while the material used for the two paths is flagstone. Bricks are utilized to spell out Zane in the inner triangle. The different pathway materials complement each other to provide a high aesthetic value. Right beside the triangle are two benches that are made of concrete. The rest of the area is covered in groundcover to cover up the maintenance boxes and provide more aesthetic value.

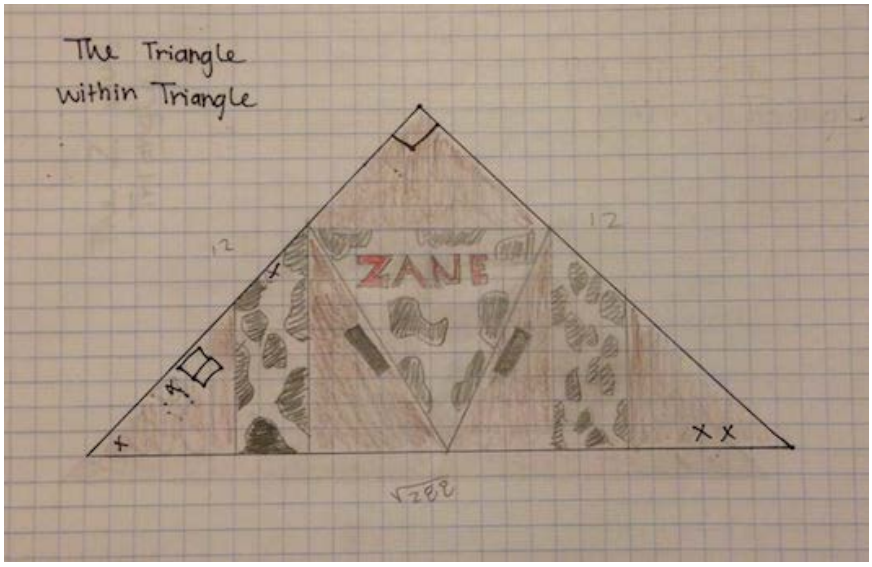

Figure 5-7 The Triangle within Triangle contains flagstone, urbanite, and brick in the pathways, two concrete benches, groundcover (Photo by Nancy Charco)

5.3.8 The Z Plus the Triangle

In the Z Plus the Triangle design, displayed in figure 5-8, the pathways are made from a mosaic like pattern of flagstone and urbanite to form a 'Z' pathway crossing through a triangular centerpiece. The pattern adds to the aesthetic value of the design and the sustainability by reusing concrete. The open areas contain a hardy evergreen groundcover to keep maintenance costs low.

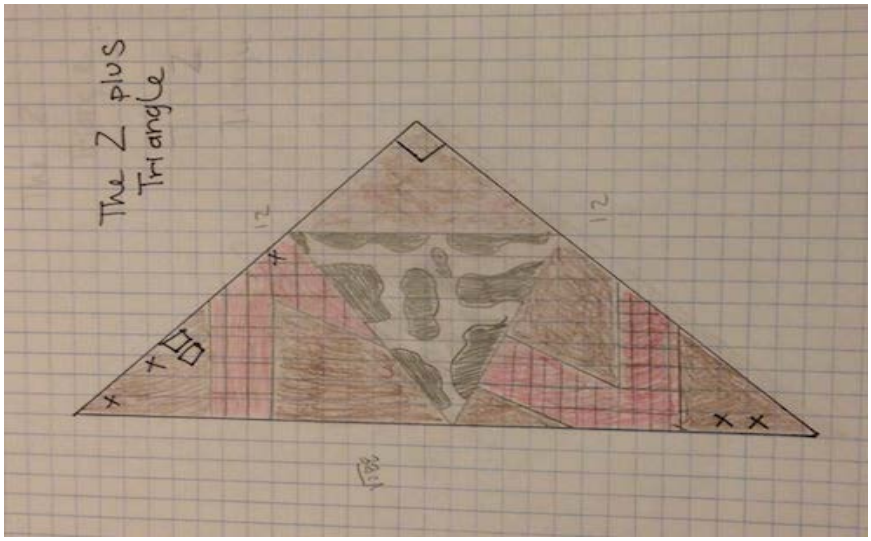

Figure 5-9 The Z Plus the Triangle features flagstone and urbanite pathways along with groundcover (Photo by Nancy Charco)

5.3.9 The Z Triangle

In the Z Triangle design shown in figure 5-9, there is an urbanite pathway in the shape of a ‘Z’ to promote school spirit and aesthetic value. There are two concrete benches running alongside the pathway to provide a functional area for the students to stop and rest. The open areas contain grass to promote aesthetic value and ease of maintenance.

