PORTABLE BACKPACK CUBBIES

DESIGNED BY: TEAM TONALITES

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ENGINEERING 215 INTRODUCTION TO DESIGN

Spring 2018

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1 Problem Formulation

1.1 Introduction

In Phase 1 of the design project, the Tonalities start by establishing an objective statement as well as a black box model as shown in Figure 1-1. The client is looking for a way to be able to have a cubby system that will be portable, yet durable to be able to hold up to the wear and tear over the years.

1.2 Background

The client wants the cubbies because a space is needed for the student's backpacks. The backpacks are underneath the tables at which the students sit. With the portable cubby system, the client will be able to have the backpacks out of the way, reducing the risk of students or the client tripping over the backpacks.

1.3 Objective

The objective of this project is to design and construct 32 portable backpack cubbies that are made out of recycled material. The cubbies will serve the purpose of holding the student's backpacks.

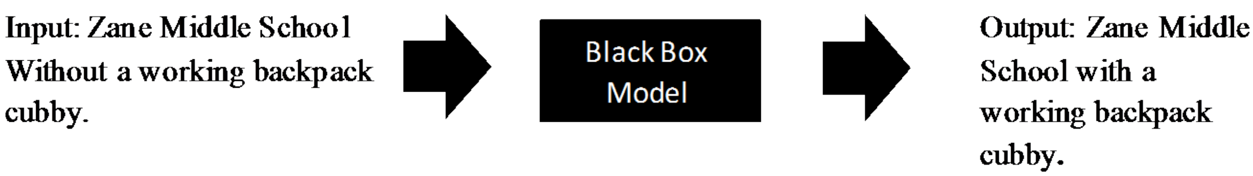

Figure 1-1 This is a more simpler way to state what our team objective is

2 Problem Analysis

The problem analysis contains the parameters of the project and the considerations that were made for the project. The specifications of what could be built. The criteria & constraints of what can be built building are shown in the Table 2-1 The production volume of how many students will be at the advantage of the project, and how those students will be using the project is also included

2.1 Specifications and Considerations

The design team has been given the minimum requirements for the project. The following specifications are:

- The cubby system has a minimum of 30 cubbies
- The cubby system is portable, so the representative can move them around to best maximize the class room space
- The dimensions of the cubbies are 20 inches long by 16 inches wide by 14 inches high

2.1.1 Considerations

The considerations that the team is considering when designing the cubby system are the following:

- How many students are using the cubbies
- The safety of the students
- Designing the cubbies to be light weight to be easily moved

2.1.2 Criteria

The Criteria listed in the Table 2-1below demonstrates the standards that have been decided upon the Tonalites and client. Each Criteria have their constraints and ranking from High (10) to Low (1) of importance.

Table of Criteria		
Criteria	**Constraints**	**Weighted (most to least important)**
Safety	Prevent any damage to the students and the teacher.	10
Portability	Easy to move to best fit the classroom	10
Durability	Must hold backpacks and other materials without breaking	9
Cost	Range $0-$300	8

Table 2-1 Table of Criteria (weighted from most to least important)

The Table 2-1 shown above highlights the criteria for the project. The most important criterion that the Tonalites are assigned to by the representative are safety, portability, durability and the cost. Safety is ranked as the number one criteria because when designing the cubby system, the design team to into account the student's and teacher's safety in order for no one to get hurt while using the cubbies. Portability is ranked just as important as safety because our representative wants the cubbies to be easily movable for activities during lab experiments and to be able to maximize the limited space. Durability is a ranked as a nine because the cubbies are designed to last well into the future, and the cubbies need to be strong enough to hold the weight of the cubbies for all those years. Cost is important because the team wanted to design a cubby system that was effective yet stayed within the maximum budget of 300 dollars.

2.1.3 Usage and Production Volume

The design that the team is going to use will be holding the thirty student's backpacks during class. The cubbies are going to be used during school hours and could be used after school hours if the representative decides to use the cubbies in a different way. That different way could be the representative using them as storage holders for books or other classroom supplies.

The representative needs a production of a minimum of thirty cubbies in order for all of the students' backpacks to be held. More cubbies could be made if the time arises.

2.2 Introduction to Literature Review

In this section, the Tonalites produced different ideas that will help the design team to create a portable cubby system. In the following section, the team does research on Zane Middle School, materials, aesthetics, and the audience.

2.2.1 Zane Middle School

Catherine Zane Middle School is a STEAM focused school, meaning they're focused on improving student's understanding of subjects including science, technology, engineering, art and math. Their hope is to promote creative expression, critical thinking, and digital literacy. Working with HSU, design students introduce the students at Zane to people they can look up to and see where they can be if they keep at their studies. The average class size at Zane Middle school is 32, meaning the design team will accommodate enough cubbies for all of the students that our representatives has.

Figure 2-1 Zane Middle School Greenson, T. (2015).

2.2.2 Aesthetics

When a person first looks at something, they first notice appearance and then absorb all colors. According to Scott Brouette, who has a Master's in Education and Teaching, "Color can change the entire look and feel of a space."(Brouette 2011). Brouette has spent his career as a teacher trying to improve a child's learning experience. He believes changing the appearance of a classroom is one of the best things a teacher can do for the children. The first picture below Figure 2-2 represents a typical classroom with no additional aesthetics. In Figure 2-3 the classroom that's been decorated with additional art on the wall with hanging lights.

Figure 2-2 A classroom with no added aesthetics (Facility. (n.d.)

Figure 2-3 How aesthetics can change a classroom (Somma 2017).

2.2.3 Materials

Materials are important because the materials dictate the integrity of the project. Also, the project's success depends on how well the materials work. An important aspect to the materials is if they are environmentally friendly because using recycled products are less wasteful and promotes recycling.

2.2.4 Wood

Using wood as a material for this project is a good construction material because of its stability and for its affordability. Wood has a strong to weight ratio that allows for it to be used a construction material (tree testing 2016). The forms of wood that will be researched are hardwoods, softwoods, plywood, fiber board, and particleboard.

2.2.4.1 Hardwoods

Hardwood comes from the broad-leaved (deciduous) trees; those that have their leaves fall in the fall time autumn seasons (Woodford, 2017). Those trees include, ash, birch, walnut, teak, oak, maple, mahogany and beech. Each of these woods are durable and could last for a long time if kept in good condition. Most hardwoods have nice grain lines, which makes them more ascetically pleasing to their intended audience.

