Spring 2016

The Roto-Robo-SuGo Super Table

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ENGINEERING 215: INTRODUCTION TO DESIGN

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1 Problem Formulation

1.1 Introduction

Section one will provide information on Team GERL's Spring 2016 ENGR 215 course project for our client, Zane Middle School. Our contact at Zane is Steve Wartburg, a Science and Engineering teacher.

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1.2 Objective Statement

The objective of this project is to make an innovative table that allows Lego EV3 robots to have sumo battles and not fall off the side, while maintaining the regulatory specifications for sumo competitions. The table must be portable in order for the student to be able to transport the table to various competitions and around the classroom. It must also meet any other criteria construed by the design team or the client.

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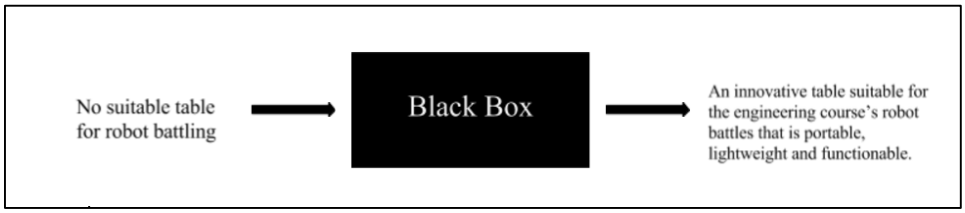

Figure 1-1: The black box model consists of a simplified version of our problem and solution

2 Literature Review

2.1 Introduction

The problem analysis provides information on the project specifications, considerations, criteria, usage, and production volume.

2.2 Specifications

The table needs to be a 4 feet by 8 feet rectangle with a 3 foot diameter circle located in the middle. The table must be either black or white, and the color of the circle must be highly contrasting compared to the color of the table. Portability is also desired and can be accomplished through the use of lightweight materials.

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2.3 Considerations

Some of the materials for the design will need to be ordered in advance. The frame of the table will likely be the most time consuming and difficult portion to construct as it must be sturdy and likely custom made.

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2.4 Criteria

Table 2-1 below is a list of our criteria and constraints put together by Team GERL and approved by our point person, Steve Wartburg.

Table 2-1: Criteria and Constraints for design project

Criteria	Constraints
Safety	Must be safe for middle school students to use
Durability	Withstand use for several years
Portability	Must be able to move through Zane Middle School's engineering lab
Cost	Limited to $300
Aesthetics	Look pleasing to the eye

Commented [6]: Adjusted Table Centering

2.5 Usage

The table will be used by Zane Middle School's Robotics students and staff.

2.6 Production Volume

Only one table will be produced for our client.

2.7 EV3

2.7.1 Lego Overview

LEGO is a toy company who makes an assortment of products that center around creativity. They manufacture everything from small plastic blocks to simple electrical computers. The LEGO products are able to connect in many different ways allowing for nearly endless possibilities. Their original product was focused on blocks of various sizes. Today, LEGO has much more complex products such as the Mindstorm EV3 that involve programming and ultrasonic sensors (Lidz 2013).

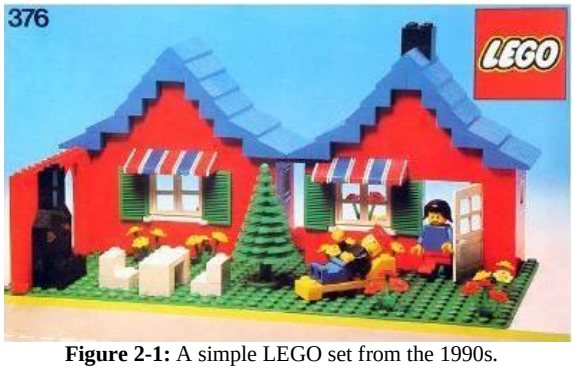

Figure 2-1: A simple LEGO set from the 1990s.

2.7.2 Lego Mindset

The LEGO Mindstorm EV3 line of products is the third installment if their "Mindstorm" line. The EV3 products are able to be programmed and built to do a variety of tasks and actions. The EV3 programmable block requires the following software.

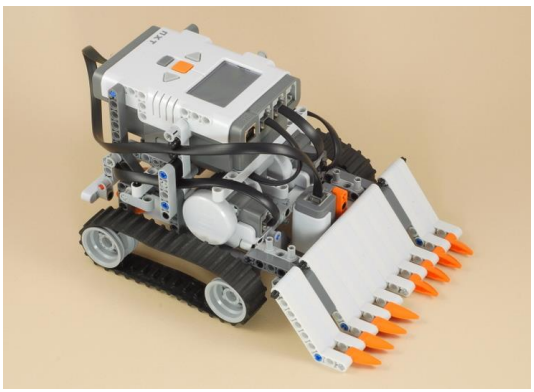

Figure 2-2: An EV3 robot with a programmable block

2.7.3 System Requirements PC (Microsoft Windows)

- Windows XP (32-bit only) and Vista (32/64-bit) excluding Starter Edition – with the latest Service Packs. Windows 7 (32/64-bit) and Windows 8 desktop mode including Starter Edition – with the latest Service Packs
- Dual-core processor 2.0 GHz or better
- 2 GB of RAM or more
- 2 GB of available hard-disk space
- XGA display (1024 x 768)

- 1 available USB port
- *Only for installation and use of the EV3 Programming Software

2.7.4 System Requirements Apple Macintosh (OS X)

- Mac OS 10.6, 10.7 and 10.8 with the latest Service Packs
- Dual-core processor 2.0 GHz or better
- 2 GB of RAM or more
- 2 GB of available hard-disk space
- XGA display (1024 x 768)
- 1 available USB port
- *Only for installation and use of the EV3 Programming Software

2.8 EV3 Battle Regulations (Robots)

2.8.1 Common Class Rules

- The Robot must be made ENTIRELY out of LEGO parts, with the only exceptions being the "Sumo Eyes" and shorter "NXT cables". A maximum of 1 NXT for control and 3 motors for movement/actuation can be used.
- The robot must fit inside a 7" x 7" square box (no height limit) when it is in it's starting configuration.
- The robot must be designed to wait five seconds, after the contestant presses a start button, before it moves.
- All actions must be totally pre-programmed. The use of any form of remote control is prohibited.
- The robot will not include a device that obstructs the control of the opponent’s operation, such as a jamming device or strobe light.
- The robot will not include any parts that might damage or deface the playing field.
- The robot will not include any part that fixes the robot to the playing field surface. The robot must always move.
- In addition, each SuGO Class adds one or more extra rules, as follows:

2.8.2 Limited Parts Sub-Class

The robot may only be constructed from a specific subset of LEGO parts. This subset is defined by the event organizer prior to the competition. An example might be: "Only those LEGO items found in a retail LEGO MINDSTORMS NXT 2.0 kit" or perhaps "any component located on the Parts Table".