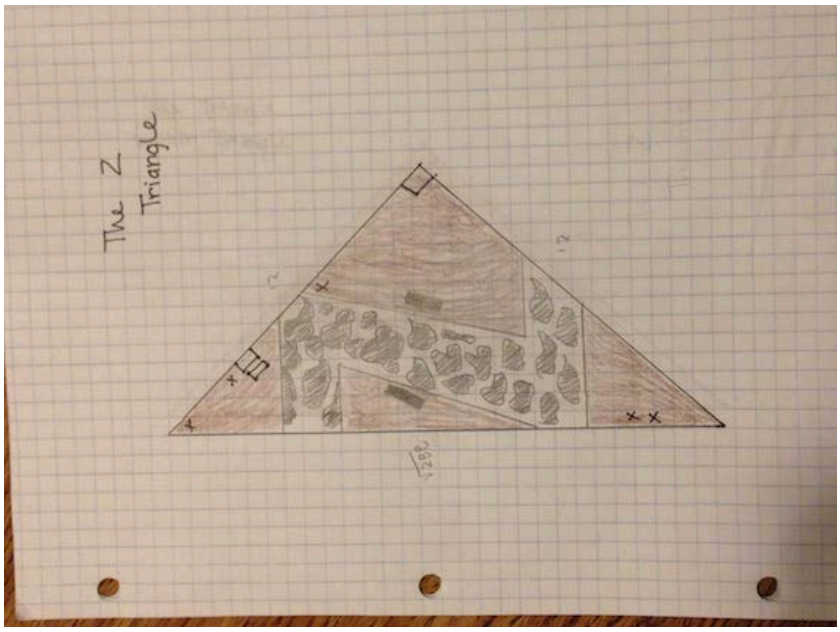

Figure 5-9 The Z Triangle contains two concrete benches and an urbanite pathway in the shape of a ‘Z’ (Photo by Nancy Charco)

5.3.10 Triangle Paths

Triangle Paths shown in figure 5-10, is a design that features a circular gathering area in the center of the triangle with three paths making a triangle around the circle. These paths lie just tangent to the circle and act as a way to both cross the triangle and to get to the circular gathering area. These paths are made out of urbanite. Inside the triangle is a ‘Z’ shape made from mosaic tile pieces. Three benches line the border of the circle, out of the way of the pathway entrances. These benches are made out of wood and are designed like a wooden park bench. The open patches of land have native flowers and groundcover growing with shredded redwood bark to fill in the space and match existing landscape designs.

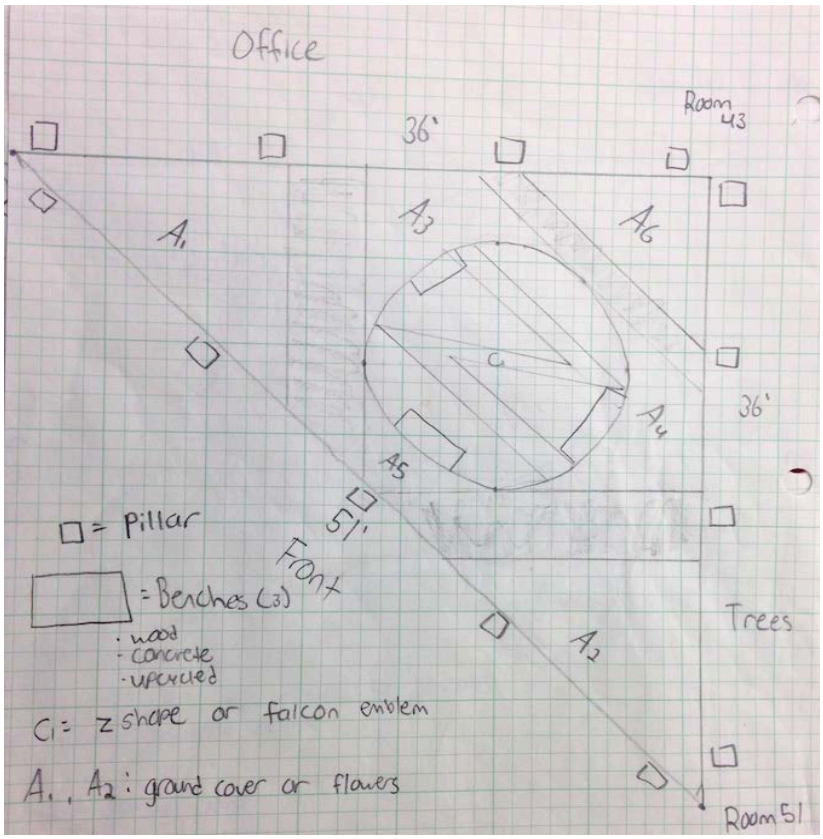

Figure 5-10 The Triangle Paths design features three benches and pathways with a 'Z' centerpiece and native plants in the open areas (Photo by Joseph Caminiti)

5.3.11 Semicircle Bench Triangle

Semicircle Bench Triangle shown in figure 5-11 is a design that contains three paths coming into a circle in the middle of the triangle with a semicircle bench around the backside of the circle. The paths are made from urbanite, which promotes the overall sustainability of the design, while the bench is constructed from brick. A 'Z' shape made from mosaic tile pieces makes a design in the circle. The open patches of land have native flowers and groundcover growing with shredded redwood bark to fill in the space and match existing landscape designs.