Figure 2-4 Images of cut French oak (English Woodlands Timber 2014)

2.2.4.2 Softwoods

Softwood comes from the evergreen (coniferous) trees meaning they will retain their needles and cones year-round. (Woodford, 2017). Some examples of softwoods would include redwoods, pine, cedar, cypress, fir, and spruce. Softwoods are cheap and easy to obtain then most hardwoods, and it softwoods can be manipulated to maximize their strength (Pergamon 2016).

Figure 2-5 Scots Pine is an example of a softwood (The Wood Database)

2.2.4.3 Plywood

Plywood is a material that is comprised of multiple layers of different boards, and then bonded together to make one piece of board (Display 2 Go, 2016). Plywood has two different grades, one for more construction-based projects, and the other for furniture. Plywood is a strong material that comes in different thicknesses and can come in different kinds of wood.

Figure 2-6 Example of hardwood plywood. (Exporters India)

2.2.4.4 Medium Density Fiberboard

Medium Density Fiberboard (MDF) is a material that is made from wood composite made of wood fibers. MDF is made by “using fibers, glue, and heat to create a tight bond of material" (Display 2 Go 2016). MDF is commonly used because of its low cost and for it being a strong building material.

Figure 2-7 Example of Ranger softwood MDF. (Metro Hardwoods Maple Grove)

2.2.4.5 Particle Board

Particle board is a product that is from any part of the waste of wood. The waste from the wood is formed into particle board through a heating process (Display 2 Go 2016). Particle board is light-weight and inexpensive but has trouble when put against heavy loads. A popular type of particle board is oriented strand board (OSB).

Figure 2-8 Example of OSB particle board. (Granulas.eu, 2016)

2.2.5 Metal

Metal is strong and also and can be easily manipulated to a desired shape. However, metal is heavy and has very sharp edges. The metals in question are aluminum and steel.

2.2.5.1 Aluminum

Aluminum has a property that makes it hard to corrode which is in the favor for the team because that means it won't rust, so that will help the durability and of the product. Aluminum has a low density and is commonly used when high strength and low weight are needed (Aalco 2017). Aluminum has chemical properties that do not allow aluminum to rust because it has a layer of protection.

Figure 2-9 Aluminum in different forms (Building Materials Malaysia, 2016)

2.2.6 Plastic

Plastic can be defined as a pliable polymer that is made of various synthetic, or semi-synthetic, organic compounds where it has the potential to be manufactured into various products such as water bottles or milk jugs. Known as a durable substance, plastic's strength is derived from its long monomer (singular molecule) chain structure. When monomers are chained in this fashion they become what is known as a polymer. (American Chemical Society).

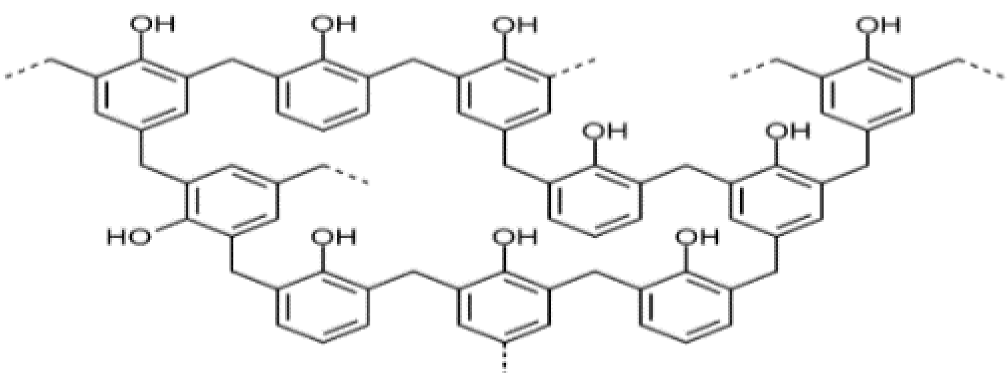

Figure 2-10 Bakelite molecular structure (Byjus Classes, 2016).

2.2.7 Magnets

Magnets are just two metal pieces that have a field around them that either retract or repel an object depending if they are also magnetic. In this magnetic field, as shown in the figure below, there are different forces that interact with other materials. (Science Buddies, 2018). If something has the opposite attraction, then it will stick to the magnet. However, if the two objects have the same attraction, then they will repel each other.

The magnets could potentially be used as a way to get them to stick together so they don't roll away from each other. In addition, the magnets could be interesting for design because it could add a teaching moment to the cubbies. The magnets could be showing off how magnets are attracted to each other as shown in the figure below.

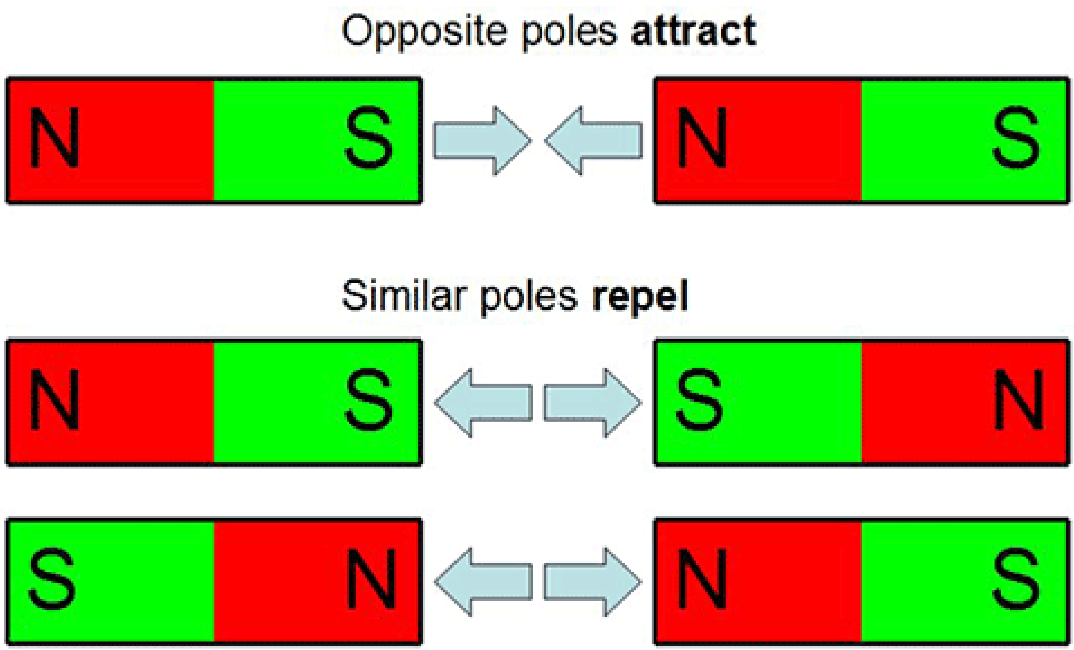

Figure 2-11 This is a picture of showing how magnets are retracted or repel from each other. (Science Buddies 2018).

