LEGO MAKER SPACE

Legos on the Oregon Trail

Eric Douglas, Nester Lopez, Jesus Rincon, Cuong Tran

Table of Contents

Table of Figures

Table of Tables

1 Problem Formulation

1.1 Introduction

This semester the team will be working with a middle school teacher Teresa Pambianco at Zane Middle School. Our goal is to provide them with a stable and creative Lego station. The purpose of this table is to allow the students to have a workstation where they could play with their Legos freely and also have the liberty to move it outside or to another room.

1.2 Objective Statement

Our objective is to maximize the storage of Legos with our apparatus. Our client has several containers of Legos that she desires to make portable. We have to come up with a design where we implement most of all the Legos and provide a way to transport them safely from class to class. We expect it to change as more designs surface.

1.3 Black Box

Input	Black Box	Output
• **Problems with Lego Storage and Lego transportation around Zane Middle School**		• **Transportable cart for Lego storage.**

2 Problem Analysis and Literature Review

2.1 Problem Analysis Introduction

Our client for this project is Zane Middle. The primary goal is to provide an easy way to transport a large volume of Legos across school grounds effectively. This section primarily focuses on the client's criteria as well as the expected production volume the team is expected to undertake. Also included is a rough estimate for the amount of the use the project is likely to withstand.

2.1.1 Client Criteria

The client emphasized four important priorities for this project: safety, mobility, durability, and maximum effective use of space, in that order. In addition, the client desires the Lego cart to double as a play area, but this is not absolutely required. Simplicity and pragmatism are the benchmarks this project

emphasizes. In addition, there is a solar powered Lego robot charging cart that was designed by a previous ENGR 215 group. The client would appreciate it being integrated into our design but is by no means required. The primary goal is to provide an easy way to transport a large volume of Legos across school grounds effectively. The school is also willing to provide the team with a cart to modify to accomplish this and reduce costs for both parties. Like the solar charger cart it is a recommendation not a requirement. It could serve as an effective project base provided free of charge. Other options include purchasing or building a transportation design more in tune with our final specifications.

2.1.2 Production volume and usage

One model will be produce and we expect moderate daily usage.

2.2 Literature Review Introduction

Section 2.2 contains the literature review. The group primarily focused its research efforts on solutions to efficient storage space and usage of recycled materials. The client also provide several parameters for consideration.

2.3 Safety

Safety is of particular concern because the final device will be surrounded by and utilized by children, some of which have special needs. Several of the current designs being considered involve hinges and moving parts which create safety hazards. The risk of pinching or fast moving parts striking the body must be mitigated or eliminated completely. Soft close hinges rated for child protection is one such apparatus that fits these parameters. As a hinged device closes the child safety hinges decelerate the object, reducing the potential for pinching or being struck by fast moving unfolding parts. (Dershewitz and Williamson, 1977)

Another worry is making the cart too top-heavy, to the point where there is a potential for tipping. Some sort of ballast may be required. It would best be easily concealed or aesthetically pleasing. Ballast can range from something as simple as adding a cinder block or small number of bricks to the lower shelf of the cart to incorporating heavier drawer/storage designs.

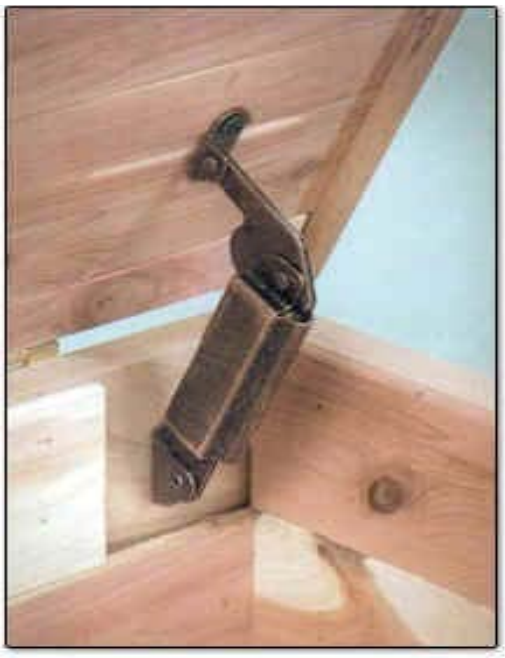


Figure 2-1 : Child Safety Hinge

2.4 Mobility

The client wants to be able to move whatever we construct quickly and easily from room to room. The cart we are being provided with comes with wheels that allow for easy mobility and turning. Its size also allows it for easy transportation by children and has the added advantage of already being a familiar object. Currently there is little incentive to modify the wheels or change transportation method. To increase the life of the cart the team will consider adding larger and more durable wheels. These wheels would be able to support a larger weight and tolerate more wear and tear.