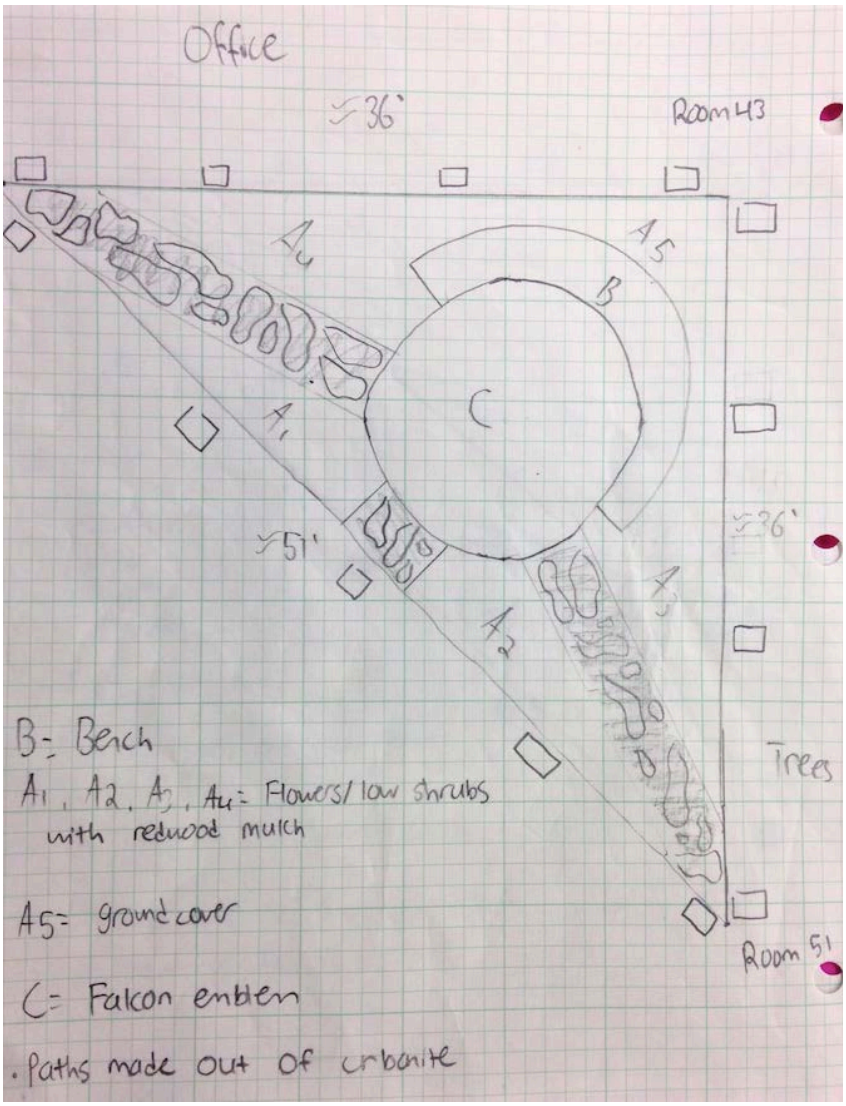

Figure 5-11 The Semicircle Bench Triangle contains a large semicircle bench made from bring and three urbanite pathways surrounded by native plants and redwood mulch (Photo by Joseph Caminiti)

5.3.12 Logical Triangle

Logical Triangle as shown in figure 5-12 is a design with the most logical and functional walkway pattern for the students' walking patterns. The paths are laid out for the easiest way to get across the triangle. These paths are made entirely out of urbanite to increase the sustainability of the design. The center circle is made from a mosaic 'Z' shape to encourage school spirit and five smaller upcycled benches are spread around the circle, to further promote the sustainability. The open patches of land contain native flowers and groundcover growing with shredded redwood bark to fill in the space and match existing landscape designs.