2.8.3 Standard Weight Sub-Class

The robot must weigh no more than 1 lb. 10 oz. when in its starting configuration.

2.9 EV3 Battle Regulations (The Game Itself)

2.9.1 SuGO

The overall SuGO contest is structured using a double elimination tournament format, where each robot must lose two matches to be eliminated from the tournament. A SuGO match involves two contestants whose robots operate in the sumo ring according to the game rules presented here. The match continues until four SuGO points are scored by one of the contestants over several games.

2.9.2 Playing Field Specifications

The playing field is a raised circle with the dimensions as shown below.

- 36” Diameter (not including border)
- 1.25” Border
- 0.5”x 4” Red Starting Line Centered
- Surface is Smooth and Flat
- Surface is Glossy White
- Fields may use sheet materials, stickers or be complete fields with supports.

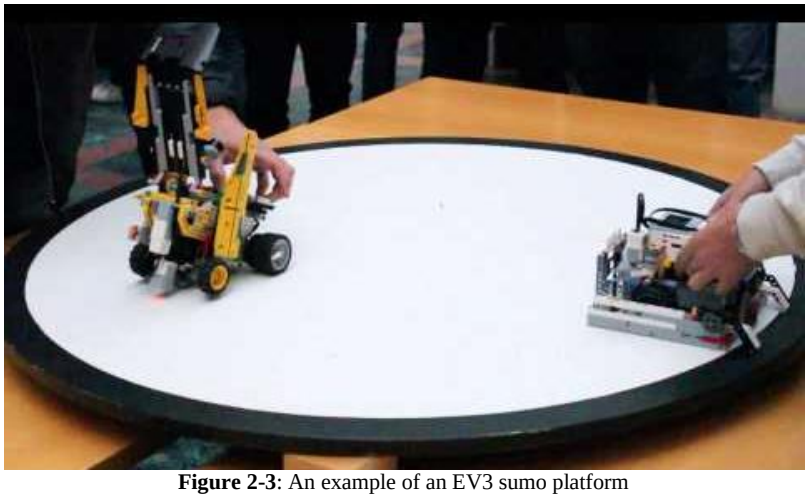

Figure 2-3: An example of an EV3 sumo platform

2.9.3 Game Principles

A standard match consists of three games of up to three minutes each. The first contestant to win four SuGO points is the winner of the match. If no player has 4 SuGO points at the end of three games, the player with the most points wins. If both players have the same number of points after three games the referee can call a winner, or choose to run one additional game.

2.9.4 Game Procedure

1. Before the game, the contestants greet each other outside the playing field following the chief referee's instructions, and then enter the playing field.
2. The contestants can place their robot anywhere behind their starting line. No part of the robot can be in front of the starting line before the match begins.
3. At the referee's signal, the contestant presses a single button on the NXT (usually the orange button). The game begins five seconds after the referee's signal. The contestants must exit the playing field during this 5 second period.
4. Prior to the start of a match, the entire robot must fit inside a square box as defined for the weight class. At any time after the start of the match, the robot can expand outside these dimensions.
5. The game ends when the referee calls the winner. Both contestants should thank each other for a fair and competitive match after removing their robots.

A Game will be stopped and a rematch will be started under the following conditions:

1. The robots are locked together in such a way that no more action appears to be possible, i.e. they have rotated in circles for 30 seconds or more.
2. Both robots touch the exterior of the playing field at the same time.
3. Any other conditions under which the referee judges that no winner can be decided.

In case of a rematch, maintenance of competing robots is prohibited, and the robots must be immediately placed in the designated starting position. If neither of the competing robots win, or lose, after a rematch, the referee may reposition both robots to a specified location and restart. If that does not yield a winner, the match may continue at any location decided by the referee, until the time limit is reached.

2.9.5 Scoring SuGO Points

Two SuGO points are awarded for a Victory. The following conditions define a Victory: When a robot ejects its opponent from the playing field with a fair action. The robot is considered ejected the moment ANY part of the robot touches the exterior of the playing field. A robot hanging over the edge of the playing field or only touching any part of the cylindrical side of the playing field is not considered ejected, and the robot is still in play. When the opponent's robot goes out of the playing field on its own for any reason. When the opponent's robot stops moving on the playing field for more than 10 seconds. If the opponent's operator interferes with either robot, or the field, during the match. One SuGO point is awarded for an Advantage. The following conditions define an Advantage: An opponent's operator fails to start their robot at the referee's command (false start), the opponent's preparation for the start of the next match takes more than 30 seconds. Parts of the opponent's robot (weighing more than 1 ounce), are separated and dropped from the robot. Any other actions occur that are be deemed unfair by the judge.

2.9.6 Violations

A contestant who takes any of the following actions will be disqualified from the game:

- A contestant does not attend the appointed playing field when called at the beginning of the game.
- A contestant ruins the game, such as by intentionally breaking, damaging, or defacing the playing field.
- A contestant's robot does not meet the robot specifications.
- A contestant displays unsportsmanlike behavior.
- A contestant intentionally injures the opponent's operator.
  (Taylor 2016)

2.10 Arena Materials

2.10.1 Lightweight Arena Top

The internal structure could be hollow with a honeycomb-like interior, possibly made out of restructured cardboard. Hollow plastic would be a suitable alternative to cardboard. Another alternative could be vinyl foam composite with laminate finish. A laminate is a permanently assembled object by heat, pressure, welding, or adhesives. They are commonly used as countertops or floorboards. Lamination is the process of making a material in many layers. Doing this will give the material more strength, stability, and appearance. Based on the table shape, the lamination process will vary (circular/rectangular shape).

2.10.2 Folding Legs

Internal structure could be hollow with a honeycomb-like interior, possibly made out of restructured cardboard. Hollow plastic could be an alternative to the cardboard. Another alternative could be vinyl foam composite with laminate. A laminate is a permanently assembled object by heat, pressure, welding, or adhesives. They are commonly used as countertops or floorboards. Lamination is the process of making a material in many layers. Doing this will give the material more strength, stability, and appearance. Based on the table shape, the lamination process will vary (circular/rectangular shape).Folding Legs
Support lightweight arena top. Hollow construction. Aluminum. Wood with braces. Synthetic composite. Strength depends upon mass of top

2.10.3 Second Tier "Fall Zone"

- Netted
- Tiered system
- Less fall distance is desirable

2.10.4 Hinges

A hinge is a movable joint that connects to objects and is mainly used for doors and cabinets. There are different types of hinges, but our design is most compatible with a butt hinge or a barrel hinge. The knuckles of the hinge hold a pin, keeping together the two flaps of metal. This

gives the mechanism the ability to move back and forth. The flap has correct size holes for nails to be drilled into the table. It must be able to support stress of the table top and transportation. Rigid construction metallic in nature.

