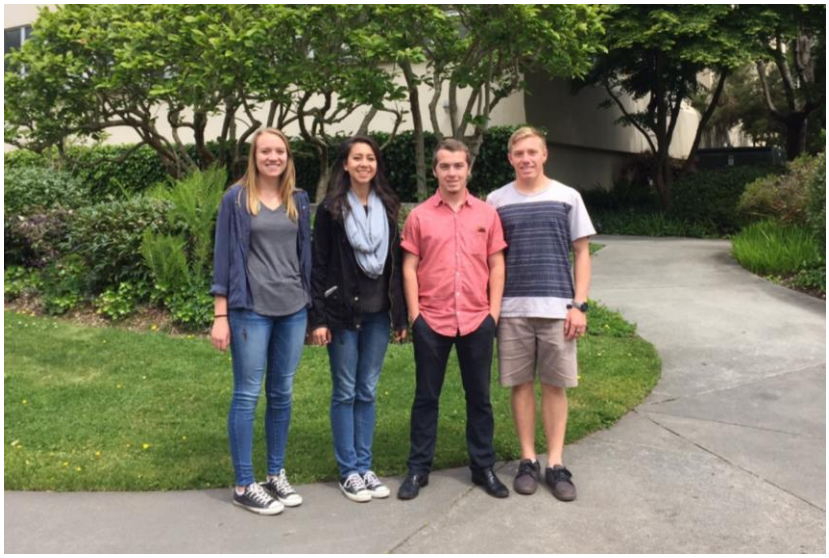
SMART CART: REPLACEMENT CONCESSION CART

CONCESSION CART CREW
HUMBOLDT STATE UNIVERSITY
ENGINEERING 215: INTRODUCTION TO DESIGN, SPRING 2016
CLIENT: BENIE LEVY, ZANE MIDDLE SCHOOL



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1 PROBLEM FORMULATION

Section One of the document will use a black box diagram presented in Figure 1-1 below, to analyze and illustrate the objective. For the Engineering 215 design class, we are going to replace a faulty concession cart for our client Zane Middle School through our point person Bernie Levy.

1.1 OBJECTIVE

The objective of our replacement concession cart is to provide a dynamic, quiet, and dependable mode of transportation for snack and beverage sales. There are currently an excessive amount of concession carts that are loud, heavy, faulty, and unreliable.

1.1.1 BLACK BOX DIAGRAM

This diagram displays how the inputs influence the design that happens within the black box and the resulting outputs.

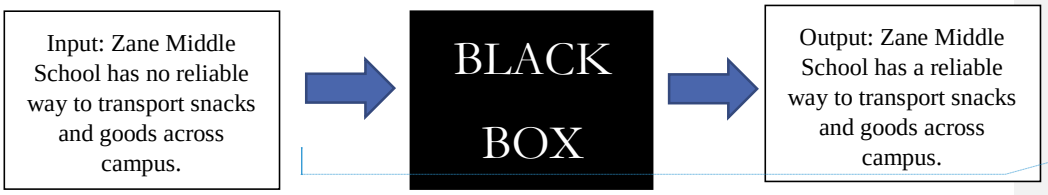

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Figure 1-1: The black box diagram illustrates the state of the world before and after the solution.

2 PROBLEM ANALYSIS AND LITERARY REVIEW

2.1 PROBLEM ANALYSIS INTRODUCTION

Section Two includes the input variables along with their limiting outputs given for the concession cart. The problem analysis will cover the specifications, considerations, criteria, usage, and production volume.

2.1.1 SPECIFICATIONS

The following specifications are guidelines for designing the concession cart:

- have the capacity to carry their current amount of stock
- be quieter than current carts
- be more efficient to transport

- must be dependable enough to last

2.1.2 CONSIDERATIONS

Factors that must be taken into consideration when drawing out the concession cart's blueprints:

- the varying product box sizes
- student height and strength for transporting
- dimensions due to doorways

2.1.3 CRITERIA

To meet the client's standards, Table 2-1 lists the criteria and constraints that must be implemented into the design of the cart.

Table 2-1: Criteria and constraints to be met.

Criterion	Constraints
Safety	Cannot harm the children, nothing sharp or dangerous
Noise	Limit sound around classrooms
Durability	Must last many years
Stability	Keep items from dislodging
Transportation Efficiency	Minimize number of carts, comfortable handle height
Weight limit	Sturdy enough for all products, light enough for children to push
Environmentally Sustainable	Implement upcycled materials
Cost	Under $325

2.1.4 USAGE

This cart will be used every day when school is in session for at least ten minutes at nutrition break. It is expected to last multiple years, under the operation of middle schoolers and teachers alike.

2.1.5 PRODUCTION VOLUME

One cart will be produced for Zane Middle School to store and sell concessions.

2.2 LITERATURE REVIEW

The purpose of this literature review is to present appropriate background information needed to design the concession cart. Topics that will be covered in this section are: client criteria, materials,

wheels, presentation of goods, storage areas, extendable shelves, bottle racks, attachment of two carts, efficient size, and covers.

2.2.1 CLIENT CRITERIA

Bernie Levy at Zane Middle School in Eureka presented the criteria that he expects to have implemented into the design of the new concession cart. His main goal is for it to be a dependable and efficient way in transporting snacks and goods across the school campus. His biggest concern for the new cart is the noise level that it will make when being pushed across the campus and past classrooms. Other criteria that our client is concerned about is: handles for easy transportation, the weight of the carts being too heavy for students to push, the strength of the shelves on the cart not being able to withstand the weight of the supplies being sold, reducing the four carts they have now into one or two, creating lips around the shelves so that objects will not fall off, creating cushions on the perimeter of the cart to prevent damaging doorways, and creating a cover for when the carts are being stored. Figure 2-1 below, shows a photo of our client's current cart.

Figure 2-1: Photo of our client's current cart (Photo taken by Austin Fenn).

2.2.2 MATERIALS FOR SHELVES AND LEGS

There is a limiting range of materials that can be used for the shelves and legs of this concession cart. The main constraints are the weight it must be able to support, appearance, and its sturdiness, making it the most reliable. The following will weigh the advantages and disadvantages of using wood, metal, and plastic.

2.2.2.1WOODEN SHELVES AND LEGS

There are a variety of options of wood all with different properties. This material would be easy to work with since it is fairly simple to shape to specific dimensions and to secure to binding parts. It can look appealing if sanded and coated properly; oppositely, can look unprofessional if the wood is uncured and has unfinished edges. When considering wood as a potential material, one must take into account the additional time and expenses to assure that the cart looks presentable by sanding, painting, and sealing the wood.

Wood is sturdy enough to support the concessions, primarily the heavy beverages. According to *Forest Products and Wood Science*, one can calculate, "[the] distributed force per unit of area…. usually expressed in psi (pounds per square inch) or in pascals," commonly known as stress. Knowing the stress will allow us to determine the thickness of wood needed. Figure 2-2 illustrates the stress and strain in a uniformly loaded beam (Haygreen and Bowyer, 2016).

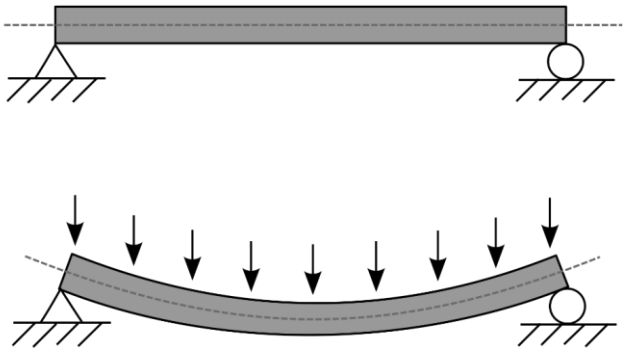


Figure 2-2: Stress and strain in a uniformly loaded beam (Haygreen and Bowyer, 2016).

