04/21/20

EML4551-2

Team 506: MeWee Table

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Abstract

Picture yourself arriving at the school library to do work only to find there seems to be no open seats at most tables. In reality, these tables still have available seats. To solve this problem, Campus Reimagined is sponsoring the MeWee Table which will enable use of all available spaces. To implement our design, we are prototyping our computer model by 3D printing the parts for a rough assembly. We are also buying parts, building, and testing our table so our final model is ready for its showcase. The MeWee table has four independent whiteboard dividers, four power sources, and group or individual workspace. The tabletop shape provides plenty of working area and places individuals a reasonable distance from each other. The table's whiteboard dividers and power sources were added to improve quality of the work environment. The dividers keep an individual isolated and are a solution to visual and sound disturbances in libraries. This was proven important by a Gensler research study about libraries. The table's ability to collapse makes it easier to relocate. Each leg of the table locks 90 degrees apart for ease of setup and equal space. It is important students or library workers can set up the table in an easy and effective manner. Use of the table's dividers creates four individual spaces and provides extra writing or drawing space. The dividers will separate each section when people approach the table for work. When students want to work in a group, the dividers can push down into the legs. With the dividers down, the table provides a large area for seamless collaboration. These tables create a more user-friendly experience for all students.

Keywords: Product Design, Workspace, Experience, Team Collaboration.

Acknowledgement

- We would like to give a huge thanks to Campus Reimagined for sponsoring our project. And a special thank you to Mr. Peter Butler for being such a wonderful liaison.
- Thanks to our faculty advisor Dr. Patrick Hollis for his guidance throughout the project.
- Thanks to the FAMU-FSU College of Engineering machine shop for playing a large part in the machining of parts for our prototype. And a thanks to the vendors we used to obtain our materials.

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Notation

AHP	Analytical Hierarchy Process
dBA	A-weighted decibels
MDF	Medium Density Fiberboard
PPE	Personal Protective Equipment

Chapter One: EML 4551C

1.1 Project Scope

Project description: Produce a multi-workspace table where people can choose to work individually or in a group setting.

Key Goals: Design and create a cooperative table that is ergonomic, simple, safe, and adjustable. The table should be able to accommodate at least four people each having their own space for laptops or work.

Primary Market: University/school libraries where students will use tables to do work.

Secondary Market: Coffee shops and social areas where people gather to work individually or in a group.

Assumptions: The product is intended for college age students. Standard 15-amp 120-volt outlets can be used for any charging components.

Stakeholders: The users of the product are college students as well as people who go to social places to work. The beneficiaries are Dr. McConomy, Dr. Hollis, Mr. Butler, Campus Reimagined (CRI), university libraries and coffee shops.

1.2 Customer Needs

Table 1 displays the questions, customer statements, and the interpreted needs that are involved for the design of the MeWee table. The questions section includes questions that we thought were important for the construction of the table. We asked these questions to our sponsor Mr. Peter Butler so that we could obtain a better understanding of the project with specific parameters and an idea of why and who we are making this for. Mr. Butler was asked these questions because he has the best understanding of the specifications and limitations regarding the project. The customer statement section provides the response that our customer, Mr. Butler, gave us for each question. They provided clear answers that we were able to interpret into design parameters. The interpreted needs section is our understanding of what needs to be done to the project in order to satisfy our customer's needs. It provides us with quantifiable milestones that we need to accomplish by the end of the project.

Table 1
Interpreted Customer Needs

Question	Customer Statement	Interpreted Need
What is the most concerning factor for the design?	The design must be safe and simple.	Our top design priorities are safety and simplicity.
Does the table have an electric element to it?	The table should have outlets and phone ports to charge items.	The design can include a power source that charges people's electronic items.
Who is our primary and secondary market?	The table is being built for the FSU CRI to be used in the student library but use anywhere work can be done would be beneficial.	The primary market is University libraries and the secondary market is coffee shops / office buildings.
What are we hoping to accomplish with the design?	The idea for this table came from observing students who waste available space; sitting by themselves at a multi-person table. Other students avoid the awkwardness of approaching that student to ask to sit at the table.	The table will increase the amount of utilized space when compared to a traditional table.
Can the table be any shape?	Yes, circular tables have already been used for the conceptual idea but any shape and size are allowed.	The table can be any geometric shape, but more research is needed to find optimal design.
Does the table have to be stationary or mobile?	The table does not need to be mobile, but the easier it folds and moves, the better.	The table allows for simple relocation.
Is there a specific age range for our market?	College Students	The age of the users ranges from 17-25.

Synthesis of Interpreted Needs

Based on Table 1, our project will focus on making the space adjustable for individuals and groups alike. The project is a redesign of a table to eliminate wasted space in densely populated work areas. The customer stated that simplicity and safety are large factors in this project. Safety is important, because previous mocked designs have had points that could cause injuries for users. Simplicity is important because we want users of all ages and sizes to easily get started in their own workspace without hassle. The primary market for our project is university libraries while our primary demographic is people from ages 17 – 25. The shape of the table will be determined by and designed for use by multiple people either as a group or as individuals. An electric element will be incorporated into the design so that devices like laptops, tablets, and phones can be powered. The table that we are designing allows for easy relocation.

1.3 Functional Decomposition

Introduction of Functional Decomposition

Functional Decomposition is utilized to track and measure work effort, and to help in simplifying a design problem. Figure 1 is the functional decomposition that maps our project's most significant functions in a hierarchical manner, beginning with the primary tasks of the design, filtering down to the basic secondary-functions, and ultimately ending with the major sub-functions of each secondary function. The customer required a multi-purpose table that can be used by people individually and for a group. Our team broke down the core elements of the table that make it multi-purpose and categorized that as the primary tasks. In order to know what fulfills those primary tasks, we had to break down the core elements into basic secondary functions. The major sub-functions are created when the secondary functions are broken down to even more basic components that describe the most basic tasks which cannot be broken down any further.

Discussion of Data Generation

By utilizing our project brief and conversation with the customer, information was gathered on the necessary functions, capabilities, and physical properties of our project. The project brief informed us about the purpose of the project, to create a multi-purpose table that allows for people to work in a contained, organized workspace. The customer made it clear that the table is required to accommodate both groups and individuals. With the customer's needs in mind, we determined that the table must have the ability to provide secluded space for people who want to work by themselves as well as the ability to have space for people who want to collaborate on work together. Our customer also stated that our product should have a power source to charge users' electronics. Mobility of the table was also discussed and we found that while the customer does not need the table to be mobile, it would be preferred. The table being mobile will allow it to be stored more easily while allowing for easier deployment of the table in its intended space. Including a power source to the table will allow people to use their devices for as long as they want while they are working. With all of this in mind, we created our Functional Decomposition Flow Chart that illustrates all of the requirements from our project brief and our customer needs and how we plan on achieving them.

Functional Decomposition

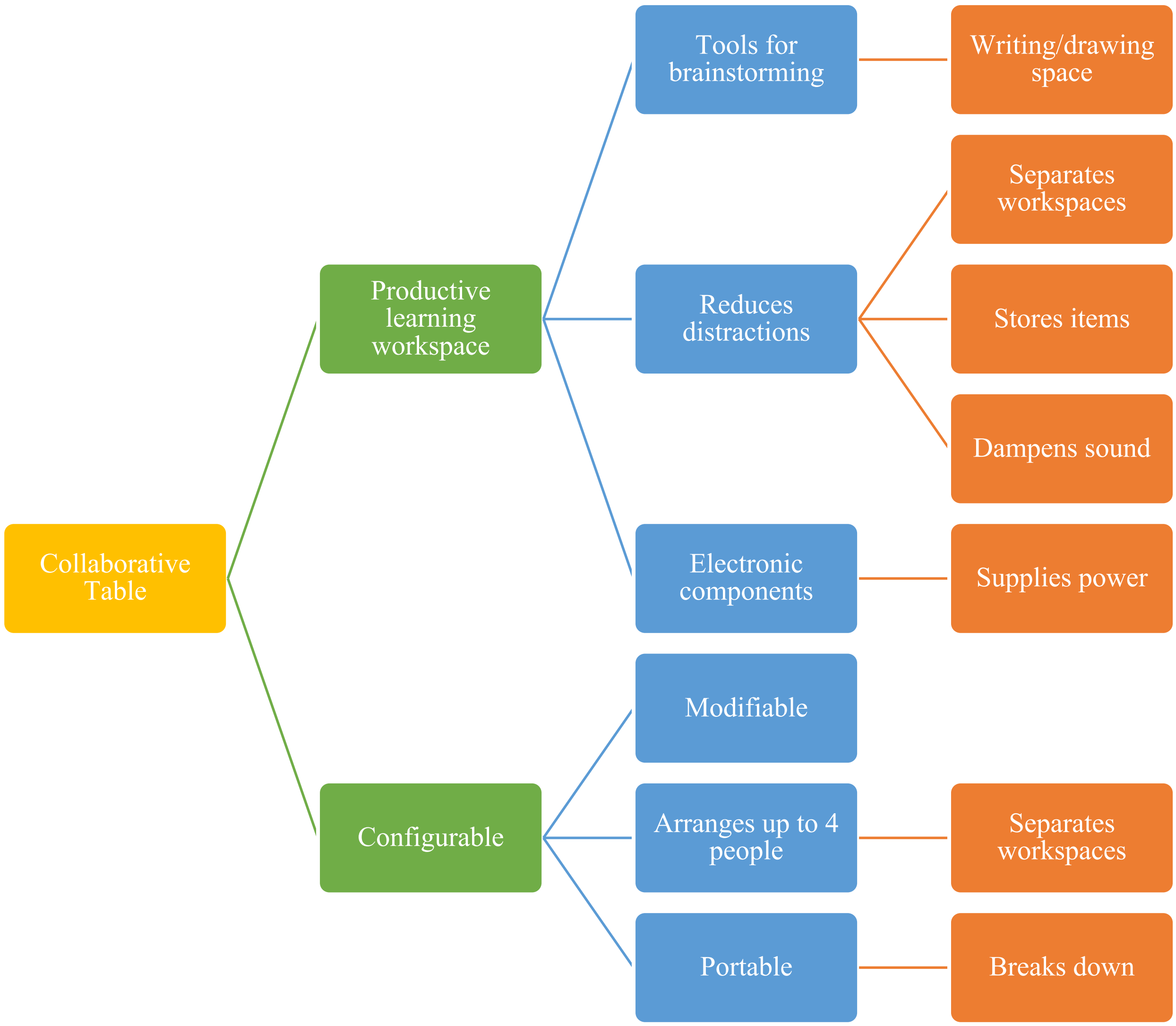


Figure 1. Functional Decomposition.

Connection to Systems

The primary functions of our project are that it must be configurable and must be a productive learning workspace. Each of these functions are required in order for our project to be successful and meet our customer needs. The sub-functions to each function explain how each of these functions are achieved. For the table to be configurable, it needs to be portable, can arrange up to four people, and adjustable for different people. The table will be defined as a productive workspace if it has tools for brainstorming, reduces distractions, and has electric components.

Smart Integration

Cross-section relationships bridge the gap between primary functions of the design because they have the same actions to complete the function. A cross-sectional relationship that we have in our functional decomposition is the separation of workspace. This falls under adjustable and reduces distractions because it can be modified depending on the people at the table and is useful for focusing on individual work.

Action and Outcome

The actions that the project must do are described by the layers of the function decomposition. The basic actions that our project must perform are supplying power, providing a drawing space, having built in storage dampening sound, having moving components, and being portable. By implementing these actions into our design, the project will be able to fulfill its main functions being configurable and having a productive workspace.