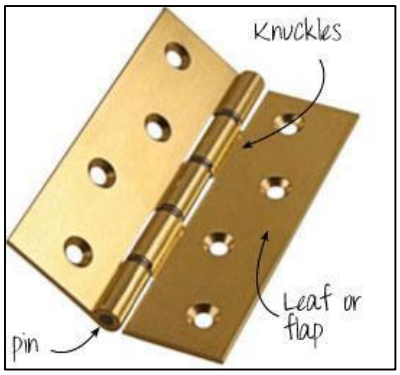

Figure 2-4: Hinge Composition

2.10.5 Casters with Brakes

A caster is a set of small wheels that are able to move in any direction. They can be fixed to a piece of furniture, making it able to move easily. Casters are commonly used for chairs for the purpose of them to easily move across the floor. Casters have bolt hole spacing in order to be attached to the piece of furniture. Brakes are optional on casters. If used properly, they can provide stability by keeping the wheel from moving. Must support weight of all other construction. Casters have a weight limit, depending on the number of casters on the piece of furniture. Must be placed with mind to collapsibility. Our purpose for casters in is to make our design portable. Depending upon contest area (indoors/outdoors etc.) must handle different floor surfaces.

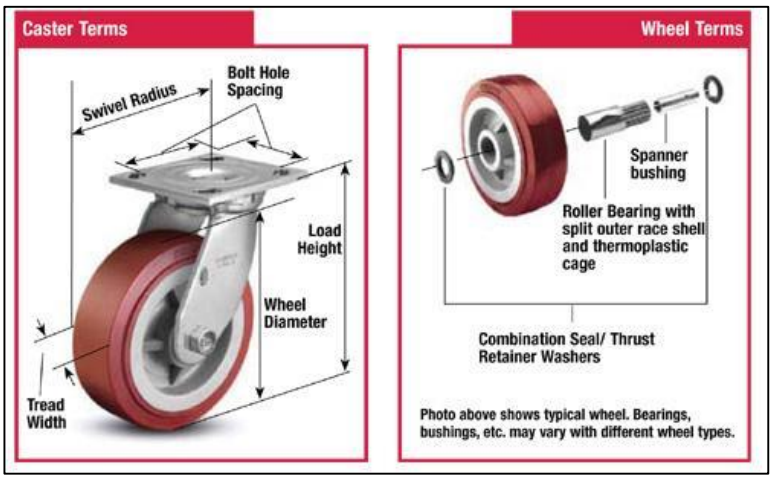

Figure 2-5: Caster and Wheel

2.10.6 Handles

- Comfortable to hold
- Strong enough to pull entire structure
- Must be placed with mind to collapsibility

2.10.7 Black and White Surface

Depending upon tiered construction and top material will vary

- Painted
- Finished
- Laminated
- Taped
- Separate Materials
- Possibly raised

2.11 Current Table Design

2.11.1 Current Design at Zane Middle School

Currently at the school the students are using 4 foot circular lifetime collapsible table. On the table there is a 3 foot diameter circle made out of black electrical tape.

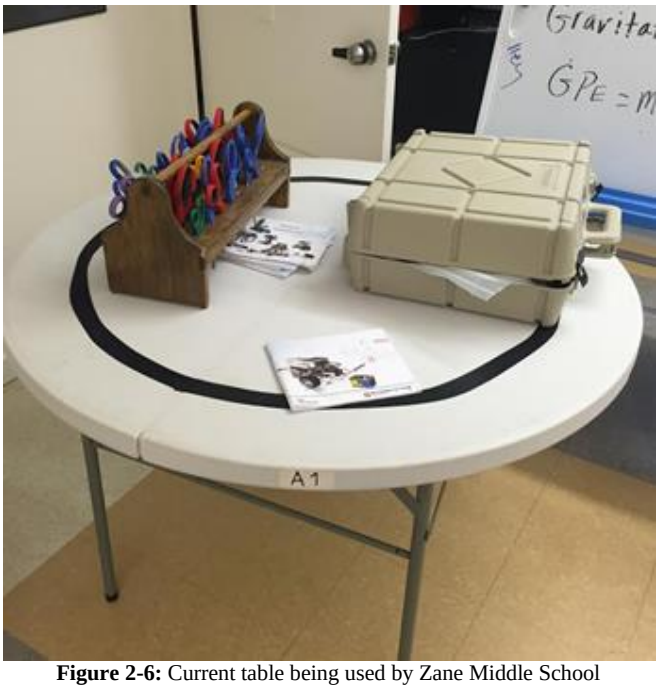

Figure 2-6: Current table being used by Zane Middle School

2.12 Existing Models of Fighting Arena

2.12.1 Practice Tables (Rectangle)

The main type of practice table is called a half table. The practice table is 93” by 45” with rim that is 3” tall plus or minus half an inch. There is a mat that must be laid down that is smaller than the size of the table. The practice table does not need to be raised off of the ground since it is only for practice and the actual competition

Non-Collapsible

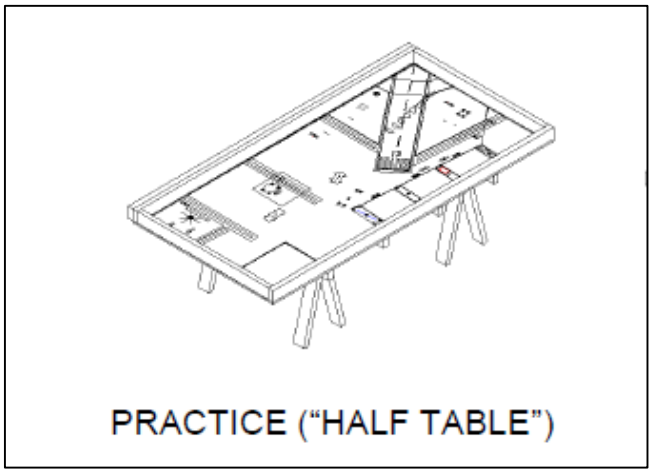

Figure 2-7: Image of Non- Collapsible practice table

Collapsible
This style is lightweight making it easier for the students and teacher to take the table where ever they need to go. The design is also able to fold down in order to go to the different competitions. This table requires there to be a second table underneath or to lay the table on the ground.