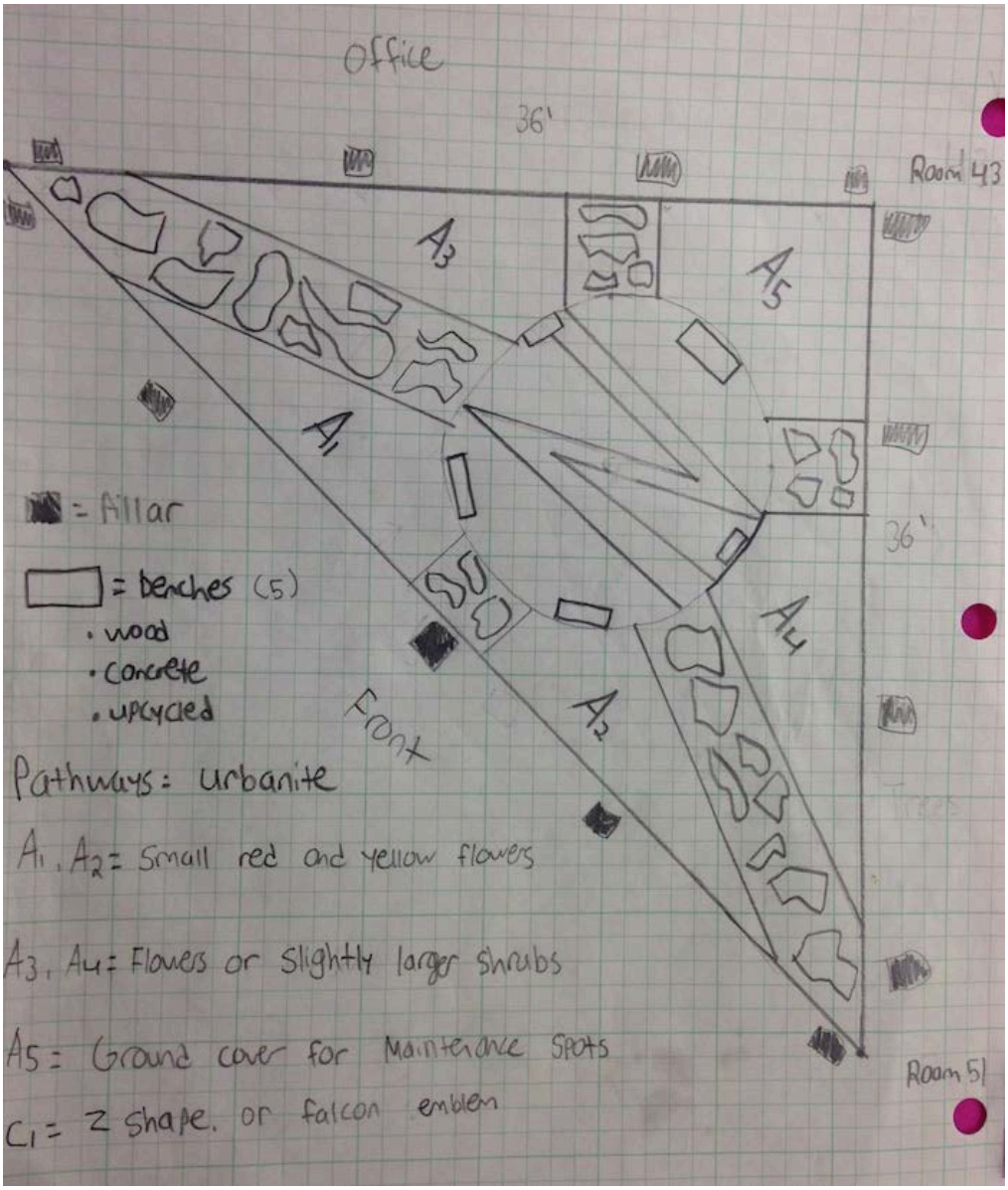

Figure 5-12 The Logical Triangle featuring urbanite pathways, 5 upcycled benches, and native flowers surrounded by redwood mulch (Photo by Joseph Caminiti)

6 Decision

In Section 6 the final decision is chosen. In this section all the alternative solutions are evaluated to be ranked the highest for which solution fits the criteria the best. The criteria taken into consideration are as follows: aesthetics, functionality, maintenance, durability, safety, cost, and sustainability. A Delphi Matrix is utilized in the process for choosing the final design. The Delphi Matrix is used to place numerical values on the alternative solutions to determine the best design.

6.1 Criteria

Each criteria, as referenced from section 4.3, is refined through many group sessions and are defined below.

Aesthetics: The visual appeal to individuals who see and utilize the design.

Functionality: The pathways provide a safe and effective way to cross the triangle and the centerpiece provides an area for students to socialize.

Low Maintenance: The least amount of change in the maintenance staff's workload.

Durability: The design is walked on and thus experiences daily wear and tear. The design needs to be able to resist the daily wear and tear to last for at least a couple years.

Safety: The overall safety and well-being of the students must be preserved. The pathways must be securely packed together and the plants cannot cause harm to the students or be used by a student to cause harm to other students.

Cost: The goal remains to keep the overall price of the design as low as possible. The cost for all materials should not exceed our budget set in Section 2.

Sustainability: The design should contain a large portion of recycled and/or upcycled materials to lower the embodied energy of the design.

6.2 Alternative Solutions

Listed below are the alternative solutions considered for evaluation on which best fits the criteria. Section 5 of the document contains each alternative solution in detail. The alternative solutions are in the order as listed in section 5:

1. Falcon Triangle
2. U-Shape Triangle
3. Urbanite Triangle of Life
4. Circular Triangle of Life
5. Thunder Z Triangle
6. Triangle within Triangle

7. The Z Plus the Triangle
8. The Z Triangle
9. Triangle Paths
10. Semicircle Bench Triangle
11. Logical Triangle

6.3 *Decision Process*

In the decision process, a Delphi Matrix, shown in Table 6-1, is utilized to determine the best design. The Delphi Matrix consists of the alternative solutions, ranked scores for each alternative solution, and weighted criteria for the design. Each alternative solution receives a weight in each criterion section on a scale from 0-50, 50 being the highest possible value, meaning that the alternative solution represented that criteria well. The weights for the criteria are entered on a scale from 0-10, 10 being the highest possible value. The products of the values and the weighted criteria are summed for each alternative solution, and the solution with the highest overall score is considered the best design.