Synthesis of Functional Decomposition

Table 2
Main Functional Systems

Function	Configurable	Productive Learning Workspace
Writing/Drawing Spaces	O	X
Stores Items	O	X
Dampens Sound	O	X
Supplies Power	O	X
Has Moving Components	X	O
Separates Workspace	X	X
Breaks Down	X	O

With this functional decomposition, we realized that we didn't have many functional, with the only relationship being the separation of workspace. This was gathered through a collection of the customer needs, project scope and details given by our sponsor and mentor. Analysis of the project was needed to discover what our main project functions were, and how they were going to be organized. The only relationship the two main systems shared was the separating workspace, because in order to create an   When conducting the functional decomposition, the table was broken down into two primary tasks. Each of these primary tasks have their own sub-functions that elaborate on how the function is achieved. The first function is that the table must be configurable in multiple different ways. The second was that the table should help create a conductive and efficient workspace. These were then broken down into smaller components. The features that make the table configurable were that it arranges a varying amount of people and that it is adjustable. These features were to be implemented by having moving parts. The key features of creating a productive learning space were adding electronic components, reducing distraction, and tools for brainstorming. The reason that there was only one functional relationship is due to the functional decomposition focusing on the mechanical components of the table and the productive learning space focuses on additional features to make the table effective. These features are usually simple and require no moving components which is why it they don't contain many factors in common.

1.4 Target Summary

In order to create targets and metrics for our project we had to examine the functions from our functional decomposition and decide how we would accomplish each of these. Each function has at least one target and metric attached to it that quantifies how we would accomplish the function. Some additional targets were added too that we didn't consider as functions.

Method of Validation

Writing/drawing space will be tested by writing out engineering related math problems on the drawing space. If the math problems can be solved with the space provided, it will be deemed sufficient. Ability to separate workspace will be validated by having multiple people place their objects and belongings in each section of the table and observing how usable it is. If every persons' work items can be accommodated in the space, then the target will have been met. The ability to store items will be tested by attempting to fit multiple items into the allotted storage space. Once all the items can fit appropriately into the space then it will be deemed as successful. Dampening sound will be tested by placing a microphone in one separated workspace while the dividers are up and sound will be produced in the adjacent sections. The volume of sound captured by the microphone will be compared with the relative volume of the sound produced in the workspace when no dividers are present. The power supplied to the table will be tested by using a multimeter to test both the voltage and amperage of the power source. If the power source produces enough power to charge the users devices while plugged in, then the function is effective. The innovative function will be tested by surveying people of their interest in the table and how likely they are to work at it. The survey will provide a way to put people's feelings of the table into numerical data so we can determine if people enjoy our design, so that we can determine if the target will be satisfied. Compatibility will be tested by measuring the size of the table when it is in its open form and again after it has been folded into its more storable form. If the table is measured to be less than 75% of its original size, then the functional will be considered as effective.

Critical Targets & Metrics

The critical targets/metrics for our project are separate workspaces, supplies power, and compactable. We decided that these are the most important targets to meet because each impact a key element of the purpose for our design, to produce a table that both individuals and groups can use at the same time without wasting space. For the table to accommodate people working by themselves and with others, each section of the table needs to be spaced evenly and have enough space for people to have all their items such as laptops and books out and open for work. In order for the table to be usable by multiple people at different locations, it needs to be able to break down and be compactable. The table also needs to be able to charge people's devices for work so that they will stay at the table. There needs to be enough power and plugs for up to four people to be able to charge all of their devices.

Other Targets & Metrics

A target that we thought of that wasn't attached to one of our functions is the weight of the table. The table needs to weight enough to be stable for users to work at but also needs to be light enough for a single person to be able to move the table when its in its folded form. The table should weigh no more than 40 kg and will be weighed on a scale to test to see if we reached our target. The total size of the table is another target that needs to be addressed. It needs to be large enough for four people to sit at and work on. The total size of the table should cover 1.5 to 3 m^2. Once the table is built, we will be measuring the dimensions to make sure we have reached our target. Another target we thought of is the strength of the table. The table needs to be strong enough to hold all of a user's devices and work without worry of failure. Weights will be placed on the tabletop to test how much it can support with a minimal weight it should be able to hold is 600 lbs.

Derivation of Targets & Metrics

The targets and the metrics were determined by research into how to quantify and test each of our functions. For writing/drawing space we thought what a sufficient size for people would be to write on with a whiteboard. We found that the typical size of a medium size whiteboard is 24 x 30 cm. The target/metric for the separate workspaces function was defined as the size needed for a person to use their laptop, book, and worksheets on a table and was found to be at 0.5 m². For the target/metric for stores items, the size of the space was determined by measuring the size of small items like phones and car keys and deciding how much space is needed to hold them being 280 cm². Dampens sound target/metric was determined by researching what decibels are quiet sounds. It was found that 20-40 dBA are quiet sounds that don't disturb people. The target/metric for supplies power was found researching how much power is needed to charge a laptop, tablet, and phone. The total charge was found to be 120 volts at 60 Hz. For the target/metric for innovative we decided that people's opinion would determine how innovative the table is. We decided that if the table could be compacted to 75% of the original weight for the target/metric, it would be easier to move around. The target/metric for the weight of the table was decided by researching what the weight is of a standard four-person table. We found that the average size was 40 kg (88 lbs). The target/metric for the size of the table and the amount of support the table can hold was also determined by researching the average size and support of a four-person table being 1.5 m² to 3 m² and 350 kg respectively.

Targets & Metrics Table

Table 3
Targets and Metrics

Function	**Target**	**Metric**	**Tools**
Writing/Drawing Space	A whiteboard that is 24x30 cm in size	Size (cm)	Tape measurer
Separates Workspace	Each section of the table will be 0.5m²	Size (m²)	Tape measurer
Stores Items	The storage space is 280 cm²	Size (cm²)	Tape measurer
Dampens Sound	dampen sound to within 20-40 dBA	Sound energy	Microphone

Supplies Power	Provides 120 Volts at 60 Hz	Electric potential (V and Hz)	Multimeter
Innovative	The table is inviting to the public	Opinion (survey)	Survey what people think of the table
Compactable	Reduce size to 75% of the original size	Size (m^3)	Tape measurer
	Weighs no more than 40kg	Size (kg)	Scale
	Covers between 1.5m^2-3m^2	Size (m^2)	Tape measure
	Supports 350 kg	Weight (kg)	Scale

Summary of Targets & Metrics

One target for the table design is to have a non-paper writing space built into it. This allows for more working space and the option of a paperless workspace. Our current idea includes integrating a whiteboard into either the dividers or desk surface to provide a useful area for notes outside of a computer or paper. Our target for this is a specific area or amount of space to work. We will be measuring this target using a tape measure. Workspace is a very important factor when designing a useful table.

The most important target, or at least the reason the project was started, is the ability to separate the workspaces. The goal of this table is to have a user sitting at a four-person table and the user be able to separate themselves from anyone else working at the table. The idea is to use some sort of dividers that can fold out or pop up from the table that would lock into place.

Another important feature is the ability to store items within the table. The target for this is to have 280 cm^2 of storage space. The storage is an important feature because it allows distractions to be stored away, such as a cell phone. Since this table is designed with libraries and universities in mind it is important to consider workflow and work towards improving it. This target will be measured with a ruler (height x width).

Sound travels in waves and is measured in frequency and amplitude. The energy in a sound wave can be measured using decibels. 0 dBA is the lowest level that an average human can hear, and normal speaking voices are around 65 dBA. With the sound of rain around 50 dBA and a whisper being around 20 dBA, we decided our target would be to dampen sound from the adjacent workspaces to within 20-40 dBA to create a more ideal individual workspace environment.

Supplying power to the MeWee table is a very important function. Every day more and more people are using their own personal devices such as laptops, phones, and tablets to work and play and our table needs to provide power so users can do it all while never leaving the table. There needs to be enough outlets and USB chargers for up to 4 people to be able to charge up to 3 devices each. A standard North American power outlet provides 120 volts at 60 Hz and we will be targeting to get these numbers as well. We will measure our electrical output using a multimeter to find if our target has been achieved.

Something important to both our sponsor and us is that the table is innovative. It is important for people to see this table in their local school library and think, "I could spend the next 2-3 hours working at this table." We plan to measure the table's "wow factor" by surveying students and asking questions to gauge how likely people would use our table. The table has been around for a long time, so our team is tasked with bringing innovation to the table for solo and group work.

For the function of compactable, we made it a target to reduce the area to 75% of its original size for the table to be both more portable and easier to store. The metric used will be total area, and a tape measure will be used to verify if we reached this target. Being compactable, while not a major function for the table, would be a key selling point for anywhere with smaller amounts of storage space.

A basic component that all tables have is the ability to support some amount of weight. This is a target in the design of the MeWee table. The table should be designed to withstand 350kg upon the surface of the table at one time. This might be a challenge as there may be many joints along the table; this number came from the fact that a table might have to support 116.7 kg, so a safety factor of three was used.

The amount of space a table has is also very important to its design. The MeWee table should cover roughly 1.5m^2 – 3m^2. This number was generated based on the preferred amount of space on a desk. When tables are too small no one wants to use them and when tables are too large they take up too much space.

The table's weight should be under 40kg since a goal of the table is its portability. If the table weighs too much, then it will be a detriment to this aspect. Since it must be able to support 350kg, the table must be sturdy which may increase the general weight of the table. A balance between these two targets must be reached.

1.5 Concept Generation

The goal of our project is to create a productive table that can be used for individual work and group work. To complete this goal, we brainstormed many concepts that fulfilled the requirements of our project. With 5 members in our group, each of us produced 20 ideas so that we could have 100 concepts to start with. While coming up with these concepts we did research on different types of tables so that we can come up with more ideas. A collection of different procedures were used during concept generation to help come up with over one hundred ideas that were narrowed down to high fidelity and medium fidelity concepts. The variety of methods that assisted us in generating concepts were the morphological chart, biomimicry, and the nay-sayer strategy.

Nay-Sayer

For the nay-sayer strategy, four of our group members generated a plethora of ideas and pitched them to our fifth group member. The fifth group member critiqued each idea and either rejected them or corrected them to accommodate the needs. This member made sure that our ideas are feasible and that they meet our requirements.

Morphological Chart

A morphological chart was used because it produces multiple solutions to different problems. For our project, we defined our problems as actions the table needs to accomplish. The table needs to reduce unused workspace, provide individual workspace, provide group workspace, support work tools, and reduce distractions. Each of these problems were given 3 different solutions. When evaluating each problem with their unique solution, 243 different solutions to the overall problem are produced. These solutions are great concepts to use for designing our project.

Table 4
Morphological Chart

Reducing unused workspace	Provides individual workspace	Provides group workspace	Supports work tools	Reduces distractions
Portable with wheels	Multiple dividers that create 4 sections	Dividers can be taken off	Power supply to charge items	Sound dampening
Adjustable with moving components	People at the table have to push a button to detach a divider	Parts of the table extend for someone to use	Whiteboard	Storage space to place phones
Expandable with additional components	A section of the table can be removable	Table can change shape to account for different people	Measuring tools	Desk dividers that surround people

Biomimicry

Biomimicry is the imitation of biological systems to produce a design. We applied this concept generation tool to our project by studying the Vogelkop superb bird of paradise and the Wahne's parotia. Both birds can extend and collapse their wings to different sizes. This is a great ability to mimic because we want our table to be portable so that it can be used at different places as well as expandable for multiple people to use it. By studying the anatomy of these birds, we were able to generate more concepts to use for our design.

Figure 2. Vogelkop superb bird of paradise (left) and Wahnes's Parotia (right).