The use of wood may cause a deflection in the shelf if it is too thin; the weight is then limited so it does not collapse. Using a thick enough piece of wood will eliminate this problem.

To utilize wood as the legs of the cart as well, it abides to the same standards as the shelves. Wood will provide a less than professional look unless finished properly. The sturdiness is dependent of the diameter of the legs.

2.2.2.2METAL SHELVES AND LEGS

Metal is an additional alternative to use for the shelves and/or legs of the concession cart. It would give the cart a clean, professional appearance. This material does weigh more than wood pound for pound, but can handle more weight per square inch so it does not have to be as bulky. The chance of the shelf bowing with weight is much lower, therefore we can use thinner pieces. When connecting the shelves to the legs, metal is going to require heavier machinery since it is much more

dense than wood. The metal carts our client currently use are heavy to push but that is mainly a factor of the small wheels. Using metal does not necessarily mean a metal sheet, but could also be a grill-like shelf. This would ensure the cart to be significantly lighter and since all of the products will be in boxes, it is not to our concern of the items falling through the gaps. Figure 2-3 illustrates a grill-like metal shelf that would support the concessions modeled after BBQ Smoker Mods (BBQ, 2016).

Figure 2-3: Example of metal grill shelf (BBQ, 2016).

2.2.2.3 PLASTIC SHELVES AND LEGS

Plastic is an adequate material as well but based on our client's current plastic cart, it does not have the strength to support the heavier items. We could modify the plastic version by having a thicker shelf, but plastic is harder to work with than wood or metal. Attaching the shelves to the legs would also be the most difficult compared to the other two options. On the other hand, plastic is the lightest material so it would be easy to maneuver. Plastic legs may bend if too much weight is applied. This material does not meet the environmental sustainability criteria that our client desires. According to Hankett, plastics volatilize harmful chemicals just from existing. In the presence of food and children, the avoidance of plastics is the smartest option (Hankett, 2016).

2.2.3 WHEELS

When determining physical aspects and parameters necessary for an efficient wheel, it is important to understand your options regarding appropriate material and size. Subsequently, these factors should each play significant roles in sound reduction, mobility, and in general optimizing the functionality of the overall system. The authors of *The Ergonomics of Manual Material Handling* support this claim when they state that we should "match wheel material and diameter with floor surface conditions [because] reducing the rolling and turning forces reduces the forces that the person must apply" (Darcor, 2001).

2.2.3.1 MATERIAL

Depending on what material is rolling against the ground there could be anywhere from extremely minimal sound to a rowdy clatter of noise produced. Material also helps determine the weight limit the wheels can handle. A couple different wheel materials to consider include plastic and rubber. Web research for plastic wheels points to a plastic worm wheel as being a potentially efficient wheel option shown in Figure 2-4. The authors of *Durability Characteristics Analysis of Plastic Worm Wheel with Glass Fiber Reinforced Polyamide*, an article that analyzes the durability of plastic worm wheels, tell their readers that they are "widely used in the vehicle manufacturing field because [they are] favorable for weight lightening, vibration and noise reduction, as well as corrosion resistance." This statement is an exceptional description of the positive aspects that are all uniform of plastic worm wheel. The only con regarding its design is that a light and plastic wheel could mean a shorter lifespan, which would make the entire cart less sustainable (Kim, 2013).

Figure 2-4: A Plastic worm wheel on its side (Kim, 2013).

Rubber is another potential material for the concession cart's wheels as shown in Figure 2-5 below. Because of rubber's elasticity, it can absorb more impact and return to its molded shape. Longboard wheels are one example which tend to be fairly silent when rolling over rocks and other various debris. One downfall of rubber wheels is the eventual deterioration of the material due to aging.

Figure 2-5: Example of a rubber wheel. Photo is courtesy of Austin Fenn.

2.2.3.2WHEEL SIZE

The wheel's diameter and its material are directly correlated to the strength potential and how well the wheel handles obstructions in the surface it's designated for. Darcor's manual suggests a larger wheel size depending on ground conditions when they state that "even in facilities with very smooth floors, the operator often crosses cracks, seams, expansion joints, grates, door thresholds, or other surface irregularities that can cause a small diameter wheel to stop. A larger diameter wheel will roll over such irregularities with relative ease" (Darcor, 2001).

2.2.4 BASE AND STORAGE AREA

When designing the cart, it is required by law under the U.S. Food and Drug Administration that food must be stored a minimum of six inches off the ground (FDA, 2015). This restricts where the bottom shelf should be placed. To maximize the storage space that this shelf will provide, it should be close to the limit, about half a foot off the floor. This space will allow the client to store some of the food when transporting, and when not in use. An issue with the current carts is that some of the products fall off of the shelf when in transit. The space would also ensure that nothing is stolen when the cart is sitting unattended. A shield around the front and side of this storage area would guarantee no products to be lost and provide a neat, orderly façade. Cabinet doors for the back side are also a possibility depending on how much the client is concerned about the products being stolen when in storage. Within the half closed box now, there are endless options for bins or buckets to organize the concessions for easy access.

2.2.5 PRESENTATION

The presentation of goods and materials being sold are extremely important to the psychological aspect of consumerism. It is essential for the presentation of goods to be at its highest potential so that it may attract consumers. This is why vendors will use a tool called a *planogram*, which is a

"diagram or model that indicates the placement of retail products on shelves in order to maximize sales" (Oxford, 2016). This section will discuss the importance of an aesthetic display.

2.2.5.1 SHELVES

Placing goods on specific shelves and/or locations is a fundamental marketing technique that impacts the consumer's decision processes. Most grocery stores will present their food and merchandise in the following order: generic brands on the bottom shelf, gourmet brands on the top, best-selling items on the middle, and kid-friendly products on the shelf eye-level to children (Keller, 2013). Best selling products should always be in perfect eye view because these are the products that customers will see first. The accessibility and familiarity of a product will make it more likely for people to buy it. Generic brands will always go on the bottom shelf because purchasers who are looking for cheaper prices will already be looking around, therefore there is no need to waste space on the eye-level shelf for these products.

2.2.5.2 COLORS

Colors have a powerful effect on the mind because they set a general personal impression towards objects. When they are properly used, they can alter one's emotions and cause certain attraction towards things that may have otherwise not been. Yellow is considered to be happy and relaxing while red is exciting and inviting; Zane's school colors are red and yellow. Small amounts of flashy colors like blue, red, and orange draw in attention and typically attract people to them (Beakley, 1974). A study done by two psychologists found that the top three favorite colors in children were blue, then red and yellow (Terwogt, 1995). Many fast food restaurants like McDonald's use bright, inviting colors like red and yellow to appeal to their customers as seen in Figure 2-6 (The Wire, 2014).

Figure 2-6: Many fast food restaurants use colors to their advantage (The Wire, 2014).

2.2.6 EXTENDABLE SHELVES

Additional shelves can be added to the cart to give more space to display items, but also be collapsible or removed when in transit due to doorway restrictions. The items that would be presented on the extendable shelves can be stored in the base storage area while not in use. The following will cover materials that can be used for these particular shelves, the design necessary to support the weight it must carry, and a way to make sure the items stay on the shelves.

2.2.6.1MATERIALS

For these extending shelves one has to keep in mind that these will not be holding the heavy concessions but rather the lighter ones that can be removed and placed in the base storage area when in transit. Plywood is a material easy to come by that is relatively inexpensive. The downfall of this option is its heaviness and lack of weather durability; when wet it tends to fall apart. Composite wood has a professional presence that is relatively lightweight and very strong. Consequently, the higher quality will result in a pricier investment. Stainless steel has a very presentable image that would be easy to maintain and clean, though this can be expensive and hard to come by. Recycled or reclaimed wood can be found at a scrapyard or mill and is generally always cheaper than buying new, unused wood. To find recycled materials in substitute would support our client's environmental value. It must be taken into consideration that any material that we end up using will be outdoors and is susceptible to wear and tear. "Temperature and global solar radiation [have] the greatest influence" on outdoor wood, plastics, and composites (Ebe and Sekino, 2014).

