THE FALCON-JACKS

UPCYCLED CADDY

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Designed for

ZANE MIDDLE SCHOOL
HOME OF THE FALCONS

Humboldt State University **Engineering 215- Spring 2014**

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1 Problem Formulation

1.1 Introduction

The Problem Formation section includes an objective statement that describes the goal of the project and a black box model.

Team Falcon- Jacks will be partnering with Zane Middle School, in Eureka, California. In 2013 Zane Middle School transitioned to a magnet school implementing a STEAM program. This program emphasizes Science, Technology, Engineering, Art, and Math, preparing students from sixth to eighth grade with skills for today's workforce.

1.2 Objective

The objective of Team Falcon-Jacks is to design and build an upcycled caddy aimed at helping the client improve classroom functionality and create student accountability.

1.3 Black Box Model

The black box model in Figure 1.1 shows the state of Zane Middle School as it is now and the state of Zane Middle School after the implementation of Team Falcon-Jacks solution

Figure 1-1: The Black Box Model shows the initial state, solution, and subsequent state.

2 Problem Analysis

2.1 Introduction to Problem Analysis

The problem analysis addresses specifications, considerations, criteria with constraints, usage and production volume regarding the Upcycled Caddy.

2.2 Specifications

The specifications are the minimal requirements for the upcycled wall caddy project. The specifications are as follows:

- Supplies stored in caddy should be visible.
- Caddies must be able to be moved outside of classroom.
- Must be repairable by the teacher.
- Should encourage students to want to be in the classroom and have fun.
-Caddies must have ability to be labeled.

2.3 Considerations

The considerations are requirements that are derived from the specifications from the client. The considerations are as follows:

- The caddies will be used every day by teens.
- The caddies may be moved around frequently.

2.4 Criteria and Constraints

The criteria and constraints listed below will provide quantifiable goals to judge the quality of the upcycled wall caddy.

Table 2-1: Table describing the criteria and constraints of the Upcycled Caddy project.

Criteria	Constraint
Safety	Must be visually pleasing for both teacher and student; more visually stimulating for students.
Student Accountability	Teacher can easily tell what students don't return which materials.
Aesthetically Pleasing	Visually pleasing for both teacher and students; more importantly be visually stimulating for the students.
Portability	Require only 1 person to transport.
Durability	Can withstand daily use by teens; last more than 1 year be requiring repairs.
Teacher Input	Takes less that 2 minutes to have students place materials away.
Cost	Implementation of design must cost no more than $400.
Maintenance	Repairable with minimal input from teacher; easy access to what parts needs repairing and necessary materials.
Upcycled	80% of material used must be upcycled

2.5 Usage

The upcycled caddies will primarily be used inside the classroom by middle school teens between ages ten and twelve. There are about thirty-three students in each class that rotates every forty- five minutes during the school day. Zane Middle School's school year runs from August till June and there is about twenty- two more days of no school that the caddies will not be in use. The caddies will help provide organized support for the client as well as easy access of materials for the students.

2.6 Production Volume

A set of nine hanging wall caddies for the calculators, a set of nine tabletop caddies for the desks, and a storage caddy with nine individual cubbies to hold the desktop caddies when not in use.

2.7 Introduction to Literature Review

The literature review section is a collection of research related to the upcycled caddy design for Zane Middle School. Topics covered are client criteria, onsite resources at Zane Middle School, different styles

of caddies, possible materials used to construct caddies, examples of upcycling materials in structures, art and products, natural based paints, how color in a classroom pertains to learning, and an overview on teens in middle schools.

2.8 Client Info

Beth Baker, a mathematics teacher from Zane middle School, presented the requirements for the upcycled caddy project. These requirements are to create an upcycled caddy that can be supplied with materials that are used on a daily basis. According to our client, there are currently thirty- three students in the class but would like to have extras. The caddy needs to be transparent so the teacher can easily see what materials are missing and need to be refilled in each day. Baker would also like a type of labeling system to the caddy so there is student accountability. The main goal for the caddy is to have students learn how to use the caddy and properly store their materials with minimal input from a teacher (Baker, 2014).

2.9 Examples of caddy designs

2.9.1 Tabletop Caddy

Seelmade, a company that creates products using upcycled materials, designed a caddy using old wooden boxes or crates. As shown in Figure 2-1, this organization product is meant to sit upon a raised surface, such as a desk or table.

Figure 2-1: Hand-crafted tabletop caddy made from upcycled wooden boxes and crates

2.9.2 Wall caddy

Figure 2-2 shows Earth911 blogger Lee Meredith's upcycled wall caddy design using old coffee cans to store objects.

Figure 2-2: Wall caddy designed from coffee cans

2.9.3 Classroom desktop caddy

On the blog space, Lessons with Laughter, a fourth grade teacher expresses her excitement with the use of these table caddies in her classroom. As shown in Figure 2-3, these can be used to organize supplies, and are easily stored.

Figure 2-3: Colored table caddies used for organizing and storing school supplies.

2.10 Building Materials

2.10.1 Bamboo

Bamboo, shown in Figure 2-4, is a versatile building material that can be found in many countries around the world. Having a high strength-to-weight ratio makes Bamboo useful for construction. Bamboo is also used in many other industry's to make paper, textiles, medicine, shoes and because of its low cost and high availability. Bamboo is restricted by its natural durability and difficulty in jointing; most structures are viewed as temporary with lifespan of about five years (Inoue, 2008).

Figure 2-4: Woven bamboo baskets- the people of the Medar community, from Dandeli in North West Karnataka, has been crafting bamboo baskets for many generations.

2.10.2 **Corrugated Cardboard**

Heavy-duty paper based product commonly known as cardboard come in many different thicknesses and strengths (Friant, 2009). Corrugated Cardboard is used heavily around the world and in today's marketplace. Cardboard is a cheap and readily available resource that is environmentally friendly. Cardboard structures will be temporary but can be maintained or replaced fairly easily. An example of a strong structure made from cardboard is shown in Figure 2-5.

Figure 2-5: Cardboard boat- Dave Friant in his handmade and environmentally friendly cardboard.

2.10.3 **High Density Polyethylene (HDPE)**

HDPE is a plastic made from petroleum and is very popular in today's marketplace. After commercial production began in the 1930's, HDPE has become widely used with billions of pounds being made each year. Most water bottles, water pipes, food containers, and plastic bags are all made from HDPE. HDPE

is slightly stronger than low-density polyethylene and is also light and flexible. HDPE disadvantages are caused by its low strength to stiffness properties and susceptibility to stress cracking (Bear Board, 2002).

2.10.4 **Hemp board**

Hemp board, shown in figure 2-3, is a medium density fiberboard made from the Hemp plant. Hempboard can be used for a variety of different structures due to its uniform consistency and absorption of various treatments. Hempboard is a lighter board with similar properties to many woods, which makes it ideal for building. It can also be produced annually and is an all natural with no chemicals included (Hemp Traders, 2010).

2.10.5 **Fiberglass**

Fiberglass is a composite material made of plastic matrix reinforced by fine filaments of glass. Fiberglass is popular in construction and is also lightweight and durable. Fiberglass is hard to recycle so thought must be put into maximizing longevity of use (Johnson, 2010).

2.10.6 **Pallets**

Most Pallets are made from tough and durable wood. They are readily available because of their use in the shipping and transport industry as transport structures to support goods. Pallets are fairly easy to work with and popular for pallet crafts and up-cycled construction. A more durable pallet is made from plastic, which is more expensive but reduces the overall cost because of their longer life (LeBlanc, 2010).

2.11 Examples of Upcycling

There are various way of upcycling and as well as the materials used. Upcycling is the process of reusing discarded materials or objects in such a way to create a product of higher quality or value.

2.11.1 **Upcycled building**

Norwegian company Lendager Architects built an upcycled metal house, shown in Figure 2-6, using old shipping containers. The outer panels are made of post-consumer paper that has been heat treated and pressed. The interior is made of a large amount of champagne cork remnants and tiles that are made of recycled glass. Other surfaces in the house are made of oriented strand board left over from various construction sites (Jewell, 2013).

Figure 2-6: The Lendager Architects Upcycled Metal Home (Jewell, 2013).

2.11.2 **Upcycled Pallet Design**

Pallet Furniture Plans is a company that creates quality products from upcycled wooden pallets. As shown in Figure 2-7, pallets can be upcycled in a variety of ways; some include building vertical gardens, or using them as a wall base for hanging objects (Admin, 2013).

Figure 2-7: Pallet Furniture Plans' pallet wall base design with hanging planter pots (Admin, 2013).

2.11.3 **Upcycled Fence**

Gail Wilson of My Repurposed Life built a sturdy shelving unit using old wood from fence in her yard, as shown in Figure 2-8. Wilson took apart the fence and used the same wood pieces to create a shelf (Wilson, 2010).

Figure 2-8: Gail Wilson's upcycled shelving unit.

2.11.4 **Upcycled Windows**

On the Eclectically Vintage blog space, a user made a list of ten unique ways to repurpose windows. When a house is demolished usually the windows and wood, and all the other pieces of it are destroyed. As Figure 2-9 shows, most of the pieces can be used again (Kelly, 2014).

Figure 2-9: Upcycled Windows used as a shower screen (Kelly, 2014).

2.11.5 **Upcycled Consumer Good**

The community at Built-by-Kids designed a bench using an upcycled snowboard, as shown in Figure 2-10 (Admin, 2013).

Figure 2-10: Snowboard bench by Built by Kids (Admin, 2013).

2.11.6 **Upcycled Glass**

Shown in Figure 2-11 is one of many stained glass window pieces by Daniel Maher made from glass bottles (Maher, 2010).

Figure 2-11: An upcycled glass bottle stain glassed window from the Daniel Maher Stained Glass Studio (Maher, 2010).

2.11.7 **Upcycled Wood**

Brazilian artist Henrique Oliveira creates upcycled installations and art pieces, as shown in Figure 2-12, using old plywood, fencing and PVC as his artistic mediums (Inspiration Green, 2013).

Figure 2-12: Henrique Oliveira's Cascasa installation located in Brazil made from upcycled plywood.

2.12 Natural Based Paints

Many paints contain volatile organic compounds (VOCs), fungicides, biocides and chemical toxins in pigments that are not all natural. Naturally based paints, tend to meet better health requirements due to lower VOCs and biocides as well as using natural pigments. However, a study done by the Swiss Federal Office for the Environment, Forestry, and agriculture found that natural resin oil paints produced more emissions and were more environmentally toxic than your average acrylic enamels. Natural based paints mainly consist of binding agents such as oils, resins or waxes, solvents and pigments (Abraham 1999). They are derived from citrus, balsam and other minerals and are petroleum-free and do not off- gas biocides of fungicides. Although, some often contain terpenes, which are VOCs derived from plants (Berthold-Bond, 2003). Figure 2-13 shows color samples made from berries, plants and household spices.