Medium Fidelity Concepts

Our medium fidelity concepts were chosen as 5 concepts from our list of 100 that are important enough to include in our concept selection. These concepts take into consideration most of the requirements that our table needs to be successful. One medium concept is having 1 outlet and 2 USB plugs per person at the table. This is important for users to be able to charge all their devices while working including laptops, phones, and tablets. The 1 outlet 2 USB combo is already in standard use worldwide which will allow for quicker and cheaper production. Another idea is having the table be double layer with the bottom layer being the table itself and the top layer being made of cubic pieces that can be folded upwards to act as a divider. This works as an easy to use divider for people when they want to work independently. The table having a small pillar in the middle that has dividers in it is another medium concept. It allows for people to separate themselves from others when trying to work by themselves. Another concept that was assessed to be medium fidelity would be having table dividers that act like a paper hand fan. This would be a foldable fan that expands by the user pulling one end towards themselves. Another medium fidelity concept is deploying the dividers of the table with a motor. This concept makes the table more user friendly by relying on the motor to separate people. Incorporating the table with a pully rope system with ropes is another medium idea. It allows for simple use that people can use to raise and lower dividers. This is also something that everyone is familiar with and would be simple for them to use.

High Fidelity Concepts

Our high-fidelity concepts were chosen as 3 well thought out concepts from our list of 100 concepts. The concepts take into consideration most of the requirements that our table needs to be successful. An important concept for our project is to be adjustable. The origami design accomplishes this by starting in the center and if pulled outward gets elongated in the x and y directions, moving at a 45-degree angle outward. This idea is useful for covering a lot of area as well as accommodating multiple people. A retractable whiteboard along with a folding table is another one of our high-fidelity concepts. The inclusion of a movable whiteboard that acts as a divider and an area for workspace is a great concept that meets a lot of our requirements. One concept that has some potential viability is using aluminum as the support structures for the table. Using aluminum would help reduce total weight of the table while still producing similar strengths and toughness to steel supports. The cost of aluminum is also cheaper per pound and cheaper to mill then most other metals used in production.

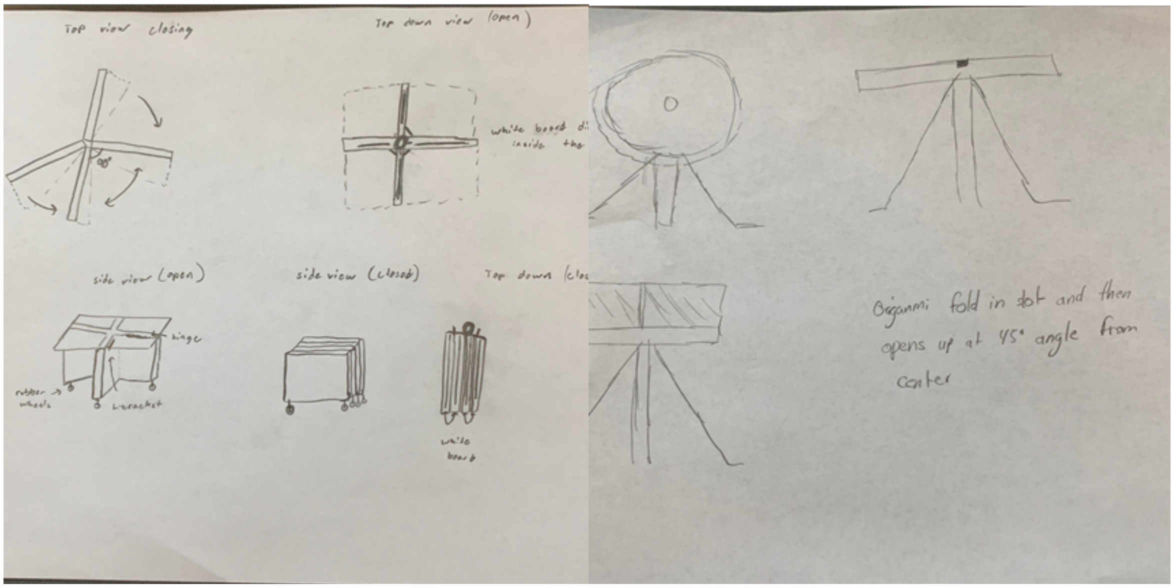


Figure 3. Initial Concept Ideas.

1.6 Concept Selection

To produce a multipurpose table for people to work at, our group created multiple concepts with each of them having their own unique approaches to our project. To narrow down what concepts are best suited for the project, we used multiple concept selection tools to evaluate each idea. All the selection tools allowed us to reevaluate our concepts by demonstrating the pros and cons of each of them. We want our final design to satisfy all our customer requirements so that our design will produce an efficient working environment. By creating a house of quality chart, Pugh Chart, and analytical hierarchy process, we decided on what concept would be used for our final design.

House of Quality

The house of quality is a selection tool that is influenced by the customer's requirements and the functional requirements of the product. It compares the two sets of requirements and illustrates which functions satisfy which customer needs. A binary pairwise chart was also created in Figure 1 to compare the functional requirements to each other to understand which are most important. The house of quality needs the functional ratings achieved from the binary pairwise to produce a ranking of each concept. For our project, our consumers need a table that is functional, simple, safe, compactable, aesthetically pleasing, cheap, and light. All these customer requirements are needed for people to sit down and work effectively at our table. The table must be functional for people to work on it. It must be simple, safe, and appealing so that people will want to work on it. It also must be compactable, cheap, and light so it is more accessible to the consumer. The functional requirements for our table are writing/drawing space, time to set up, power integration, workspace size, time to divide workspace, ease of transportation, sound dampening, injury risks, ability to store items, consensus of table design, and price of construction. Workspace size is based on producing an effective work environment along with a whiteboard, sound dampening, item storage, and power integration. Time to set up and divide the table are requirements because the table needs to accommodate people who want to work by themselves and with others. Ease of transportation, consensus on design, injury risk, and price are requirements that need to be fulfilled so that the table can be as pleasing as possible to a multitude of people.

Customer Needs	1.	2.	3.	4.	5.	6.	7.	Total 1
1. Functionality	-	1	1	1	1	1	1	6
2. User Simplicity	0	-	1	1	1	1	1	5
3. Safety	0	0	-	0	1	1	0	2
4.Compactability	0	0	1	-	1	1	1	4
5. Aesthetics	0	0	0	0	-	0	0	0
6. Cost	0	0	0	0	1	-	1	2
7. Weight	0	0	1	0	1	0	-	2
Total 2	0	1	4	2	6	4	4	n-1 = 6

Figure 4. Binary pairwise chart.

			Functional Requirements										
		Direction of Improvement	□	▼	□	□	▼	▲	▲	▼	□	▲	▼
Relative Weight	Customer Importance	Customer Requirements	Writing/drawing space integration	Time to setup table	Power integration	Workspace size	Time to divide workpsace	Ease of transportation	Sound dampening	Injury risks	Ability to store items	Consensus of table design	Price of construction
26%	5	Functionality	●	▽	●	●	○	▽	○	▽	●	▽	▽
21%	4	User's Simplicity	▽	●	▽	▽	●	○	▽	●	▽	○	▽
5%	1	Safety	▽	▽	▽	▽	▽	▽	▽	●	▽	▽	▽
16%	3	Compactability	▽	●	▽	○	○	●	▽	▽	▽	▽	▽
11%	2	Aesthetics	▽	▽	▽	▽	▽	▽	▽	▽	▽	●	▽
11%	2	Cost	○	▽	●	○	▽	▽	○	▽	○	▽	●
11%	2	Weight	○	▽	○	●	▽	▽	○	▽	○	▽	○
		Importance Rating Sum (Importance	352.63	395	416	447	353	268	195	311	353	226	205.3
		Relative Weight	11%	12%	13%	13%	11%	8%	6%	9%	11%	7%	6%

Figure 5. House of quality.

Relationships		Weight
Strong	●	9
Medium	○	3
Weak	▽	1

Direction of Improvement	
Maximize	▲
Target	□
Minimize	▼

Figure 6. House of quality relations.

House of Quality Analysis

From our house of quality in Figure 5, it is seen that workspace size, power integration, time to set-up, ability to store items and writing space are all important features for our table. Workspace size, power integration, and writing space are all important to the table because these increase the productivity of the user. Power integration is required based on the number of electronics people use and workspace size is important because there should be enough space to lay out all your materials. The writing space and storage are needed for greater productivity and to reduce distractions. Time to set-up is important to ensure that it is quick and simple to fully set up the table and also make use of the table's dividers.

Pugh Chart

A Pugh Chart is another concept selection method that identifies the most promising concept out of a list of alternatives. The chart juxtaposes each concept to a reference concept and to a list of criteria to illustrate if each concept is better than, worse than, or the same as the reference concept regarding the criteria. The criteria that we used for our project is the same as our functional requirements from our house of quality. Five concepts are being compared to one another: a folding table, a pop-up table, a panel table, a branch table, and an origami table. The results from the Pugh Chart, Figure 7, showed that our best concepts are the folding table, the origami table, and the pop-up table. To compare our best concepts to one another, we created another Pugh Chart, Figure 8, where the reference concept became the pop-up table because it had a moderate rank in the previous Pugh Chart. We also dropped the panel and branch table designs because they had low rankings. The results of that Pugh Chart showed that both the folding table and origami table are better designs than the pop-up table. We then made another Pugh Chart, Figure 9, in which the foldable table is the reference concept and compared it to only the origami table concept. The origami table concept came out to have three positives and three negatives being equivalent to the folding table concept in terms of satisfying our functional requirements.

Alternatives	Baseline	Folding Table	Panel Table	Branch Table	Pop-Up Table	Origami Table
Writing/drawing space integration	▲ 0	▲ 1	▲ 1	○ 0	▲ 1	○ 0
Time to setup table	○ 0	▼ -1	▼ -1	▼ -1	▼ -1	▼ -1
Power integration	○ 0	▲ 1	▲ 1	▲ 1	▲ 1	▲ 1
Workspace size	○ 0	▲ 1	▲ 1	○ 0	▲ 1	▲ 1
Time to divide workpsace	○ 0	▼ -1	▼ -1	▼ -1	▼ -1	▼ -1
Ease of transportation	○ 0	▲ 1	▼ -1	▲ 1	▲ 1	▲ 1
Sound dampening	○ 0	▲ 1	○ 0	○ 0	○ 0	▲ 1
Injury risks	○ 0	▲ 1	▲ 1	▲ 1	▲ 1	▲ 1
Ability to store items	○ 0	▲ 1	○ 0	○ 0	▲ 1	▲ 1
Consensus of table design	○ 0	▲ 1	▲ 1	▲ 1	▲ 1	▲ 1
Price of construction	○ 0	▲ 1	▲ 1	▲ 1	▲ 1	▲ 1
Values	Positive	▲ 9	▲ 6	▲ 5	▲ 8	▲ 8
▼ -1	Negative	▼ -2	▼ -3	▼ -2	▼ -2	▼ -2
○ 0	Rank	1	4	5	2	2
▲ 1						

Figure 7. First Pugh chart.

Alternatives	Pop-Up Table	Folding Table	Origami Table
Writing/drawing space integration	0	1	0
Time to setup table	0	-1	-1
Power integration	0	0	0
Workspace size	0	1	0
Time to divide workpsace	0	0	1
Ease of transportation	0	1	1
Sound dampening	0	0	0
Injury risks	0	0	1
Ability to store items	0	0	0
Consensus of table design	0	0	0
Price of construction	0	0	1
Values	Positive	3	4
-1	Negative	-1	-1
0	Rank	1	2
1			

Figure 8. Second Pugh chart.

Alternatives	Folding Table	Origami Table
Writing/drawing space integration	0	-1
Time to setup table	0	1
Power integration	0	0
Workspace size	0	0
Time to divide workpsace	0	0
Ease of transportation	0	-1
Sound dampening	0	-1
Injury risks	0	1
Ability to store items	0	0
Consensus of table design	0	0
Price of construction	0	1
Values	Positive	3
-1	Negative	-3
0	Rank	1
1		

Figure 9. Third Pugh chart.