2.2.6.2STYLES

There are a variety of styles to make the additional shelves extendable. One way would be to model a keyboard slide-out tray that would extend from the main shelf of the cart. This would allow easy set up but would also be sturdy enough to support the needed weight. The design could also be similar to a dining room table leaf extension where the shelf would fold down with a hinge on the side of the main shelf and when put to use, it would fold out and be supported by a pull out sliding brace such as a piece of wood, only needing to be about one inch wide. Another take on that would be to have folding legs when it folded out and would be rested on the existing shelf but this idea might take away possible space that can be used for products. As illustrated in Figure 2-7, it could also be modeled after a folding shelf bracket that would enable the shelf to fold flush vertically but have a stable support when horizontal if it carries the lighter concessions (Folding Shelf Bracket, 2016).

Figure 2-7: Image of a Folding Bracket (Folding Shelf Bracket, 2016).

2.2.6.3 WEIGHT FACTORS

The design of these extendable shelves really depends on the weight limit they must withstand. From our understanding the client is primarily interested in these supporting the lighter products which can be easily stored in the storage area when the cart is in motion. If in the case the shelves must support more than just a bag of chips as the products are always changing, installing supporting brackets in the shapes of triangles would give the shelf a sturdier body. As bridge engineers' claim, the best support is, "armed with the classical geometry and inherent strength of the geometry's strongest shape: the triangle" (Phillips, 1998).

2.2.6.4 SHELF PRODUCT CONTAINMENT

When moving carts to and from the storage area, there needs to be a way to keep the items from falling off the cart. There are a couple ways this can be designed, but one is to put a simple lip around the edge of the shelf just high enough so the products stay in place. This does not have to be too big or dense, as a Plexiglas or wood lip would suffice. Depending on the material used, it would determine the cost and weight. The products could also be stored in boxes and placed in the storage area below when transporting the cart.

2.2.7 BOTTLE RACK DESIGN

To the client's request, we conducted research on a bottle rack that can easily distribute and display beverages on the cart. It has to be generic enough to comply with all size bottles as the products are always changing. A slight tilt of the rack would allow bottles to be self-restocking as gravity would pull the beverages to the front of the cart. Modeled after Display Technologies, LLC: Innovated Merchandising Solutions, the rack is "designed to gravity feed single serve cans and bottles." Figure 2-8 demonstrates how Display Technologies utilizes gravity to its advantage (Display Technologies, 2015).

Figure 2-8: Display Technologies, LLC under shelf wire rack (Display Technologies, 2015).

The rack does not necessarily need to have a metal frame but it makes it look clean and organized. A slanted tray with a lip about half the diameter of a bottle would be sufficient to do the same job. It must be designed to support the weight of the beverages as those are the heaviest contributors on the cart.

2.2.8 ATTACHMENT OF TWO CARTS

There are many ways in which two carts can be connected. This section will address various options in doing so. Based on our client's requests, it would be beneficial if the two carts were attached to each other so that less transportation trips would be needed. With a cart attachment, only one trip and person would be needed during transportation.

2.2.8.1 HOOK AND EYE LATCH

According to the Random House Dictionary definition, a hook and eye latch is a "a three-piece latching device consisting of a hook attached to a screweye and a separate screweye that the hook engages as it bridges a gap" (Random House, 2016). Hook and eye latches, as shown in Figure 2-9, are useful because they lock two things together quickly and easily. Although typically used for door locks, the hook and eye latch could work for attaching two carts together because the solid latch could prevent the two carts from drifting too far apart from each other and go around turns easily.

Figure 2-9: Hook and Eye Latch; also called a Cabin Hook (SDS London, 2016).

2.2.8.2ROPE

Another way to attach the two carts together could be by tying them together with rope. One way of using rope would be to attach hooks to the sides of each cart and tie the rope around said hooks. Similar to the hook and eye latch, the rope could also be permanently attached to one cart, then have a hook on the end of the rope that attaches to the other cart. Rope is generally low cost but in result might have complications due to deterioration.

2.2.8.3CHAIN

Similar to the rope option, one could attach two hooks to the end of a chain link to attach the two carts together. Although more expensive, this would ensure that the attachment would not rip or break as easily as the rope. Chains are also easily fixable because if one link breaks, you would not have to replace the entire chain, just that one link, making them cost efficient. Figure 2-10 illustrates a hook and chain that could be used as an attachment.

Figure 2-10: A chain with a Clevis Slip Hook attached to the end (Manufacturer Express, Inc., 2016).

2.2.9 CART COVER

Currently, the client has a problem with students stealing the food products as the cart sits openly exposed in the dining hall. To keep the cart out of sight, a cover would be enough to keep the children from acting on their urges. A cover would also keep dust and outside vectors from contaminating or disrupting the presentation of the products.

2.2.9.1MATERIALS

The cover can be created from a variety of materials being that it is durable and waterproof. It must be able to be removed easily without disrupting the items on the shelves. A possible material could be nylon, since it is known to be waterproof and heavy duty. A nylon cover would be non-transparent so the children are not tempted by the sight of the concessions. However, nylon can be relatively expensive and seen to a more commercial standard than what we need for the cart. Tarps are an additional option that would be less expensive and fit more in the budget. Though they look less professional, tarps come in a variety of colors and sizes that can be easily cut and shaped to fit our design (Nylon Cart Cover, 2016). Below, Figure 2-11 illustrates a cart with a fit nylon cover.

Figure 2-11: Image of a Nylon Cart Cover (Nylon Cart Cover, 2016).

2.2.9.2 DESIGN EFFICIENCY

Handle height is relevant because it determines what posture the person pushes the cart. Figure 2-12 illustrates the difference in posture at different handle heights. Because there is no single handle height that is "correct" for all people, the proportional height for a smaller person might cause a larger human to bend or stoop. Likewise, a handle height preferred by the taller of the two will result in the shorter person reaching up. This is essential because a person's potential force is directly related to their posture. They follow this example up later in the manual by declaring that "handhold height should be between hip height and knee height, and the handhold may need to be offset from the equipment to ensure adequate foot clearance". These excerpts from Darcor's ergonomics manual sufficiently elaborate on how an operator's size relative to the cart their maneuvering will determine the appropriate parameters for the cart's design (Darcor, 2001).

Figure 2-12: An individual's posture will determine what height their handle should be to maximize their comfort level (Darcor, 2001).

Because the cart will not always be operated by the same individual, the design must suit the varying heights of the children (Darcor, 2001). Here, the Ergonomics manual explains why it is essential that the cart system is designed to accommodate any and all body types who will be interacting with it on a regular basis.

3 ALTERNATIVE SOLUTIONS

3.1 INTRODUCTION

Section Three discusses the brainstorming process that resulted in twelve alternative solutions for the concession cart. The alternatives all meet the criteria specified in Section Two's problem analysis and are all possible ways to create the most reliable cart for the client.

3.2 BRAINSTORMING

Our group's brainstorming practice has been in progress since we were first assigned the project. Two scheduled brainstorming sessions consisted of a mix of structured and unstructured brainstorming techniques. We relocated to an unfamiliar area being a dorm lounge to initiate new ideas. Once situated, we began a scheduled "hitchhiker" session where we each got a piece of paper and had five minutes to write out our own ideas followed by two minute intervals to circle around the papers building off each other's thoughts. From there, we transferred our most realistic alternatives to a white board and had an unstructured discussion eliminating extraneous solutions. See Appendix B for complete brainstorming notes.

3.3 ALTERNATIVE SOLUTIONS

Based on our brainstorming results, we have decided upon the following alternative solutions that would make the cart most reliable and efficient for our client's needs. Each is supported with a visual aid and brief summary of its properties.