2.5 Durability

The setting for the finished design will be a middle school catering to children between the ages of 12-15 years of age. Any project delivered to the client must be able to withstand a great deal of abuse throughout its normal operating life. The cart being provided to us by the school is composed of heavy plastic and should has a satisfying life expectancy of several years. Possible alternatives include procuring a cart of different materials like metal or wood, or reinforcing the provided cart to make it more structurally sound and increase durability. A completely different cart runs would come at an increased cost but could provide a more stable foundation for the project and increase lifetime. Reinforcing the provided cart is an apparent middle ground, where interior supports added or built into the storage design itself would provide additional sturdiness. Brackets and bracings of various materials would provide a cheap and compact way to increase cart sturdiness. Overall, the necessity of internal supports and bracing depends on the final decisions regarding cart top and drawer design. (Seasoned Mom, 2014)

2.6 Effective Use of Space

In a school filled with hundreds of students and limited class space, room for activities is at a premium. Presently Lego activities take place in classrooms on the floor or at tables in the library. There are a variety of possibilities for using the provided cart as a way to expand space.
The Ideal storage solution will provide the children using it both easy access to the Legos while also being easy to clean up once playtime is finished. There are a variety of options ranging in complexity. The simplest would be to just acquire several cardboard boxes and place them on the cart's shelving for easy transport. While tempting in terms of cost and time, it is a temporary solution at best and lacks significant durability. Several stores sell plastic containers that would work similarly to boxes but possess more durability. To this end it addresses every one of the client's parameters but lacks increased utility.

A built in drawer construction greatly increases the comparative complexity of the project, but possibly allows for easier access and cleanup as well maximum effective use of space. Drawers can be constructed from a variety of materials, each with their own advantages and disadvantages. The team is primarily looking at plastic, metal, and wood constructions. Plastic is cheapest but far less durable. Metal is more expensive and heavier, but is far sturdier and takes up less space. Wood has the highest variance in cost depending on the quality of materials but is relatively fragile and easily marred while also taking up the greatest amount of space. A combination of materials is also within the range of possibilities, with the drawers composed of one material and the housing of another.

With the drawer option there are also additional considerations. Ballast once again becomes a potential issue. If all the drawers are pulled out to one side there should still be no danger of the cart tipping over. One possibility is for the drawers to be able to be pulled out from either side of the cart. This would remove the need for backing but would decrease support structure and require addition drawer modifications.

2.7 Materials for Lego Makerspace

There is a wide range of choices when it comes to materials for constructing a portable table. However there are many things we need to consider when choosing the material for our project to fit our budget and client's requirements. Our group has agreed that the material must meet our table criteria of being collapsible, fold, light, and strong. Most importantly, the materials must be easy to find in our local hardware stores. The group decided to dedicate heavy research time into examine the properties of several locally available woods

2.7.1 Maple Woods

The scientific name for Maple woods is Acer Saccharum. But, the most common names for Maple woods include Hard Maple, Sugar Maple, and rock Maple. Weight is one of the main factors the team considers for material to construct a light and portable Lego makerspace table. The average dried weight for maple wood is 44 lbs/ft^3 or 705 kg/m^3 (wood-database.com). Crushing strength is the measurement of compression when force or weight is applied parallel to the grain of the wood to find its maximum strength. We must consider this in our design due to safety and durable. The crushing strength of maple woods is 7,830lbf/in^2 or 54.0 MPa (wood-database.com). Maple wood texture makes it easy to work with both hand and machine tools. However, with high-speed cutter machine, maple wood might catch on fire or changes color.

Maple woods can be use in wide range of applications. As a result, it is as easy to obtain maple woods as drive to our local home depot or hardware store. According to Home Depot, the cost of maple wood is $4.66 per linear foot for a board with dimension of 1in x 6in x R/L (homedepot.com). According to

wood-database, hard maple can cause skin irritation, running nose, and breathing problems. Maple wood is not durable yet it is very perishable and very susceptible to insect attack (wood-database).

2.7.2 Cedar Woods

There are many classified Cedar woods. However, the most common names for it are Atlantic White Cedar or Southern White Clear. Moreover, the scientific name for Cedar Woods is Chamaecyparis Thyoides (wood-database). According to wood-database.com, the average dried weight for cedar wood is roughly 24lbs/ft^3 or 380 kg/m^3. Cedar is much lighter compared to Maple woods weight at 44lbs/ft^3. The crushing strength of Cedar Wood is 4,700 lbf/in^2 or 32.4 MPa. (Wood-database) Due to the texture of Cedar woods, it makes cedar wood one of the easiest woods to work with either hands or powered tools. It also can hold paints and finishes well (wood-database). Since Cedar trees are smaller in comparison with other types of wood and limited of its growing range has makes Cedar availability more limited. Therefore, the price of Cedar woods expected to be pricier compared to other woods. According to homedepot.com, it costs $15.96 each for a Cedar Common Board with dimension of 1in x 12in x 8ft. Even though life threatening reactions to Cedar woods are not very common, Cedar wood has been reported to cause skin irritation in some people. (Wood-database) According to wood-database, Cedar wood is durable and very resistance against decay.