Analytical Hierarchy Process

The analytical hierarchy process (AHP) is a concept selection method that analyzes the engineering requirements to each other while illustrating the importance of each requirement and determines which concepts best fulfill the requirements. We created a chart, Figure 10, that compares all our engineering requirements for our project and found that the three most important requirements are functionality, user simplicity, and compatibility. These requirements were used to evaluate each of our concepts so that we know which one to choose for our final concept. After completing the AHP charts for all five of our concepts, Figure 12 and 13, and creating a final matrix table, Figure 16, we found the two concepts that best satisfy all our needs are the origami table concept and folding table concept. This is as expected because these two concepts were tied as our two best ideas when we created our Pugh Chart.

	Development of Candidate Set of Criteria Weights [W]						
	Criteria Comparison Matrix [C]						
	Functionality	Aesthetics	User's Simplicity	Safety	Compactability	Cost	Weight
Functionality	1.000	7.000	3.000	3.000	5.000	5.000	5.000
Aesthetics	0.143	1.000	0.333	0.200	1.000	1.000	0.333
User Simplicity	0.333	3.000	1.000	3.000	1.000	5.000	5.000
Safety	0.333	5.000	0.333	1.000	0.333	1.000	1.000
Compactability	0.200	1.000	1.000	3.000	1.000	1.000	1.000
Cost	0.200	1.000	0.200	1.000	1.000	1.000	1.000
Weight	0.200	3.000	0.200	1.000	1.000	1.000	1.000
SUM	2.410	21.000	6.066	12.200	10.333	15.000	14.333

Figure 10. Criteria comparison matrix.

Consistency Check		
Weighted Sum Vector	Criteria Weights	Consistency Factor
2.972	0.379	7.837
0.402	0.052	7.715
1.648	0.210	7.842
0.742	0.097	7.614
0.891	0.111	8.056
0.528	0.068	7.727
0.633	0.082	7.717
Average Consistency Vector		7.787
Consistency Index		0.131
Consistency Ratio		0.097

Figure 11. Consistency check.

	Folding Table			
	Functionality	User Simplicity	Compactability	
Functionality	1.000	5.000	3.000	
User Simplicity	0.200	1.000	1.000	
Compactability	0.333	1.000	1.000	
SUM	1.533	7.000	5.000	
	Normalized Folding Table [NormC]			
	Functionality	User Simplicity	Compactability	[Pi]
Functionality	0.652	0.714	0.600	0.656
User Simplicity	0.130	0.143	0.200	0.158
Compactability	0.217	0.143	0.200	0.187
SUM	1.000	1.000	1.000	1.000

Figure 12. Folding table AHP.

	Origami Table			
	Functionality	User Simplicity	Compactability	
Functionality	1.000	5.000	3.000	
User Simplicity	0.200	1.000	1.000	
Compactability	0.333	1.000	1.000	
SUM	1.533	7.000	5.000	
	Normalized Origami Table[NormC]			
	Functionality	User Simplicity	Compactability	[Pi]
Functionality	0.652	0.714	0.600	0.656
User Simplicity	0.130	0.143	0.200	0.158
Compactability	0.217	0.143	0.200	0.187
SUM	1.000	1.000	1.000	1.000

Figure 13. Origami table AHP.

Consistency Check (Folding Table)		
Weighted Sum Vector	Criteria Weights	Consistency Factor
2.004	0.656	3.058
0.476	0.158	3.014
0.563	0.187	3.014
Average Consistency Vector		3.029
Consistency Index		0.014
Consistency Ratio		0.028

Figure 14. Folding table consistency check.

Consistency Check (Origami Table)		
Weighted Sum Vector	Criteria Weights	Consistency Factor
2.004	0.656	3.058
0.476	0.158	3.014
0.563	0.187	3.014
Average Consistency Vector		3.029
Consistency Index		0.014
Consistency Ratio		0.028

Figure 15. Origami table consistency check.

Final Rating Matrix				
Selection Criteria	Functionality	User Simplicity	Compactability	Criteria Weights
Folding Table	0.656	0.158	0.187	0.379
Branch Table	0.389	0.511	0.100	0.052
Pop-Up Table	0.480	0.406	0.115	0.210
Origami Table	0.656	0.158	0.187	0.097
Pannel Table	0.724	0.193	0.083	0.111

Figure 16. Final rating matrix.

Concept Selection	
Concept	Alternative Value
Origami Table	0.296
Folding Table	0.296
Pop-Up Table	0.153

Figure 17. Concept selection.

Final Selection

Our final concept was selected by using our house of quality, Pugh Chart, AHP, and our own reasoning. With all of that in mind, we found our final concept to be the folding table concept, shown in Figure 18. The Pugh Chart and AHP stated that our two best concepts are the origami table and the folding table. We decided to go with the folding table based mostly on our own judgment because we believe that it meets our requirements better than the origami table. The origami design wouldn't have whiteboards integrated into the design and it wouldn't dampen sound as much as the folding table. Also, the origami table design would not be as sturdy and would not have as long of a lifespan which would not make it a cost-effective investment by a university or public library.

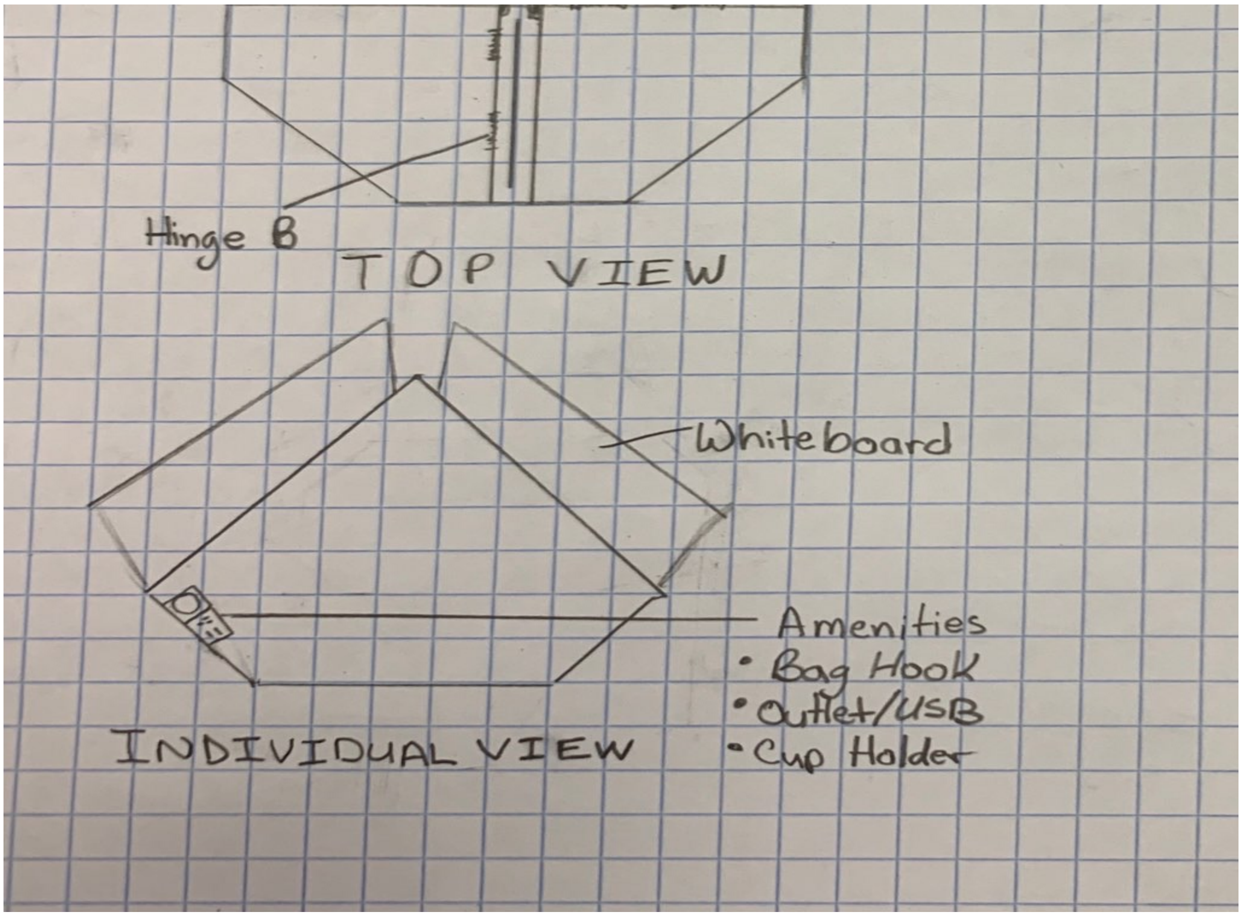


Figure 18. Rough folding table concept sketch.

1.8 Spring Project Plan

Timeline (from last day to start of the semester)

- DR 7 (Final turn in/last day) - 4/29
- Staff Meeting - 4/22
- DR 6 / Engineering Design Day - 4/15
- DR 5 – 3/25
- Finished Table - 3/15
- Spring Break Ends - 3/13
- Spring Break Starts - 3/9
- Testing - 3/5
- Staff Meeting – 3/5
- DR 4 – 2/25
- Start Construction – 2/4
- Order Parts – 1/15
- Prototype - 1/9
- Return from Winter Break – 1/6

Finals

Finals week for Senior Design II is presenting the final product of our design for Engineering Design Day. To make sure we that our design is finalized, we will make sure that our table is safe to use and that the table is fully functional with all the utilities. A demonstration of how the table works will be needed for finals week so we must be sure that our table functions exactly how we want it to.

Engineering Design Day

We will present our final design on engineering design day as a large, informative poster along with a physical prototype of the MeWee table.

Testing

We will have to devise different ways to test all the features of our table. The power supply of the table will be tested using a multimeter. All four outlet/USB-A plugs will be tested to make sure they are supplying the standard power output of 120V at 60Hz. The noise damping effect of the dividers will be tested by placing a microphone on one desk space while playing a sound of consistent volume in the adjacent desk space. The sound levels will be recorded with the dividers in the up and down positions and then the difference taken to arrive at total volume decrease. Total weight of the table will be tested by weighing all components of the final design. Our goal is for the weights to be very similar. Both the productivity and appeal of the table will be tested using a survey. The survey will be sent out to a wide variety of students to get the diverse data for the table. Safety of the table will be tested by finding all the "pinch" points and any place on the table that could cause injury. If possible, the areas we find high risk will be eliminated or remodeled to decrease risk of injury. The final test will be the strength of the table. This will be the last test as it is the most likely to cause a failure. This test will be conducted by increasing the weight on top of the table either until failure or until its strength surpasses the weight capacity we have originally set.

- Total weight of table - lbs
- Test safety
- Test productivity/ appeal - survey
- Test power supply - V and Hz
- Test noise damping - dBA
- Test strength – lbs

Construction

Construction of the table will begin once parts have arrived. All safety measures and PPE will be followed due to the risk that is involved with any power tool usage. We will begin by building the base of the table which will include the housing for the dividers. It will be important to make sure everything is flush to allow for a sturdy and level tabletop. The final part of construction will be building and fitting the tabletop. The top must be smooth and level to provide the correct studying environment.

Materials

Materials for our table will be ordered based off our Bill of Materials. The raw parts will be ordered through an FSU Campus Reimagined supplier in order to follow our budget restrictions. Parts will be ordered earlier in the semester so that if any holds due to special parts or reorders will not affect our time schedule.

Gantt Chart

Table 5

Gantt Chart

	Jan 6 – Jan 24	Jan 25 – Feb 7	Feb 8 – Feb 21	Feb 22 – Mar 6	Mar 7 – Mar 20	Mar 21 – April 3	April 4 – April 17	April 18 – May 1
Prototype								
Order Parts								
Start Construction								
DR 4								
Staff Meeting								
Testing								
Spring Break Starts								
Finished Table								
DR 5								
DR 6 / Engineering Design Day								
Staff Meeting								
DR 7 (Final turn in/last day)								

Chapter Two: EML 4552C

2.1 Restated Project Scope

Project description: Produce a multi-purpose table that supports an efficient work environment for people to do their work together or separate.