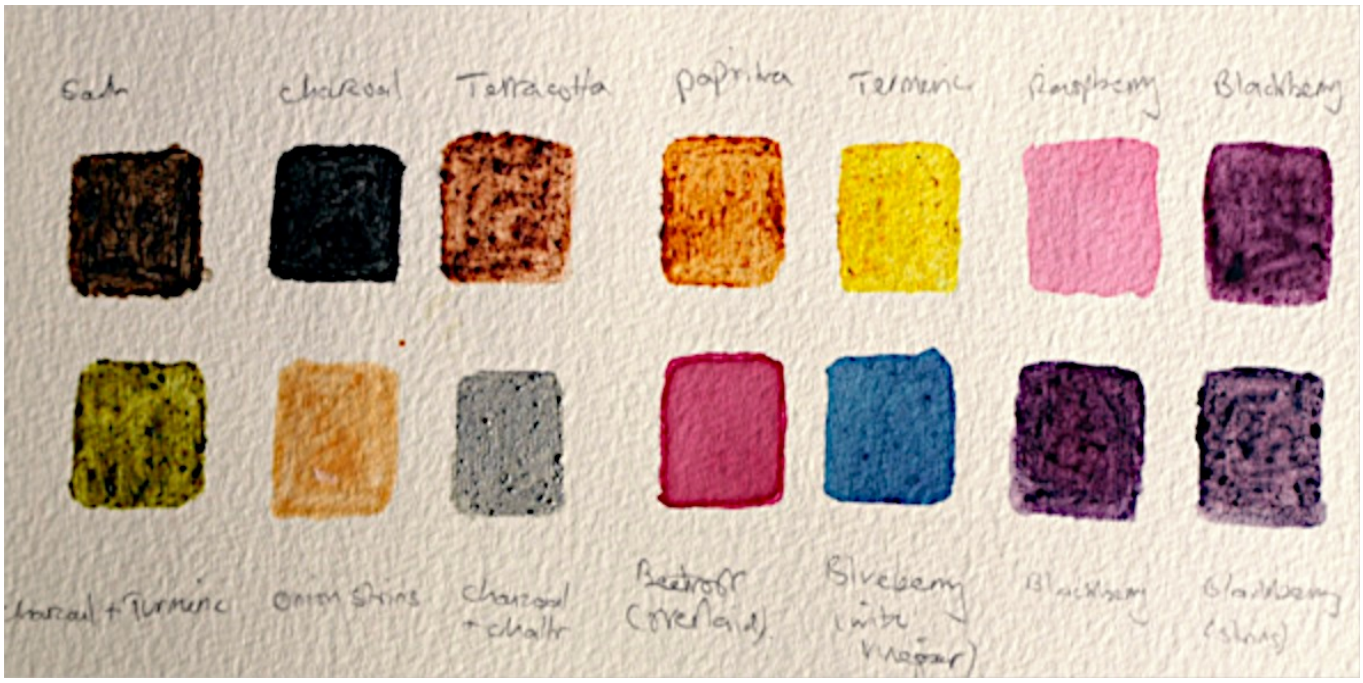

Figure 2-13: Color samples created from natural based paints from ArtFulKids**.**

2.12.1 **Egg Tempera**

Egg tempera is made using egg yolk, water, and earth pigments. This is a water- soluble paint that will dry quickly. The process for making these paints generally takes five minutes to prepare for each color (Natural Earth Paint, 2014). Egg tempera can last for up to twenty years and can be used indoors or outdoors (Dadd, 1997).

2.12.2 **Flour Paint**

Flour paint consists of earth pigment, white glue or flour paste, water, and sometimes an uncolored clay filler. Using glue can take only five minutes per color but with wheat paste it can take up to forty- five minutes to prepare (Natural Earth Paint 2014). Flour paint is quite versatile and can be used indoors or outdoors. Due to the use of glue the paint can be very thick but can be easily manipulated to create different textures (Steen, 2006).

2.12.3 **Casein Paint**

Casein paint is derived from milk, and therefore is not recommended to use if someone is allergic to dairy products. Casein paint can be made using casein powder, borax, and earth pigment. This type of paint is durable, water- soluble and fast drying but has a strange smell that will dissipate as it dries (Natural Earth Paint, 2014). Casein paint can be used indoors or outdoors and can be used to cover existing painted surfaces (Steen, 2006).

2.12.4 **Natural Wood Stains**

The simplest way to make a natural wood stain is by adding pure earth pigment to walnut oil and rub, with a clean cloth, onto to the wood. This technique will take anywhere from, forty- five minutes to two hours and requires each coat to dry before another coat is applied. This type of stain is successive when the wood will no longer absorb the coat. The best wood to use with natural stains is softwood, but a sealer must be applied to prevent any color transferring onto other surfaces (Natural Earth Paint, 2014).

2.13 Color Pertaining to Learning

According to the International Center for Leadership in Education, color has a major impact on student's achievements. Research shows that health, morale, emotions, behavior and the performance of learners is directly influenced by specific colors. As shown in Table 2-1, certain colors are recommended for different environments within a school, as well as what type of learning is taking place in a classroom. The emphasis of specific colors in a classroom helps to improve students' attention span by staying focused through mental stimulation. Color preferences change throughout age groups. By middle school, children lean towards bright- medium cool colors, but as they mature into adolescence it is less preferred to have large areas of primary color (Cobble, 2014).

Table 2-2: Color Recommendations pertaining to educational topics table derived from International Center for Leadership in Education (Cobble, 2014).

Topic	Emphasis	Color Recommendation
Biology	Nature	Blue, green, teal, brown, beige
Chemistry	Logic	Blue, green, indigo
Physics	Energy	Blue, yellow, green, indigo
History	Age	Amber, blue, yellow, sea green
Mathematics	Logic	Indigo, blue
Social Studies	Social	Orange, green, brown
Art	Creativity	Green, violet, red, peach, pink, light yellow
Language Arts	Communication	Sea green, blue, green

Government	Order	Blue, green, indigo, silver, gold, mauve, violet
Economics	Wealth	Emerald green, amber, violet, gold

2.14 Aspects of teens in middle school

There are many aspects of teens to acknowledge when designing a safe product that will be used daily. This overview covers the aspects that Team Falcon-Jacks felt important to consider in regard with the Upcycled Caddy.

2.14.1 Behavioral Aspects

The majority of teens during the middle school years are all going through the transition between childhood and adulthood. This transitions leads to a lot of hormone chemical imbalances causing their behaviors to vary. They are often erratic and inconsistent with their behavior that can lead to difficulties for educators. The main trait of these teens behavior is finding out who are they and what is their purpose is (Sacramento: California Department of Education, 1989).

2.14.2 Social Aspects

There are many social aspects that come about during middle school years. The middle schools that have more positive and social interaction have a better influence on the teen's social life (Gibson 1999). The main influence on teens' lives during middle school is their peers. Many look up to and follow their peers a lot more than in any other part of their life (Sacramento: California Department of Education, 1989).. Most teens also have a lot of interpersonal conflict between their family and peers, which creates most of the stress for them during this time period (Sacramento: California Department of Education, 1989). Teen's strive in sexual roles as well, and become much more attracted to the opposite sex during these years. A big problem for educators is discipline because they are more prone to challenge authority figures. Although, it is a time period where they are more willing to learn (Gibson, 1999).

2.14.3 Physical Aspects

Teenager's physical development starts to increase significantly and go through many substantial changes during middle school. Females tend to be more physically developed than males during these years as they are taller and have more women like features. Both genders heights can vary at this age, but range from five feet to five feet eight inches (Sacramento: California Department of Education, 1989).

2.14.4 **Intellectual Aspects**

Many teens, during middle school, students start to develop an intense curiosity on the things that they learn not only in school, but in their personal environment as well. They start to develop goals and critically think about the problems that they face daily; as well as the problems they will face in the future for themselves (Sacramento: California Department of Education 1989). Table 2-2 shows the eight ways teens in middle school want to learn based on preference. For the teens in middle school one attributing aspect they start to develop is a sense of active learning instead of passive learning. From this they are willing to fully interact with new things that they learn about and try to understand how to do things for themselves. They learn new skills on how to solve real life problems (Sacramento: California Department of Education 1989).

Table 2-3: Eight Multiple Intelligence and Accompanying Student Preferences (Sacramento: California Department of Education 1989).

Table 1. *Eight Multiple Intelligences and Accompanying Student Preferences*

Intelligence	Preference
Bodily–kinesthetic	Students enjoy and learn best from activities that use the body and involve movement, such as dance, crafts, mime, sports, acting and using manipulatives.
Interpersonal	Students learn well through interacting with others and prefer team and cooperative learning activities; they may function as effective leaders and mediators.
Intrapersonal	Students have a working understanding of themselves and like individual, introspective, and metacognitive tasks; they may enjoy working at own pace and setting personal goals.
Logical–mathematical	Students learn well through logical or mathematical activities, such as problem solving, experiments, logical games and puzzles, and using numbers and patterns.
Musical	Students understand and learn well through the use of rhythm and melody, tapping and rapping, singing and listening to music.
Naturalistic	Students have an understanding of the environment and patterns in nature; they learn well through outdoor activities and those that involve interacting with natural and environmental materials and concepts.
Verbal–linguistic	Students learn well through language and words; they enjoy reading, writing and speaking, and like to use language in games, puzzles, and creative activities.
Visual–spatial	Students understand and learn easily through the spatial media; they like to learn and communicate visually and enjoy creating puzzles, maps, designs, 3-D models, and graphic representations.

2.15 Teaching Sustainability and Green building

As people learn about the place they live, they begin to care more about what happens to that environment. This is called place-based education, which is fundamental in teaching sustainability. “Students develop this type of knowledge and caring through assigned projects that range form simple to complex” (Stone 2009). These types of projects encourage students to ask questions that help them develop knowledge of place and the commitment required to protect the natural environment they live in (Stone 2009).

3 Alternate Solutions

3.1 Introduction to Alternative Solutions

To determine alternative solutions several brainstorming sessions were planned once obtaining the client's criteria. During these brainstorming meetings we were able to create a handful of solutions for each three-upcycled caddy designs as well as the different materials to use. The succeeding subsections describe the brainstorming process and list our alternative solutions.

3.2 Brainstorming

We had various meetings for brainstorming though we didn't know the rules so they weren't done properly at first. We tended to jump around and throw out ideas then criticize others ideas and get off topic during these times.

We had our first successful brainstorming session after meeting with our client Elizabeth Baker. After our meeting with Baker, we decided that instead of brainstorming in the library, we wanted a change in environment to get us out of our ruts and let us think more clearly and creatively. We brainstormed heavily by acknowledging all different types of ideas and having zero criticism. We recorded our brainstorming using a white board, and paper.

In our second solid brainstorming meeting we met in a different locale again and used paper again to hone down our ideas and create even more potential options. We took a few minutes after each brainstorming session to cut down the volume of ideas. We cut out some ideas, and refined others. After this we took a few more minutes to throw out any last minutes ideas we had before closing the brainstorming for that section and moving onto other aspects of the project.

3.3 Alternative Solutions

The alternative solutions listed below were made through individual input and group consensus. Through further assessment of materials and client criteria we have chosen two alternative solutions for each of our three-upcycled caddy designs. Of the list of six possible ideas for each caddy, the two bolded in each list are those up for consideration for the final design and will be discussed in more detail.

3.3.1 Calculator Caddy:

The purpose of the calculator caddy is to store the calculators when not in use.

1] Hanging Fabric Caddy

2] Rotating Caddy

3] Upcycled Wooden Calculator Cabinet

4] Upcycled Cardboard Shelving Unit

5] Found Clay Shelving Unit

6] Flattened Aluminum Can Shelving Unit

3.3.2 Desktop Caddy:

The purpose of the desktop caddy is to give the students easy access to the supplies they need that day in an organize fashion at their desks.