Table 6-1 A Delphi Matrix to determine the best alternative solution for the final decision

Criteria	Weight (0-10 high)	Alternative Solutions										
		Falcon Triangle	U-Shape Triangle	Urbanite Triangle of Life	Circular Triangle of Life	Tunder Z Triangle	Triangle within Triangle	The Z Plus Triangle	The Z Triangle	Triangle Paths	Semicircle Bench Triangle	Logical Triangle
Aesthetics	9	38 / 342	25 / 225	35 / 315	28 / 252	30 / 270	27 / 243	33 / 297	26 / 234	25 / 225	40 / 360	42 / 378
Functionality	10	32 / 320	27 / 270	25 / 250	44 / 440	40 / 400	25 / 250	35 / 350	27 / 270	25 / 250	42 / 420	50 / 500
Durability	7	31 / 217	32 / 224	34 / 238	32 / 224	35 / 245	33 / 231	33 / 231	30 / 210	35 / 245	30 / 210	35 / 245
Safety	8	25 / 200	33 / 264	27 / 216	30 / 240	36 / 288	33 / 264	32 / 256	30 / 240	25 / 200	20 / 160	45 / 360
Cost	5	40 / 200	41 / 205	33 / 165	30 / 150	34 / 170	31 / 155	28 / 140	25 / 125	21 / 105	20 / 100	40 / 200
Low Maintenance	10	35 / 350	36 / 360	32 / 320	37 / 370	35 / 350	36 / 360	33 / 330	38 / 380	35 / 350	32 / 320	42 / 420
Sustainability	9	28 / 252	30 / 270	35 / 315	15 / 135	35 / 315	30 / 270	30 / 270	32 / 288	30 / 270	33 / 297	40 / 360
Totals		1881	1818	1819	1811	2038	1773	1874	1747	1645	1867	2463

6.4 *Final Decision*

The Delphi Matrix in table 6-1 totals the overall scores of each alternative solution to determine which is the best fit for the criteria. The logical triangle received the highest score by a large margin. However, with the given time constraint, the benches are dropped from the design but space is left so that benches may be added in the future for another project or by the school. Also, the pathways were adjusted to avoid maintenance boxes, pillars, and sprinklers.

7 Specification of Solution

7.1 Introduction

Specification of Solution describes the final solution of the Triangle of Life. It covers the Solution Description, Cost Analysis, Performance, the Final Results and Instructions for Implementation. The Solution Description documents the details of the Triangle of Life. The Cost Analysis includes the retail prices compared to donations and the maintenance costs. Instructions of Implementation explain how to replicate the design. Performance details how the Triangle of Life handled during testing.

7.2 Solution Description

The Triangle of Life, displayed in Figure 7-1, is the solution to the problem nicknamed the "Triangle of Death," discussed in section 3. There are six pathways that are laid out in the most logical fashion in order to avoid all obstacles such as utility boxes, sprinkler systems, and pillars. These pathways are made out of urbanite, and are packed together with a cement mix that is recycled out of the back of cement trucks. There is a circular area in the middle of the triangle to provide students with a social gathering area. This is also made from urbanite. Urbanite is implemented to reduce the amount of CO2 that enters the atmosphere because the production of new cement creates CO2 emissions. The open areas contain weed mat to prevent a rise in maintenance costs, evergreen plants to maintain an aesthetically pleasing landscape, and redwood mulch to match existing landscapes.

Figure 7-1 The Triangle of Life completed. Containing urbanite pathways, urbanite centerpiece and low maintenance plants. (Photo by Kelly Fuentes)

7.2.1 Pathways

The pathways, shown in Figure 7-2, are constructed using urbanite. By reusing concrete, the amount of carbon dioxide reaching the atmosphere is reduced. Using recycled materials avoids the manufacturing of new cement. The making cement produces a certain amount of carbon dioxide that can be avoided by reusing materials. The size of the pathways is approximately 12' by 4'. Large pieces of recycled concrete are chosen to prevent individuals from picking up the pieces and using them to cause damage. Terrace Board borders the paths to keep the urbanite chunks from spreading apart from each other. Recycled cement mix also helps to hold the pieces together.

Figure 7-2 The urbanite pathways in the final design of the triangle of life (Photo by Kelly Fuentes)

7.2.2 Centerpiece

The centerpiece below in Figure 7-3 consists of a circle with a diameter of eight feet that is constructed from urbanite and the recycled cement mix. This provides a large area for students to socialize.

Figure 7-3 The circular centerpiece in the middle of the Triangle of Life (Photo by Kelly Fuentes)

7.2.3 Empty Spaces

The leftover space in the Triangle of Life consists of weed mat to prevent a rise in maintenance costs. The weed mat surrounds Azaleas, Ferns, and Lithodoras, and the rest of the area is covered in redwood mulch, as shown in Figure 7-4, to match existing landscapes.

Figure 7-4 Leftover space in the Triangle of Life containing weed mat, evergreen plants, and redwood mulch (Photo by Kelly Fuentes)

7.3 Cost Analysis

The cost analysis consists of three sections. Design cost covers the total time spent on the design. The implementation cost covers the monetary amount of money required to implement the design. The maintenance cost describes the number of hours required to maintain the design.