Key Goals: Create a cooperative table that is ergonomic, simple, adjustable, and fosters productivity. The table should be able to accommodate at least four people each having their own space for laptops or work.

Primary Market: University libraries where students will use them to do work.

Secondary Market: Coffee shops and social areas where people gather to work.

Assumptions: The table will be intended for college aged students, the outlets are standard 15 amp and 120 volts, and the height of the table will be based on the height of an adult.

Stakeholders: The users of the product are college students as well as people who go to social places to work. The beneficiaries are Dr. McConomy, Mr. Butler, university libraries and coffee shops.

2.2 Results

From the CAD model various data was collected regarding the proposed user experience. The first factor that was analyzed was the proposed separation of individuals spaces. In order to find this, data was collected from Allen (2009) and Taifa & Desai (2016). Allen showed that the average height of a non-adjustable school chair is 18 inches, while Taifa & Desai showed that the average height of a male user sitting is 31.7in. of user with a standard deviation 1.7in., which is shown in Figure 19 and is given by number 2. The male population was considerably taller, so they were held as the higher benchmark since anyone shorter would have increased benefits. The MeWee table measure 52.7in. in height with the divider mechanism engaged. With a standard chair of 18in. and an average male upper body of height of 31.7in. with a standard deviation of 1.7in. allows us to cover 86.6% of the male population and 100% of the female population. This means the eyeline of most users will be covered.

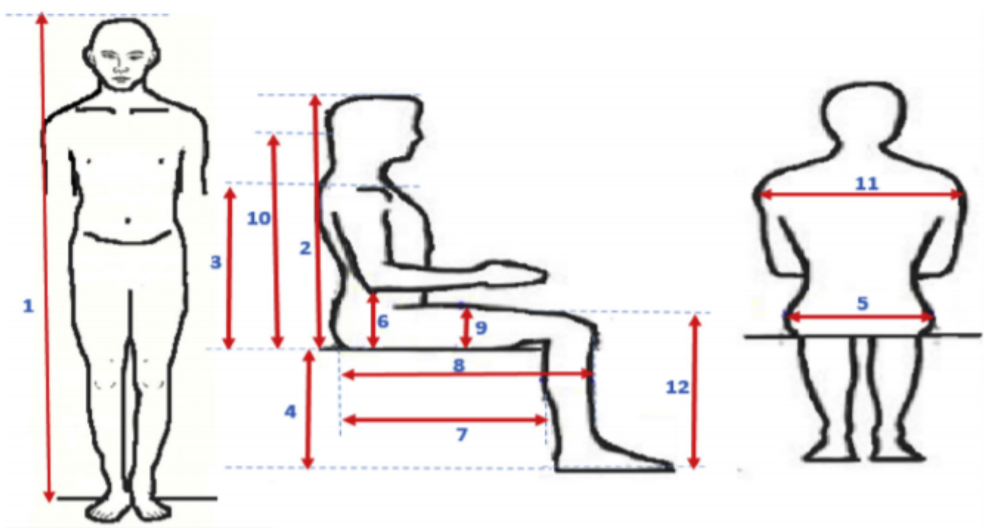


Figure 19. Body length measurements.

The MeWee table was also designed with storage and portability in mind. In this day in age there is a need for a dynamic classroom that allows for tables to be moved and changed based on the class needs (Ruthven Ruthven, Hennessy, & Deaney, 2008). In order to account for this the MeWee table has 8 caster wheels, two on each leg, one with a locking mechanism and one without. The eight wheel allows the force to be evenly distributed and allows for the table to roll easily. In order to be stored the MeWee table was designed to be folded allowing for a drop in unusable volume. When open the MeWee table takes up 65.7ft^3 of space, while as when folded takes up only 10.4ft^3 space, that is a drop of 630.4%. The table is also square in shape allowing to fit snug in various positions, wasting little space. The open configuration can be seen in Figure 20 (on the left) as well as closed configuration (on the right).

Figure 20. Open configuration (left) and closed configuration (right).

The other benefit of the MeWee table is it's added working and writing area. On average a tabletop supports 3.43ft.^{2} of working and writing area. The MeWee has working space of 5.45ft.^{2} normally and 10.25ft.^{2} of writing space when the whiteboard is deployed that 150% more writing space and 300% writing space. For a groups of two setting the whiteboard writing area is the same but the tabletop area is doubled allowing for 10.90ft.^{2} of working space and 15.70ft.^{2} of writing space. The area for individuals and users can be seen in Figure 21.

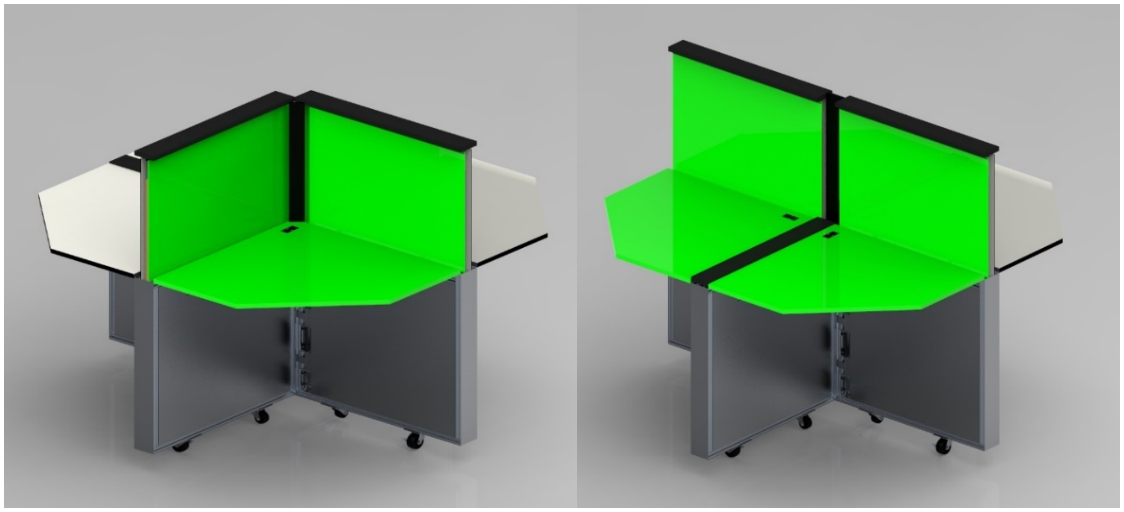


Figure 21. Individual area (left) and 2-person area (right).

2.3 Discussion

Initial Prototypes: Scaled and Full Size

To better understand the chosen foldable table design, a 1/6 scale prototype was constructed. This model's purpose was to establish the functionality of the table's collapsing feature. Despite slight imperfections in the build, such as no scaled locking model for the tabletop and hinge size and spacing, this tiny model made of thin wood help visualize the larger design. The precise sizing of the legs and tabletops would ensure stability and easier assembly of the table. The hinges on this model were very small and intended for crafts, but they revealed the necessity of offsetting one side of each hinge in order to leave space for our tabletops to fold up well with the legs. The positive revelation from this small model was the ability to make the table modular consisting of four identical sections.

The modularity of the table meant that to test out full size features it was only necessary to mockup a quarter of the table. Using plywood and simple cabinet hinges the quarter table was built up to resemble what was wanted in our resultant prototype. Since this model was full size, the height of the table could be reviewed, and a good idea of overall size was achieved. This quarter table module included two legs instead of only one for the purpose of testing a mechanism that would support the second tabletop edge once raised to parallel with the ground. Folding this module allowed for judgment of the leg hinge offset. Another thing this module allowed for was design of the divider raising mechanism. A couple different designs were tested such as a pulley system and a scissor lift type system. Both prototypes overall helped make great progress in implementing the designs into the complete prototype.

Final Design Prototype

Dimensioning

To produce an effective workspace environment for individual and group workers, we produced our unique design that satisfies both workers. The table is 4.54ft. tall with the dividers up and is 5ft. wide across the table. The tabletops are approximately 1.1x30x30in. with one of the corners being chamfered by 21in. Figure 22 shows the drawing of the CAD file we used for our table.

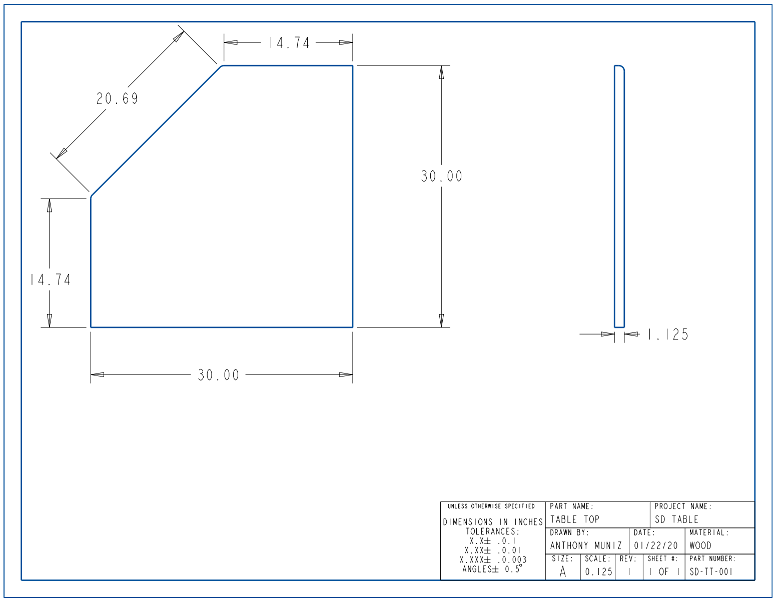


Figure 22. Dimensions of the tabletop.

The chamfer allows for people to be spaced apart more while adjusting line of sight, as well as create additional space for people to use for work. Dimensions of the legs are 3.5x30x29in. Figure 23 is the dimensions of our legs according to the CAD model.

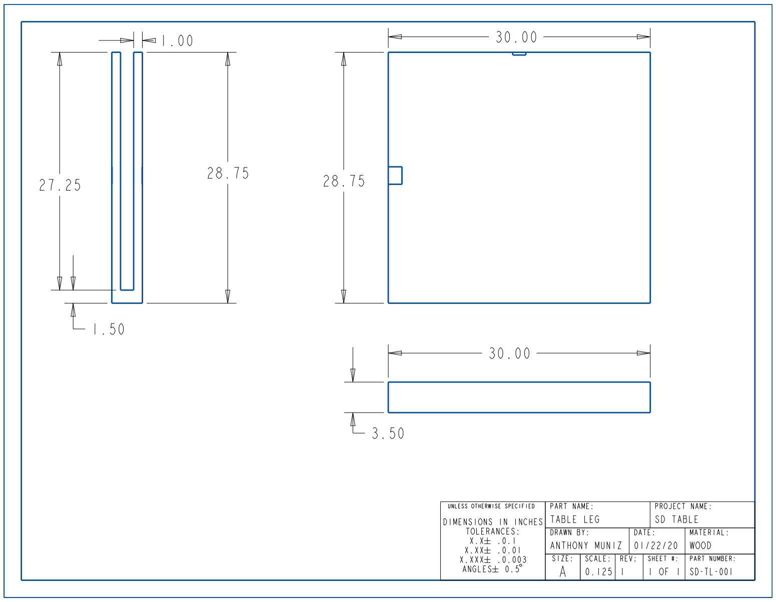


Figure 23. Dimensions of the legs.

The legs of the table are hollow on the inside by 28in. from the top down. This allows for the dividers of our table to rest inside of them. The dividers of the table are measured as 1.5x30x24in. for enough space to do work on. Figure 24 has the dimensions of our dividers.