2.12.2 Competition Table (Rectangle)

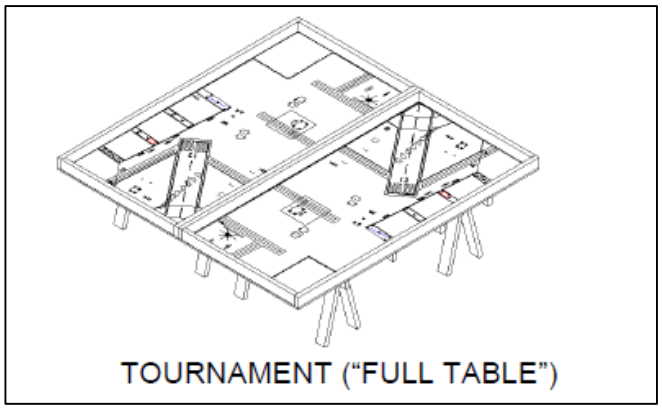

Figure 2-8: Image of Rectangular Competition table

- The competition table is 93” by 90” and has a height lip around the outside of anywhere from one inch to five inches
- There are different items that can be placed on the inside of the table, such as ramps or obstacles depending upon what competition is taking place.
- The competition table is always raised off of the ground like a table, usually on a saw horse, that is 24” from the ground.

2.12.3 Competition (Circular)

For the SuGo bots the table must have a 3 foot diameter for the fighting area
The board must be easy to move around out of convenience

2.13 Sensors

2.13.1 Touch Sensor

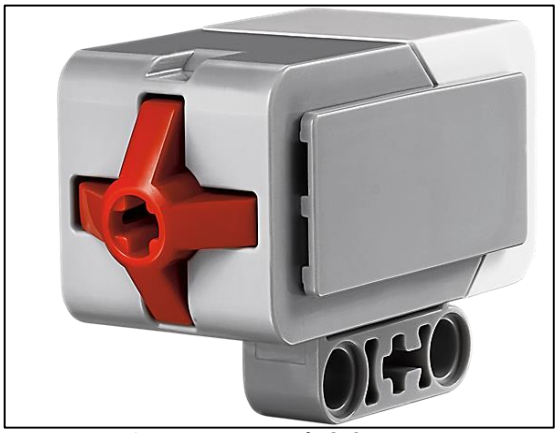

Figure 2-9: Image of a light Sensor

There are two touch sensors that are located on the EV3 educational models. The touch centers allow for the robot to know when it is touching a material. The touch sensors are mostly used during the competitions where the needs to feel something. For example when the robot needs to feel the other robot or when the EV3 needs to pick-up, push, or move something as required by a few of the competitions. Unless there is something that is actually touching the sensor it is really hard for the sensor to not sense what it is supposed to be sensing incorrectly. If that is the case the sensor just needs to be carefully cleaned by taking off the sensor, wiping it, then putting it back on to the EV3 robot.

2.13.2 Color Sensor

Figure 2-10: Image of a Color Sensor

In the education EV3 robot package there is a color sensor that looks for a contrast in color. The color sensor uses light that is reflected off of the competition arena in order to see the contrast in color. The sensor can get set off by other things that are not just what it is supposed to be. If there is any sort of marking on the inside circle of the table then there is the possibility of the light sensor sensing that if there is anything that is under the mat that causes a slight raise or bump. Deep scratches can also cause the sensor to be set off improperly

2.14 Client Constraints

- Portable
- Lightweight
- Has to be within the EV3 Competition Regulations
- Black and White
- Innovative

3 Alternative Solutions

3.1 Introduction

To determine the best alternative solution for the robotics competition table GERL had several brainstorming sessions. At these brainstorming sessions we included the client criteria to make sure that we would be able to provide the best possible table for Zane Middle School. Notes from these sessions can be found in Appendix A. GERL came up with eight designs. The following section show the ideas along with pictures and descriptions.

3.2 Brainstorm

Two brainstorming sessions were held in various locations at the HSU Library for the purpose of coming up with alternative solutions. During these sessions, team members would create ideas of solutions based on their surroundings and the rest of team would build on those ideas.

3.3 Alternative Solutions

3.3.1 The Roto-Robo-SuGo-Super Table

The Roto-Robo-SuGo-Super Table is a table that can be used for both the robotic competition for sumo wrestling as well as a whiteboard so the students can draw out other track and paths for the robot to follow for other styles of competition. The table will be able to fold in half for easy storage purposes. It also has wheels so that the table can move around the classroom. Also, when the table is not in use as a competition table, the whiteboard side will be available to write on to serve as more space for the teachers to be able to write on. One of the integral features of this design is that it rotates allowing for easy portability (similar to a whiteboard you can flip it from a horizontal-table-setting to a vertical-portable-writing surface). We would also use some form of arms in order to lock the table into either a horizontal or vertical position.

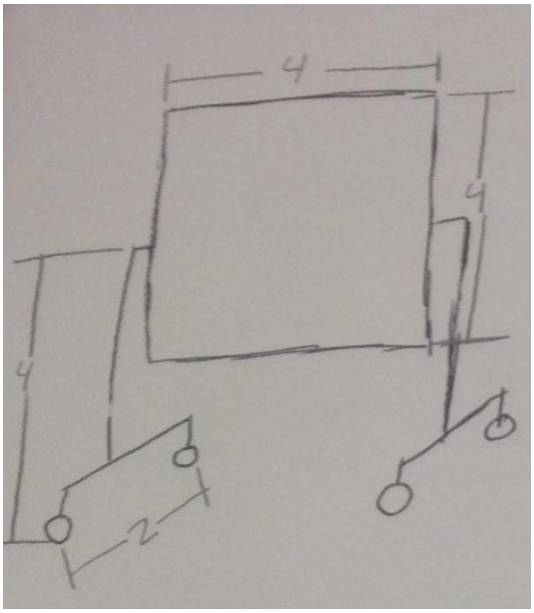

Figure 3-1: The Roto-Robo-SuGo-Super Table

3.3.2 The Wedding Cake

The wedding cake is a tiered table design created with the intent of providing both a sumo table and table for an obstacle course or task accomplishment area at the same time. It would have a 3’ diameter circle raised approximately 8” off the 4’ by 8’ rectangular table beneath it. It would be offset to one side so that others might use the remainder of the rectangle while sumo competitions are in progress. This table would have legs which would fold beneath a lip underneath (think large single sheet plastic legs that lock into the tabletop), before folding in half along the line shown in the diagram so that the tiered circle faces outward. The table would need casters on each side so that when folded the downward facing edge would be able to roll. We would also add a handle to one side in order to transport it and depending upon the materials this table could be very durable or very portable.3.3.2 The Wedding Cake