2.2.7.1 Dynamics

The dynamics behind magnets are fairly simple. In Figure 2-11, the forces on the magnet attractive to their opposites. When two of the forces are the same, then they repel because each of them don't have the attracting force required to pull them together.

2.2.8 Milk Crates

Milk crates are known for their strength and durability. It would not be environmentally responsible to buy new ones, due to the fact that they take "four pounds of petroleum-derived plastic to create a single milk crate" (Jenner 2013). However, acquiring repurposed milk crates would be considerate of resources.

Figure 2-12 Milk crate could be used for storage (picture credit Robert Carey).

3 Alternative Solutions

3.1 Introduction

Section 3 of the document is composed of the team's brainstorming ideas and the alternate solutions that the team members designed for our representative's problem. Through brainstorming and talking with the client, the Tonalites came up with seven different alternative solutions that fit the criteria that were laid out in section 2.1.2. Included with the different solutions, there are drawings of what the ideas could potential look like.

3.2 Brainstorming

The design team got together different times to discuss alternative solutions that could work for the project. One of the brainstorming occurred on a Sunday morning at Zane Middle School to meet our client. We discussed about the issues of her class. The purpose of the brainstorming during that time was to take ideas and see how our ideas can be executed. The team took an hour allowing each person to go through their alternative solution. We then went through and starting the process of seeing how each of our solutions met the specifications and considerations that were laid out in section 2.1. The brainstorm notes from this session are in the Appendix.

The following alternative solutions that were created by the team are:

- Los Cajones
- Falcon's Solution
- Heavy Metal
- Plastic Circle
- Plastic Triangles
- Backpack Packing
- The Z Solution

3.3 Los Cajones

Los Cajones shown in Figure 3-1 below shows the milk crates and how they are stack up. The milk crates are sized, so there can be 30 cubbies to fit the criteria that is laid out in section 2.1.2. The cubbies are light, so they can be arranged in a desired fashion. At the bottom of the cubbies, there are wheels, so the cubbies can be portable. The cubbies are attached together with magnets to keep them from moving a part. The milk crates are recycled and make for a be cost effective design.

Figure 3-1 Los Cajones and how they could be oriented. (Ronald Diaz)

3.4 Falcon's Solution

The Falcon's solution shares a design much like a cabinet. As shown in Figure 3-2 below, the base of the project is designed to hold heavy weight. The wheels attached to the bottom of the wooden frame enables the repetitive to be able to move the project to maximize the classroom size. Going inside of the design, the cubbies are wooden boxes because they provide a good support system and are also easily constructible and de-constructible if necessary. The hooks in the inside of each cubby allows for the students to hang their coats, instruments etc.

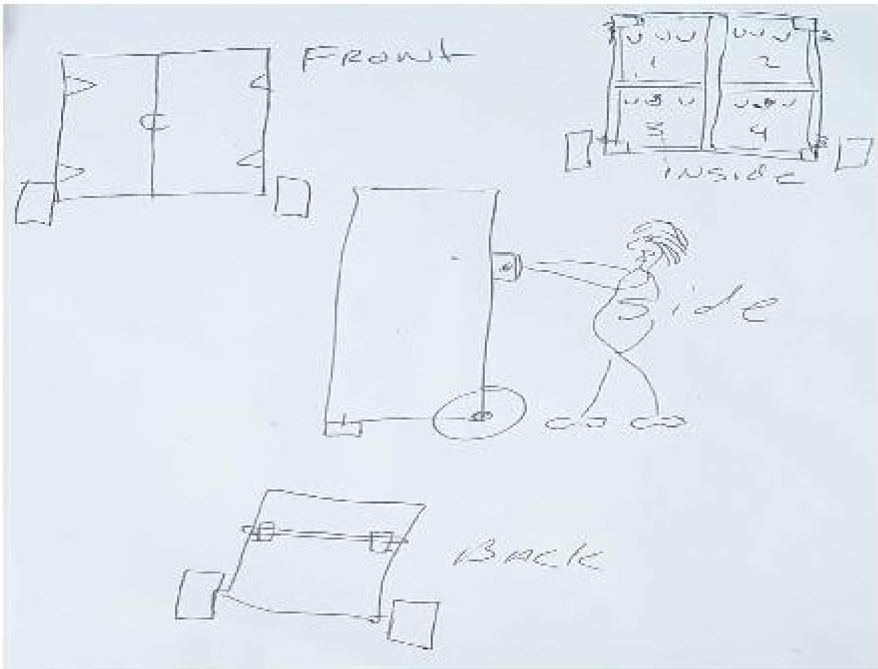

Figure 3-2 Falcon's solution (Robert Carey)

3.5 Heavy Metal

Heavy Metal as shown in Figure 3-3, below shows how the cubbies are stacked together. Being made out of aluminum, the cubbies fit the criteria that our representative laid out for us. The durability is strong because metal is not easily breakable, so the base will be strong and will be able to hold the backpacks. The cubbies are welded together to enable them from coming part from each other. The cubbies have curves on the side, which helps for putting the backpacks in easy as well as holding the backpacks in without them falling out.