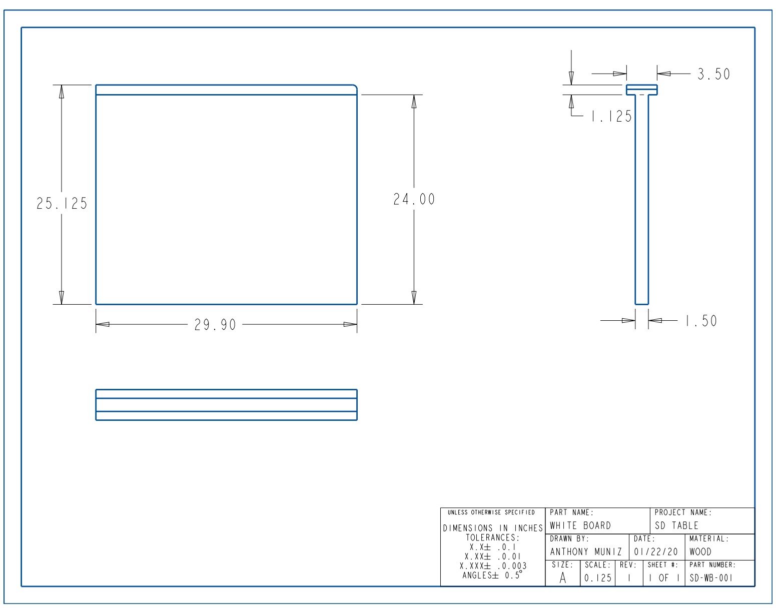


Figure 24. Dimensions of the dividers.

Near the top of the divider is a T-shape cut that is used to sit flush between the sections of the folding tabletops. The T-shape is measured as 1.1x30x3.5in. We wanted our table to be accessible for multiple people at different locations, so we included 8 caster wheels into our design. There are two on each leg with a diameter of 2.36in. Here is an image of our wheels in Figure 25.

Figure 25. Caster wheel.

When the table is in its collapsed form its dimensions are 30x30x20in. which makes it easy to storage. The surface area of the tabletops and two whiteboards are 5.45ft.^{2} and 4.80ft.^{2} respectively with a total of 10.90ft.^{2} for each section. The volume of the table is 113.5ft.^{3} when expanded and 10.44ft^3 when collapsed. In figure 26, the two dividers are up on both sides to display what each section looks like.

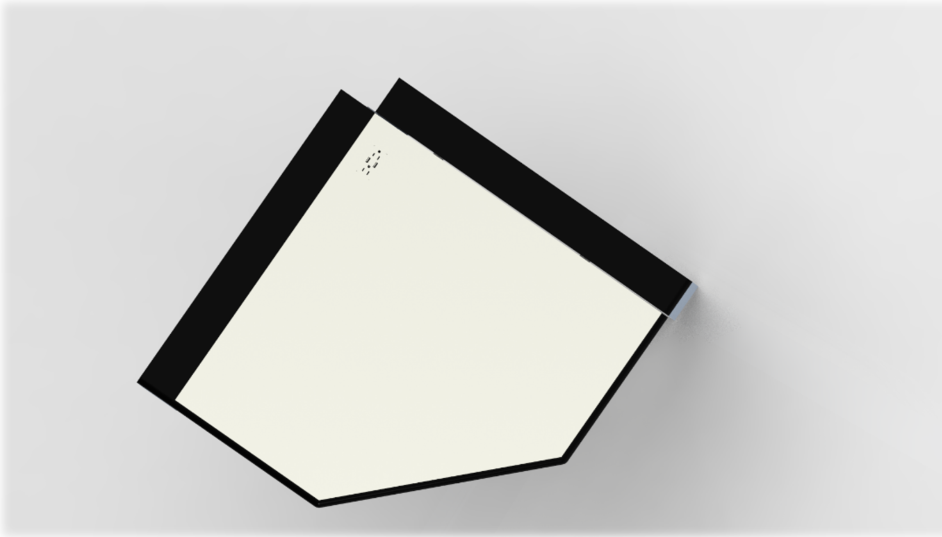


Figure 26. Two dividers and tabletop.

Materials

The reason why we decided to use whiteboards in our dividers is due to the extra drawing space they provide for people, and the promotion of group work. Another option that we considered using as dividers was sound dampening dividers, that reduce the noise surrounding the table, but would not be of very much help to the background noise.

For the legs of the table we decided to make them out of aluminum 80/20 because it is a strong, light material to use as legs. It has T-Slot aluminum profiles with channels used to connect other bars and parts to extend and collapse with. With this material, our table's legs are sturdy and adjustable with no welding required. This is especially important for stability reasons; other alternatives considered did not promote a stable frame unlike 80/20.

For the wheels of the table, we chose rubber caster wheels since they are semi-shock-absorbing, provide good traction on smooth or rough surfaces, and are non-marking. There will be four regular swivel wheels and four locking swivel wheels to lock the table in place. To engage the lock, apply pressure to the wheel to stop movement with a press of the foot.

The tabletops of our table are made from MDF Melamine Board. The reason why we choose this material is due to its low price and ease of putting screws and hinges in. For the tabletops of our table to work how we want them to, we would need to fold and support weight so MDF meets all our requirements. Other alternatives we proposed using were high density polyethylene (HDPE) and polycarbonate. Although they had a better, more glossy appearance and higher tensile strength, we were swayed away from these alternatives after discovering they were close to 40 percent of the budget and had to be custom ordered which implicated too long of delivery time.

Operation

This table is designed to be simplistic for both use and operation. First you wheel the table to its intended destination in its closed or storage setting. Next you pull the legs apart until they lock into place at 90 degrees. Pull apart all the legs to make a cross before lifting the tabletops. Don't forget to lock the wheels in place so the legs will not move. Next lift the tabletops. They will swing up on hinges and lock into place at 90 degrees making a flat surface. The extra supports are swung outwards to help support the top. Then the dividers are released by a spring-loaded pin. The dividers will then lock into place by the same spring-loaded pin at the top or open position. Repeat all steps for all four legs and the table will then be in its fully open and individual work setup setting. As students or workers fill the tables, they can choose to push down the dividers to create group work setup setting. If the table needs to be moved a few feet simply unlock the wheels and push the table to where it needs to go. If you intend to move the table through doorways or elevators or you intend to store it to use later than the table will need to be closed first. To do this the dividers need to be lowered and locked into their down position. The supports for the tabletop need to be pushed back into their tucked away position and the hinges for the tabletops need to be unlocked. Repeat this for each section before you close the legs together. Unlock the wheels and push the legs back together to enter the closed or storage setting. The steps can be seen below in Figure 27.

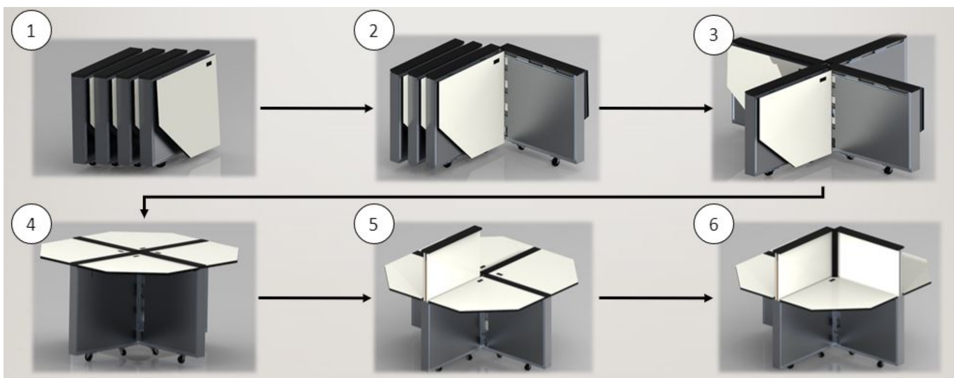


Figure 27. Steps to open the table.

Legs.

The legs of the table are made up of 80/20 aluminum frames on 360 degrees swivel rubber caster wheels. There are four legs in total that are attached together at the rear by inlaid 90 degrees locking hinges. Once the legs are pulled apart, they will swing on their hinges outward reaching 90 degrees form the leg it is attached to. This is repeated until the legs are locked in a cross setting. Each leg also houses a divider and has the tabletop attached to its face.

Tabletops.

The tabletops are MDF that is attached to the front side of each leg for a total of four tabletops. Each top lifts on a hinge support that locks at 90 degrees. On the rear side of each legs are swivel support arms that swing out towards the center of the tabletop to provide more support for the tops. The tabletops also house the charging components of the table.

Dividers.

The dividers are constructed by attaching two whiteboards back to back on a wooden frame that is then topped with a section of MDF board that is as thick as the tabletops. Underneath the dividers are the lifting mechanism that provides the forces to lift the dividers unassisted. The mechanism consists of a gas strut and steel bar that are set up in a scissor type four bar linkage. Once the divider is released by the spring-loaded pin the divider is then lifted by the gas strut. As the divider lifts the steel rod slides in a track to help provide support and remove bending and twisting moments. The divider is then locked again by the same spring-loaded pin but this time in the up position. When it is desired to have the dividers down for a group setting simply pull the spring-loaded pin and push the dividers down. Once at the bottom position there will be a click when the pin springs back into place signaling the dividers are locked in the down position

Electronics.

The table houses four power outlets that are each cable of supplying power to two standard outlets and two USB outlets. Each section of the table will have its own outlet near the center of the table. The outlet is set flush to the tabletop and the cords are run out the back through a conduit. The conduit travels through the slotted section of the 80/20 frame and travels down near the center of the open table. Each section then converges together to connect to one standard US plug that can be plugged into any standard outlet.

2.4 Conclusions

Despite not being able to finish constructing the table, we were able to create a valid simulation of how it would look and operate. Our simulation demonstrates how intuitive our design is with all its components based around supporting an efficient workspace. The dimensions of our table were designed to ensure that each section provides enough room and writing space for people to work comfortably. The materials of the table were chosen to guarantee the table is strong enough to support any accidental loading and light enough to collapse and move around. Operation is reasonable and intuitive so that anyone can set up the table to use. The MeWee table can satisfy all types of workers with its unique design and components in order to create an efficient working environment for wherever it is located. With this table, libraries and other social areas will have a flexible space for use by people to be more productive.

2.5 Future Work

Because the physical table prototype was left unfinished, the first thing needing completion is the build. Before this can be done, we must finish acquiring the final materials necessary to complete the build, such as the individual parts needed for the whiteboard divider mechanism, and the whiteboards themselves. Once this has been fully assembled any previously unforeseen errors in the build are able to be corrected.

There are some design improvements that could be implemented to improve the table. The first major change that could be made is using a hollow aluminum frame for the legs instead of the chosen 80/20 framing. This change would reduce the total cost of the table and remove many extra parts that were needed to assemble the 80/20 pieces.

The swivel arms that support the tabletop once it is raised are not ideal to access, with the user having to reach under the table to move them out into their support position. With a simple actuation mechanism, moving these arms out from their stored position could be as simple as the push of a button on the outer edge of the leg.

There were a few less important features that were not added to the table's design because of time constraints, but they would improve user experience if added. These include bag hooks on the outer edge of each leg, handles for helping to move the table on its wheels, and wireless charging pads integrated into each tabletop.

In its entirety, the design could be made quite a bit simpler mechanically. Less moving parts and static parts in general makes for a shorter list of possible replacement parts and a less complicated user experience. With all these changes the table would be more cohesive and suited for mass production.