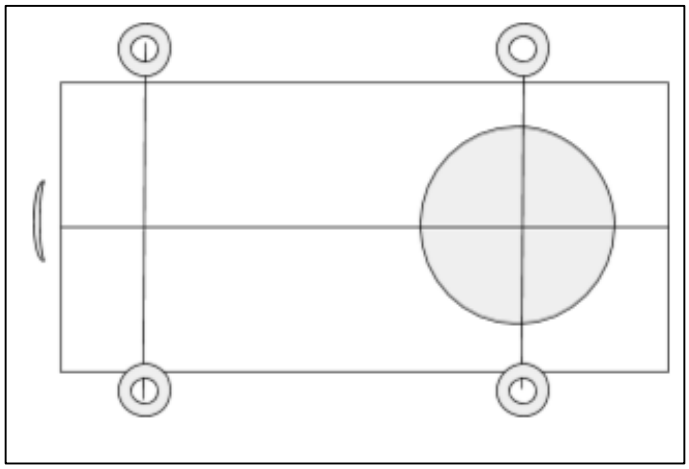

Figure 3-2: Wedding Cake

3.3.3 The Wonder Table

The Wonder Table is a folding table solution that tries to minimize the width of the table without sacrificing height. The Table folds 90 degrees at 6 places with the segments varying in length. This design also includes shock-like arms that would provide for easy transitions from folded to flat and vice-versa. These arms will be attached to the frame and to the bottom of the table. This table will also have lockable casters for easier transportation. The frame of the table would be constructed out of parts from spare TV rollers at Zane. The tabletop material could vary depending on what materials are available.

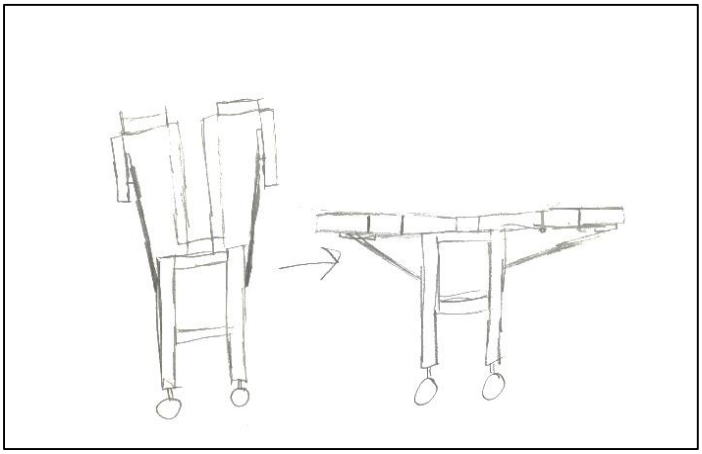

Figure 3-3: The Wonder Table

3.3.4 The Donut Hole

The Donut Hole is a table with a removable section. The tabletop surrounding the sumo arena could be removed revealing netting. The netting would extend somewhere around 6 inches from the edge of the sumo arena and encircle the arena completely. If the entire tabletop is needed, you simply set the removable section onto the platform. The tabletop could be modified to condense if necessary. The netting could be cloth if appropriate netting material cannot be acquired. This frame could also be constructed out of the TV rollers.

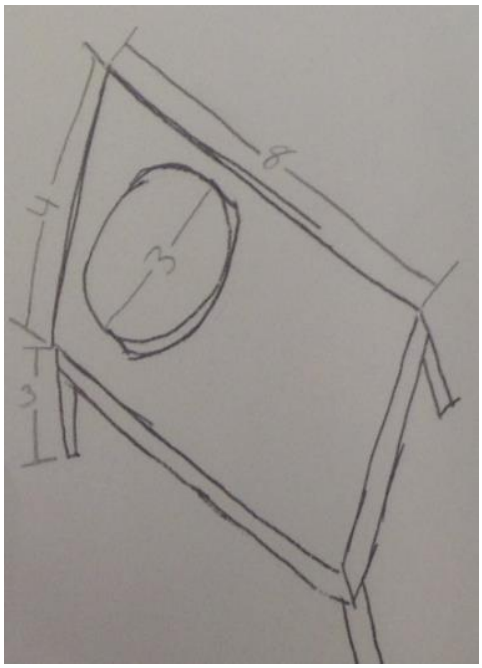

Figure 3-4: The Donut Hole

3.3.5 Compost in the Making

Compost in the Making is a table design that is mainly made out of upcycled materials. The top of the table will be made out of a thin layer of wood, while the inside of the table will have hexagon spacers made out of tightly compacted cardboard, providing a lightweight element to this design. The underside of the table will have a material window so that the users can see the inside process it took to make the design.

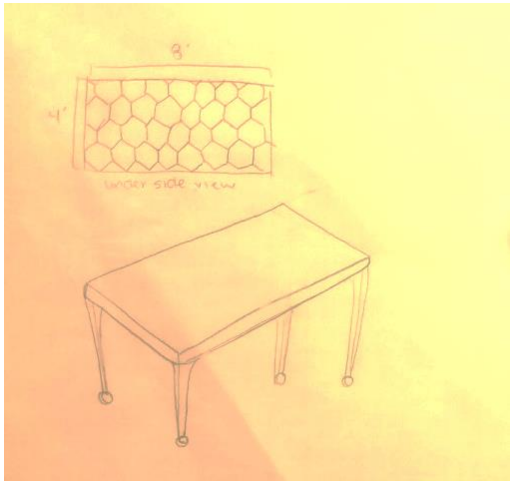

Figure 3-5: Compost in the Making

3.3.6 Laminate Drum

The laminate drum is a table customized for portability. It integrates pvc piping and chicken wire along with stretched cloth or a laminated material to produce a tabletop reasonably solid while being incredibly lightweight and easy to repair. Essentially you are stretching your tabletop over your table frame, in drum-like fashion allowing your entire frame to be hollow with the top essentially cloth/wire for maximum portability. We would likely include wheels with this design and depending upon its final weight probably handles.

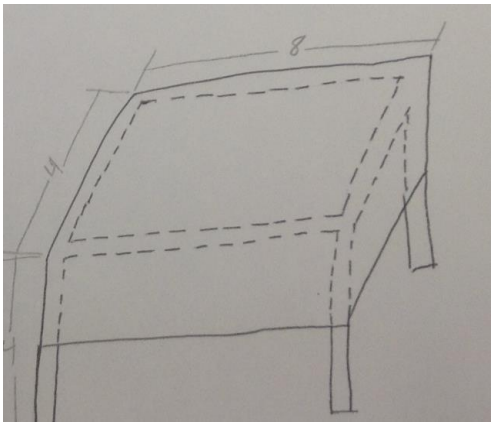

Figure 3-6: Laminate Drum

3.3.7 TableCeption

This table is named in honor of the movie *Inception* which was a movie themed around placing an idea into someone's mind and has since come to mean anything within another thing of similar definition. In this case we place a circular table inset within a rectangular table. This lets Zane have its preferred design of a circular table within a rectangular table and is very similar to the wedding tier design except there is no raised platform, it is simply a rectangular table with a circle cut out and placed within it. This table would also fold and have wheels with a handle for easy portability. The major issue we could come across with this design is mass, we would have to incorporate relatively solid materials and it could potentially be tricky. Another easy way to accomplish this design is to sand a circle down on a rectangular table and then place a thin layer of laminate for the circle within it. The whole idea is that the circular table is inset or inscribed or cut out and placed into the rectangular one. A table within a table.