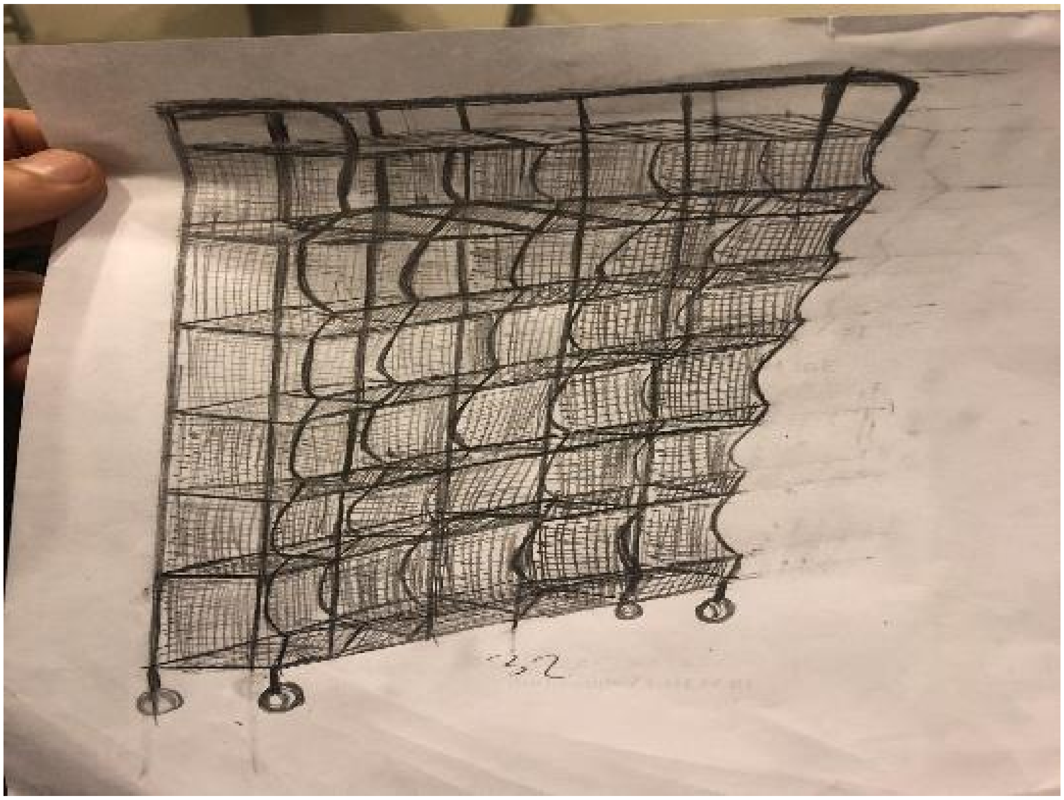

Figure 3-3 Heavy Metal (Ronald Diaz)

3.6 Plastic Circles

Plastic circles as shown in Figure 3-4 are made out of all plastic. The cubbies inside of the frame are circular cubbies that are large enough to fit the backpacks. The cubbies are connected together via velcro that is on the sides and top of the cubbies. The wheels on the bottom of the frame of the cubbies allows the representative to move all 32 cubbies at once around the room.

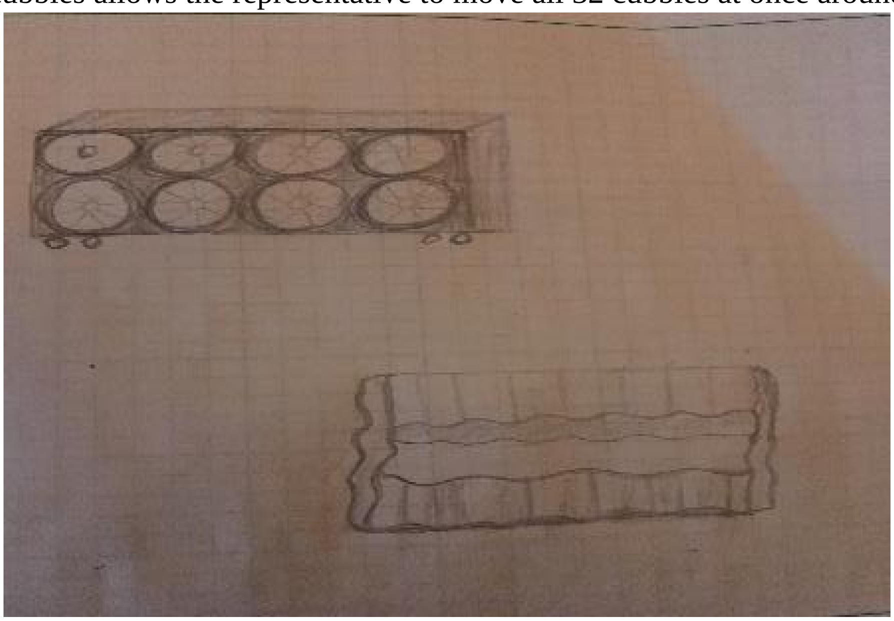

Figure 3-4 Plastic Circles (Sonnet Antio)

3.7 Plastic Triangles

Plastic Triangles as shown in Figure 3-5, show the cubbies being made as triangles. Each triangle is large enough to meet the criteria that is set out by the representative. The triangles are made out of plastic that is durable to hold the weight of the cubbies. The wheels that are attached to the bottom of the frame are so the client can wheel all the cubbies around the classroom.

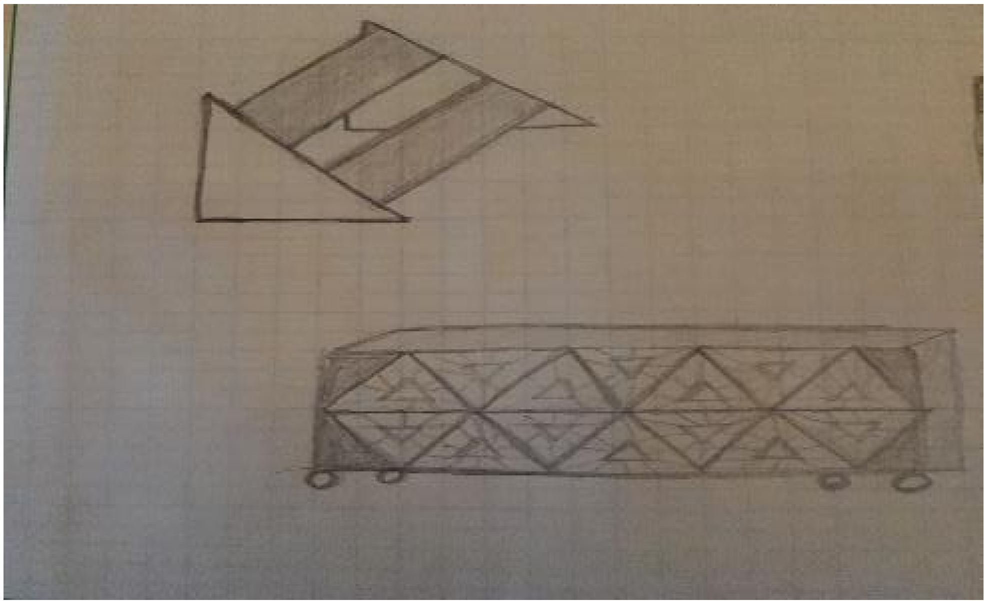

Figure 3-5 Plastic Triangles (Sonnet Antio)

3.8 Backpack Parking

Backpack parking as shown in Figure 3-6, demonstrates the use of street signs in this design utilizing resources that would otherwise be wasted. Wood is the main material used in the design, and the street signs are for purely aesthetics. The street signs have sharp edges, so the signs are grinded down to reduce injury. Magnets are used to keep the boxes together which allows the representative to manipulate the cubbies in various orientations. Each of the cubbies are individual, which allows for freedom to move the cubbies around the room. The elements of the backpack parking fit into the criteria that were laid out in section 2.1.2.