3.3.1STUFF IT UP!

Due to the possibility of theft while the concession cart is stored in the dining hall, our client has requested that a cover be utilized in order to hide the snacks on the cart from the sight of curious students. A large nylon blanket is lightweight and could be stuffed into a small nylon bag that is attached to the tarp at a corner. This way the tarp will not separate from it's bag and a minimal amount of weight will be added to the overall system. The bag can also have a drawstring to keep the stuffed blanket from protruding from it. This design covers the following criteria: cost, size, cover, weight limit, and safety. Figure 3-1 displays the process of the cover being packed and put on the concession cart.

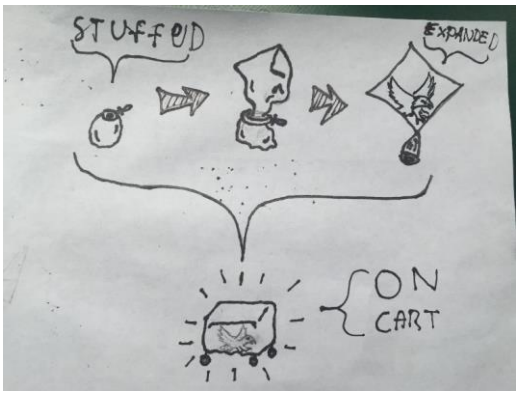


Figure 3-1: Stuffed cover removal and application. (Drawn by Austin Fenn)

3.3.2 2COOL4SCHOOL

The 2cool4school alternative is specific to the drinks that are going to be sold from the concession cart. There will be an insulated box that can be filled with ice as well as the drinks being sold in one box built for the bottom shelf. There will also be a system created to drain ouy the ice and water, which could possibly be used for another purpose. This will fulfill the following criteria: size, noise, cover, safety, durability, storage capacity and stability on the shelves. The cooler may be slightly costly because of the ice but it will keep the drinks cold and will be reused for another purpose. It also may be heavy with the ice in the bin but it is a possibility that the ice can be filled at the dining hall.

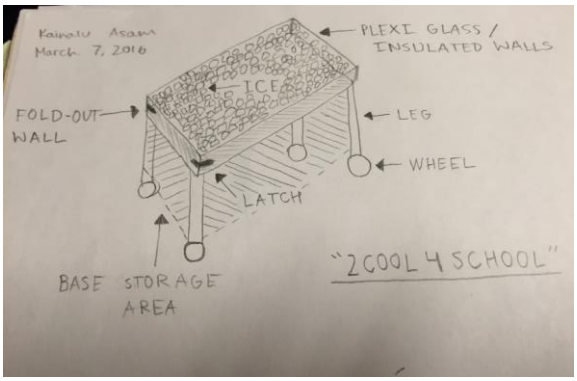


Figure 3-2: 2Cool4School design. (Drawn by Kainalu Asam)

3.3.3 ALL ABOARD THIS ALTERNATIVE

In order to make transporting the carts easier, each cart can be attached to each other to form a line of carts, or train, which only needs to be pulled by one person. The attachments can be made out of a number of things including: rope, hooks, or chains. With one person pulling the train in the front, the remaining carts will then follow the path. This reduces the amount of people and trips needed to transport each cart individually. This alternative can also be decorated to replicate the look of an actual train by adding windows and a whistle to the front. This design will cover the following criteria: size, transportation, durability, weight limit, and safety. Figure 3-3 below, illustrates how the carts will all look when attached.

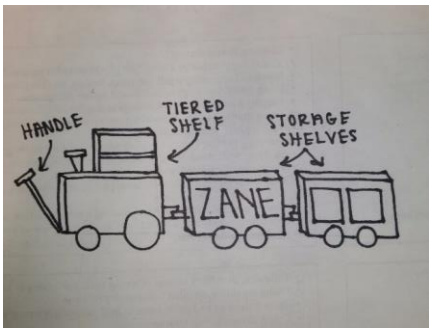


Figure 3-3: All Aboard this Alternative design. (Drawn by Tina Ortega)

3.3.4SMART CART

The Smart Cart alternative could essentially minimize the need for human intervention for moving the cart by making it remote controlled and electric powered. The system would need to have a rechargeable battery like a Tesla so it could be plugged in every night to charge for the next operating time. The controller then has a video screen that syncs with the camera on the cart in order to direct the cart without needing to be with it. If the cart has pre-installed electrical currents, pressure sensitive pads can be installed underneath the displayed items that set off an alarm if the originally recorded total weight decreases without authorization from a cart advisor. This design covers the following criteria: size, transportation, cover, durability, and weight limit. Figure 3-4 represents the very complex idea that is the "Smart Cart".

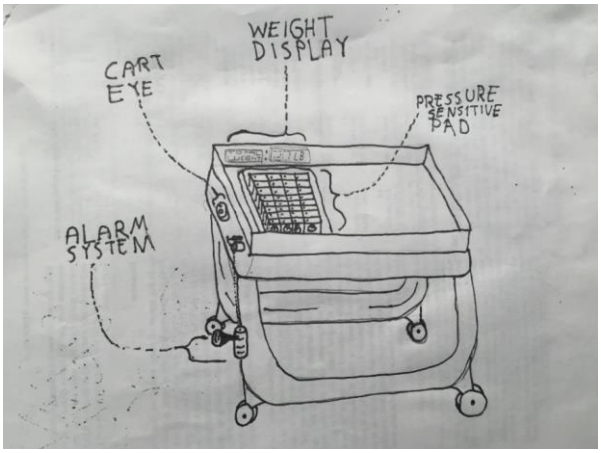


Figure 3-4: Smart Cart design scheme. (Drawn by Austin Fenn)

3.3.5SLIP N' SLIDING SHELVES

The Slip n' Sliding Shelves alternative includes extendable shelves that are able to meet the client's criteria of being able to compact the current four carts into two while supporting the same amount of stock. When transporting the cart, the extra items would be stored in the base storage area while the shelves are compacted away. These shelves would be attached under the second level shelf display and would be able to slide out to the side to create extra display space. It would be modeled after a keyboard pull out tray that can be hidden away when not in use. By making these extendable, the cart may meet the size limitations of transportation while still being able to hold the same amount of stock. This design will cover the following criteria: cost, size, durability, weight limit, and safety. Figure 3-5 below gives a visual aid of how the sliding shelf would be attached.

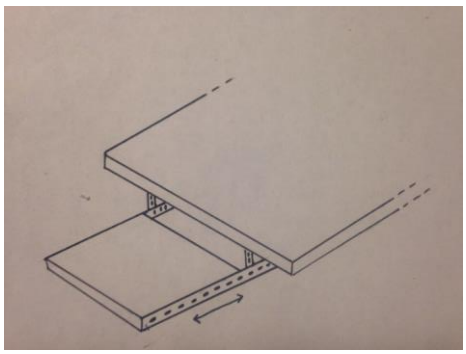


Figure 3-5: Slip n' Sliding Shelves design. (Drawn by Hanna Phillips)

3.3.6HANDLE HELPER

The Handle Helper alternative design is one way that was thought of to be able to pull or push concession carts from the storage area to the dining hall and back. Having control from the front will allow for more direct movements and will be more stable than pushing from the back of the cart. It consists of the front axle of the cart attached to a handle that comes up to about waist level; the way that you pull the handle will control the way the cart goes. Installing handles on the back end of the cart is a more realistic idea when it comes to a cart that isn't very long. This design will fulfill the following client criteria: size, transportations efficiency, durability, safety, weight limit, and stability. The client likes the idea of the being able to pull the carts using this design. Figure 3-6 is a computer aided drawing that provides a sketch of the cart itself as well as the pulling handle design.