2.7.3 Yellow Birch Woods

Yellow Birch is distribution in Northeastern North America and has a scientific name of Betula Alleghaniensis. The average dried weight for Yellow birch wood is 43 lbs/ft^3 or 690kg/m^3 (wood-database). Yellow birch is one pound less than Cedar wood in dried weight. The crushing strength of Yellow Birch is 8,170 lbf./in^2 or 56.3Mpa. The Yellow Birch wood has the strongest crushing strength compare to Maple and Cedar wood. Majority of time Yellow Birch are easily to work with hands or powered machine. However, Yellow Birch board with wild grain can cause tear during machine operation. (Wood-database) Yellow Birch can be easily found at local home center or hardware store. Moreover, Yellow Birch is generally cheaper than other hardwoods. According to homedepot.com, it costs $2.29 for each piece of 2in x 4in x 96in of wood. According to wood-database, yellow birch has been reported to cause allergic reaction in people. Some of the symptoms include skin and respiratory irritation. Yellow Birch is very perishable and easily to decay and rot if exposed to the elements. Moreover, Yellow Birch is very susceptible to insect attack.

2.7.4 Aluminum

Aluminum is not only effective for the design use but it is also something that we can obtain from Arcata Scrap Yard. Therefore road signs made of aluminum alloys are our best option for a resistive material. Therefore the design integrates six desplegable (unfoldable), independent aluminum stations coated with [Material Still to be specified], for the interaction and storage. Dr C.S.Sivaramakrishnan, who was director of the National Metallurgy Laboratory of Jamshedpur (India), in his publication, Physical Metallurgy of Aluminum, describe s aluminum being: ⅓ the weight of steel; its alloys being of equal strength as steel; highly resistant to weather (H1). The only downside of aluminum is that it is conductive, and kids will be using it. However we will coat the table so that kids are not exposed to any danger.

2.8 Playable Surface:

The team decided to challenge its abilities and integrate a play area into the table. The table surface has no requirements beyond being flat and of a height that allows children to play. However, one way to increase utility and aesthetics would be to add a Lego studded surface to increase ease and convenience of play. Options to construct this surface include purchasing Lego plates directly or having the team create them from recycled materials. Buying the plates is the more expensive option but faster, while creating the parts ourselves is cheaper but more time consuming. Specifically there is the possibility of constructing 20" by 15" Lego base pieces out of reused plastic. This option also allows for upcycling, which while not a direct criteria of the project falls into the philosophy of environmental engineering and also increases the design's prestige.

2.8.1 Upcycled Lego Surface

One possibility for creating a Lego surface is to utilize a CNC milled mold with recycled melted HDPE plastic serving as the material. The process is relatively simple: the first thing to be done to would be to calculate the total volume of the mold. Following that, the plastic that would be weighed and cleaned for use. To maximize the quality of our product, ideally the team would be able to finely shred the plastic to maintain a consistent thickness. It is extremely important to inspect all the plastic used thoroughly to make sure no other plastic besides HDPE is being melted. Other types of plastics possibly contain leachate or release dangerous, hazardous gases.(table 2.8.1) Following that the mold containing the plastic should be heated at 350 degrees Fahrenheit for 20-30 minutes. If all the plastic was a soft HDPE, like what's found in bottle caps, it should conform to the grid shape. To get the best and smoothest quality work, it's also advised to use some oil based spray to later help the product release from the mold.

Table 2-1: The health concerns of melting different types of plastic: Using plastics other than type 2 constitute a health hazard

	Type 1 PETE	Type 2 HDPE	Type 3 PVC	Type 4 LDPE
	Products?	Byproducts? Health effect?		Leachate?
Type 1 PETE	Plastic water bottles, anything labeled plastic 1	Produces Antimony and carcinogens that leach into water. Advised to avoid melting this form of plastic.		Yes, could leave dangerous residue on byproducts.
Type 2 HDPE	Milk jugs, detergent bottles, anything labeled plastic 2	Releases little to no hazardous gases		No, does not produce Leachate
Type 3 PVC	PVC tubes	Advised to avoid melting at all cost. Considered the "Most dangerous plastic product." Emits carcinogens and other toxic		Yes, leeches carcinogens as well as lead

		chemicals including the most dangerous toxin, Dioxin.	
Type 4 LDPE	Plastic wraps, grocery bags, and food containers	Releases little to no hazardous gases. Burns easily to heat. Caution is advised.	No, does not produce leachate
Type 5 PP	Tic-tac containers, grocery bags, and food containers	Little to no hazardous gases. Caution is advised if ever heated.	Yes, some reports have shown that PPs may leach biocide