1] Spin Wheel Table Top Caddy

2] Handled Upcycled Wooden Desk Caddy

3] Handled Upcycled Plastic Table Top Caddy

4] Handled Upcycled Cardboard Table Top Caddy

5] Paper Cup Table Top Caddy

6] Chicken Wire Table Top Caddy

7] Soup Can Table Top Caddy

8] Textile Plate Table Top Caddy

3.3.3 Cubby Caddy:

The purpose of the cubby caddy is to store the unused supplies that day and the desktop caddy's when not in use.

1] Upcycled Plastic Cubby Caddy

2] Closed Cubby Caddy

3] Upcycled Cardboard Stackable Cubby

4] Upcycled Wood Shelving Unit

5] Hardcover Book and Paper Mache caddy

6] Left/Right desktop caddy/extra supplies open storage

3.4 Calculator Caddy

The calculator caddy will be used to store only calculators at a height for the students to reach and is meant to create student accountability; as well as be easily noticeable for the client to see there are calculators missing.

3.4.1 Hanging Fabric Caddy

The Hanging Fabric Caddy is made of upcycled fabric and plastic bottles. The body of the caddy is made of upcycled fabric pieces using a quilting method to meet the criteria of durability and aesthetics. The dimensions of the back pieces are approximately three feet by two feet. To incorporate the transparency the client requested the pockets that hold the calculators are made out of plastic bottles that have been heat-treated, and will fulfill the criteria of the caddy being made of 80% upcycled materials. The heating treatment will be done by ironing the plastic bottles so they are flat and easier to

sew onto the fabric backing. As shown in Figure 3-1, thirty- five plastic pockets will then be sewn onto the fabric backing and a hanger sewn into the top of the fabric body for hanging. This design will allow easily visual access to the calculators, which will meet our criteria of student accountability because the teacher can quickly tell what students do not return their calculators.

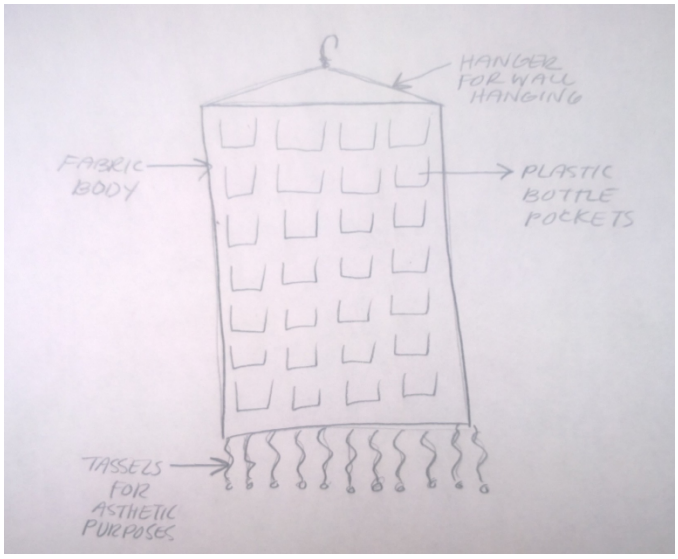

Figure 3-1: Drawn mockup of Hanging Fabric Caddy.

3.4.2 **Rotating Caddy**

The Rotating Caddy is made of aluminum cans, PVC pipes, cardboard, used bicycle wheels, and wood. This design will require a majority of the parts to be upcycled, which meets our criteria of 80% of the materials will be upcycled. The dimensions are four and a half feet tall, and the diameter is according to the size of the bicycle wheel. The stand is made out of wood and in the shape of an “X” for more support when spinning the caddy. The structure is made out of PVC piping that has been painted for aesthetic purposes. After heat-treating the aluminum cans and coating the cardboard with a specific sealant for strengthening purposes, the individual pockets are attached made by drilling holes through the sides of the PVC pipes. This will meet our criteria for durability. Four wooden or plastic rods will be inserted in between each PVC pipe so that the pockets can be hung individually.

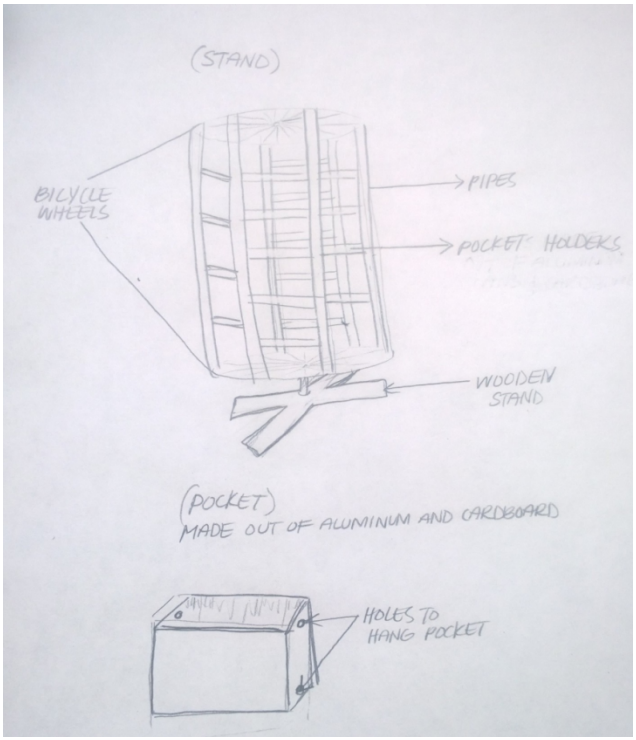

Figure 3-2: Drawn mockup of Rotating Caddy

3.5 Desktop Caddy

The purpose of the desktop caddy is to give the students easy access to their supplies they need that day and will allow the teacher to tell what students do not return which materials by the end of class.

3.5.1 Spin Wheel Table Top Caddy

The Spin-Wheel Table Top Caddy is a desk caddy inspired from the diner-style caddy's that contain condiments. It has four slots for jars (or other similar containers) that will contain the materials the students need for that day. The containers can slide in and out of the slots so that they can be replaced with other jars containing different supplies. The caddy is placed on top of students desks for easy access and will be able to be put away at the end of class. Thee caddy is mounted on a piece of upcycled wood that has a gear mounted on it so the part containing the jars with supplies will spin. This will make it easier for the students to find the school supplies they need. The caddy itself is built of upcycled cardboard, and aluminum can to increase its strength when used daily. This design will meet the criteria of durability and student accountability as well as the constraint of at least 80% of the materials used being upcycled.

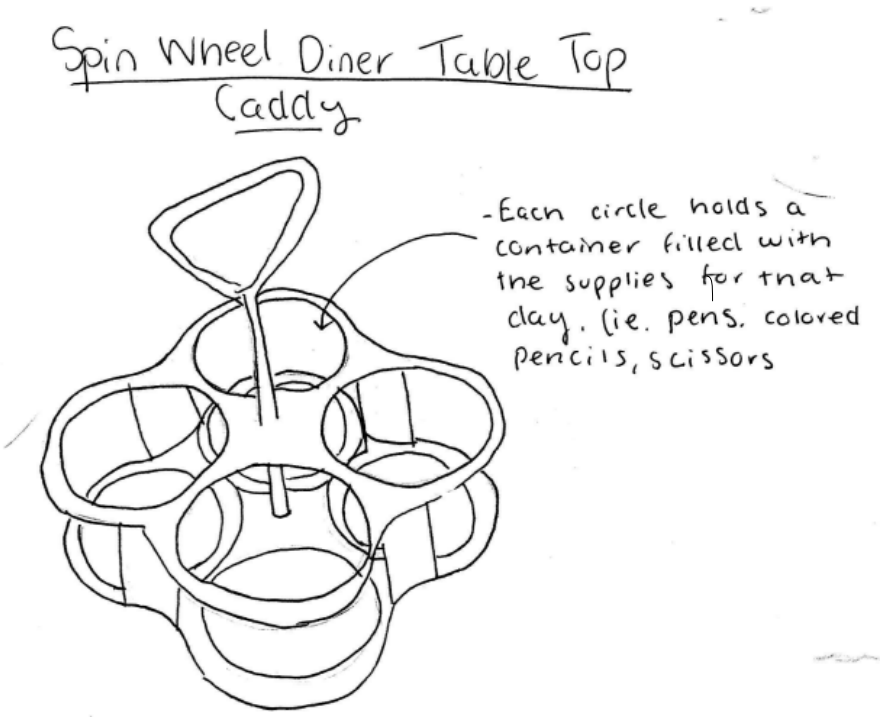

Figure 3-3: Drawn mockup of Spin Wheel Diner Table Top Caddy.

3.5.2 Handled Upcycled Wooden Table Top Caddy

A wooden tabletop caddy is built from upcycled wood held together by screws and wood glue. Its basic function is to serve as a portable organizer with four total cells. The design is based on the packaging for a six-pack of soda. By using wood, the caddy will be durable to withstand daily use by students, meeting our criteria of durability. To meet our criteria for aesthetics, the caddy will be painted different colors. The front of the caddy will have a labeling system by using laminated paper glued onto the wood.

3.6 Cubby Caddy

The purpose of the Cubby Caddy is to store the desktop caddy when not in use and inform students what materials should be located in the desktop caddies for that day.

3.6.1 Upcycled Plastic Cubby Caddy

The Upcycled Plastic Cubby Caddy will be made of plastic, aluminum cans, PVC pipes, and wood. Figure 3.4 illustrates a mockup of the design. The caddy consists of a standing self-unit with aluminum can cubby spaces. The triangular parts of the shelf as well as the frame will be made out of PVC piping and covered with a plastic tarp, mimicking a greenhouse. This design meets the constraint of 80% of the materials being used by upcycled.

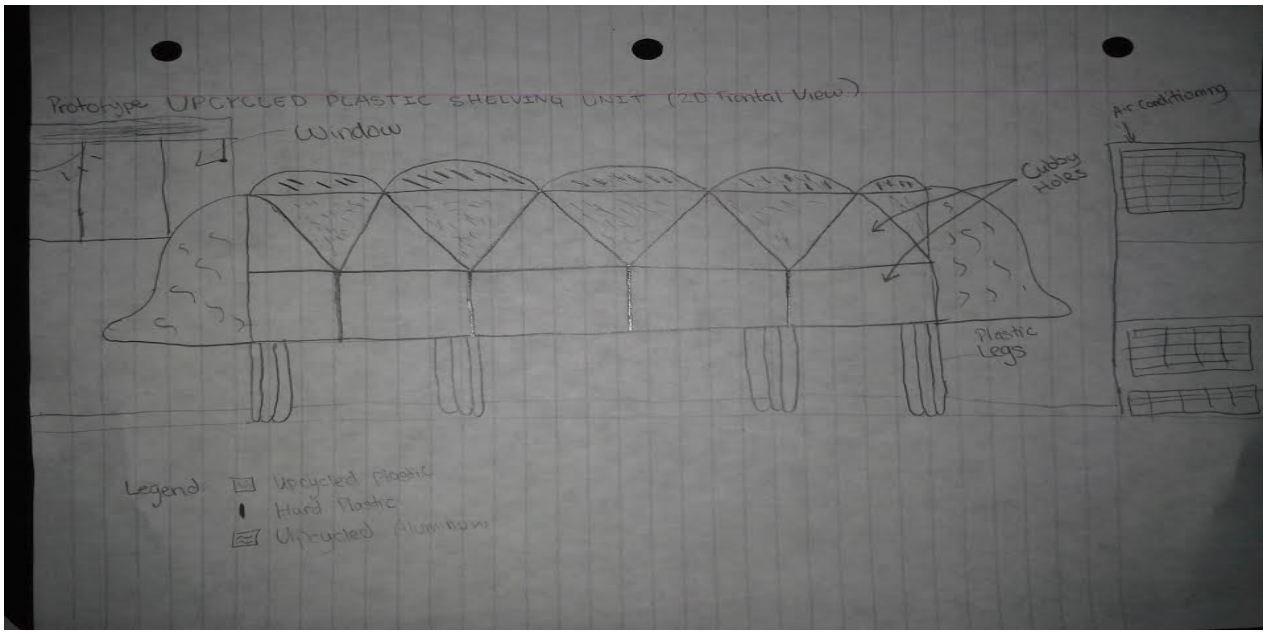

Figure 3-4: Drawn mockup of Upcycled Plastic Shelving Unit.