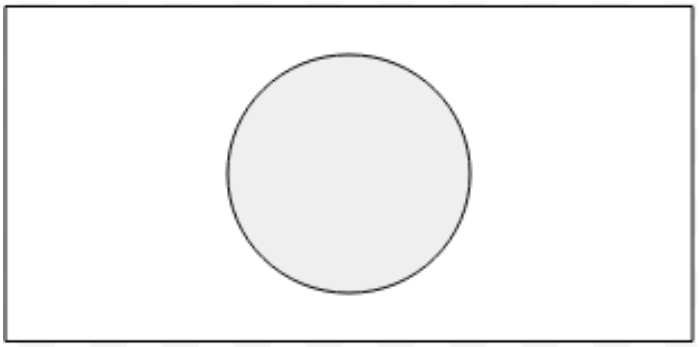

Figure 3-7: TableCeption

3.3.8 The Customizable Heavy Thing

The Customizable Heavy Thing is a table which offers the most competitive versatility to the students. Fundamentally, it is a table which has a tabletop made of pegboard, a board full of holes allowing for pegs to be slotted into them. The pegs would be attached to a material which has black and white cut outs in shapes allowing kids to build tracks or essentially customize their table top (we would of course include a 3' diameter circle specifically for the sumo competition). Peg board because it is full of structural flaws (circles cut everywhere), tends to be flimsy and is therefore often made with a denser material or wood than other tabletops. The beauty of this table lies in giving the students the opportunity to create whatever tracks or obstacle courses they can imagine even into the future such that this table could last as long as they need it.

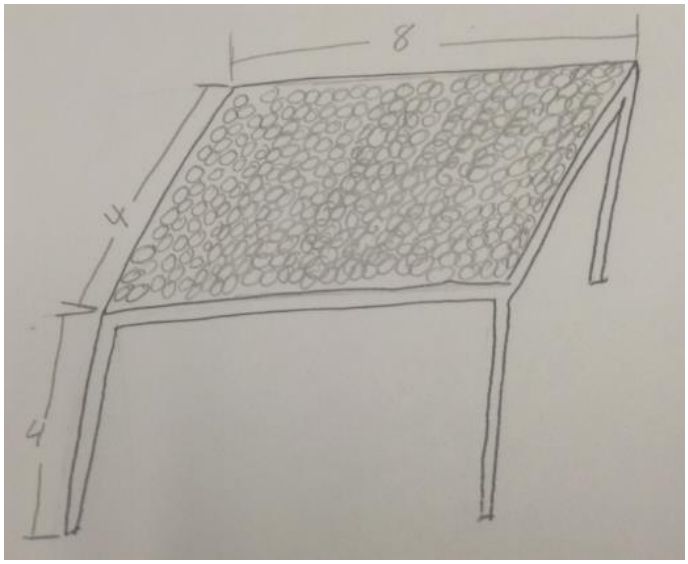

Figure 3-8: The Customizable Heavy Thing

4 Decision Process

4.1 Introduction

This section covers the criteria and alternative solutions listed in Section 3 in order to find the best solution to our project. The alternative solutions will be evaluated using the Delphi Method to determine which alternative solution fits best with our given criteria.

4.2 Criteria

The criteria with a definition is listed below:

- Safety- The table will be placed in a classroom, so the safety of the students should be of the utmost importance.
- Durability- The table should be able to withstand middle schoolers and normal wear and tear.
- Portability- The design should be able to be moved around the classroom without any difficulties.
- Ingenuity- Creativity should be a key element in the design.
- Cost- The cost of the design should not be too expensive.
- Aesthetic- The design should not look too flashy or dull.

4.3 Solutions

Below is a list of the alternative solutions that were previously discussed in Section 3:

- The Wedding Cake
- The Customizable Heavy Thing
- The Donut Hole
- TableCeption
- Compost in the Making
- The Laminated Drum
- The Roto-Robo-SuGo-Super Table
- The Wonder Table

4.4 Decision Process

The process the group used to determine which of the alternative solutions is most effective was through application of the Delphi Method. The criteria is applied a weighting on a 1-10 scale where 10 is the most important criteria and 1 is the least. The weight is multiplied by an individual score for the solution in question, determined by the group, and the products are summed to determine scores for each individual project. After determining individual scores, the pros and cons of the highest scoring solutions are considered, before selecting the final solution: the Roto-Robo-SuGo-Super Table.

Table 4-1: Criteria Weights

Criteria	Weight
Safety	10
Durability	9
Portability	8
Ingenuity	7
Cost	6
Aesthetic	4

Table 4-2: Delphi Method

Criteria	Weight	Alternative Solutions (0-30 High)							
		Wedding Cake	Wonder Table	Donut Hole	Compost Making	RS	Laminant Drum	TableCeption	Heavy Thing
Safety	10	23 / 230	16 / 160	15 / 150	25 / 250	17 / 170	25 / 250	25 / 250	20 / 200
Durability	9	24 / 216	19 / 171	18 / 162	25 / 225	20 / 180	20 / 180	25 / 225	24 / 216
Portability	8	17 / 136	24 / 192	17 / 136	17 / 136	29 / 232	26 / 208	18 / 144	16 / 128
Ingenuity	7	15 / 105	17 / 119	18 / 126	19 / 133	30 / 210	18 / 126	13 / 91	26 / 182
Cost	6	25 / 150	17 / 102	18 / 108	23 / 138	16 / 96	20 / 120	22 / 132	18 / 108
Aesthetic	4	18 / 72	19 / 76	21 / 84	20 / 80	22 / 88	17 / 68	20 / 80	22 / 88
Totals:		909	820	766	962	976	952	922	922

4.5 Final Decision Justification

The final decision is based off the Delphi Method. Roto-Robo-SuGo-Super Table scored the highest with a value of 976. Compares to the other alternatives, the Roto-Robo-SuGo-Super Table offers the most portability, ingenuity, and aesthetic values (and scores the highest in safety as long as it is operated by an adult).

5 Specifications

5.1 Introduction

Section 5 contains a detailed description of the final solution for Zane Middle School, the the Roto-Robo-SuGo-Super Table. This section includes the cost, detailed pictures and diagrams of the various components of the final solution, and general safety guidelines. The cost of our project is determined by the cost of materials, hours spent, and maintenance cost. The safety regulations are the general guidelines that the students and adults should follow in order to decrease the amount of possible injuries.