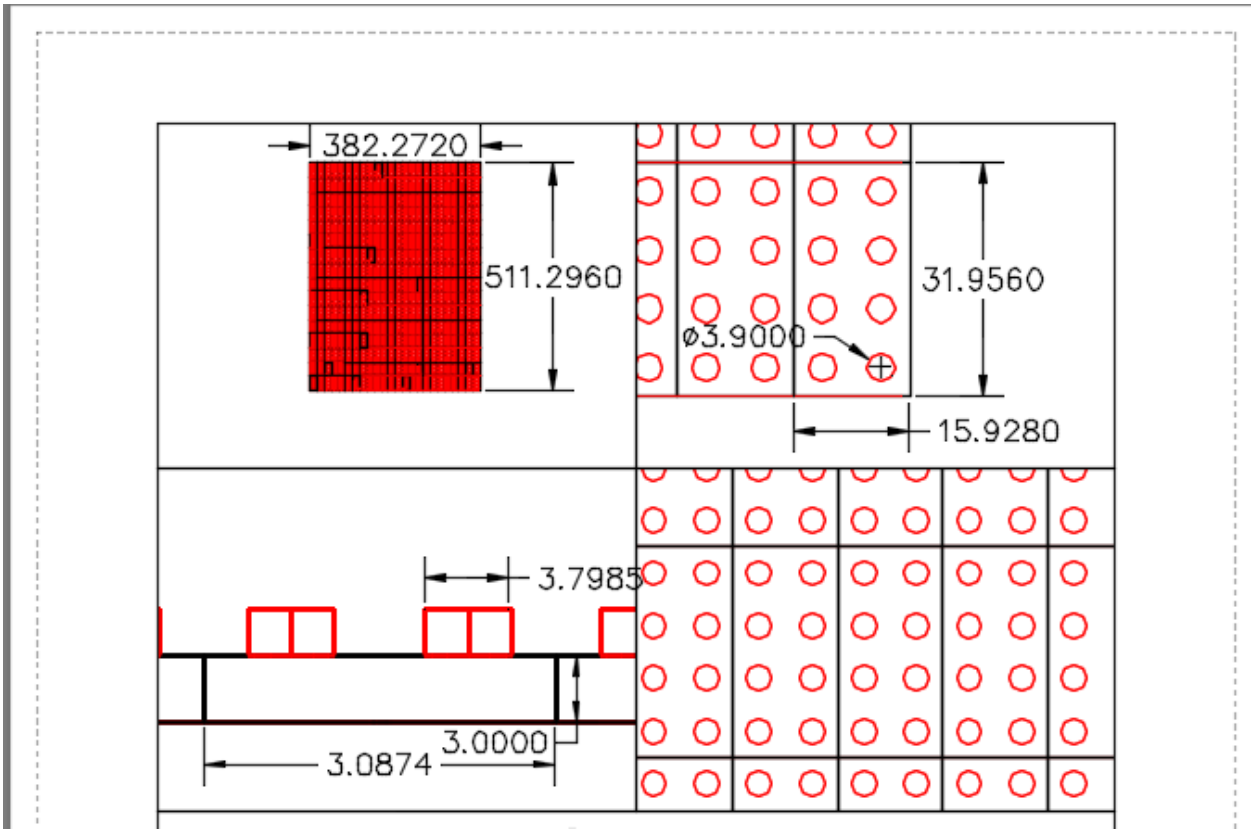


Figure 2-2 Lego 2D Grid.

2.9 Expandable Surface

Another challenge the team has undertaken to increase table usefulness is to attempt to create a surface that is able to be expanded to increase play area and provide easy access to Legos contained in the cart. Client criteria for safety and mobility are still paramount.

2.9.1 Tables Inside table.

Space efficiency expandable alternative surface design that slides out six different independent tables for kids to interact on. This design increases the surface of the table, providing an expandable surface that is safe for kids to use since it is not composed of sudden moving parts or heavy lifting objects. Also hinges and moving parts are secured under surface to prevent accidents and add up to the safety factor. This design proposes a safe and space efficiency contraction option for easy transportation for the design of our expandable surface. One inconvenience of this designs is that when it expands it does not create an even surface. (Fig 2.3)

Figure 2-3 Inspiration for Tables in Table (HomeDim, 2016)

2.9.2 Horizontal Expansion Table Storage box

Space efficiency expandable alternative surface design that expands horizontally, breaking it in half to expand one side to the left and the other one to the right, opening in the middle for access to storage. Hinges and expanding parts are covered by bottom of surface to prevent accidents with moving parts. This model does not increase the surface area of interactions. It expands to open storage space.

Figure 2-4 Inspiration for Tables in Table (1stdibs, Inc. 2015)

2.9.3 Vertical Expandable Sharing Canal Table

Space efficiency expandable alternative surface design that expands vertically leaving an opening, similar to a canal in the middle. This canal is used also as storage space and as place to share parts between users. Hinges and expanding parts are under surface to prevent accidents from happening. This model does not increase the table's surface area. While similar to the horizontal expansion design in the previous section, the purpose if the gap is different. The main purpose of this gap (canal) is the interaction and sharing of parts between users. The main disadvantage of this new convenience is a reduction in storage space.

2.10 Wheel Design

Good wheels are essential to the mobility and convenience of the final design. Several options exist. The provided cart comes with wheels. Even if the team declines the use of the entire cart, it will still be allowed to use the wheels. These four wheels are all free moving in order to provide easy mobility. Another option is to create them using plastic in a similar manner to that explained in Section 2.10.1.