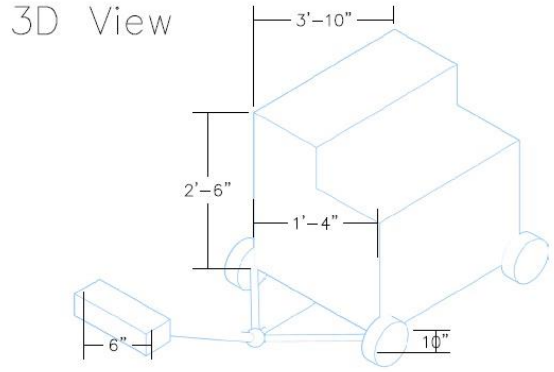


Figure 3-6: Handle Helper design. (Drawn by Hanna Phillips)

3.3.7 THE HIDDEN CABINET TO NARNIA

The Hidden Cabinet to Narnia is an alternative solution to implement a cover our client desired. Substituting the current cloth they have laying over the concessions with a full cabinet would make the cart look more professional. This solution would ensure to not disrupt the items when the "cover" is removed. This alternative would also solve the problem of items falling off the shelves when in transit since it would be enclosed. The doors would then be designed to have small shelves on the inside of them to maximize the compact efficiency of the cart. The outside could then be decorated with the school's logo or even the prices on the inside. This design will cover the following criteria: size, transportation, cover, durability, safety, and stability. Figure 3-7 below illustrates the cabinet to hide the concessions.

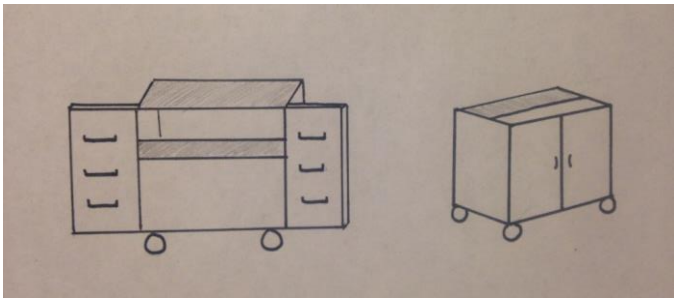


Figure 3-7: The Hidden Cabinet to Narnia design. (Drawn by Hanna Phillips)

3.3.8 POP 'EM

The Pop 'em alternative is one feature that meets the client desires to have some type of padding around the edges of the cart, to prevent it from damaging doorframes when being transported through them. Implementing the use of padding, like recycled bike tires for example, will cause the cart to bounce off of the doorframes with little to no damage at all. Using a recycled material instead of buying a padding new will also work well with the client's wish for the cart to be as environmentally friendly as possible. This design includes the following criteria: cost, size, transportation, weight limit, safety, sustainability, and durability. Below is Figure 3-8, that demonstrates where the rubber will be attached to prevent damage to the doorways.

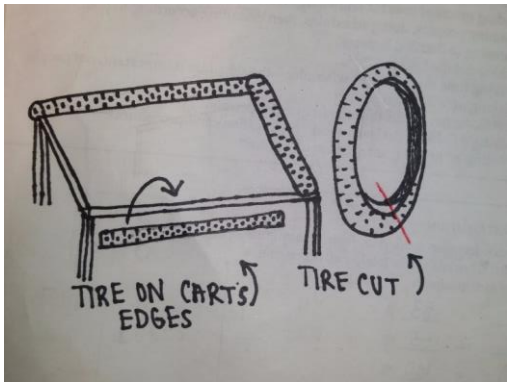


Figure 3-8: Pop 'em design. (Drawn by Tina Ortega)

3.3.9 CARING CANISTER

Caring Canister is a design specific to the aspect of carrying drinks on the cart. This design, rather than a cooler, is a grid of pieces of wood in a box sitting on the bottom shelf of the drink cart; the dividers can be moved around and adjusted to fit the needs of space for the client's beverages. This alternative would be a less expensive alternative to the cooler, while keeping the drinks much more organized. There will be area available in front to display what drinks are held in each specific section. This design will be able to fit maximum drinks in each area at the same time providing a stable platform. This design will cover the criteria: cost, size, noise, efficiency, durability, weight limit, safety, storage capacity, and stability. Two different views of a computer aided drawing for this aspect are presented in Figure 3-9.

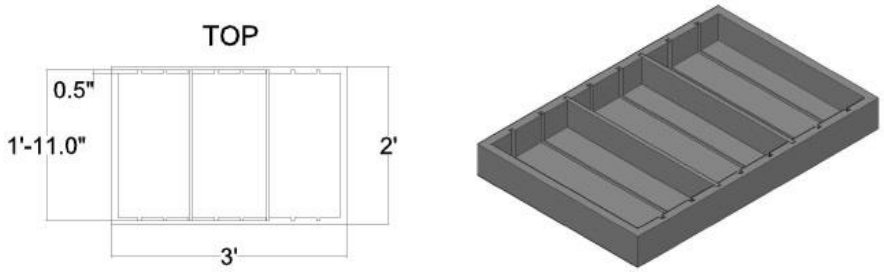


Figure 3-9: Caring Canister design. (Drawn by Kainalu Asam)

3.3.10 ONE BOTTLE AT A TIME

The One Bottle at a Time alternative is designed to take two liter bottles and cut them into strips roughly one foot long and one inch wide. These then could be sewn together with fishing line and a needle to make long strings of these plastic bottles. From there they would be wrapped around a metal frame and weaved into each other to form a shelf that would be sturdy enough to support the lighter items such as chips. This design will cover the following criteria: sustainability, cost, weight limit, noise, size. Figure 3-10 gives a general idea of what the shelf would look like as well as an idea of where the material comes from.

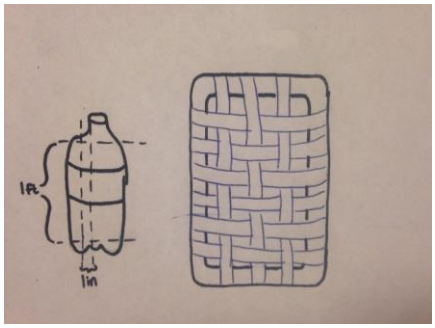


Figure 3-10: One Bottle at a Time design. (Drawn by Hanna Phillips)

3.3.11 HONEY I SHRUNK THE CONCESSION CART

The Honey I Shrunk the Concession Cart alternative is a collapsible cart that would allow for extra convenient cart storage and an improvisational means to storing items in order to keep up with changing stock items. The cart would consist of two parallel walls of criss-crossed pivoting beams that could expand upwards for more room or downwards for storing purposes. When expanded out to their full height, the scissor lift arms will click into a position that creates tracks for the shelves to slide into to provide maximum space usage. This design meets the following criteria: cost, size, transportation, durable, and noise. Below is Figure 3-11 that is depicting said conceptualized system.

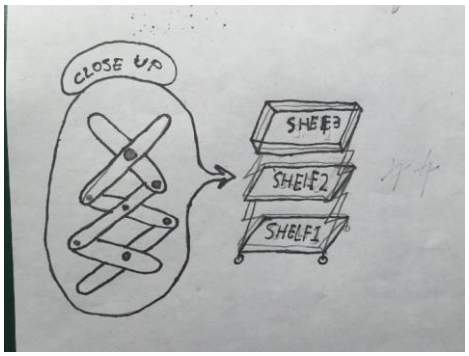


Figure 3-11: Profile and 3D view of shrinking design. (Drawn by Austin Fenn)

4 DECISION PROCESS

4.1 INTRODUCTION

Section Four includes the decision process and how the final design project was determined. This section will assess a few of the alternative solutions that were developed in Section Three of this document. The conclusive design was established using a Delphi Matrix method of analysis, which determined the best alternative solution using the weighted criteria from Section Two.

4.2 CRITERIA

Below is the criteria from Section Two that was used when deciding which alternative solution would be preferred. Each criterion has a descriptive definition of why it is needed.