3.6.2 Closed Cubby Caddy

The closed cubby caddy is a cabinet style and made of upcycled solid wood or pallets and aluminum cans. The left side is shelves for supplies not being used that day. This side is made of upcycled wood and cardboard. The right side is a cabinet with closeable doors, which is made of flattened aluminum cans. This cabinet opens to nine cubbies made for the desktop caddy storage. By making the design primarily out of upcycled wood, this will meet the criteria for durability and the constraint of 80% of the materials being upcycled.

4 Decision Process

4.1 Introduction

Section 4 describes the decision process for the three caddy designs. This section evaluates the top 2 alternative solutions for each specified caddy, and uses the Delphi method to decide the final solution for each of the three caddies. This section will describe the criteria in more depth and help give further guidance for a reasonable solution decision.

4.2 Criteria

The following criteria from section 2 are used to determine the final decision for our three designs.

- ***Aesthetically Pleasing:*** This set of caddies is visually stimulating for students by creative use of materials.
- ***Safety:*** All sharp edges are covered or sanded down to prevent injuries.
- ***Portable:*** All caddy systems are designed to be portable by two people at most, with handles being added to the Street Sign Storage caddy to allow for easy portability
- ***Minimal Input:*** The set of caddies purpose and use is easily explained by an instructor to young students.
- ***Student Accountability:*** Design allows for instructor to see who has returned their materials and who has not
- ***Durability:*** All are created to last through the rigor of use by middle school students daily
- ***Minimal Maintenance:*** All are expected to last at least one year, with the Desktop Caddy and Street Sign Storage caddy anticipated to last more than two years without repairs.
- ***Upcycled:*** All caddy systems are made of partially upcycled materials
- ***Cost:*** The cost of all three caddy designs, including must falls below $400

4.3 Solutions

Listed below are the top 2 solutions for each of the three caddies

- **Calculator Caddy**
  - Hanging Fabric Caddy
  - Rotating Caddy
- **Desktop Caddy**
  - Spin Wheel Diner Table Top Caddy
  - Handled Upcycled Wooden Top Caddy
- **Cubby Caddy**
  - Upcycled Plastic Shelving Unit
  - Closed Cubby Caddy

4.4 Decision Process

A Delphi matrix is used to produce a final decision on what solution best fits our criteria. This type of decision matrix technique is used by weighing each criterion between 1, being least important, to 10, being most important. Next, each alternative solution is given a rating from 1, being the least fitting for the criteria, to 20, which best suits the criterion. As shown in Table 4-1, Team Falcon-Jacks came to a consensus for each alternative solution based on how well it fit the criteria. The final step in this decision process is to then multiply each alternative solution by each criterion weight; the sum of the multiplied scores are added and used to determine a final solution. The solution chosen is one with the highest weighted sum that best fits each criterion based on the ratings assigned.

Table 4-1: Delphi table of alternative solutions and how they meet weighted criteria

Criteria		Solutions					
		Calculator Caddy		Desktop Caddy		Standing Storage Caddy	
List	Weight	Hanging Fabric Caddy	Rotating Caddy	Spin Wheel Caddy	Handled Wooden Caddy	Closed Cubby Caddy	Upcycled Plastic Caddy
Safety	10	20 / 200	13 / 130	20 / 200	20 / 200	20 / 200	13 / 130
Student Accountability	10	20 / 200	10 / 100	16 / 10	20 / 200	19 / 190	16 / 160
Aesthetically Pleasing	9	15 / 135	7 / 63	10 / 90	13 / 117	16 / 144	16 / 144
Portability	8	13 / 104	9 / 72	12 / 96	15 / 120	14 / 112	12 / 96
Durability	8	5 / 40	15 / 120	20 / 160	18 / 144	20 / 160	14 / 112
Teacher Input	7	15 / 105	12 / 84	5 / 35	16 / 112	15 / 105	10 / 70
Cost	6	17 / 102	10 / 60	11 / 66	10 / 60	11 / 66	17 / 102
Maintenance	5	17 / 85	7 / 35	16 / 80	16 / 80	13 / 65	20 / 100
Upcycled	3	3 / 9	8 / 24	5 / 15	8 / 24	6 / 18	8 / 24
	Total	980	688	752	1057	1060	938

4.5 Final Decision

The Delphi matrix concluded that for the calculator caddy, the wall hanging fabric design would best suit the criteria. The cost would be very low, and since it is fabric, it would allow for the easiest portability, durability and could easily be fixed. For the desktop caddy, the closed cubby design would be more aesthetically pleasing, more durable and require less maintenance.

Table 4-2: Delphi table for the final decision with each solution modified.

Criteria		Solutions		
List	Weight	**Calculator Caddy**	**Desktop Caddy**	**Storage Caddy**
		Hanging Fabric Caddy	Handled Wooden Caddy	Closed Cubby Caddy
Safety	10	20 / 200	15 / 150	13 / 130
Student Accountability	10	20 / 200	20 / 200	16 / 160
Aesthetically Pleasing	9	15 / 135	20 / 180	18 / 162
Portability	8	20 / 160	20 / 160	18 / 144
Durability	8	8 / 64	19 / 152	15 / 120
Teacher Input	7	15 / 105	19 / 133	16 / 112
Cost	6	8 / 48	18 / 108	14 / 84
Maintenance	5	9 / 45	17 / 85	17 / 85
Upcycled	3	3 / 9	19 / 57	20 / 60
	Total	966	1225	1057

5 Specifications of Solution

5.1 Introduction

The Specification of Solution section covers a detailed description of the final solution. These specifications include a solution description, cost analysis, instructions for implementation and maintenance, and performance results, diagrams and photos of solution are included to help provide in-depth understanding of the final solutions. The cost analysis will include design costs, implantation costs, and maintenance costs. The instructions for implementation will provide information on how to use and maintain the three caddy designs. The performance results describes how the solutions performed during use and testing.

5.2 Solution Description

The final solution is a total of three separate Upcycled Caddy designs each provideing a different purpose. Team Falcon- Jacks built a total of nineteen caddies. The three caddy designs are created to improve classroom functionality as well as create a system of organization that promotes student accountability.

Figure 5-1: Finished caddy designs (photo showing only one of Hanging Calculator Caddy and Desktop Caddy).

5.2.1 Hanging Calculator Caddy

The Hanging Calculator Caddy, shown in Figure 5-2, is a fabric pocket caddy that hangs on the wall by a wooden clothing hanger. Each hanging Calculator Caddy can hold up to four calculators. Team Falcon-Jacks built nine Hanging Calculator Caddy's. One caddy is provided for one group of students; each group consists of four students. The caddy is 18' long by 15' wide and is made of dishtowels, themed cotton fabric, and plastic taken from the front of old binders to create a labeling system. The dishtowel backing has four snap pins towards to top that allow the caddy to be hung off the wooden hanger as well as be taken off and washed in a washing machine.

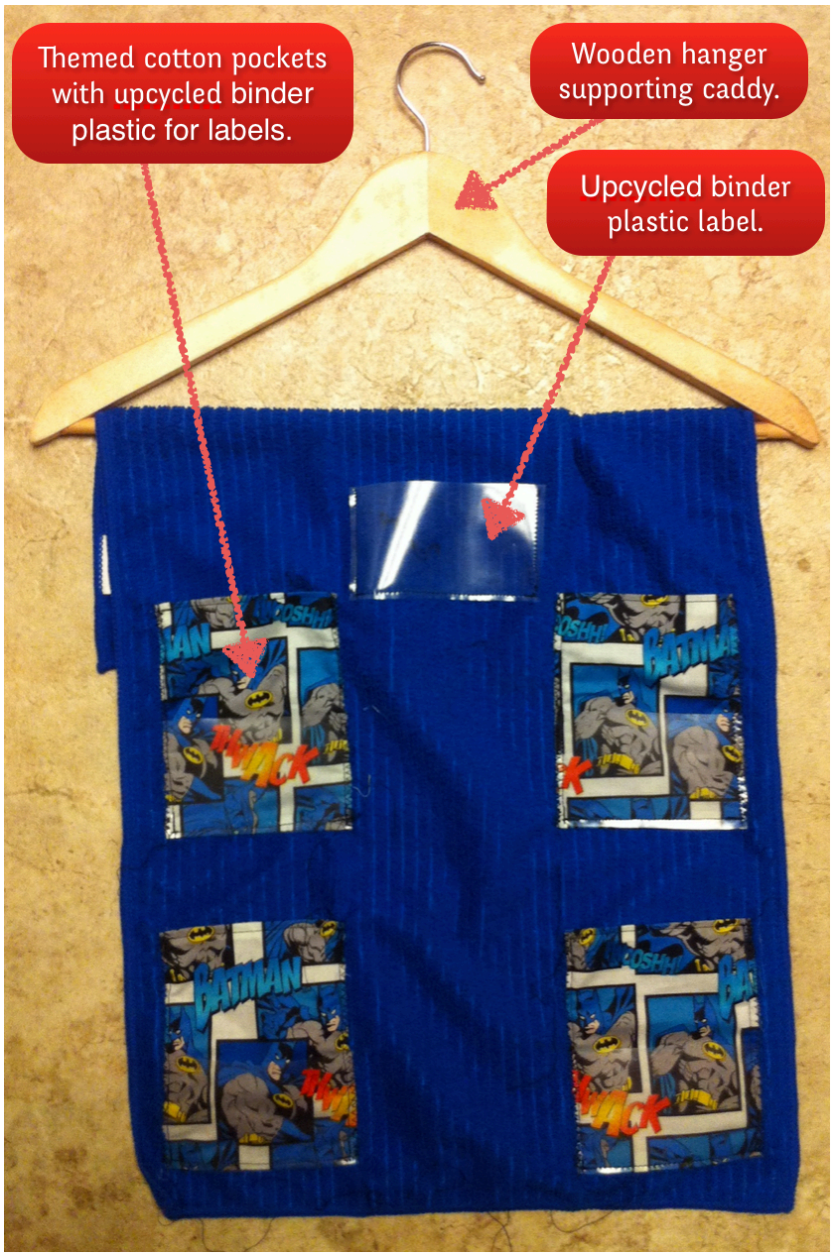

Figure 5-2: Final Hanging Calculator Caddy with labeled descriptions of parts.