2.10.1 Upcycled Plastic Wheels

The team has the option of melting plastic and pouring it into molds to create useful parts for the cart. This will save money as well as demonstrate to Zane Middle School Students the benefits of recycling. This option will also recycle plastics otherwise destined for landfills. There are also several downsides. The surface of the wheels will not be smooth and that can cause complication in the portability of our design (Fig 2.5). There is also the possibility they will not be strong enough to stand against all the stress placed on it throughout its lifecycle. There are concerns it will not last to a five year goal.

Figure 2-5 Upcycled Wheel

Table 2-2 Criteria list and weight

Criteria List /Weight	
Cost	8
Size	8
Storage Volume	5
Safety	10
Weight	7
Aesthetics	3
Mobility	9
Sustainability	6
Durability	9
Total	65

3 Section: Alternative Solutions

3.1 Introduction:

In this Section were covering our research and potential alternatives for our project. The team separated responsibilities based on components. Each alternative solution contains advantages and disadvantages that correspond to the design criteria outlined in section 2.

3.2 Brainstorming Sessions

The team held two brainstorming sessions, the first being unstructured and the second structured. The first session allowed for unbiased production of creative ideas which were then examined and debated over in the second. The team made use of white boards, sketching paper, and visual aids during the sessions.

3.3 Alternative Solutions

3.3.1 The Comfortable Conformable

The team has the option of using a cart provided by the school which would provide a solid base to build off of. The fact that it is free and also familiar to students are powerful incentives. The cart contains two shelves and flat top, making it easy to build off of and modify. Shelving can be constructed from a variety of materials and designs with the only constraints being the size of the cart itself. These constraints are the cart's largest downside, and any design decisions need to conform to the cart's dimensions.

3.3.2 Amalgamation Plasticization

Building off using recycled plastic and molds for a Lego tabletop, this can be taken one step further by constructing the entire cart and shelving units. This offers two benefits of being made of 100 percent recycled material and allowing for completely customizable dimensions. Structure and support can be added using other recycled materials like pallet wood and salvaged metal. Recycled material would be melted over low heat in an oil bath. The melted plastic can then be poured into molds in a variety of shapes. These blocks can be utilized in a manner similar to wood and would create a safe, durable cart.

Shelving units and containers can be made the same way. The main drawback to using plastic would be the team's unfamiliarity in using the medium. This restricts the team to simple shapes and would also be time consuming in melting, shaping, and testing plastic designs. Shelves and containers produced would likely be rudimentary in construction and lack complex parts. This however could also been seen as an advantage in terms of simplicity of design and ease of use.

3.3.3 Legos on the Oregon Trail

This design features a large, heavy duty wagon as the mode of transportation. The wagon bed and walls would be covered in a safe, durable material that would prevent leakage. Legos would be place in the bed and ideally covered with a Lego studded covering which would allow children to use it as a play area. One option to help facilitate play would be to have slots for children to reach in and grab what they need. The top would also be able to open for quick and easy clean up. The most prohibitive disadvantage of this option would be cost and weight. It must be light enough that one child would be able to pull it without much difficulty.

Figure 3-1Potential Janitorial

3.3.4 The Janitorial

This design alternative takes the familiar housekeeper cart and transforms it into a Lego transporting device. The cart is a relatively simple design, consisting of a flat surface on wheels with a shelf in the middle. Bags can be attached to the top of the shelf and create a large amount of storage. Ideally the bags will be modified so that they can be opened from the bottom and allow Legos to be fed into a waiting container, which children can then use to play. When the activity is over the Legos can be easily cleaned up and dumped back into the bag for easy transport. The main disadvantages to this design is that the Legos are not organized and the top layer lacks the space for a large play area. Acquisition of materials may also be problematic or consist of a hybrid solution with other alternatives.

Figure 3-2 Potential Janitorial Base

3.3.5 Legos of the Hexagonal Table

The criteria we are looking for in our tables shape and use is to allow multiple students to play at the same time. We set a design minimum at 6 students. If it's possible we would consider even more. We estimate each child would need at least 15" of workspace and have some sort of device that allows them to work quietly. Currently, children play on library tables with suppressing mates. Most likely some sort of rubber mate. One criteria is to incorporate that into the design and allow them to continue to work quietly at the library. To top it off we need to implement mobility to our design. It's the last but most important criteria when picking a design or shape. In this section we will be mainly focusing on what shape allows a well-balanced work space with lego accessibility.

3.3.6 Legos Poolside

From the beginning only a rectangle seemed to be the best possible table shape. It's the only one that allows for our station to be transported through a door. An average door is 36" wide and 80" tall. This small parameter allows only for skinny shapes to be used; cutting off all options. However a hexagon is our second best option. As seen from figure one, the hexagon provides exactly 6 stations, with enough room for children to play. As a visual representation, the gray circle in the middle represents the potential Lego storage area. It's designed to be a spread out section just for Legos to allow clear visibility and easy access.