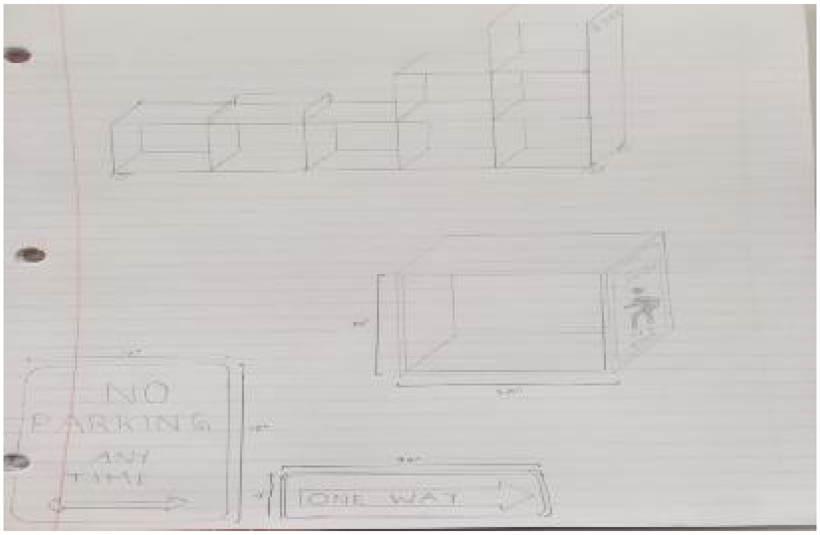

Figure 3-6 Backpack Parking (Elise Riegelsberger)

3.9 The "Z" Solution

The Z solution as shown in Figure 3-7, shows the cubbies are arranged in a Z pattern to represent the first letter in Zane Middle School. The frame of the Z would be made out of wood because wood is durable and can hold the backpacks of the students. Each of the cubbies that make up the Z would be screwed together. The bottom that is holding the Z would be made out of plywood because it is light and durable. The base would also be able to have cubbies to hold larger backpacks or student's instruments. The Z would be on the base that has a handle and wheels to be able to move the cubby system around the room.

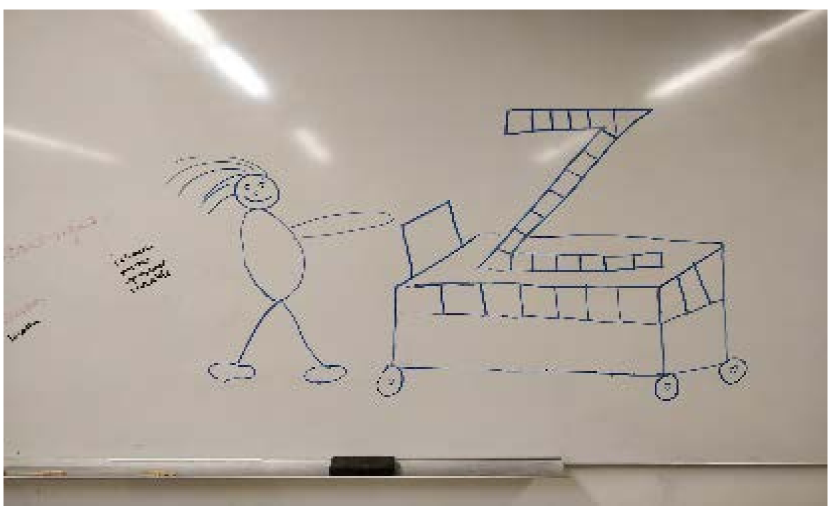

Figure 3-7 The Z solution. (Robert Carey)

4 Decision Process

4.1 Introduction to the Final Decision

Section four's purpose is to describe the decision process. The alternative solutions listed in Section three are outlined and analyzed based on various criteria. The final design decision was made based on the criteria that were chosen and decided with input by the Delphi Method.

4.2 Criteria

The criteria from section 2.1.2 are used in the decision process:

1. **Safety**: Maintaining the health and wellbeing of the user.
2. **Portability**: The ability to be moved easily without straining the user.
3. **Durability**: The ability to be able to hold up to damage and wear from using the cubbies
4. **Cost:** The amount of money that it takes to build the product

4.3 Solutions

The solutions the team created are as follows:

- Los Cajones
- Falcon's Solution
- Heavy Metal
- Plastic Circles
- Plastic Triangles
- Backpack Parking
- The "Z" Solution

A detailed analysis of each proposed design is located in Section 3 of the document.

4.4 Decision Process

After the brainstorming process, the top ideas are picked based off of functionality. Optimizing cubby space while keeping the cubbies compact, in order to fit in the small classroom, is one of the most challenging aspects during the decision-making process. The portability is also difficult because there are several different ways to make the cubbies portable and determining which way works best with different materials was difficult. The product also needs to be durable and achieve longevity which is a challenge in itself, being that heavy materials tend to be stronger, but the heavier the project the more difficult it is to move, compromising portability.

The client also narrowed down the decision with her own opinions of what would work best. Originally, milk cartons were the top solution; the client expressed that this would not work for her do to the limited sizing of the crates. Using the prototype drawing, the next best options are analyzed, including the Plastic Design and Backpack Parking.

Criteria	**Weight**	**Alternative Solutions (0-50 high)**					
	(0-10)	***Cajones***	***Falcon***	***Metal***	***Plastic***	***Parking***	***"Z"***
Durability	9	32 / **288**	38 / **338**	42 / **378**	33 / **297**	45 / **405**	34 / **306**
Portability	10	43 / **430**	41 / **410**	30 / **300**	23 / **230**	39 / **390**	6 / **60**
Longevity	7	30 / **210**	33 / **228**	45 / **315**	31 / **217**	50 / **350**	15 / **105**
Safety	10	41 / **410**	33 / **330**	10 / **100**	44 / **440**	37 / **370**	1 / **10**
Cost	8	45 / **360**	20 / **160**	10 / **80**	42 / **336**	24 / **192**	15 / **120**
Total		**1698**	**1465**	**1173**	**1520**	**1707**	**601**

Figure 4-1 Delphi Model

4.5 Final Decision

The design that will be used for the final product is the Backpack Parking design. With the use of the Delphi Method in conjunction with the client's preferences, this design is the most realistic and best fit for the criteria. Being that this design is easily portable with the attachment of magnets to keep them conjoined, it is optimal in this criterion. Also, because the cubbies have the ability to be taken apart and reorganized to fit any place the client has adaptability with the placement and orientation of them. The use of street signs in this design is purely aesthetic, with dedication to the past cubby design that failed where this design will succeed.