- **Safety-** Since the cart will be around children, it should have no obvious safety concerns.
- **Noise-** Because the cart is pushed past classrooms that are in session, it needs to have little to no noise while going over the cracks in the cement so that the children are not distracted in class.
- **Durability-** The reason this project was initiated was because the client's current carts are old and breaking down. To prevent the need for more carts in the future, this cart needs to last many years.
- **Stability-** The cart needs to be stable enough to support the given weight of the goods.
- **Transportation Efficiency-** The client is currently using four different carts and having to make individual trips for each cart. This criterion is implemented to reduce the amount of carts and trips needed from the storage area to the area where the merchandise is sold. An efficient sized handle will need to be implemented as well to make it easier to push or pull the carts.
- **Weight Limit-** The cart needs to be sturdy enough to contain and hold all of the merchandise, but still be light enough for the students to push around.
- **Environmentally Sustainable-** The cart should implement materials that are recycled and renewable.
- **Cost-** The cost of the final project should not exceed $325.

4.3 SOLUTIONS

The following is a list of alternative solutions from Section Three that are to be considered for the final design:

- Stuff It Up!
- 2cool4school
- All Aboard This Alternative
- Smart Cart
- Slip n' Sliding Shelves
- Handle Helper
- The Hidden Cabinet to Narnia
- Pop 'em
- Caring Canister
- One Bottle at a Time
- Honey I Shrunk the Concession Cart

4.4 DECISION PROCESS

To decide which alternative is best for the final design decision, the criteria is weighted on a scale of 1-10 which was decided with collaboration of our point person, Mr. Levy. Each alternative is then ranked on a scale of 1-30 based on each criterion. Table 4-1 displays the ranking of the weighted criteria that we created along with input from our client. Table 4-2 organizes the ranking calculated using the criteria and each alternative in a Delphi Matrix; the full matrix is presented Appendix C.

Table 4-1: Weighted Criteria

Criterion	Constraints
Safety	10
Noise	9
Durability	9
Stability	8
Transportation Efficiency	8
Weight limit	7
Environmentally Sustainable	5
Cost	4

Table 4-2: Delphi Matrix of top five alternative solutions.

Criteria	Weight (1-10)	Caring Canister	Pop 'em	Stuff It Up!	Handle Helper	Slip n' Sliding Shelves
Cost	4	22 / 88	30 / 120	25 / 100	15 / 60	20 / 80
Noise	9	30 / 270	30 / 270	30 / 270	25 / 225	25 / 225
Transportation Efficiency	8	30 / 240	25 / 200	15 / 120	30 / 240	18 / 144
Cover	6	25 / 150	25 / 150	30 / 180	20 / 120	30 / 180
Durability	9	23 / 207	20 / 180	20 / 180	25 / 225	20 / 180
Weight Limit	7	25 / 175	25 / 175	30 / 210	25 / 175	20 / 140
Safety	10	25 / 250	30 / 300	20 / 200	15 / 150	20 / 200
Stability	8	30 / 240	20 / 160	20 / 160	30 / 240	25 / 200
Environmentally Sustainable	5	20 / 100	30 / 150	22 / 110	10 / 50	10 / 50
Totals		1720	1705	1530	1485	1399

4.5 FINAL DECISION

For this specific project, each alternative was just one aspect of the entire cart. The top five aspects will be the Caring Canister, Pop 'Em, Stuff It Up!, Handle Helper, and Slip n' Sliding Shelves, which will all be implemented into the final design.

5 DESIGN SPECIFICATION

5.1 INTRODUCTION

Section Five includes a full description of the final design decision and process for the concession cart. It will also include the qualitative and quantitative costs in addition to tables representing those values. Installment, use, and maintenance recommendations will be described, followed by the final results through the testing process.

5.2 DESCRIPTION OF SOLUTION

The following section describes each aspect of the cart in detail. Figure 5-1 below is an AutoCAD depiction of our final solution.

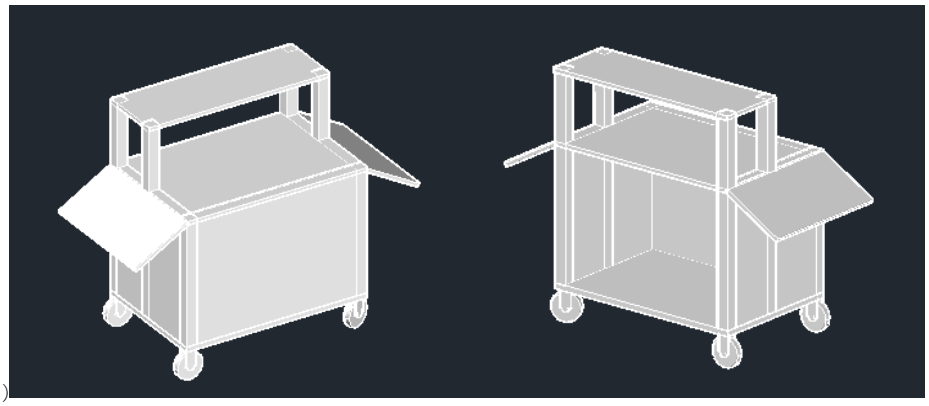


Figure 5-1: AutoCAD of final design. (Drawn by Kainalu Asam)

5.2.1POSTS/SHELF MATERIAL

The shelves we reclaimed from the scrapyard are made of old road signs. The larger sign used for the bottom shelf was roughly three feet by two feet. The two signs used for the top shelf are each one foot by one and a half feet. They are connected via the slotted angle posts with screws and washers and supported by a two inch by two inch wooden frame. Figure 5-2 and 5-3 below illustrate the posts and shelves used in the final design.

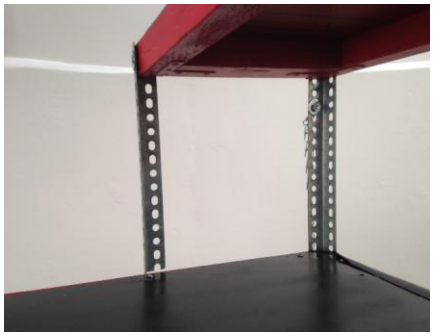


Figure 5-2: (Left) Slotted angle frame post.

Figure 5-3: (Right) Road sign shelves with a two by two inch wooden frame.

5.2.2EXTENDABLE SHELVES

The extendable shelves are constructed of a thin sheet of plywood attached using a double sided hook and U-Bolt with a non-locking hinge to the bottom shelf and a hanging chain connected to the top shelf; this will be detached during transit. Figure 5-4 below shows the extendable shelf mechanism.

Figure 5-4: Extendable shelf of final design.

5.2.3STORAGE AREA

The storage area will provide a space for the merchandise from the extendable shelves when in transit. It will be enclosed with a thin sheet of plywood on three sides. Figure 5-5 shows the base is made of wire racks and a sheet of plywood.

Figure 5-5: Base storage area of concession cart.

5.2.4WHEELS

The wheels are five inch polyurethane casters. The front two are swivel and the back two are non-swivel. This allows easy turning and stable steering when needed. The polyurethane material they are made out of will prevent the noise our client currently has an issue with. Figure 5-6 and 5-7 show the difference between swivel and fixed casters.

Figure 5-6: (Left) Fixed five inch casters.

Figure 5-7: (Right) Swivel five inch casters.

5.2.5COVER

The cover is made out of a reclaimed bedsheet from a thrift store. Its purpose is to hide the merchandise from the children's view in order to prevent the urge to steal the snacks. The cover will be resized to fit snug around the cart. Figure 5-8 below shows how the cover fits on the cart.

Figure 5-8: Bedsheet cover for cart.

5.2.6RUBBER BUMPER

The rubber bumpers are made from upcycled bicycle tires that were reclaimed from a local bicycle shop. They will provide extra protection for the edges and corners of our cart to prevent damages made to the cart itself and to doorways when in transit. Figure 5-9 and 5-10 show how the rubber bumpers are attached around the cart.