7.3.1 Design Cost

The hours spend in the project is the design hours the Triangle of Life put into the project. A total of 153 hours were spent in the design project. The majority of hours were spent on Section 5 and the least of hours were spend on Section 1. The percentage of total time invested in each task of section 5, are shown in the figure 7.5.

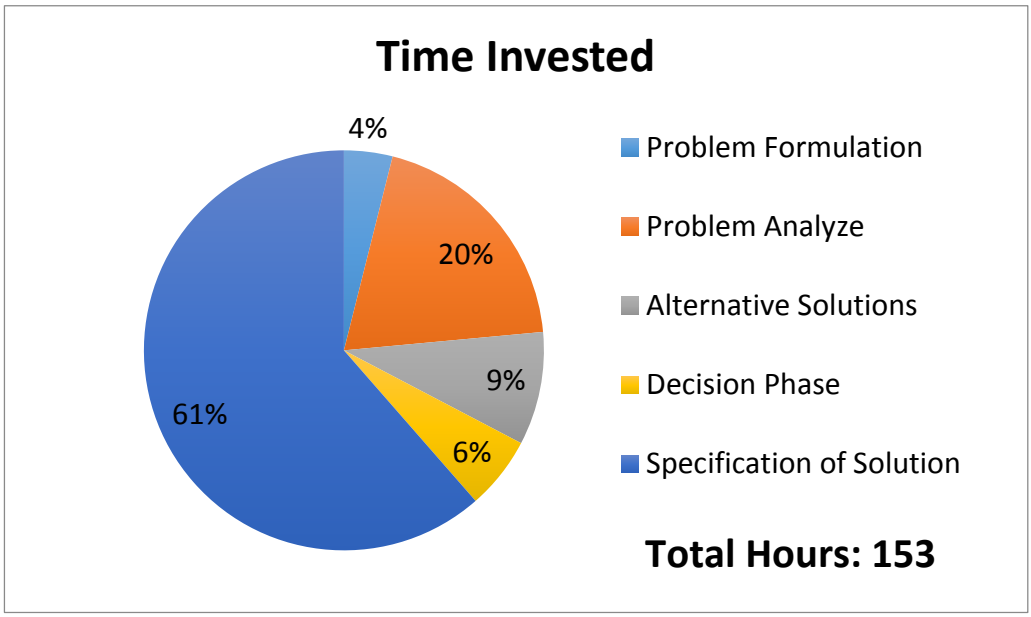

Figure 7-5 Pie chart for the total hours spent working on the design and the percentage of time that each section took

7.3.2 Implementation Cost

The total implementation cost of the triangle of life, shown in Table 7-1 includes both purchased and donated materials. The table shows the retail price compared to the amount spent by the team triangle of life. Some materials were donated by local businesses, which decreased the amount spent.

Table 7-1 List of retail costs for the design implementation versus the actual cost for the team

Material Cost			
Material	**Use**	**Retail Cost**	**Our Cost**
Urbanite	Pathway	$0.00	Donated
Recycled Sand	Pathway	$0.00	Donated
Plants	Empty Space	$75.00	Donated
Gardening Material	Clean/ Built	$50.00	$25.00
Edging	Pathway	$120.00	$60.00
Weed Mat	Under the Design	$60.00	Donated
Tested Material	Safety	$70.00	$70.00
Total		**$375.00**	**$155.00**

7.3.3 Maintenance Cost

The maintenance cost is estimated over monthly time periods. Maintenance cost is based on the seasons of how rapidly weeds grow and the cleanliness of the area due to it being at an elementary school.

Table 7-2 Maintenance of design in hours/month

Maintenance	
Task (Monthly)	**Cost (Hours)**
Weeding	2.00
Cut plants and clean area	2.00
Total	4.00

7.4 Instructions

Instructions to re-implement the Triangle of Life are located in the Appendix C and on the Appropedia page. First the area needs to be cleaned out of any weeds and worn down materials. The area is to be marked for accurate measured pathways. The areas marked were excavated approximately six inches. This allows for the upcycled urbanite chucks to be placed into the pathways. Gravel mixed with sand or recycled cement is placed below and between the urbanite to compact it in and keeping the pathways from deteriorating. The borders are placed in along the urbanite chunks to help keep the pathway in place. In the areas surrounding the pathways, weed mat is incorporated into the area, preventing weeds from growing. Desired

plants are planted in the empty spaces. Redwood mulch is the final step, and it is placed all around the areas surrounding the pathways.

7.5 Final Results

Figure 7-6 Final design of the Triangle of life

To test how well the area kept its form, the group walked on the pathways multiple times and pulled a wheelbarrow across the pathways to see how well the pathways are kept in place. The pathways are watered down to see if the area handled water well. Both experiments were taken place and both resulted in satisfactory results that met the groups' criteria.