5.2.2 Desktop Caddy

The Desktop Caddy, as shown in Figure 5-3, was constructed from upcycled particleboard that came coated with melamine; this allows the caddies to be easily cleaned using antibacterial wipes. The caddy has four cells that will be used to fill with different supplies used by students for that day. On the front of the Desktop Caddy is a labeling system made out of laminated paper to allow the teacher to write which caddy belongs to what group. The caddies were also painted along the raw particleboard edges and the handles to be more aesthetically pleasing to the students. Teams Falcon- Jacks built nine individual Desktop Caddies.

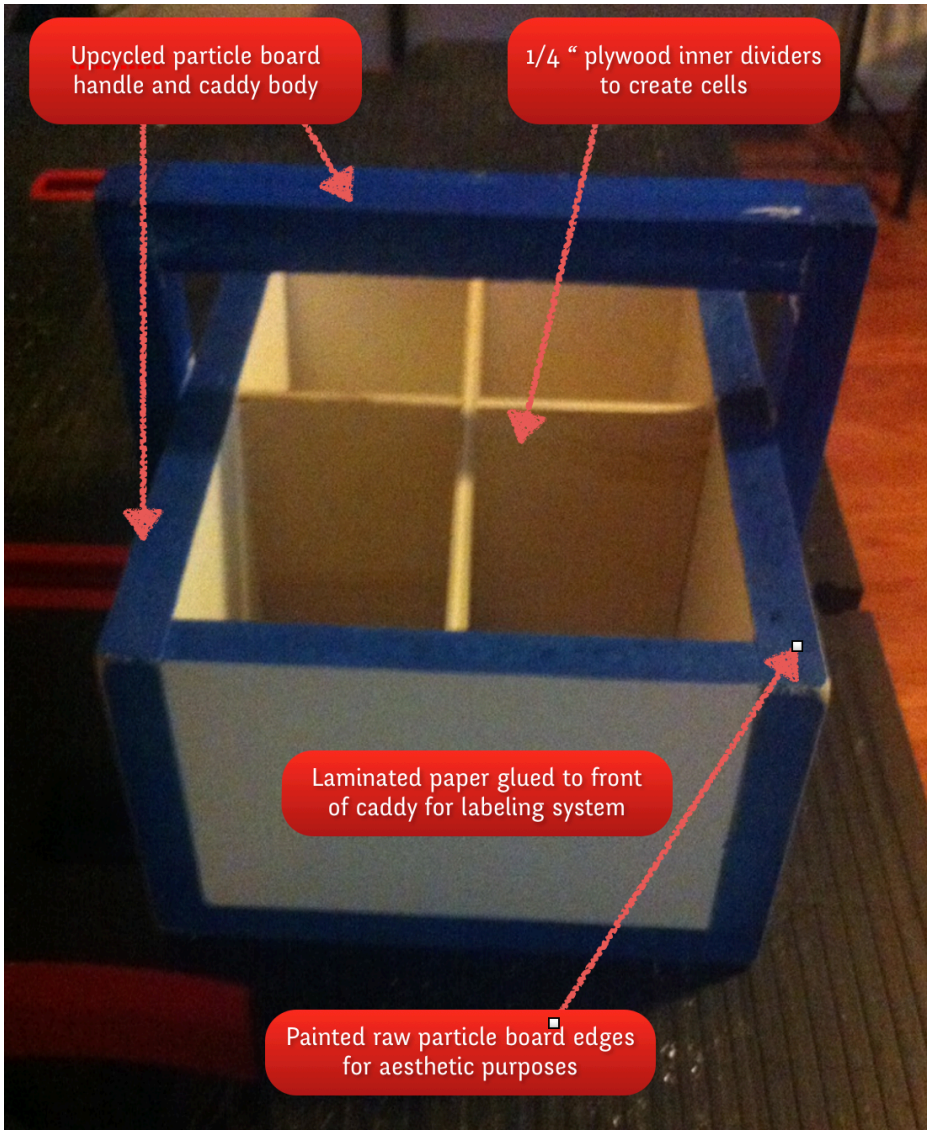

Figure 5-3: Final Desktop Caddy with labeled image description of parts.

5.2.3 Street Sign Storage Caddy

The Street Sign Storage Caddy, shown in Figure 5-4, is a shelved unit made from upcycled street signs. It is a shelving unit with nine individual cubbies for storing the Desktop Caddy's when they are not in use. On one side of the caddy is a hinged white board made from laminated paper glued to the back of a street sign; the hinge allows the white board to be closed against the side of the caddy to make transporting easier. The white board allows the teacher to be able to instruct students what supplies should be located in the desktop caddies once returned at the end of the day. To ensure safety when in use or being transported, all edges of the caddy are lined with vinyl tubing to cover any sharp areas.

Figure 5-4: Final Street Sign Storage Caddy design with labeled description of parts.

5.3 Cost

5.3.1 Design Costs

The design costs shown in Figure 5-1 is measured in hours spent on each section of the design process. The total amount of time spent on the Upcycled Caddy project is 362 hours.

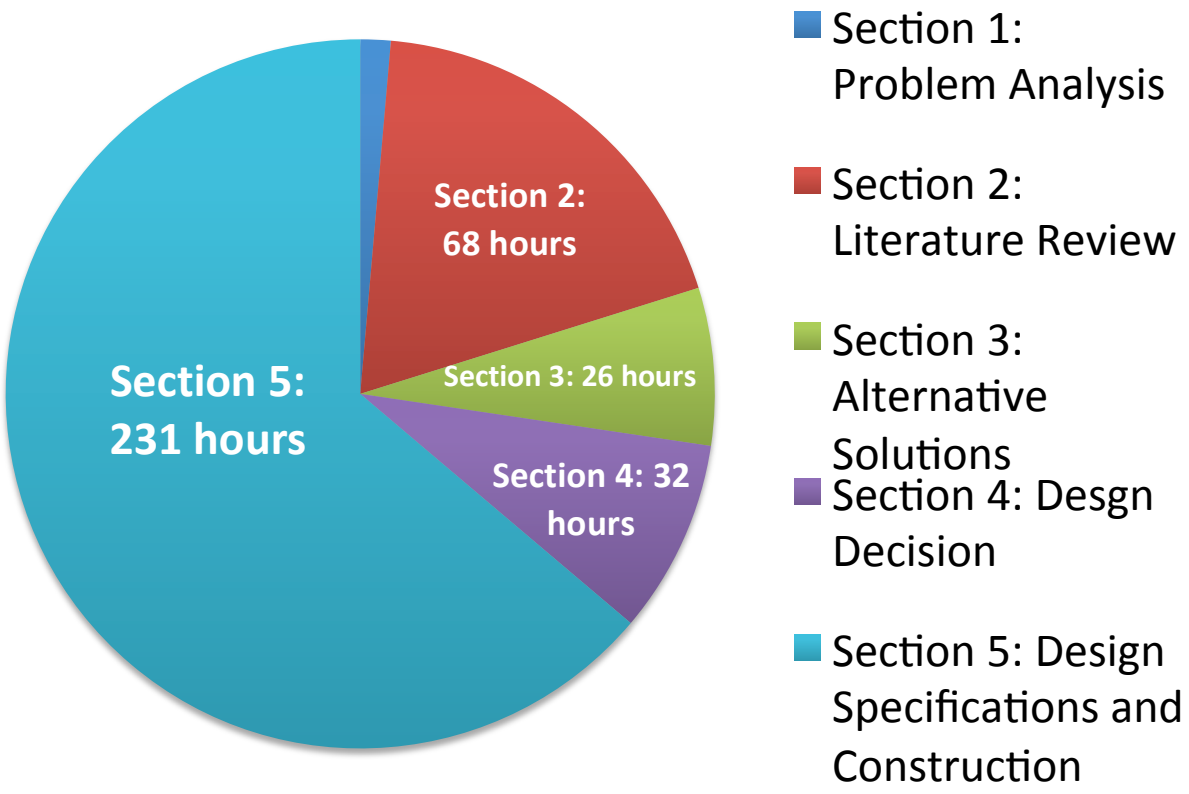

Figure 5-15: Pie Chart of Design Costs totaling to 362 hours.

5.3.2 Implementation Costs

The total implementation costs of all three Upcycled Caddy designs are shown in Table 5-1. The items and costs include the materials used in the construction and tools purchased for construction. Not all materials in the implementation cost table are required to recreate any of the three caddy designs.

Table 5-1: Final Desktop Caddy with labeled image description of parts.

Cost				
Item	**Cost per Item**	**Quantity**	**Store**	**Team Cost**
1.5 in Corner Brace	$0.99 each brace	42 each	Ace	$19.80
1/4 inch Plywood	$24.69 per 4x4	1 4x4	Ace	$24.69
1x2 wood	$2.99 per 8ft	1 1x2	Ace	$2.99
3/16 Cobalt Drill Bit	$7.59 each	1 bit	Ace	$7.59
3x3/4 in Corner Brace	$1.59 each brace	16 each	Ace	$25.44
Acrylic Paint	random sizes	9 colors	Donated (Allie)	$0.00
Aluminun Street Signs	$1.00 per pound	36 pounds	Aracata Salvage	$36.00
Black Thread	$0.25 per spool	3 spool	Humboldt Scrap	$0.75
Bolts	box of 100	2	Ace	$6.99
Christmas Lights	random sizes	1 pack	Donated (Allie)	$0.00
Clear Gloss Laquer	$12.99 per quart	1 quart	Ace	$12.99
Dish Towels	$1.00 each	9	Dollar Store	$9.00
Drawer Handles	$2.00 per handle	2	Humboldt Scrap	$4.00
Foam Paint Brush	$0.99 per brush	2 bruses	Ace	$1.98
Hinge Kit	$5.59 per kit	1 set	Ace	$5.49
Nuts	box of 100	2	Ace	$3.99
Outdoor Wood Screws	$6.79 each	1 pack	Ace	$6.79
Particle Board	random sizes	7	Donated (free pile)	$0.00
Rivet Gun	$23.99 each tool	1 tool	Ace	$23.99
Rivets	$4.49 each rivet	1 each	Ace	$4.49

Sand paper	$4.59 each pack	1 pack	Ace	$4.59
Screws	box of 100	1	Ace	$7.99
Sew on Snaps	$2.99 per pack	5 packs	Jo-ann Fabric	$14.95
Steel Slotted Angle	$13.99 each	1	Ace	$13.99
Themed Cotton Fabric	$6.99 per yard (on sale)	3 yards	Jo-ann Fabric	$20.97
Upcycled Binder Plastic	random sizes	8 sheets	Donated (Allie)	$0.00
Vinyl Tubing	$0.35 per foot	21 feet	Ace	$7.35
Whiteboard	random sizes	1 board	Donated (Diego)	$0.00
Wooden Hangers	$24.99 per pack	1 pack	Target	$24.99
			Tax	$21.43
			Totals:	$313.23

5.3.3 Maintenance Costs

The Street Sign Storage Caddy is designed to be durable and last a maximum of two years with no repairs. The Desktop Caddy's may require repainting, sanding or wood putty if dropped small areas cracked. The Hanging Calculator Caddy's however are more fragile, with the constant tugging on the fabric and plastic sheeting. With this in mind the maintenance costs cover the simple repairs of the Hanging Calculator Caddy are shown in Table 5-2 in retail cost.

Table 5-2: Maintenance costs for the Hanging Calculator Caddy annually.