Figure 5-9: (Left) Rubber padding around front.

Figure 5-10: (Right) Rubber padding around back.

5.2.7HANDLES

The handles are from two plastering trowels that have been detached from the metal sheet. The plastic handle remaining is then bolted to the metal post frame between the top and bottom shelf. Figure 5-11 below shows how the handles are attached to the frame.

Figure 5-11: Handles for pushing.

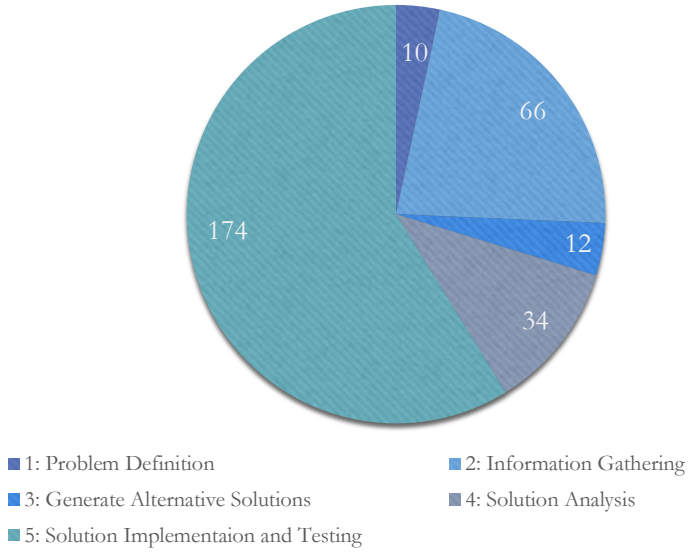
5.3 COSTS

The following section describes the qualitative and quantitative costs of the construction of the concession cart.

5.3.1DESIGN COST (HOURS)

We have worked at total of 296 hours on this design project for Zane Middle School. The pie chart, Table 5-1, illustrates the division of hours for each phase of the project.

Table 5-1: Table below divides the number of hours spent during the project into each phase.



5.3.2IMPLEMENTATION COST ($)

Table 5-2 indicates the cost of materials that have been purchased for the implementation of the cart. A total of $263.39 has been spent on materials which is below the projected budget of $325.00.

Table 5-2: Final materials list of items implemented.

Materials List			
Criterion	**Quantity**	**Actual Project Cost ($)**	**Projected Cost ($)**
Scrapyard Road Sign (3'x2')	1	5.45	5.45
Scrapyard Road Signs (1.5'x2')	4	10.90	10.90
Wire Rack	2	2.50	2.50
Plywood (1/4")	24 sqft	43.68	43.68
Fender Washers (1/4")	50	4.97	4.97
Hinges	4	12.00	12.00
Lumber (2"x4")	12 ft	4.76	4.76
Lumber (2"x2")	24 ft	8.39	8.39
Slot Angle Post (1.25"x1.25")	12 ft	35.00	35.00
Screws	100	4.18	4.18
Bedsheet	1	4.00	4.00
Metal Braces	10	9.04	9.04
Metal Corner Brackets	19	18.81	18.81
Spray Paint	3	15.12	15.12
Red Paint	1	13.18	13.18
Paint Brush (3")	1	1.60	1.60
Paint Brushes (2")	2	2.18	2.18
5" Fixed Caster	2	17.32	17.32
5" Swivel Caster	2	23.76	23.76
Double Loop Chain	5 ft	3.16	3.16
U-Bolt	2	2.98	2.98
Double Hook Snap	2	5.18	5.18
Notch Trowel	2	4.58	4.58
Tire Intertubes	3	Donated	0.00
Liquid Nails	1	5.00	5.00
Nuts	6	0.54	0.54
Nuts	12	1.08	1.08
Bolts	12	1.32	1.32
Hardware	2	0.34	0.34
Hardware	4	0.68	0.68
Hardware	12	1.44	1.44

Hardware	1	0.25	0.25
	Total	263.39	263.39

5.3.3 MAINTENANCE COST ($)

The expected maintenance cost for this project is minimal. Durability was weighted high on the criteria list for this reason. Since it is used on a daily basis, and by middle school children, we as a group had designed it so it would last many years; this is also why it is being replaced. Because of this, the only maintenance needed would be paint touch ups ($15 a quart), replacing the shelves after years if they show signs of wear ($8 a shelf), and replacing the chain attached to the extendable shelves if were to break ($1 per foot). The maintenance cost in hours is only expected to be around two hours per year.

5.4 INSTRUCTIONS FOR IMPLEMENTATION AND USE OF MODEL

The concession cart is designed to transport snacks and goods across campus in a reliable way. Handles have been implemented into the design to make it efficient for students to push or pull from the storage area to the courtyard where they are to sell the items. In order to make the least amount of trips possible, the cart has been constructed in a way where there are extendable shelves to limit the size while still being able to hold the same amount of stock. While the cart is in motion, the goods will be stored in the bottom and later placed on the shelves the kids will fold up when preparing the cart. A chain will have to be hooked onto the shelf to extend. The cart must be re-stocked with goods as items are purchased. A cover will be placed over the cart to prevent theft from the students.

5.5 RESULTS

Upon completing the carts construction, we came across a few unforeseen errors. These technical faults included: an ungrounded wheel; paint that wasn't willing to dry; sharp, protruding corners; and overly lengthy screws that kept the carts extendable shelves from collapsing completely. To solve the problem regarding the uneven wheel, a quarter inch wooden square was implanted above the problem wheel which let it contact the ground, thus allowing the cart to roll at maximum efficiency. What we originally thought was regular black paint turned out to be an oil based paint that still wasn't dry a couple days after its application. As for the sharp corners, we've sanded them a rounder, smoother edge to maximize safety and adding a rubber edge. The most appropriate solution for the extra screw length is to sand down their ends to allow the shelf to fold down parallel to the carts

walls. The final design is sturdy, quite, safe, environmentally sustainable, and durable concession cart for Zane Middle School to use for snack sales. Figure 5-12 below is the final product of our design.

Figure 5-12: Final Product

6 6. APPENDICES

6.1 APPENDIX A: BIBLIOGRAPHY

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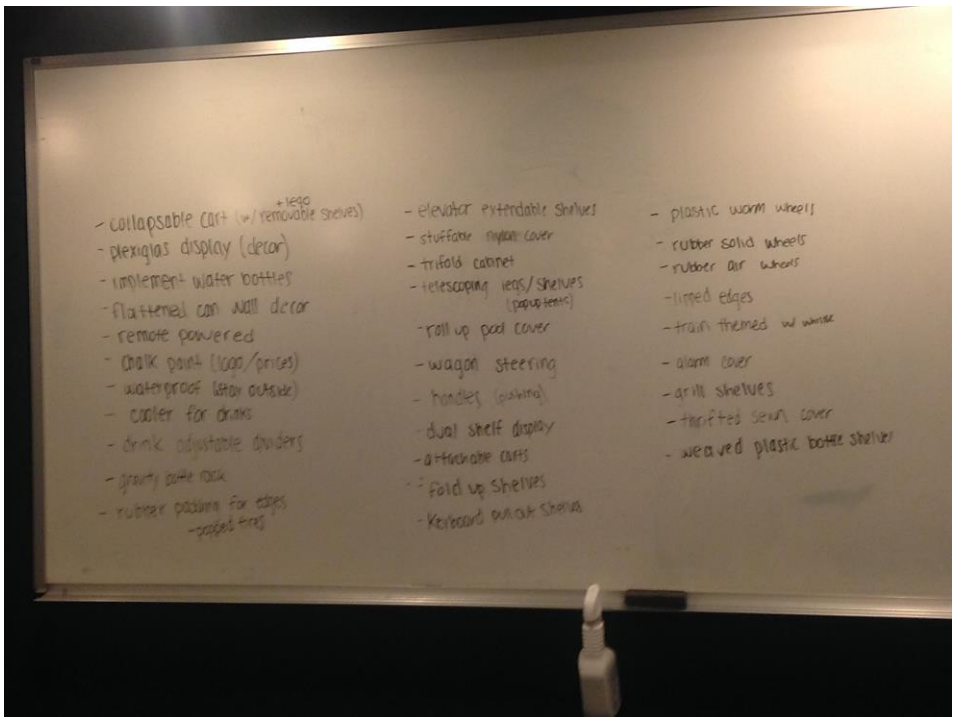
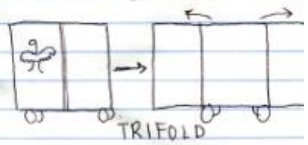
6.2 APPENDIX B: BRAINSTORMING NOTES