A good example of a workable, realistic rectangle shaped Lego Work Station is figure 2. This example was found on the "Instructables" website where hundreds of creative builders share Ideas for free. This table's slick design provides a smooth and durable surface for "toddlers to stand, older children to stand and adults to knee." It stands at 18 inches, a realistic height for our projects plan. Its area is 70" by 30", and has 4, 10" by 15" Lego base mats. This design actually turns out to be exactly what we need. However, it only provides 4 work stations; we are actually looking for 6. It does however fit through the door. At a width of 30", it has 6" of space to squeeze by a door and be moved to a different room.

The best part of this type of shape and design is the enormous square space the table has in the middle. As seen in the figure, it provides a flat, convenient place to sort out legos and continue with their creativity. It's part of the advantages of a rectangle.

Also this figure is a stationary table, not meeting our other criteria. However it does serve as a good reference on what we could do with basic tools and plywood. If we somehow averaged a perfect height for children to play comfortably, we could possibly follow this type of design and just add mobile wheels.

4 Decision making process

4.1 Introduction

Section 4 describes the decision making process used to find the final design solution. The process utilizes a Delphi Matrix that includes weighted criteria comparing all the alternative solutions. The design that best incorporates the criteria on all levels receives a heavy bias in the selection process.

4.2 Criteria definition

The following is a list the team and client have defined as criteria. In the following section each will be assigned a weight and used to compare alternative solutions.

- **Cost**: The project budget cannot exceed $300
- **Size:** The project should be compact and able to be stored out of the way or beneath a table when not in use.
- **Storage Volume:** The solution must provide vast, additional space for storing of Legos. There should no longer be need to store Legos in the plastic bin currently in use.
- **Safety:** The project must be user friendly and safe to be used by children.
- **Weight:** The solution must remain relatively lightweight and easy to transport.
- **Aesthetics:** The device should have an efficient design and possess compartments that allow for easier organization.
- **Mobility:** The project should have the ability to stay Stationary. Children should be able to move it around with little difficulty.
- **Sustainability:** The design should utilize as many recycled materials as possible.

- **Durability:** The design should be able to withstand vigorous daily use by children. Moving parts must be heavily reinforced and capable of standing heavy abuse.

4.3 Solutions

The solutions the group is considering are: (see section 3.3 for more specific information on each.)

- **The Comfortable Conformable**
- **The Janitorial**
- **Legos on the Oregon Trail**

4.4 Decision Process and Delphi Matrix

The most viable solution was found through a combination of team brainstorming and debate, consulting with the client, and the use of a Delphi matrix. A Delphi Matrix assigns a weight to each criteria from one to ten and gives a score of one to fifty based on how well each alternative solution meets that criteria. The scores are multiplied by their weights and summed. The one with the highest score represents the optimal solution.

Table 4-1Delphi Matrix

CRITERIA		Solutions				
List	(1-10)	Tables Inside Table	Vertical Expansion Cart	The Janitorial	Legos on the Oregon Trai	The Comfortable Conformable
Cost	8	40 / 320	40 / 320	30 / 240	30 / 240	50 / 400
Size	8	35 / 280	35 / 280	30 / 240	50 / 400	20 / 160
Storage Volume	5	40 / 200	30 / 150	40 / 200	50 / 250	40 / 200
Safety	10	40 / 400	25 / 250	20 / 200	50 / 500	40 / 400
Weight	7	10 / 70	15 / 105	45 / 315	50 / 350	30 / 210
Aestetics	3	30 / 90	25 / 75	40 / 120	30 / 90	25 / 75
Mobility	9	40 / 360	40 / 360	50 / 450	40 / 360	40 / 360
Sustanability	6	30 / 180	30 / 180	40 / 240	50 / 300	25 / 150
Durablility	9	50 / 450	40 / 360	30 / 270	30 / 270	50 / 450
Total		2350	2080	2275	2760	2405

4.5 Final Decision

The Delphi Matrix has Legos on the Oregon Trail rated the highest. This solution is also highly rated by the client. The team has reached consensus and agrees Legos on the Oregon Trail will be the chosen design.

5 Section

5.1 Introduction:

This section provides all the information on the results of the “Oregon Trial” and how well it kept to our criteria. Overall the most important task of providing a mobile play station was accomplished and our project kept to its criteria.

5.2 Description of Solution

Our planning and time resulted in a sturdy, strong table that accomplished our targeted task. The base was accompanied with four steel cylinder supports that raise the top portion of the table by five inches to provide additional storage space. The top portion of the table is constructed with a road sign that slides and opens into a hollow, aluminum rectangle that provided most of the storage needed for large amounts of legos. It also has a light, aluminum metal sheet that slides out with grooved drawer runners that were modified to allow the sliced sheet to expand outwards to provide maximum surface area.