Hanging Calculator Caddy Maintenance		
Item to Repair	**Frequency**	**Projected Cost/Years ($)**
Snap pins	1 year	$2.99 per pack
Wooden Hangers	1 year	$24.99 per pack
Sewing Repairs	1 year	$2.79 per spool
	Totals:	$30.77

5.4 Instructions for Implementation

Because there are three different caddy designs in this organization system, they each have their own separate processes for implementation. Step by step instructions on how to replicate each caddy design

can be found in Appendix D or found online at the Zane Middle School Upcycled Wall Caddy Appropedia page: http://www.appropedia.org/Zane_Middle_School_upcycled_caddy

5.5 Results

Each caddy has its own individual function in the classroom, but they all manage to reach the larger goal of student accountability and helping the client improve organization and clutter in the classroom.

5.5.1 Hanging Calculator Caddy

To test the durability and student accountability aspects of the Hanging Calculator Caddy, they were filled in each pocket with calculators to make sure every calculator was easily visible and the entire caddy was capable of holding the weight of a full set. The caddy was also tugged on in in different areas of the dishtowel backing as well as the pockets to test the durability of fabric and stitching of pockets. Although no fabric ripped, it is still anticipated that after vigorous daily use some parts may require sewing such as the snaps or broken hangers.

5.5.2 Desktop Caddy

To test durability a member of Team Falcon- Jacks dropped each of the Desktop Caddy's from shoulder height to make sure no chipping would occur. After doing so each caddy was inspected, to find only one with a slight chip on the corner, though it was easily fixable by sanding and wood putty. To test effectiveness they were filled with supplies and tools to make sure that the students could easily handle them, and manage their supplies in their caddy. Due to the Desktop Caddy's having somewhat sharp edges, and being slightly heavy it is not recommended they be used when there is no supervision. They can cause injury if used to hit someone with.

5.5.3 Street Sign Storage Caddy

The Street Sign Storage Caddy was tested by filling it of fully loaded Desktop Caddy's to make sure it could handle the weight. The caddy was capable of holding up all the Desktop Caddy's with no issues. To make sure it was completely safe a member of Team Falcon-Jacks ran their hand along every previously sharp area to make sure the vinyl tubing was thick enough to cover all sharp areas; this will continue to ensure safety as long as tubing remains adhered to street sign. The members of Team Falcon-Jacks also spent approximately five minutes using the caddy. The member's put the Desktop Caddy's in and out, did things around the caddy to test its stability, and make sure there would be no hidden sharp parts or dangerous parts that were previously overlooked. In the five minutes of use no injuries occurred. The members of Team-Falcon Jacks also put various amount of force on it in a to make sure it wouldn't tip; it stayed stable on the flat surface on however the white board door will not stay open if on a angled surface.

5.6 Discussion

Team Falcon-Jacks encountered various problems during the construction of the three caddy systems. The Discussion section will describe issues with each caddy design as well as how they were resolved.

5.6.1 Design Issues with Hanging Calculator Caddy

In the section 4, Decision Process, Team Falcon-Jacks decided on using a quilted method to create the backing for the Hanging Calculator Caddy. Upon further research and testing, Team Falcon-Jacks decided to use new store bought dishtowel as a backing. This decision was based upon dishtowels being more sturdy then a quilted method, and more likely to hold up to the wear and tear of middle school students.

5.6.2 Design Issues with Desktop Caddy

The original design of the Desktop Caddy's, used only screws to connect the handles to the body of the Desktop Caddy. This turned out to not work because the screws allowed for the handle to rotate, which made carrying them unstable. Instead, a combination of wood glue and screws were used to reassure there would be no movement while being carried. The melamine, which was already coated on the upcycled particle board, also turned out to be sharper than expected once cut. Because of this, the sides were sanded down as much as they could be. The particle board also split on the bottoms in some caddy's because of the pilot hole was too small. Once a large pilot hole was provided the drilling went smoothly. All cracks were covered with wood putty.

5.6.3 Design Issues with Street Sign Storage Caddy

Almost the entire design Street Sign Storage Caddy had to be rethought, once it became clear that using wood would be too heavy, and it wouldn't hit the upcycling criteria. There were many other options for building a storage caddy, but focusing on the aesthetic criteria and the upcycled criteria, street signs became a clear option. After purchasing 36 pounds of street signs, Team Falcon-Jacks redesigned, and renamed the Street Sigh Storage Caddy. The caddy was now to be built entirely out of street signs. Large ones were used to make the backing, the sides, the top, and the bottom. Smaller parking signs were used to make each of the interior pockets. After showing the Street Sign Storage caddy to the client, she decided plotted angles instead of L brackets to hold together the larger parts of the Street Sign Storage caddy, so that it would last many years of hard use.

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Appendix B- Brainstorming

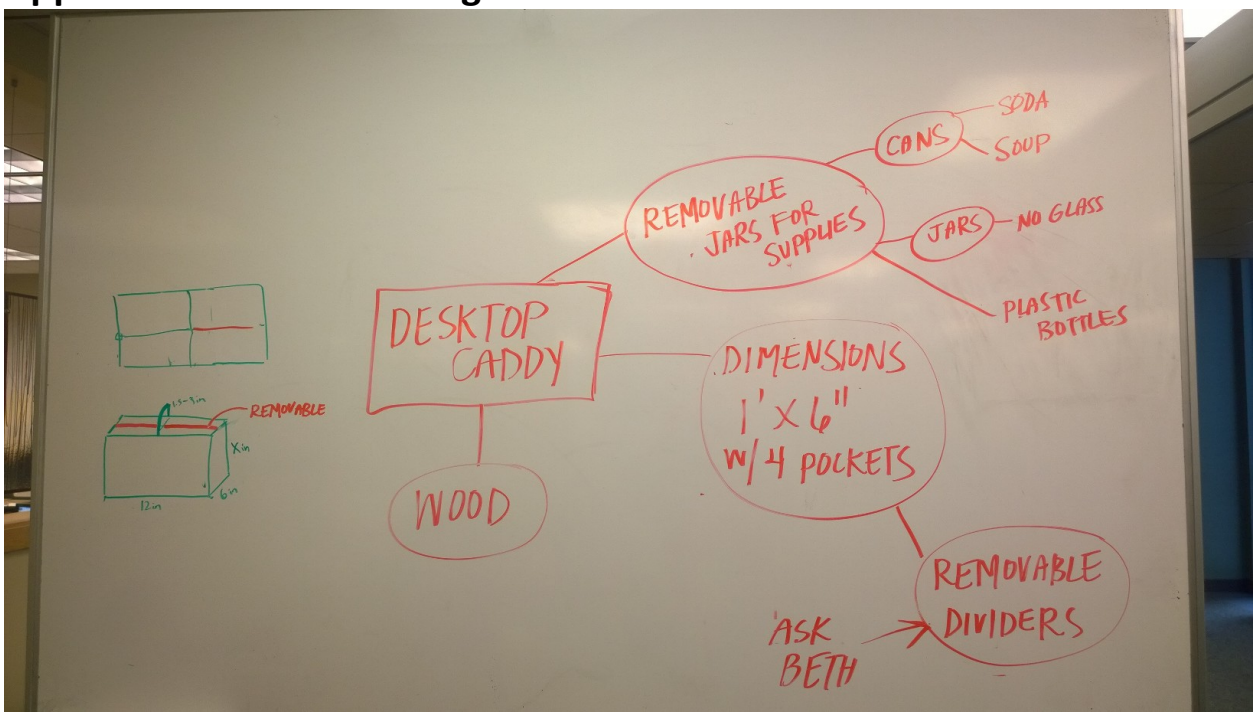


Figure B-1: Brainstorming for the Desktop Caddy.

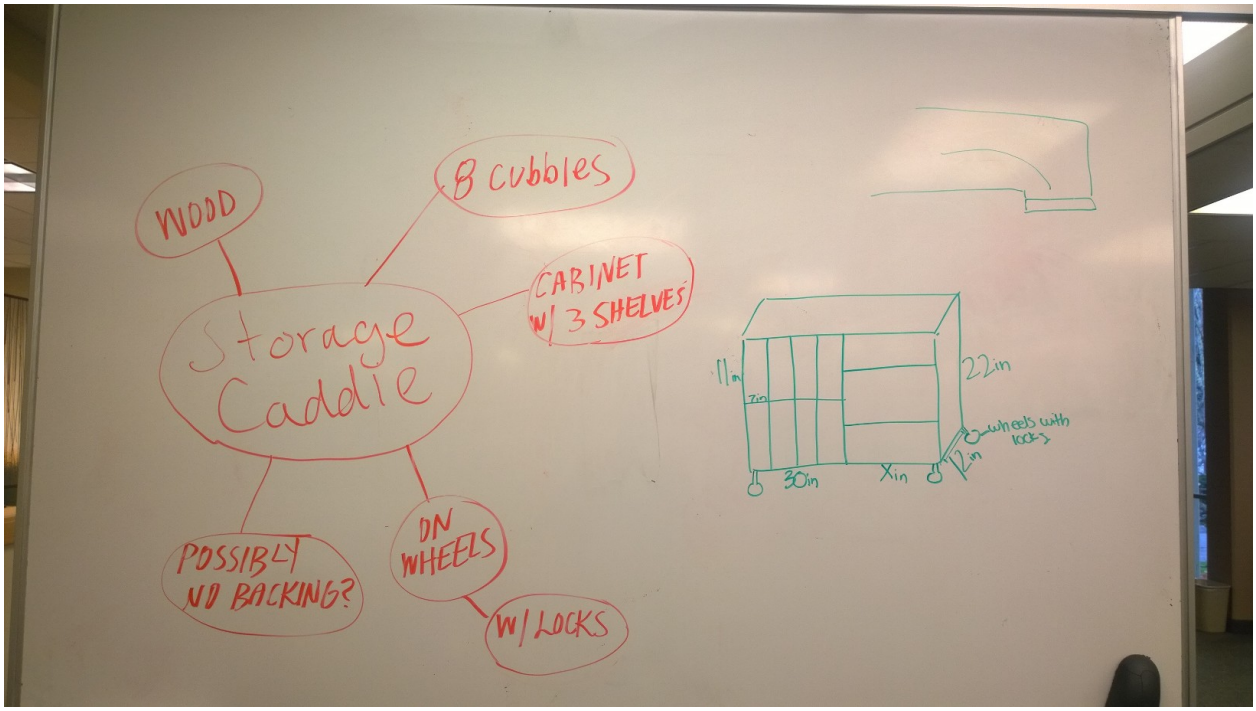


Figure B-2: Brainstorming for Storage Caddy.