References

Allen, Crimson. (2009). *Selecting the correct height school chair* School Furniture blog

Ruthven, K., Hennessy, S., & Deaney, R. (2008). *Constructions of dynamic geometry: A study of the interpretative flexibility of educational software in classroom practice*. Great Britain: Elsevier Science B.V., Amsterdam. Retrieved from https://login.proxy.lib.fsu.edu/login?url=http://search.ebscohost.com.proxy.lib.fsu.edu/login.aspx?direct=true&db=edsbl&AN=RN230119671&site=eds-live&scope=site

Taifa, I. W., & Desai, D. A. (2017). *Anthropometric measurements for ergonomic design of students' furniture in India* Elsevier B.V. doi:10.1016/j.jestch.2016.08.004.

Appendices

Appendix A: Code of Conduct

Mission Statement: Our mission is to simplify the utilization of space for the individual or group in a safe, ergonomic, and effective manner.

Team Roles:

Alec Ellis: Project Manager/Human Factors Engineer

Kyle Innis: Geometric Integration Engineer

Anthony Muniz: Mechanical Systems Engineer

Rieley O'Brien: Systems Engineer

Lauren Smith: Materials Science Engineer

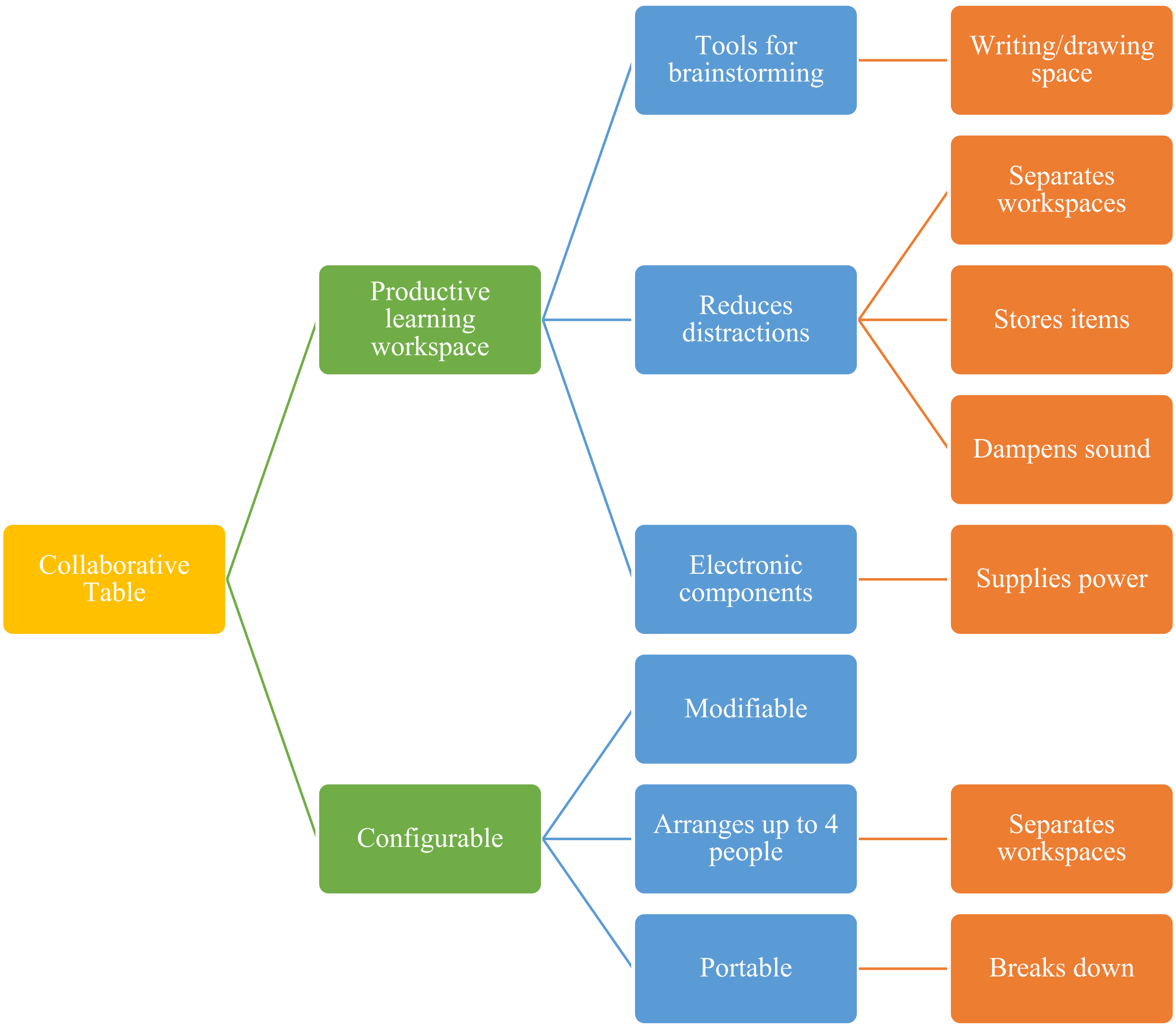
Communication: Team members will communicate via What's App for messages and will use email to receive information or work. Google Docs will be used when necessary for team shared documents. Each member provides their class schedule so that everyone knows when they are available. A meeting date and time will be established for team members to come together to collaborate whenever all, or most, members are free. Members will check their email at least twice a day for messages or notifications. An appropriate max delay in response is 24 hours after a specific member was messaged either through messages or email.

Dress Code: For sponsor/advisor meetings, casual outfits will be worn by team members unless otherwise specified 24 hours in advance. Presentation dress will be business professional attire for all members. Business professional will be defined as neutral color suits and ties for men and a dress/blazer for women.

Attendance Policy: Attendance for scheduled group meetings is required for every group member except for external issues such as sickness or a death in the family. Attendance will be kept by the project manager and note will be taken of why a specific member could not attend. External resolution will be sought after one or multiple group members have not attended multiple meetings without a valid reason.

Statement of Understanding: Each member of the team will adhere to the standards set forth by the Code of Conduct. Any member who strays from upholding the conduct of the group will be first confronted by the group and if necessary be brought to Dr. McConomy for further consultation.

Appendix B: Functional Decomposition

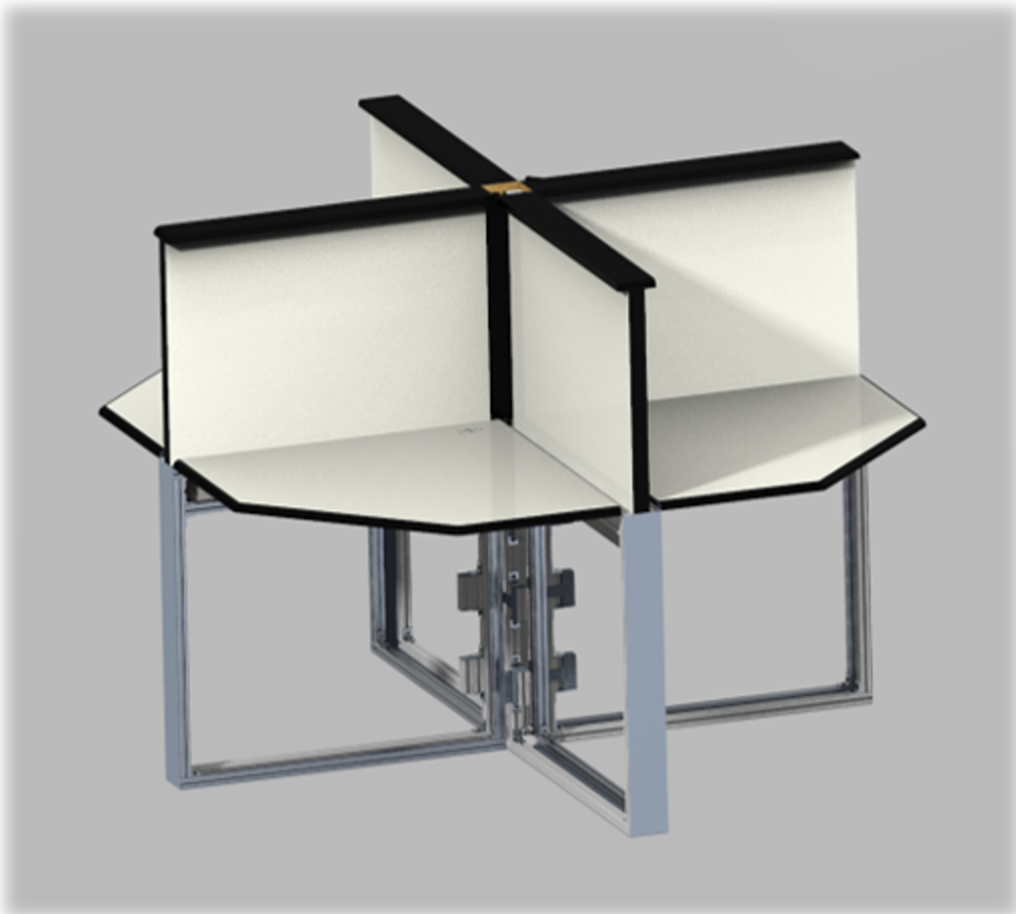


Appendix C: Target Catalog

Function	**Target**	**Metric**	**Tools**
Writing/Drawing Space	A whiteboard that is 720cm^2 in size	Size (cm^2)	Tape measure
Separates Workspace	Each section of the table will be 0.5m^2	Size (m^2)	Tape measure
Stores Items	Storage space is 280cm^2	Size (cm^2)	Tape measure
Dampens Sound	Dampen sound to within 20-40 dBA	Sound energy	Microphone
Supplies Power	Provides 120 Volts at 60 Hz	Electric potential (V and Hz)	Multimeter
Innovative	The table is inviting to the public	Opinion (survey)	Survey what people think of the table
Compactable	Reduce size to 75% of the original size	Size (m^3)	Tape measurer
	Weighs no more than 40kg	Size (kg)	Scale
	Covers between 1.5m^2-3m^2	Size (m^2)	Tape measure
	Supports 350 kg	Weight (kg)	Scale

Appendix D: Operation Manual

<u>MeWee Table Operation Manual</u>



The MeWee Table is used to optimize all available library space by creating table spaces for use by individuals or groups to accomplish work. The table seats four individuals and configures to provide either four individual spaces, a collaborative full-size table, or variations in between. The table is on wheels and is collapsible to less than 25% size of its fully open configuration for ease of mobility and storage.

Necessary Physical Prototype Completions

- Holes cut in each tabletop for power receptacles.
- Slot cut in tabletop edges for plastic stripping.
- Whiteboard ordered and pieces cut and sandwiched.
- Legs machined for hinges to create seamless opening and closing
- Scissor lift assembled

Bill of Materials

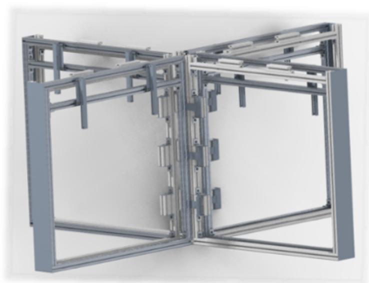
Parts	Qty
Aluminum T-Slotted Framing 30”	12
Aluminum T-Slotted Framing 28”	8
Aluminum T-Slotted Framing 27.75”	8
Aluminum T-Slotted Framing 26.75”	8
Aluminum T-Slotted Framing 5”	8
Aluminum T-Slotted Framing 1.5”	16
Whiteboard 0.25”x26”x30”	8
Medium Density Fiberboard (MDF) 30”x30”	4
Multi-position Foldaway Shelf Bracket - 12”	8
Straight Blade Power Receptacle with 2 USB-A Ports	4
Gas Spring - 29.49” Extended Length	4
Polyethylene Plastic Trim - Push-in Stem - 0.75”x10ft	1
Cart-Smart Caster Wheel - Swivel with Brake - 2.5” Diameter Wheel	4
Cart-Smart Caster Wheel - Swivel - 2.5” Diameter Wheel	4
T-Slotted Framing Rail-to-Panel Guide Slider	16

Parts	Qty
Retractable Roller Blind	4
Strap Hinge	12
8” Tension Spring	4
2-Hole Inside Corner Bracket	88
T-Nuts	192
0.25”x3” Bolt	8
0.25” Nut	8
0.25”x25” Steel Bar	4
Aluminum Flashing 3.5”x87.5”	4

Table Components / Modules

Some of the modules of the table include collapsible legs, power outlets for each section, a retractable roller blind, and wheels for the legs. The legs can collapse into themselves by having multiple hinges that can extend up to 90 degrees. This allows each section of the table to folds roughly to 30”x30”x20”. Two outlets and two USB connections are available for each section of the table and are powered by a 120 V outlet connection. The retractable roller blind is used to close a gap across each section of the table to prevent eye contact. Each leg has two caster wheels attached near the front and back of the leg for the table to be transportable.