5 Specifications

5.1 Introduction

In this section, there is an in-depth look into the solution that has been decided on in the previous section. In this subsection there are also AutoCAD illustrations of how the cubby systems look and get put together. The cost of the cubbies is included with a table of materials showing how much each of them costs. A table of design showing the time that took the team to design the product, and a table for maintenance costs. Included into this section is a step by step building to show how the cubbies are built. In conclusion, there will be a results subsection talking about how the project went.

5.2 Description of Solutions

The solution that is decided on is a mixture of the alternative solutions that were brainstormed. The team ended up mixing the ideas of the Falcon solution and the Backpack Parking solution. Instead of making the cubbies in columns like the falcon solution proposed, the client instead wants to go with velcro that are fitted to the top of a cubby and the next cubby can be stacked onto it. In the Figure 5-1 below shows one of the cubbies being set on top of each other cubby. Also, with the cubbies constructed this way, it greatens their portability because the client can take them apart easily and can manipulate them in any way for a given situation. During building process, the design team implemented the velcro instead of the dowel and hole system.

The material that the team has decided to go with is fiber board that has two faces of laminate on top. With the current design for the cubbies, there will be no walls on either side. The team decided on no walls because when the first prototype was constructed, it was deemed too heavy to move. So, instead of having two sides of the cubbies, there will be just supports that will hold the weight of the next cubby. To hold the backpacks inside of the cubbies, there will be a small walls that serves a dual purpose; to hold the backpacks inside as well as helping to support the legs.

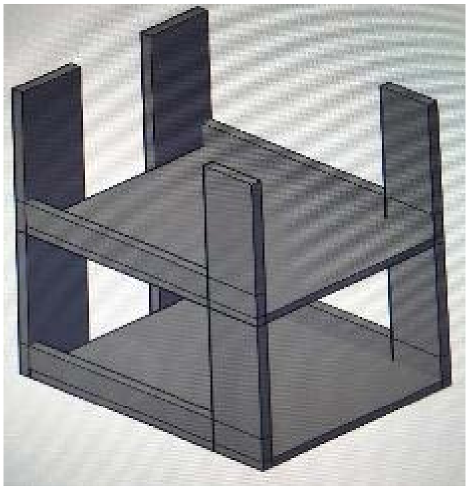

Figure 5-1 AutoCAD drawing of the Skeleton. (Robert Carey)

5.3 Cost

5.3.1 Material Cost

Table 5-1 shows the following materials that were needed for the project as well as and how much it costs for each of the items. The amount so far that has been spent on the project was $176.86. The total budget that was set aside for this project was $300.00.

Quantity	Material	Source	Cost ($)	Total ($)
1	Wood Glue	The Mill Yard	4.78	4.78
2	Sandpaper	Ace Hardware	3.79	7.58
1	Velcro(package)	Amazon	8.62	8.62
2	Paint	Ace Hardware	8.01	16.02
7	Screws	The Mill Yard	7.58	53.06
16	Fiber board	Almquist Lumber Company	5.43	86.80
			Total Cost	**176.86**

Table 5-1 Cost of Materials

5.3.2 Design Cost

The pie chart, shown below in Figure 5-2, shows how many hours the Tonalites put into the design process of the project. The chart is broken down into sections to see where the team spent most of the time in. The chart shows that phase three, Alternative Solutions, took the most time.