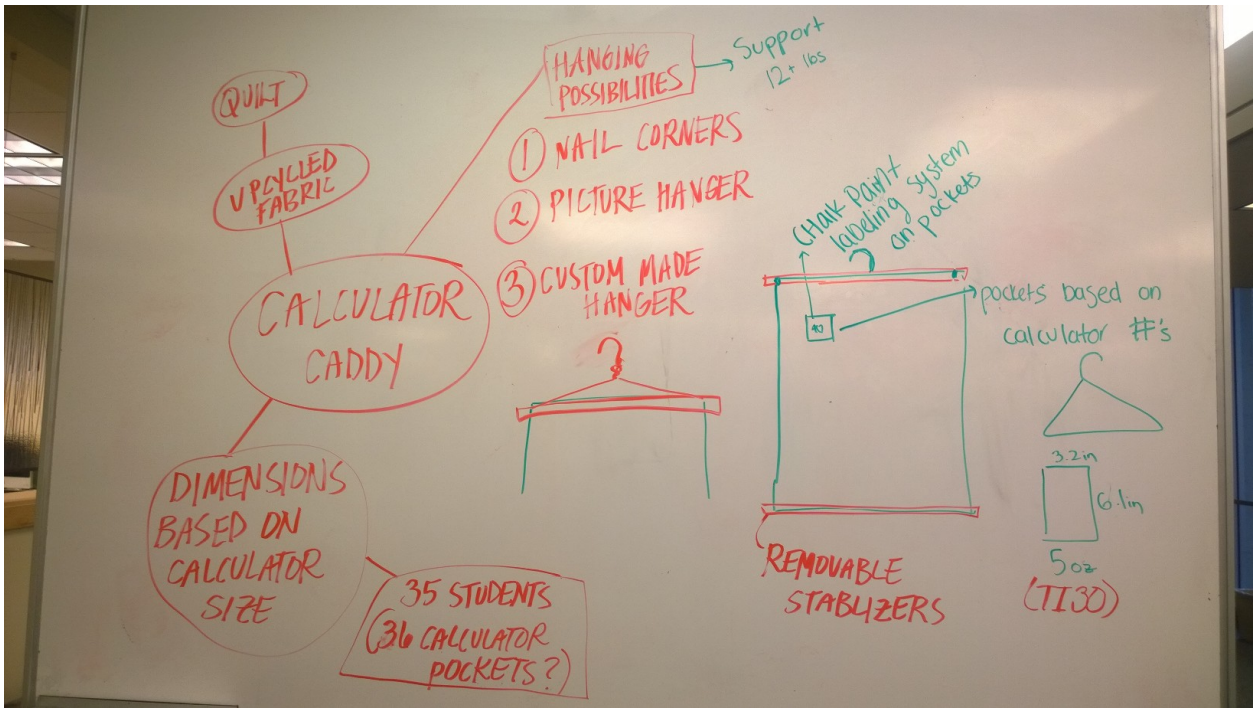


Figure B-3: Brainstorming for Calculator Caddy.

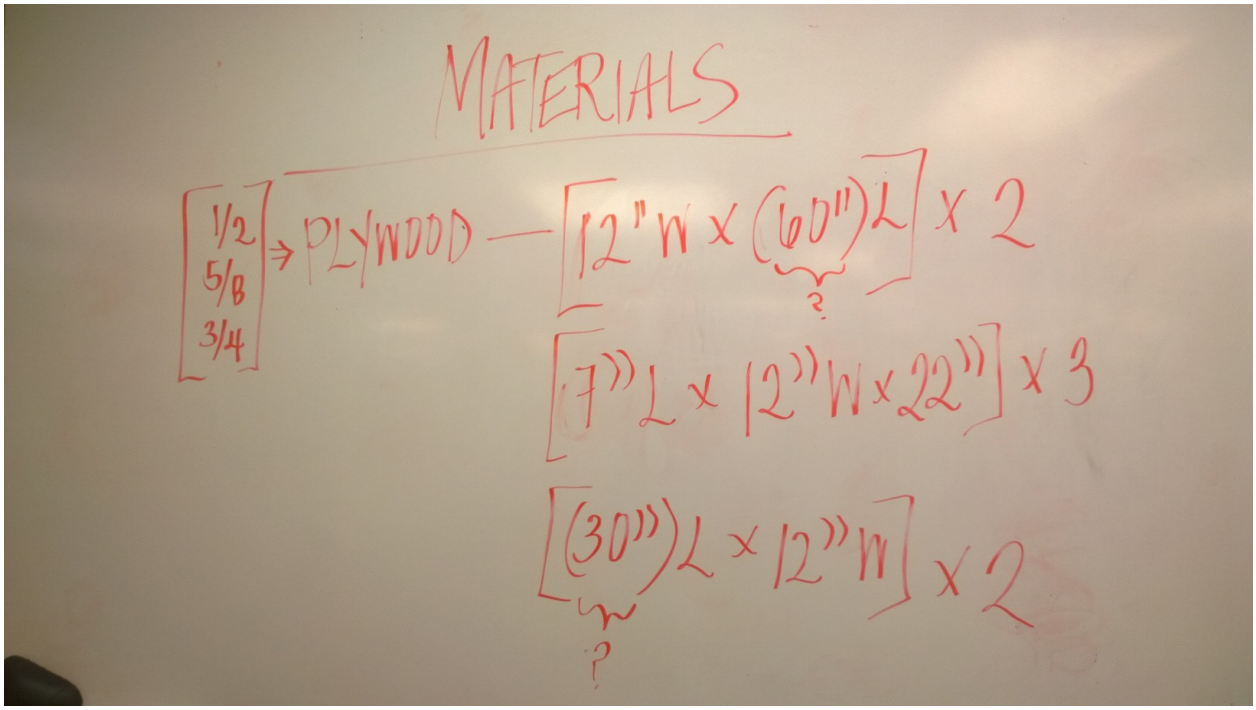


Figure B-4: Brainstorming amount of total materials needed if using plywood.

Appendix C- AutoCAD Drawings

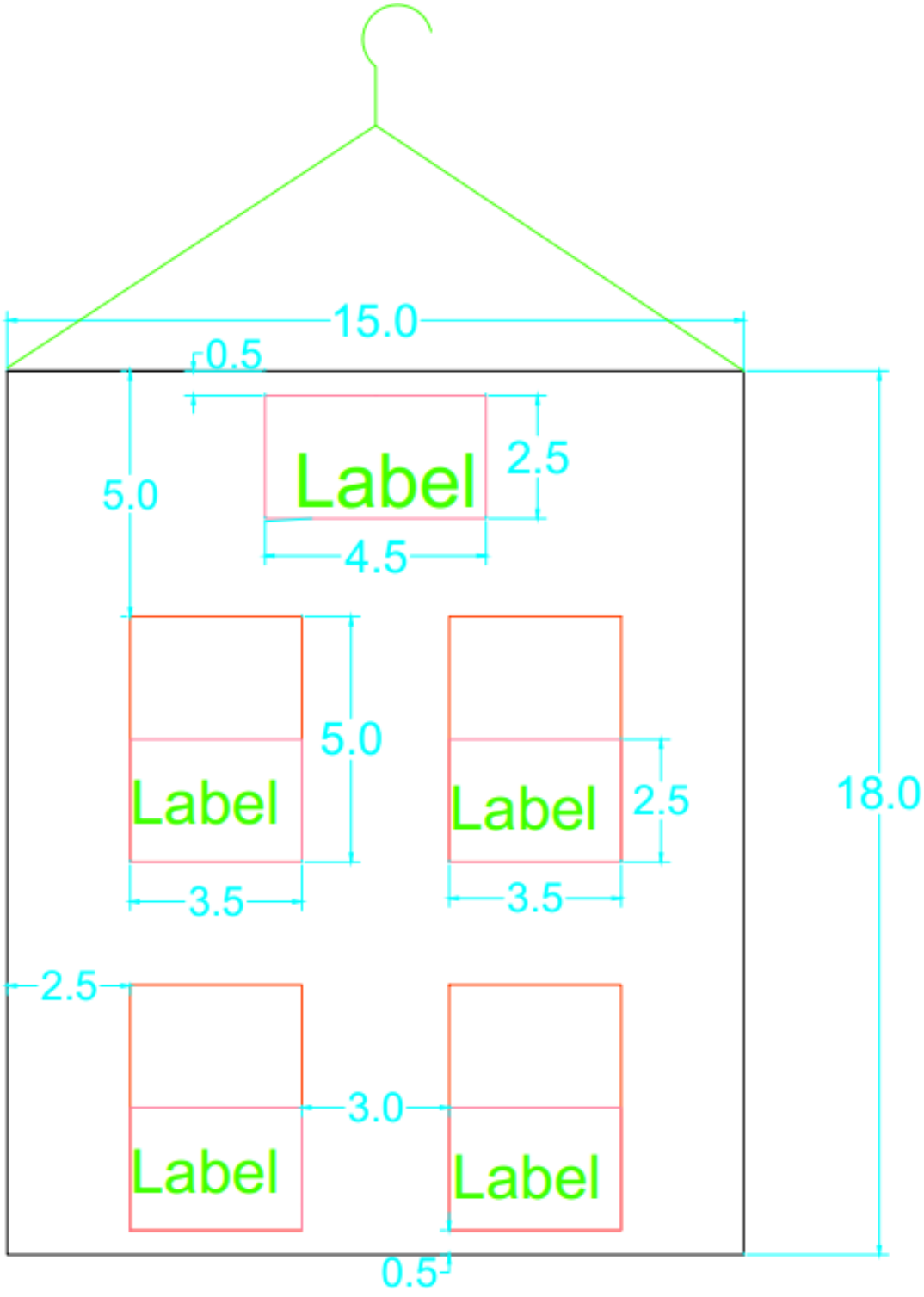


Figure C-1: AutoCad Drawing of the Hanging Calculator caddy (by Mackenzie Danies).

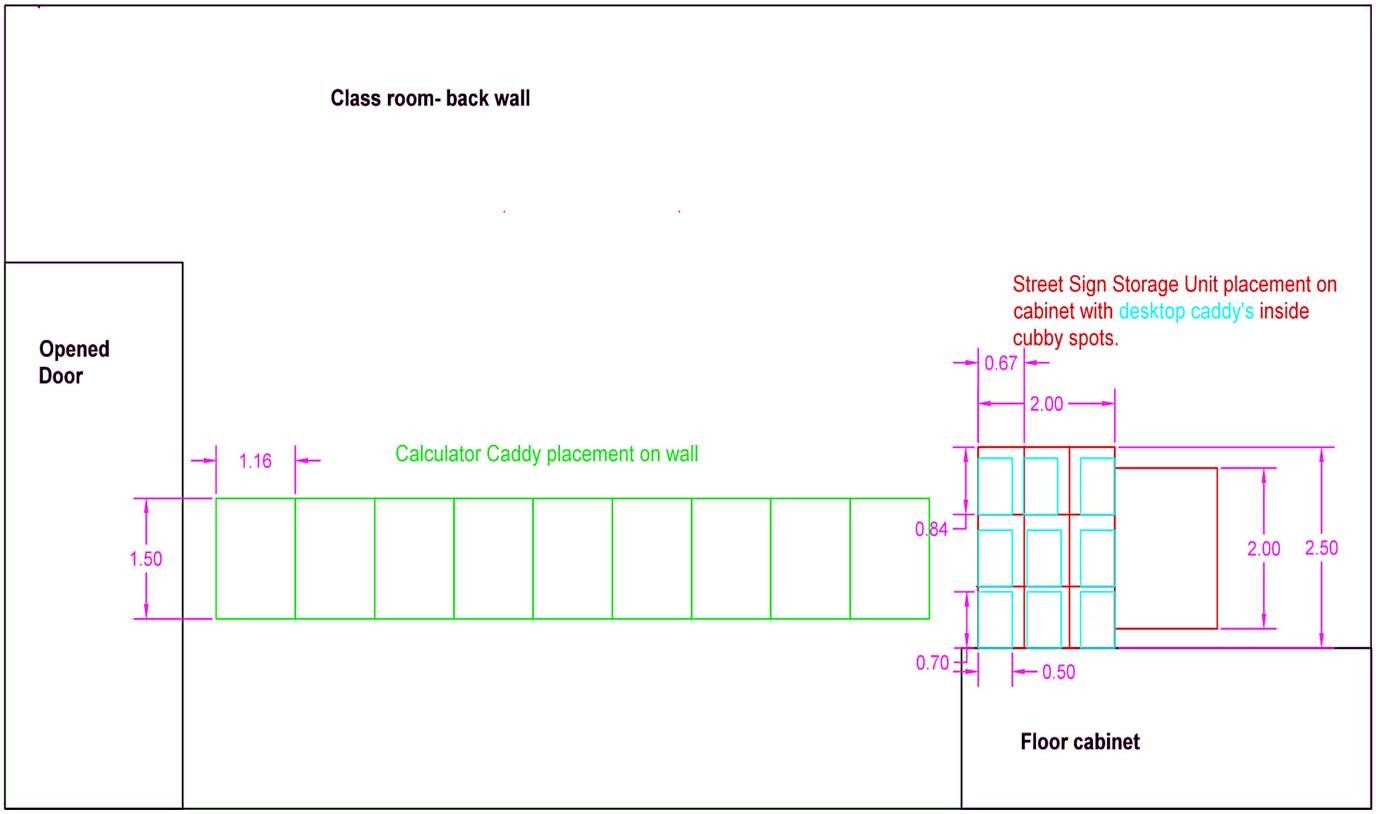


Figure C-2: AutoCad drawing of placement of all 19 caddy designs in classroom (By Allison Tapaya).