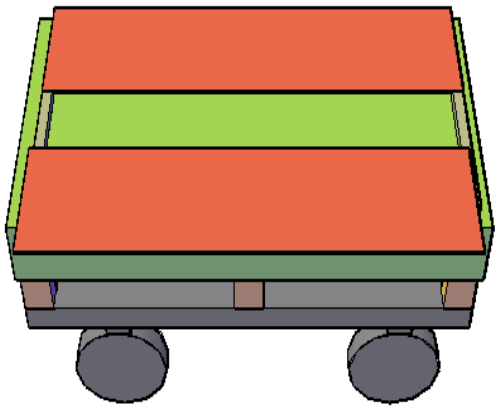


Figure 5-1 AutoCad Design for Legos on the Oregon Trail Top 3-D view

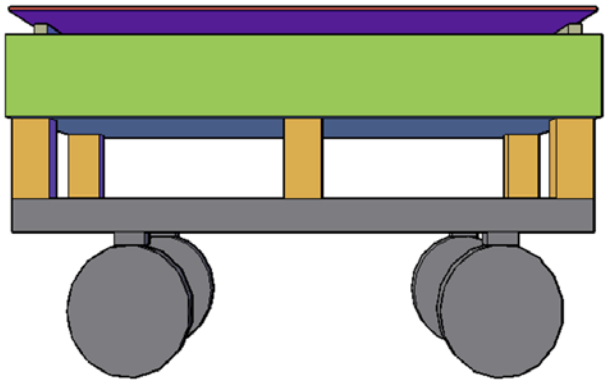


Figure 5-2 AutoCad Design for Legos on the Oregon Trail front 3-D view

5.2.1 Wagon Base

The legos on the Oregon Trail Design provides a wagon base for transportation from classroom to classroom around Zane Middle School. And the handle of the wagon provide a comfortable range of motion for easy transportation.

Figure 5-3 Wagon

5.2.2 Supports

The majority of issues occurred during the building phase of the project. The most challenging aspect was finding the solution to putting the different pieces of the wagon together. Connecting the steel base to the aluminum container proved surprisingly complex, with the team failing several times to find adequate welding and connecting material. The solution was to abandon the welding altogether and create supports using steel pipes with steel squares to as heavy duty washers all threaded through with a steel rod that is bolted securely to both the base and aluminum container. While there was initially some fear of the pipe

slipping off the base if the cart was jostled too hard, this was solved by shortening the height of the supports and utilizing a thicker threaded steel rod.

Figure 5-4 Steel Supports

5.2.3 Construction Zone

The table top is composed of an expandable table top made of a scrap construction sign.

The drawer section proceeded smoothly with two pairs of sliders installed on each side. It was later decided to add an additional pair to the center to give improved support.

Figure 5-5 Construction Zone

5.2.4 Storage

The “Lego on the Oregon Trail” design provides and expandable table top that opens into a storage area so that legos can be transported and contained in the cart at the same time.

Figure 5-6 Aluminum Storage

5.2.5 Padding and Safety

Child Safety proved to require a great deal of planning as well. Most of the team’s materials were salvaged from the scrapyard and contained sharp edges and large amounts of rust. The rust was dealt with via vigorous scrubbing and painting it with rust resistant spray-paint to cover and mitigate further corrosion. Sharp edges were filed down until no longer deemed a danger. Plastic padding was added over the table top’s sides.

Figure 5-7 Padding and Safety materials for cart

5.2.6 Sustainability

Most of our design is made from scrap materials from the local scrap yard.

5.2.7 Aesthetics

A hole in the aluminum container was patched with a small sheet of aluminum siding. The team then had “ZANE” etched onto the material to improve aesthetics.

Figure 5-8 Zane Patch

5.2.8 Final Product

The Objective of this criteria provided for this project was meet with the final design of the “Legos on the Oregon Trail”.

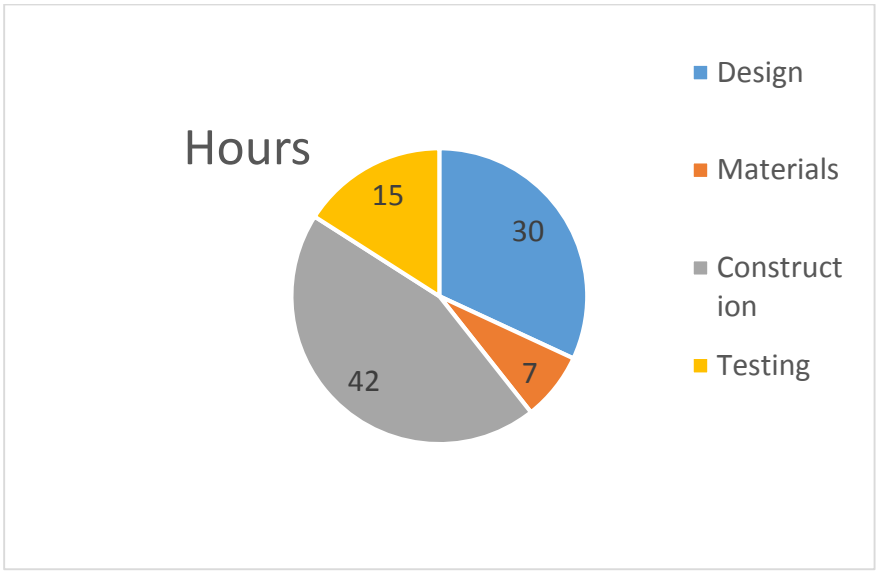
Figure 5-9 Final Product: Legos on the Oregon Trail

5.3 Cost of project

The total cost in time and currency was around our targeted criteria. Our total budget spent (that is provided on the chart below) was way below our criteria of 300$. The budget criteria was meet.