Tina Ortega
3/1/16

- 4 cart train (with a conductor and Bell)
  (each cart made of a different recycled material)
- One long cart with bicycle wheels
  (bicycle wheels made from paper mache)
- Cart with stackable shelves (take off for storing cart) (slide out stack shelves.)
- Cart that opens like this



Draw Falcon on front

- Cart made of metal rods that fold to make smaller (-metal rods are carbon fiber actually.)

- telescoping shelves / legs to collapse to store smaller
- cover that rolls over like a pool cover
- 5 wheels, one to steer w/ handle to pull - wagon
  - pull w/ handle that moves front wheels

- cans or bottles as wheels
- cardboard for base are cover
- Bicycle tires and wheels for cart

Hanna Phillips
3/1/16

5 min original
2 min hitchhiker

Structured

- collapsable cart so fits under shelf
- shelves made of plexiglass w/ ant farm inside ⇔ ladybugs instead?
- frame is plexiglass tubes that are fish tanks
- weave cut strips of plastic bottles to make shelves
- stack crushed water bottles to make legs
- old cookie trays as shelves (trays are super see ~~through~~ new)
- wheels that lock (only 3 wheels)
- J trays to use as shelves
- Flattened cans as the storage area & walls

J sushi as wheels

glued together with thick paper mache stuff?

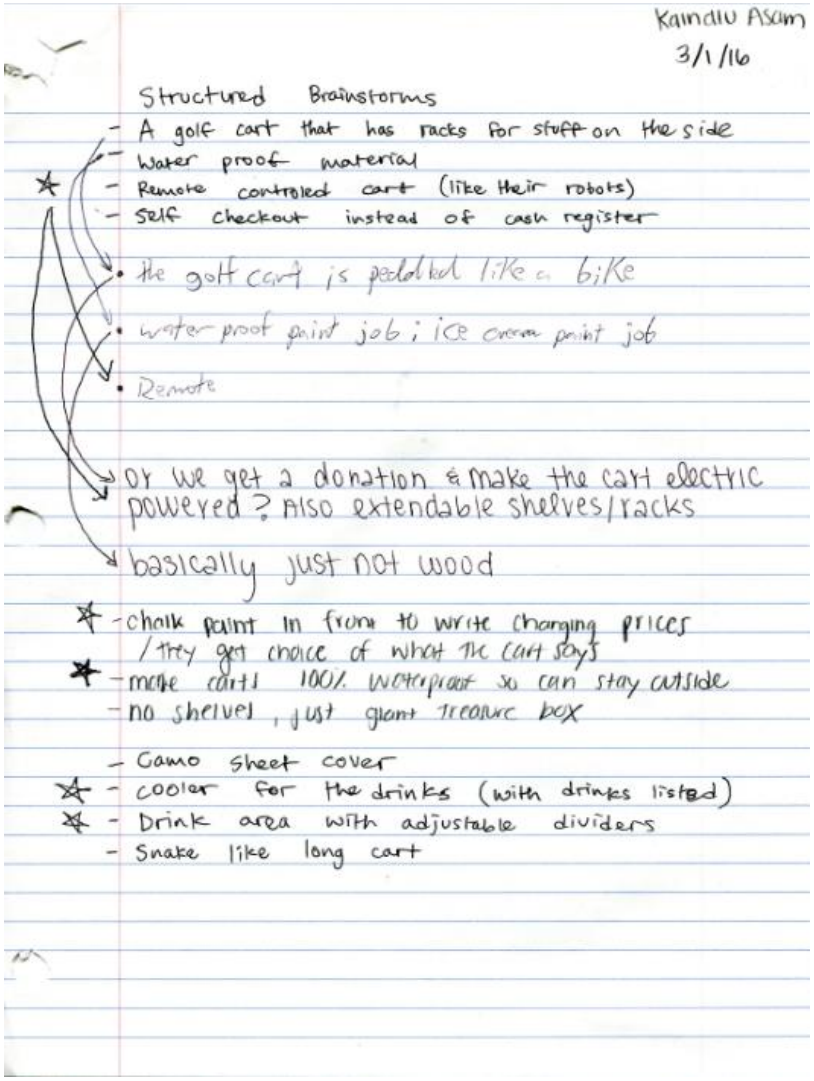
or front of storage base area?

Austin Fell
3/1/16

1. Cart is a metal tray that collapses via criss cross spring bars like a scissor thing. Arms pivot and push it down.
2. wheels are balls that can move any direction like an orb in a bowl.
3. drinks get dispensed via claw arm and you insert money to play/ get drink
4.

Add-on shelves that can be put on after the cart is expanded. Attachable train for storage

- wheels are hamster balls
- drinks get rolled down by gravity, to self restock
- Shelves are old computer boxes pieces
- use old rubber tires to pad the edges
- the extendable sheves can come out from the bottom and slide up the sides like an elevator and lock into place
- Cart Cover comes out of nylon baggy



6.3 APPENDIX C: COMPLETE DELPHI MATRIX

Alternative Solutions (Scores 1-30)												
Criteria	Weight (1-10)	Stuff It Up!	2cool 4school	All Aboard This Alternative	Smart Cart	Slip n' Sliding Shelves	Handle Helper	The Hidden Cabinet to Narnia	Pop 'em	Caring Canister	One Bottle at a Time	Honey I Shrunk the Concession Cart
Cost	4	25 / 100	10 / 40	18 / 72	1 / 4	20 / 80	15 / 60	10 / 40	30 / 120	22 / 88	30 / 120	10 / 40
Noise	9	30 / 270	15 / 135	10 / 90	10 / 90	25 / 225	25 / 225	25 / 225	30 / 270	30 / 270	25 / 225	15 / 135
Transportation Efficiency	8	15 / 120	15 / 120	30 / 240	30 / 240	18 / 144	30 / 240	25 / 200	25 / 200	30 / 240	20 / 160	5 / 40
Cover	6	30 / 180	25 / 150	20 / 120	30 / 180	30 / 180	20 / 120	30 / 180	25 / 150	25 / 150	25 / 150	10 / 60
Durability	9	20 / 180	30 / 270	18 / 162	10 / 90	20 / 180	25 / 225	15 / 135	20 / 180	23 / 207	12 / 108	15 / 135
Weight Limit	7	30 / 210	10 / 70	25 / 175	20 / 140	20 / 140	25 / 175	5 / 35	25 / 175	25 / 175	15 / 105	10 / 70
Safety	10	20 / 200	25 / 250	25 / 250	15 / 150	20 / 200	15 / 150	10 / 100	30 / 300	25 / 250	25 / 250	5 / 50
Stability	8	20 / 160	30 / 240	25 / 200	20 / 160	25 / 200	30 / 240	20 / 160	20 / 160	30 / 240	15 / 120	15 / 120
Environmentally Sustainable	5	22 / 110	10 / 50	15 / 75	1 / 5	10 / 50	10 / 50	1 / 5	30 / 150	20 / 100	30 / 150	7 / 35
Totals		1530	1325	1384	1059	1399	1485	1080	1705	1720	1388	685