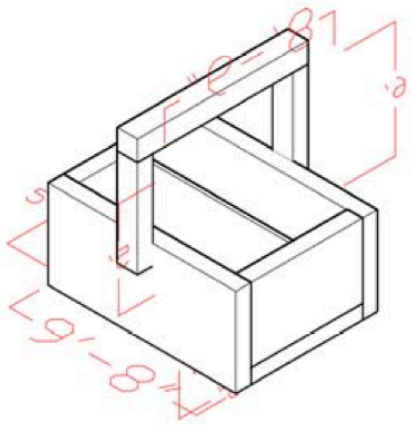


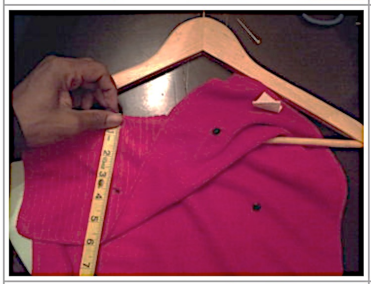
Figure C-3: AutoCad drawing of desktop caddy (By Kamau Bethea).

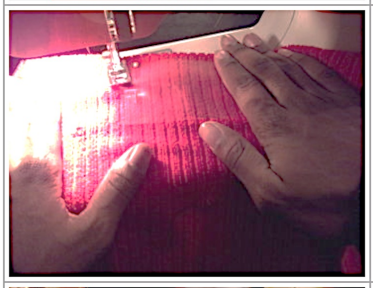
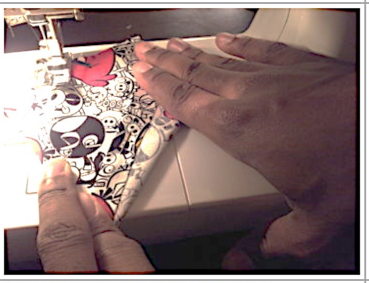
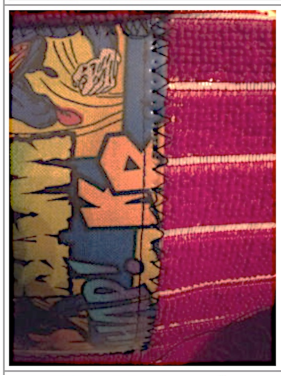
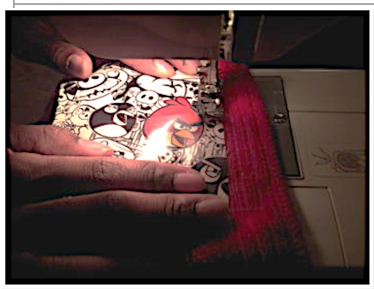
Appendix D- Build It Yourself

D-1 Hanging Calculator Caddy

Supplies and tools needed: Sewing machine, thick thread, dishtowel(s), fabric for pockets (preferably cotton), sew on snaps, hanger, and plastic for labeling pockets if desired.

Table D-1: Step by step with image descriptions on how to build a Hanging Calculator Caddy.

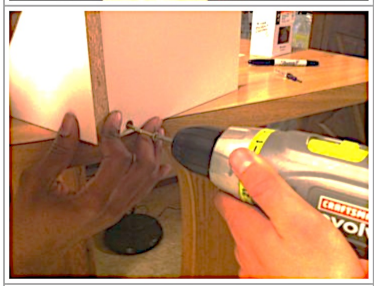
How to build a Hanging Calculator Caddy	
Image Description	**Step**
	**Step 1 :** Measure size of calculators to be used before cutting fabric. Cut fabric for pockets to desired size as well as plastic used for labeling system. Take in account if fabric needs to be hemmed as this will make the pockets smaller.
	**Step 2 :** On dishtowel, measure how much material is needed to allow to be hung off a hanger.
	**Step 3 :** Before sewing snaps, measure where can be placed on fabric and covered by the pocket. This is because the snaps are visible from the front, so we will be sewing pockets over what can be seen for aesthetic purposes.
	**Step 4 :** Sew snaps in desired location, be sure they line up when snapped together and are not crooked.

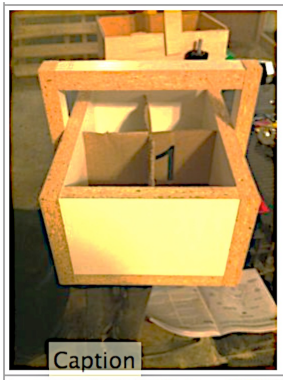
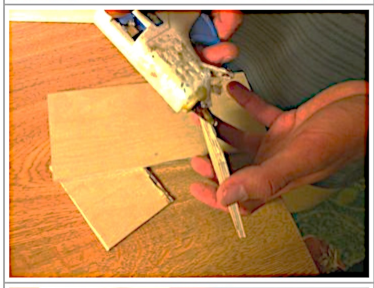
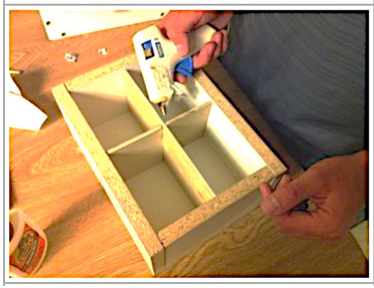
	**Step 5 :** Measure the pocket placement as well as plastic labels and pin to fabric.
	**Step 6 :** Sew on top label first.
	**Step 7 :** Sew a hem on the top and bottom of the fabric for the pockets.
	**Step 8 :** If a hem was not considered on the sides of pocket fabric use a zig zag stitch (to keep fabric from fraying over time) when sewing onto dishtowel.
	**Step 9 :** Sew pockets and plastic labels on together so that only one stitch is needed (for aesthetic purposes). If using a hem, fold small piece of fabric over on each side and continue to sew all together. DO NOT sew top of pocket to dishtowel, as this creates the pocket.

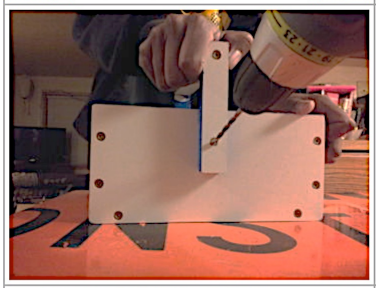
D-2 Desktop Caddy

Supplies and tools needed: Wood (plywood or particle board preferred), drill, drill bit for wood, screws (all purpose wood screws), acrylic paint, clear coat, wood glue.

Table D-2: Step by step with image description on how to build a Desktop Caddy.

How to build a Desktop Caddy	
Image Description	**Step**
	**Step 1 :** Cut wood material into desired size. Make sure to include the width of the wood when measuring.
	**Step 2 :** Before drilling pilot holes, make markings on the wood to ensure where needs to be drilled.
	**Step 3 :** Carefully drill pilot holes using proper drill bit; there are different types of drill bits required for different materials. Make sure hole has gone through both wood pieces.
	**Step 4 :** Slowly drill screws in pilot holes. Be sure to screw in straight otherwise wood may crack.

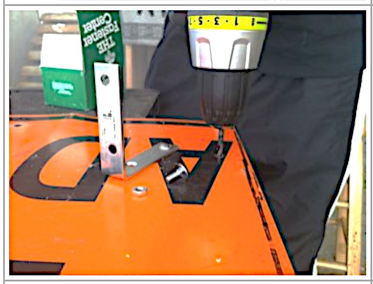
 Caption	**Step 5 :** Before cutting wood for the inner dividers of caddy, use cardboard to see what thickness would be preferred. The thickness of the inner divider will change the size of the cells used for storage.
	**Step 6 :** Cut inner divider wood to desired size.
	**Step 7 :** Glue inner divider wood pieces together before inserting and gluing into caddy body.
	**Step 8 :** Once dividers have dried, carefully glue into the caddy body. Be sure to clean up any excess glue inside caddy body.

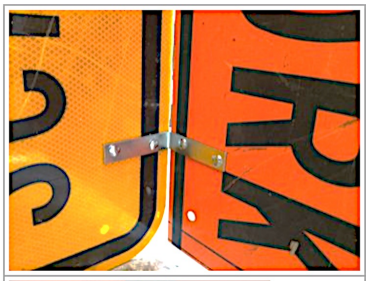
	**Step 9 :** Glue handle together prior to drilling in screws. This ensures that the handle will not rotate once attached to caddy body.
	**Step 10 :** Once glue has dried on handle, secure handle by drilling in screws.
	**Step 11 :** Put glue on lower insides of handle (that will be against caddy body) as glue is still wet attach to sides of caddy body and drill in final screws.
	**Step 12 :** Paint as desired. Cover outside of desktop caddy with a clear coat to protect paint.

D-3 Street Sign Storage Caddy

Supplies and tools needed: Street signs (depending on size desired), L-brackets (80 1 & 1/2 inch and 16 3 & 3/4 inch), plotted angle, drill, bolts, nuts, mallet, vinyl tubing, super glue.

Table D-3: Step by step with image description on how to build a Street Sign Storage Caddy

How to build a Street Sign Storage Caddy	
Image Description	**Step**
	**Step 1 :** Cut aluminum street signs to desired size. be sure to use the proper blade for cutting aluminum
	**Step 2 :** Make markings on street signs for where to drill the holes for the brackets that will connect signs together. Be sure to use the proper drill bit for drilling through aluminum.
	**Step 3 :** Be sure holes are right size for bolts, and the holes match up with the plotted angle.
	**Step 4 :** Insert bolts into bracket through correct street signs and tighten.

	**Step 5 :** Check to make sure sides of signs are flush against each other and brackets are straight.
 Caption	**Step 6 :** Attach plotted angle to all corners to maintain stability.
	**Step 7 :** Measure where to place shelves for cubbies. And Attach cubbies with L-brackets and bolts.
	**Step 8 :** Make sure shelves are leveled with one another.
	**Step 9 :** Bend top of caddy using a machine, or can be done with a mallet with sign clamped to hard, sturdy surface. Attach top using 4 L-brackets on the sides and a plotted angle on the back.