8 Appendix A References

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9 Appendix B Brainstorming Notes

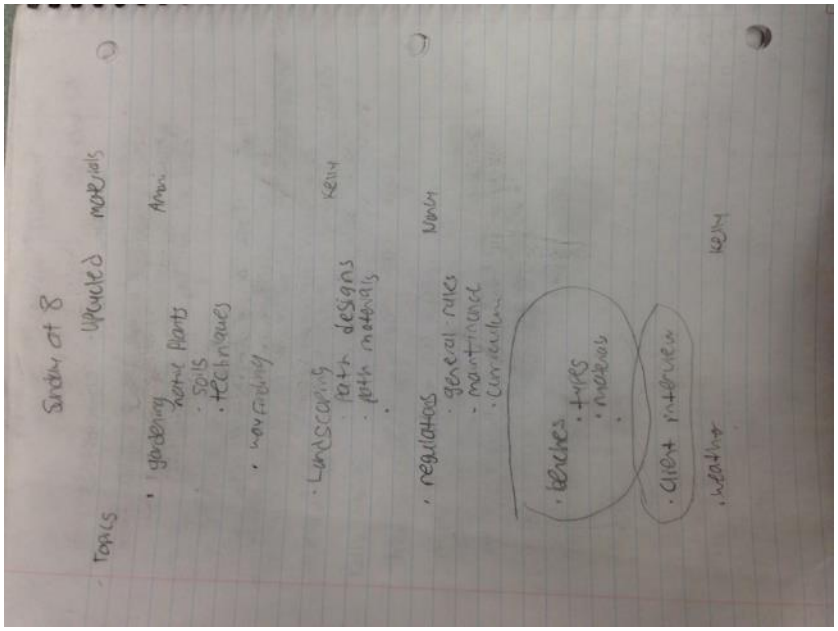

Figure 9-1 Literature Review Brainstorming (Photo by Joseph Caminiti)

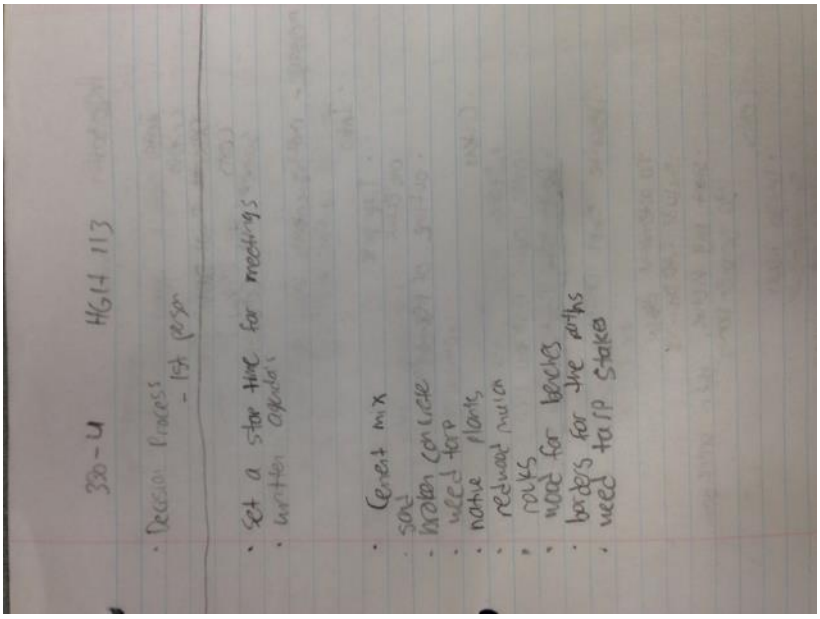

Figure 9-2 Notes of brainstorming the materials. (Photo by Joseph Caminiti)

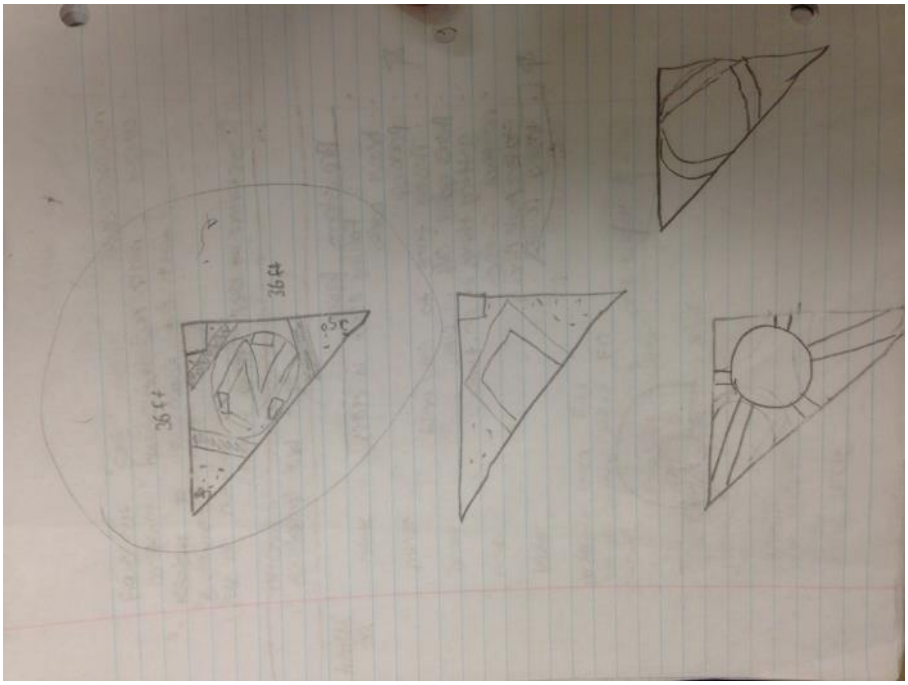

Figure 9-3 Brainstorming of Designs (Photo by Joseph Caminiti)