5.2 Description of Solution

The Roto-Robo-SuGo-Super Table (RS) is a 4' by 8' table which folds into a 4' by 4' square and rotates in order to be portable, and incorporates a whiteboard surfacing so that students can customize their competition course. The R.S. features a locking mechanism integrated into the leg system which uses a circular "rod in hole" design allowing for students or teachers to lock the table into its large state at several degrees of inclination. With the main goals of safety and durability in mind, this table attempts to maximize the ability of the students to create their own competition environment or allow their teacher to assign interesting day-to-day tasks or activities for their students to accomplish.

5.2.1 The Tabletop

The tabletop can be seen as five individual pieces in **Figure 5-1.** The centerpiece can be seen as a 4’ x 4’ square, the two slightly smaller sides are 4’ x 3”, and the smallest pieces are two 4’ x 3” in measurement.

GERL

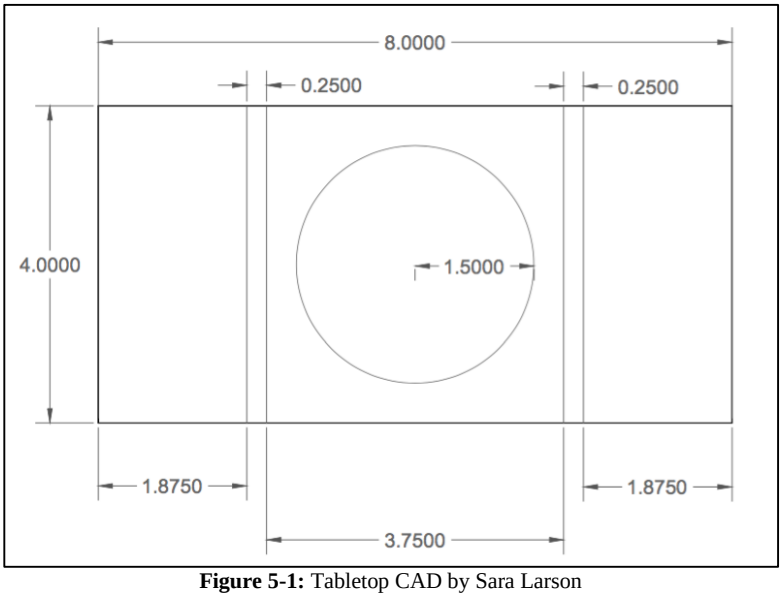

Figure 5-1: Tabletop CAD by Sara Larson

5.2.2 The Frame

Figure 5-2: Frame

5.2.3 The Locking Mechanism

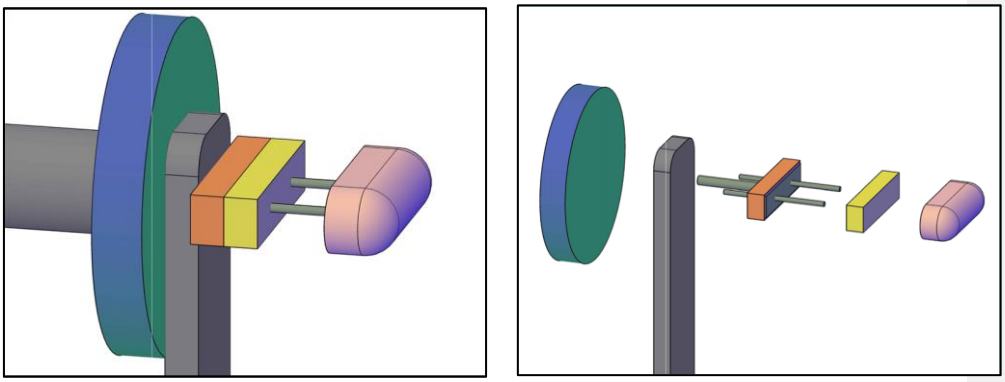

Figure 5-3: Locking Mechanism CAD by Chase Richardson

5.3 Cost

5.3.1 Design Cost

The Design costs inform the amount of hours that GERL put into this design project. The majority of GERL's hours were spent in the Specification section of the project. **Figure 5-1** below illustrates the amount of hours GERL has spent working on each section of the project.

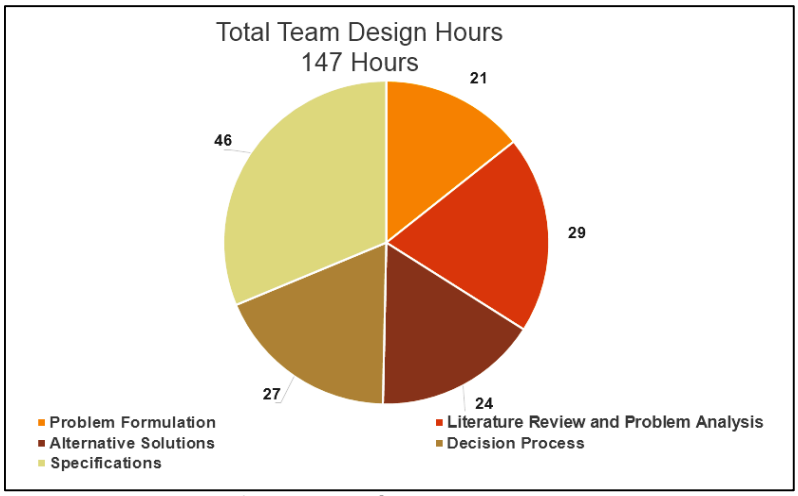

Figure 5-4: Total Team Design Hours

5.3.2 Materials Cost

Table 5-1 (below) displays the cost of the materials used to build the Roto-Robo-SuGo-Super table. Some of the materials were generously donated by the client, making the overall costs not as expensive as it would have been if GERL bought the donated materials.

Table 5-1: Materials Cost

Item	Each Cost ($)	Quantity	Total Cost ($)
Hinges (3” x 3”)	4.99	8	39.92
Plywood (8’ x 4’ x 0.5”)	40.00	2	80.00
Frame and Metal Caster	N/A	1	Donation
Dry Erase Roll	15.99	1	15.99
Dry Erase Sheets	6.36	1	6.36
Sandpaper (60 Grit)	4.99	2	9.98
Dry Erase Paint	23.99	1	23.99
Latex Primer	?	1	?
2” L Brackets (4 pack)	3.56	1	3.56
2” L Brackets (Individual)	3.49	4	3.49
0.5” Philips Flat Screws (16 Pack)	1.44	1	1.44
Pine Board (8’ x 3.5” x 0.75”	4.13	3	12.40

Sandpaper	2.49	3	7.47
Vinyl Remnants	1	13	13.00
Rubber Cement and Brush	13.28	1	13.28
Spray Paint	4.31	1	4.31
Saw blades	3.04	3	9.13
Total:			**244.32**

5.3.3 Maintenance Cost

The Roto-Robo-SuGo-Super table was made to last for several years, but maintenance might be required at some point. The RS table was built knowing that it will be in a classroom environment, but an environment such as that is unpredictable, so there might be a situation where the table is misused and needs maintenance. **Table 5-2** displays that there is no expected yearly operation and maintenance costs.