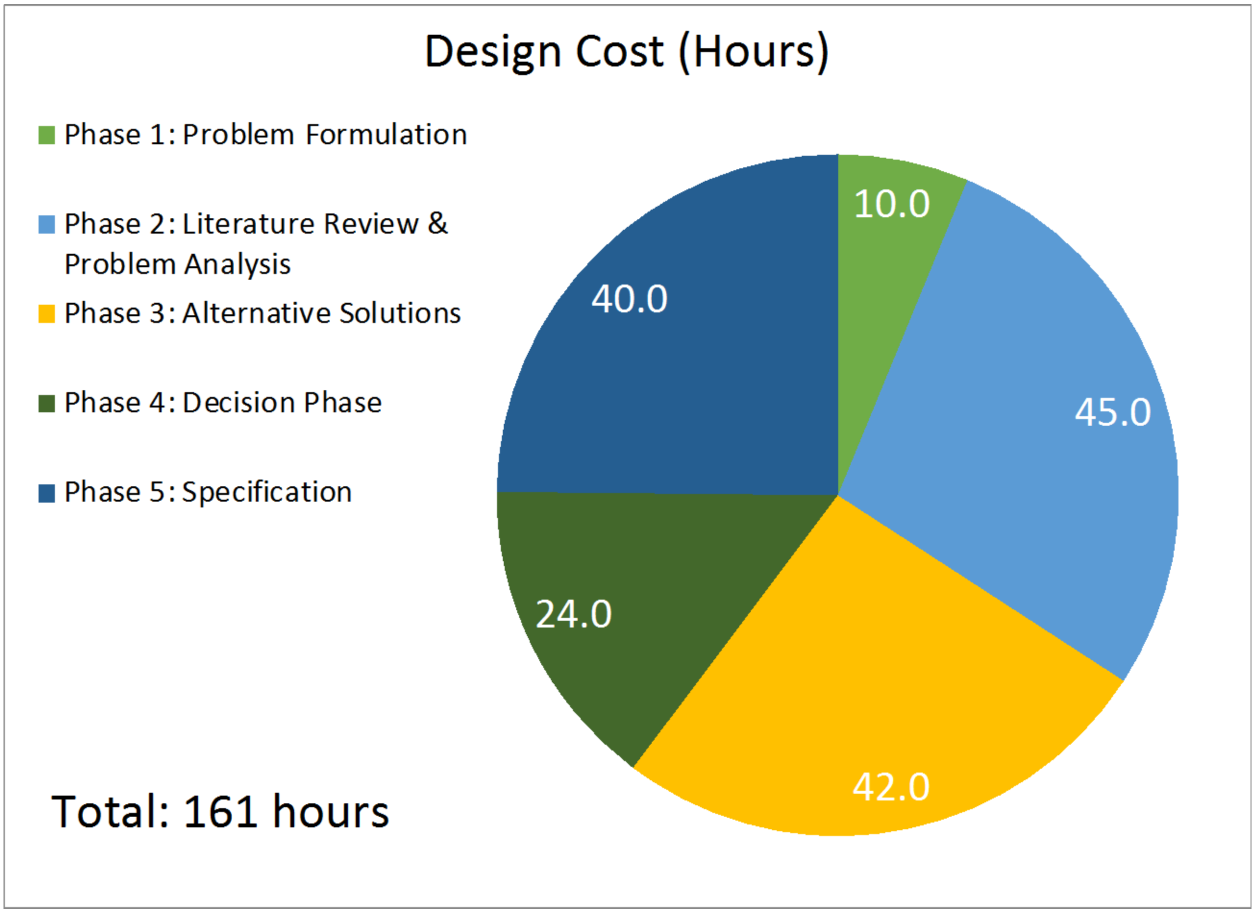

Figure 5-2 Design Hours of the team

5.3.3 Maintenance Cost

For example, if one of the cubbies were to break, creating a new one would be inexpensive. The Table 5-2 below shows the estimated cost one cubby would be. To create a cubby, one would need one sheet of particle board along with some screws and velcro.

Task	Frequency	Amount of Time	Cost
Making a new cubby	When Needed	1 hour	$30.00
Replacing velcro	When Needed	5 minutes	$5.00
Replacing a Top/bottom to a cubby	When needed	1 hour	$10.00
Painting the cubbies	When needed	30 minutes	$8.00

Table 5-2 Maintenance Cost

5.4 Instructions for Implementation and Use of Model

This section has the implementation of the portable cubby system as well as building steps on how to construct the cubbies.

5.4.1 Implementation of the Cubbies

The portable backpack cubby system has met the specifications and the criteria that was laid out in section 2.1 of the document. Our representative will be using the cubbies as a way to hold the student's backpacks during class.

5.4.2 Building steps

In the following section there will be detailed description of how to build the portable cubby system.

1. Find and buy the material

Figure 5-3 MDF material used to build the cubbies. (Robert Carey)

2. Start by measuring out the dimensions, make sure to carefully mark the lines straight.

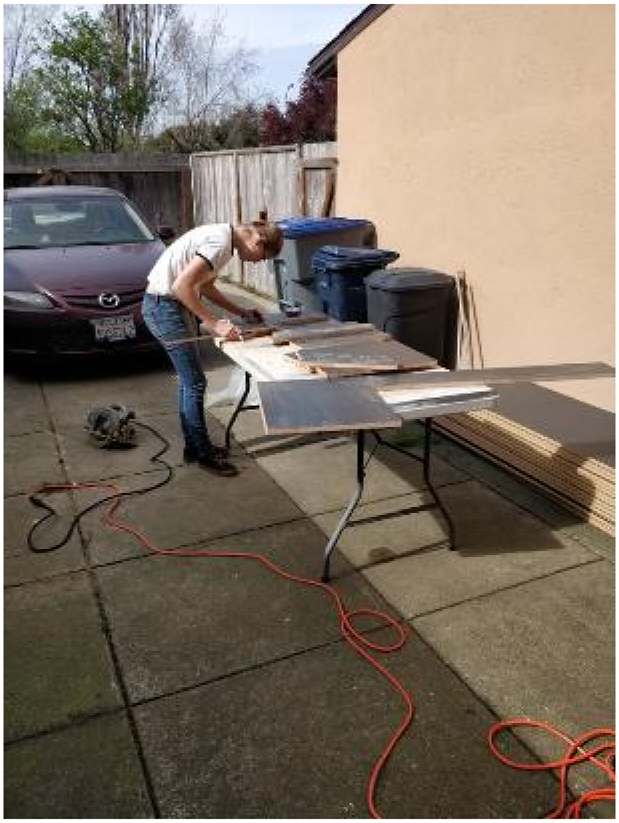

Figure 5-4 Elise drawing out lines for cutting. (Robert Carey)

3. Cut the pieces of wood to the dimensions that were measured out.

Figure 5-5 Cut the pieces of material. (Sonnet Antio)

4. Screw together the pieces of material to make the cubby

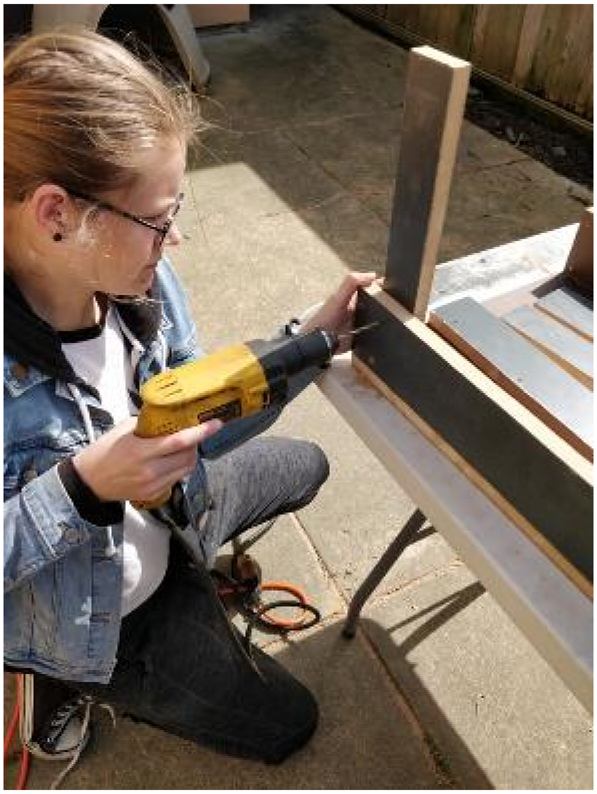

Figure 5-6 Elise screwing the cubbies together. (Robert Carey)

5. Once the cubby has been built, now sand the cubby to remove all of the sharp edges.

Figure 5-7 Sonnet sanding the edges to make them smooth. (Robert Carey)

6. After sanding the cubbies, paint the cubbies black 0

Figure 5-8 Ronnie painting the cubbies. (Robert Carey)

7. After painting all of the 32 cubbies, put the velcro on the top of the supports and the bottoms of the cubbies for the linking of the cubbies.