10 Appendix C Step by Step Implementation Instructions

Table 10-1 Process of Implementation of Design (Photos by Nancy Charco)

Image	Step
	**Step 1** Observe and plan out what to do on area before starting.
	**Step 2** Clear out area of weed tarp, weeds, dirt, and other green waste.
	**Step 3** Mark out areas for walkways and center circle.
	**Step 4** Dig out marked areas of dirt to desired specifications.
	**Step 5** Put in place urbanite for centerpiece and walkways.

	**Step 6** Test to make sure walkways are level, stable, and durable.
	**Step 7** Put in weed tarp.
	**Step 8** Add redwood mulch.
	**Step 9** Plant desired plants and flowers

11 Appendix D Autocad Drawing of the Triangle of Life

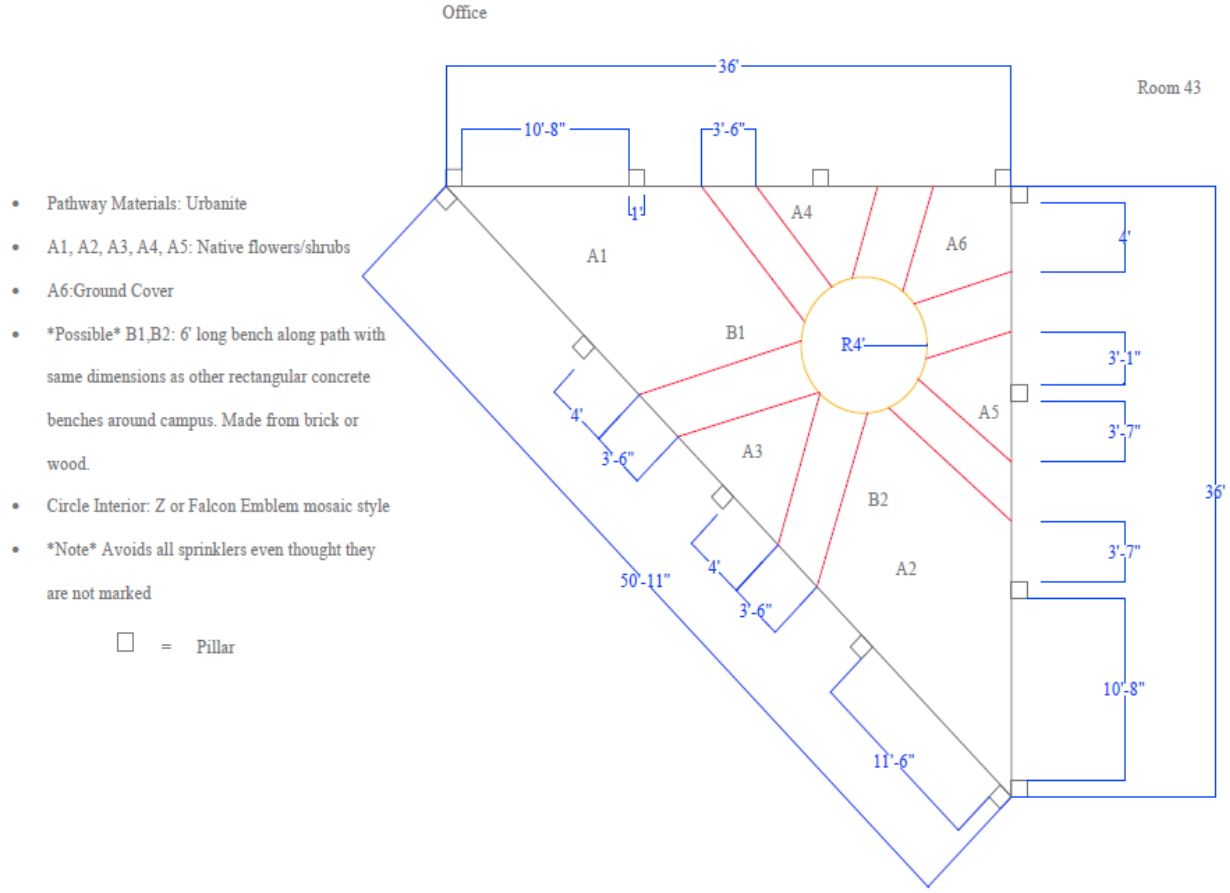

Figure 11-1 Autocad Drawing of the Triangle of Life