Table 5-2: Maintenance Cost

Maintenance Task:	Cost/Year ($)
Replaceable parts	0.00
Total:	0.00

5.4 Instructions for Implementation, Usage, and Maintenance

In order to use the Roto-Robo-Sugo-Super table, one must first rotate the table to the desired angle of inclination, and then lock the rotating mechanism in place. Then the R.S. will then unfold to its full length and expand into its full 4’x8’ size. After expanded, one can fully customize the course utilizing a whiteboard marker. After the course setup, one can utilize the table for competition play or practice or as essentially one wishes

5.5 Results

The result of the Roto-Robo-SuGo-Super table is that Zane Middle School now has an innovative table suitable for the engineering course's robot battles that is portable, lightweight, and functional. The design is convenient for its portability and ability to fold in half for easy storage purposes. When the table is not used for competitions, it can be used as a whiteboard for teachers and students, making the RS Table the ideal solution given the criteria listed in **Table 2-1**.

References

Fabricators & Manufacturers Association. (FMA). “Reinventing the Caster Wheel” <http://www.thefabricator.com/article/materialshandling/reinventing-the-caster-wheel> (February 2016.)

Garber, Gary. (2015). *Learning LEGO MINDSTORMS EV3*, Packet, E-Text: https://books.google.com/books?hl=en&lr=&id=beVrBgAAQBAJ&oi=fnd&pg=PP1&dq=ev3+mindstorm&ots=zBEJ0Dlo_f&sig=i1rKuKMayIzRk4bEWk7sJiYdXfw#v=onepage&q&f=false

Gibson, Scott (2009.) *Fine Woodworking Design Book Eight: Original Furniture from the World’s Finest Craftsman.* Pages 4-51. Taunton Press Inc, Newtown, CT. Pages 4-51.

Graves, Garth (1997.) “The Woodworker’s Guide to Furniture Design: The Complete Reference for Building Furniture.

Griffiths, Alyn. (2014). “Benjamin Hubert's lightweight Ripple table is now strong enough to stand on.” *Dezeen Magazine*, <http://www.dezeen.com/2014/03/26/benjamin-hubert-launches-production-ready-version-of-the-ripple-table/> (March 27, 2016).

Hexcel Corporation. (2016). “Product Selector Guides.” *Hexcel Resources*, <http://www.hexcel.com/resources/selector-guides > (March 27, 2016).

Høibø, Olav, Eric Hansen, and Erlend Nybakk. (2015). "Building material preferences with a focus on wood in urban housing: durability and environmental impacts." *Canadian Journal Of Forest Research 45*, no. 11: 1617-1627.GreenFILE, EBSCOhost (accessed March 27, 2016).

Lidz, F. (2013). “How Lego Is Constructing the Next Generation of Engineers.”Smithsonian, <http://www.smithsonianmag.com/innovation/how-lego-is-constructing-the-next-generation-of-engineers-37671528/?no-ist> (Feb. 19, 2016).

Noe, Rain. (June 2, 2014). “The Internal Honeycombs that make Tabletops Rigid, Lightweight, and Cheap.” *Core77,* <http://www.core77.com/posts/27035/The-Internal- Honeycombs-That-Make-Tabletops-Rigid-Lightweight-and-Cheap> (March 27, 2016).

Taylor, Jonathan. "SuGO Robot Classes (with rules)." (n.d.). SuGO Robot Classes (with rules), <http://www.sugobot.com/robot.htm> (Feb. 29, 2016).

ThomasNet. (2016). "Evolution of the Hinge" <http://www.thomasnet.com/articles/hardware/hinge-evolution> (February 2016).

United States Patent and Trademark Office. (2011.) "Class 16: Miscellaneous Hardware.(E.G., Bushing, Carpet fastener, Caster, Door closer, Panel hanger, Attachable or adjunct handle, hinge, window sash balance, etc.)

Waters, A. (2015). "Lego Mindstorms: A History of Educational Robots." Hack Education, <http://hackeducation.com/2015/04/10/mindstorms> (Feb. 19, 2016).

Appendix A Brainstorming List

Brainstorming Idea List

1. **The Wedding Cake**
    a. circle raised above rectangular base
    b. either removable or centered/folds in half when needing transport
    c. Think 2 layer wedding cake, circle over rectangle
    d. optional net or squishy base to minimize sumo-push-damage
2. **The Customizable Heavy Thing**
    a. imagine a pegboard (essentially a rectangular table with a bunch of peg-sized holes drilled into it)
    b. Removable laminate circles, rectangles, corners, curves allows for the building of various maze-paths or adding a giant circle
    c. pieces detach and all fit on via peg to peg table base
    d. allows students to fully customize their table space
    e. portable because the peg table could be pretty light and as long as we standardize peg-spacing options are quite varied
3. **The Netted Donut Hole**
    a. This idea doesn't really incorporated the rectangle but would essentially b3e a 3ft diameter circle with a net catchment system
    b. prevents lego bots from falling/destruction
    c. ultra-portable one light circle with few moving parts
    d. sacrifices function for portability
4. **The TableCeption**

   a. Rectangular table with lightweight material
   b. Circle is cut into and layered on top of rectangle creating one even plane
   c. Looks clean, doesn't offer the same versatility of the peg table
5. Tables could collapse
6. tables could come apart/detach in carrying case
7. Clear table
   a. With the circle under
   b. Laser can see through
8. **Compost In the Making**
   a. Cardboard spacers in hexagon shapes
   b. Material windows
   c. Constructed out of Predominantly upcycled materials
9. Detachable legs
10. The table folds over into another table
11. Wooden table
   a. Maybe not it would be heavy
12. Hydraulic piston slow downy thingy
13. The Laminated Drum
   a. PVC frame
   b. Laminate stretched over the surface
   c. Chicken wire as a support
   d. Very light weight
14. Lighting from underneath making it white circle when switched on
15. Accordion fold
16. Super-Ping Pong-Whiteboard
   a. One side a white board
   b. Half Fold
   c. Rotate along short side
   d. Spin along the x-axis
   e. Tilt and locking frame the table
17. Speakers
18. Some way to incorporate a vortex
19. Legs fold like arms of glasses
20. magnets might mess with the programming
21. Make out of records/CDs
22. Raised circle 6 in with netting system
23. The Wonder Table
   a. Quarter fold

b. Make thin for storage purposes
c. Wheels

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