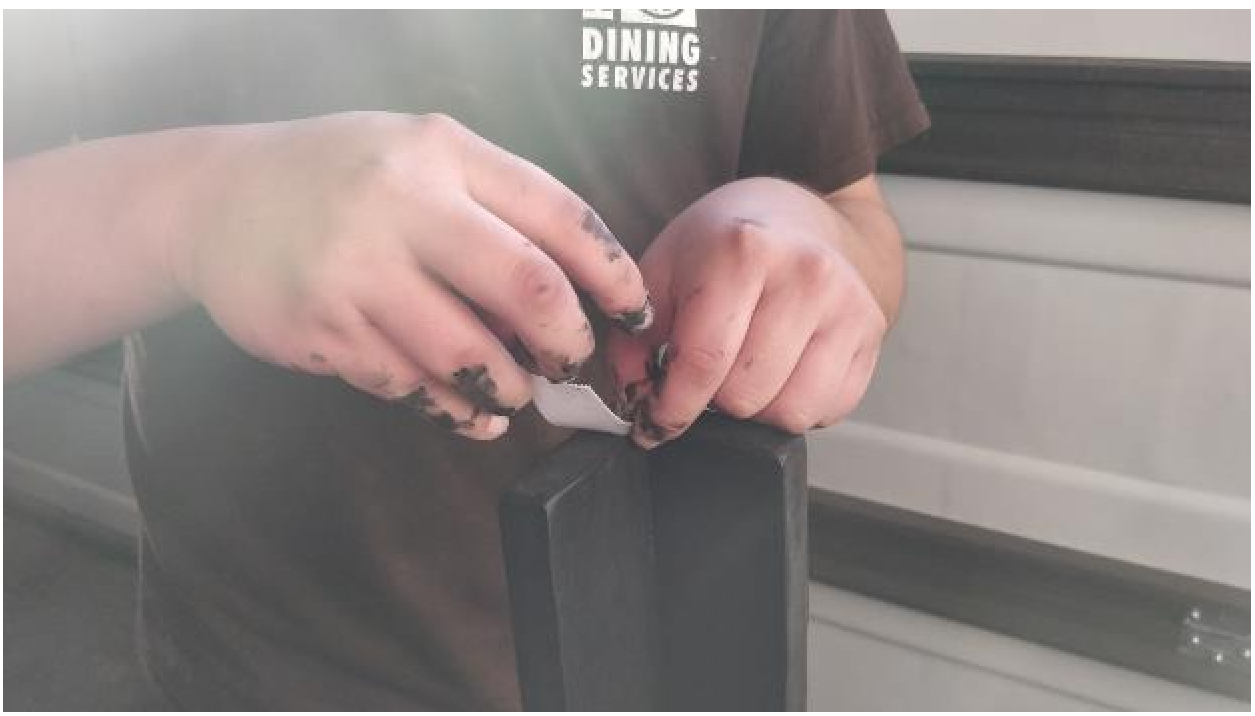

Figure 5-9 Ronnie applying velcro onto a support. (Robert Carey)

8. After all that is done, the cubby should look like this:

Figure 5-10 Final Picture of the cubby

5.5 Results

As a result of the prototype that the design team built, we were able to make modifications to the cubby to make it into the final product that is in the Figure 5-10 above. In Appendix B, there is a photo of the first cubby design. The final model of the design is a fully function portable backpack cubby system that meets the specification and considerations, as well as the criteria that was set out in section 2.1 and 2.1.2. The team has built thirty-two portable cubbies that can be oriented to any way that the representative desires.

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Photo of the Aluminum

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Appendix A

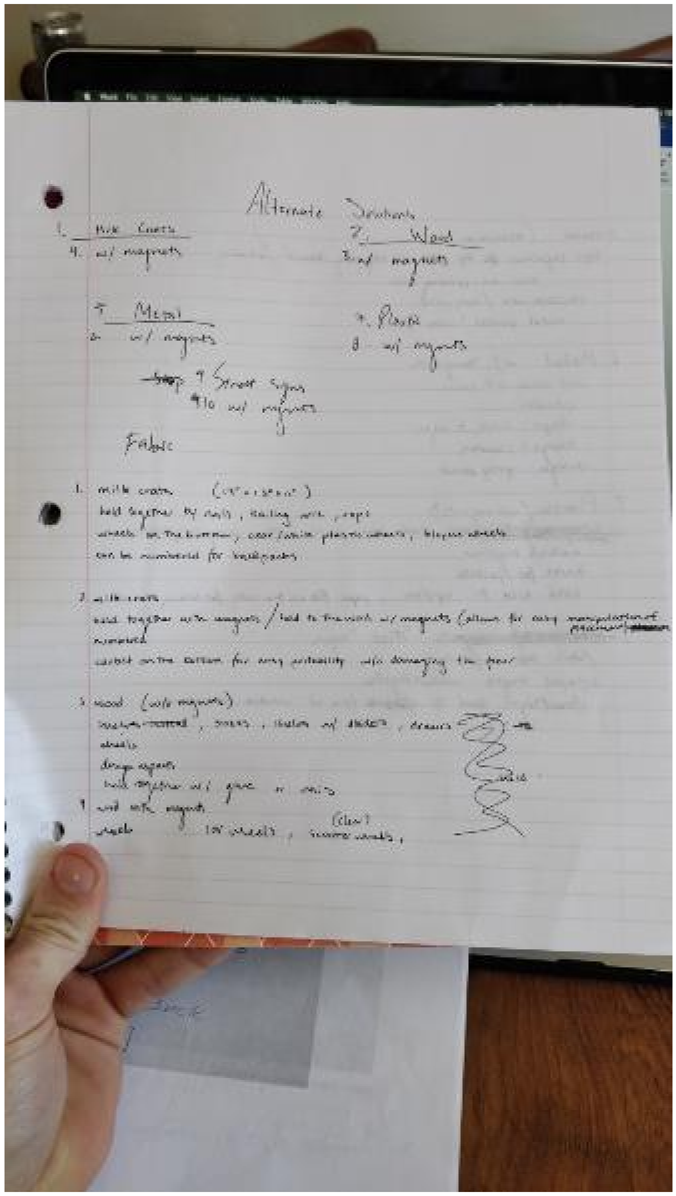

Figure A-1 Brainstorming of Alternative Solutions. (See Section 3)

Appendix B

Figure B-1 1st Prototype. (See Section 5)