5.3.1 Design Cost (hours)

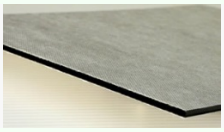
Table 5-1 Design Cost in Hours



5.3.2 Implementation Cost

Table 5-2 Materials Cost Table

Image	Description	Price per Item	Quantity	Place Purchased	Total Cost
	Wagon	25.00	1	Arcata Scrap Yard	25.00
	Table Top	10.00	1	Arcata Scrap Yard	10.00
	Street Sign	9.00	1	Arcata Scrap Yard	9.00
	Rail Slider	12.80	3 pairs	Almquist lumber	38.4
	Screws	Free	20x	Marty's Shop	Free
	Nuts	Free	20x	Marty's Shop	Free
	Steel bar	5.00	4	Arcata Scrap Yard	5.00

	Steel Plate	2.50	1	Arcata Scrap Yard	2.50
	Rubber Protection Strip	14.99	2	Walmart	29.98
	Plastic padding	10.99	3	Walmart	32.97
	Sandpaper	1.99	4	Ace's Hardware	7.96
	5.99	Rust Spray paint	2	Ace's Hardware	11.98
Total Cost : $ 134.39					

5.3.3 Maintenance Cost

Occasional lubrication of wheels is part of the maintenance cost. No other maintence cost applies.

5.4 Instructions for Implementation and Use of Model

The use of the “Oregon Trail” is easy and straightforward. For transportation, we have provided a rotating suspension system on the base to allow of 45 degree angle turns radius for easy maneuvering. Our design also implemented a rope for easy pull acceleration and convenience when storing in tight places. The top portion of the table pulls out horizontally as respect to the width to provide a greater play area.

5.5 Results

The majority of issues occurred during the building phase of the project. The most challenging aspect was finding the solution to putting the different pieces of the wagon together. Connecting the steel base to the aluminum container proved surprisingly complex, with the team failing several times to find adequate welding and connecting material. The solution was to abandon the welding altogether and create supports using steel pipes with solid cast iron disks to act as heavy duty washers all threaded through with a steel rod that is bolted securely to both the base and aluminum container.

Child Safety proved to require a great deal of planning as well. Most of the team’s materials were salvaged from the scrapyard and contained sharp edges and large amounts of rust. The rust was dealt with via vigorous scrubbing and painting it with rust resistant spray-paint to cover and mitigate further corrosion. Sharp edges were filed down until no longer deemed a danger.

A hole in the aluminum container was patched with a small sheet of aluminum siding. The team then had “ZANE” etched onto the material to improve aesthetics.

5.5.1 Testing of the upcycled Molds

Before the full production of upcycled Legos began, a test was conducted to see if the silicon mold would mold the recycled HDPE melted plastic. The whole process happened as it should have. The test was conducted in a well ventilated area with an oven that was at a steady temperature of 350 F; a temperature that was researched to be the ideal melting point. After the 15 minutes specified by the literature review, the plastic didn’t seem to melt and become a liquid. The temperature was increased to 400 F and the time was expanded. At this point it was best to just stop the test and conclude that making our own molds was not possible. After a clear analysis, we concluded that without a specially designed tool and the right equipment, it’s not possible to replicate what an industrial company does. Additionally, making a specialized tool would be a project of its own driving up our costs.

Unfortunately after this test the team concluded that the addition of a Lego gridded table top was not possible.

5.5.2 Stability of the Sliding Rails

The sliding rails will have enough support since three rails where implemented on each wing to provide enough support. However, it is possible that the rails could be released under stress. When this happens just slide the rail back in and it would come back to function.

6 Appendices

6.1Works Cited

Brockman, J. (2004). *Curious minds: how a child becomes a scientist*. Pantheon Books, New York.

Colgar.cathercist.com,. “Modern Expandable Kitchen Table”, *Wonderful Kitchen Ideas.* N.p., 2016. Web. 07 Mar. 2016.

Dershewitz, R. A., and Williamson, J. W. (1977). “Prevention of childhood household injuries: a controlled clinical trial.” *Am J Public Health American Journal of Public Health,* 67(12), 1148–1153.

“Guest Post: 10 Tips for Buying a Child Proof Sofa - The Seasoned Mom.” (2014).*The Seasoned Mom*, <http://www.theseasonedmom.com/guest-post-10-tips-buying-child-proof-sofa/> (Feb. 20, 2016).

HomeDim ,." Make the Most of Your tables – Expandable Designs.". N.p., 2016. Web. 07 Mar. 2016.

"Plastic Smithing: How To Make Your Own HDPE Plastic Anything (DIY Plastic Lumber)". *Instructables.com*. N.p., 2016. Web. 10 Mar. 2016.

"The Very Important Guide Of Plastic Safety." *Cut Out Keep*. Web. 03 Mar. 2016.