An extremely important module for the MeWee table is the whiteboard divider that separates each section. When all whiteboards are in the down position, they are kept in a T-slot aluminum frame that keeps them within the legs of the table. When the whiteboards are in the up position, they are raised by a scissor lift mechanism that uses a gas strut and spring system to keep the whiteboard in tension. The dividers are locked in the top and bottom position using spring loaded pins, which allows them to raise while the individual remains seated.



Assembly

Each leg section is built up entirely from sections of the aluminum 80/20. The legs can be broken into two, the left and right leg. Together they make up a quarter of the leg section of the table. There are four of these quarter sections to make a table. The 80/20 bars that make up the sections of tables are attached together at intersections with L-brackets and nuts specifically designed for the T-slots in the aluminum 80/20.

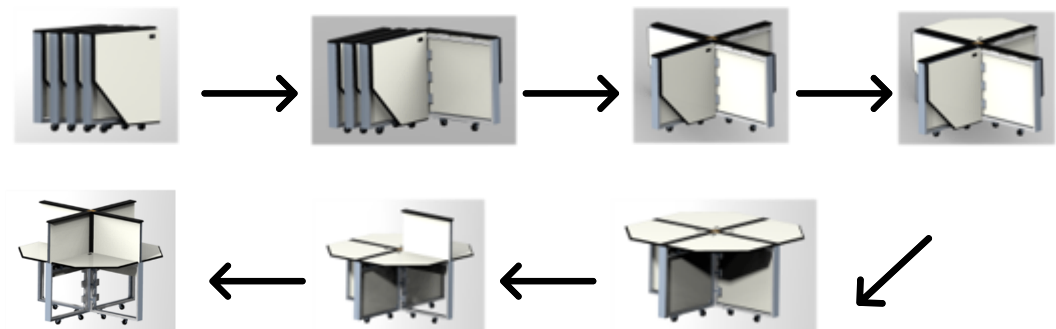
Two small swivel arms made of the 80/20 are bolted through the top of the left leg. On the right leg, two 90-degree locking shelf brackets are bolted to the top bar and a lower cross bar. In order to lift the whiteboard a gas strut and arm are bolted to the bottom on the inside of each leg frame. A tension spring is attached at the top end of the arm. Sliders are attached to both sides of the whiteboard divider which allow for the dividers to slide within the slotted sections of the aluminum 80/20. The bottom of the divider then attaches to the end of the spring, arm, and gas strut.

In order to increase mobility a pair of swiveling caster wheels are attached with bolts to the bottom the leg section. The caster wheel on the leading or outside edge will be a locking wheel so the table will stay in place when locked. Because the table is modular each section will be built the same way.

Each power receptacle is screwed into each dedicated tabletop cutout. The tabletops are then attached with screws to the top of each pair of shelf brackets on each leg. With the table fully opened, the wires from each power receptacle are joined to a single cable with 3-prong plug and this is run down into the center of the table or backside when the table is in its closed position.

Setup and Operation

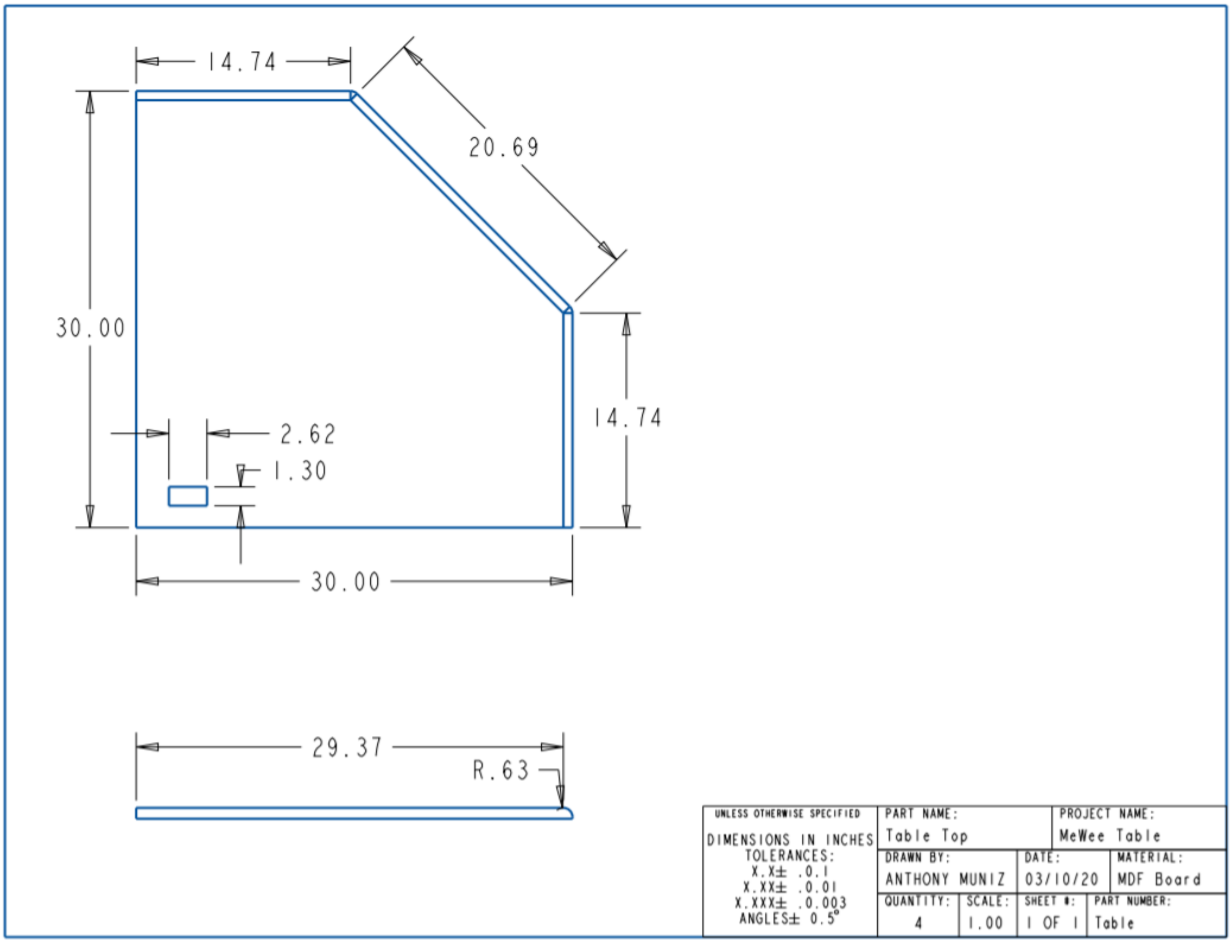
The table must be located by a floor outlet and plugged in via its main power cable. Once this is done, the first leg can be rotated 90 degrees until the hinges stop its motion. From here the next leg can be rotated to 90 degrees and then the final leg. Once the legs are setup, the outside wheels can be locked. The tabletops for each section can now be lifted to parallel with the ground and should lock. The swivel arms on the opposite leg can be swung out to support this opposite edge of the tabletop. The whiteboard dividers for each section of the table can now be raised one-by-one by pulling the locking pin on the outside of the leg. The divider will begin to raise on its own and once at full height can be locked into place with the same pin. The table is now in its fully opened form and can be modified for different workspace layouts by lowering or keeping raised the individual whiteboard dividers. This same process is done in reverse to close the table into its smallest form for either transportation or storage.

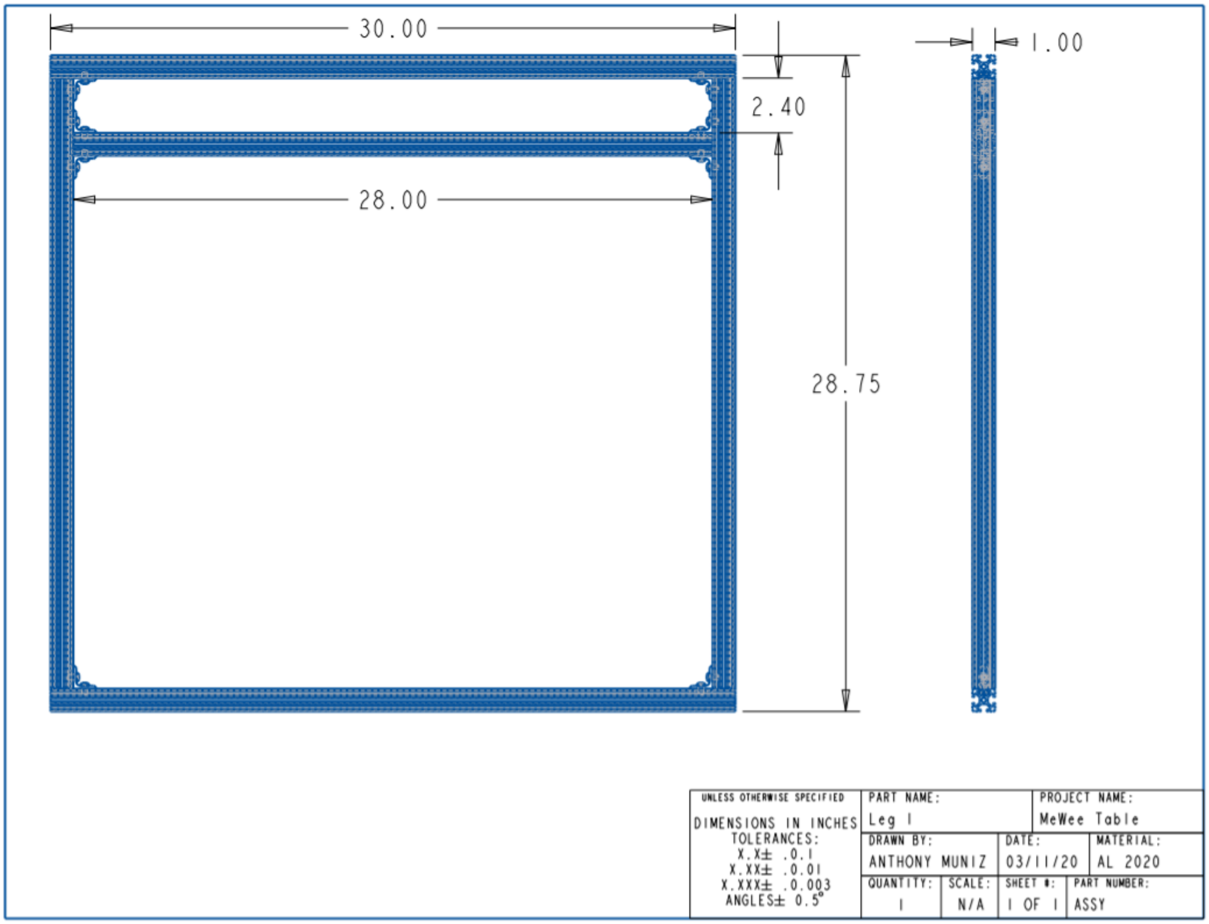


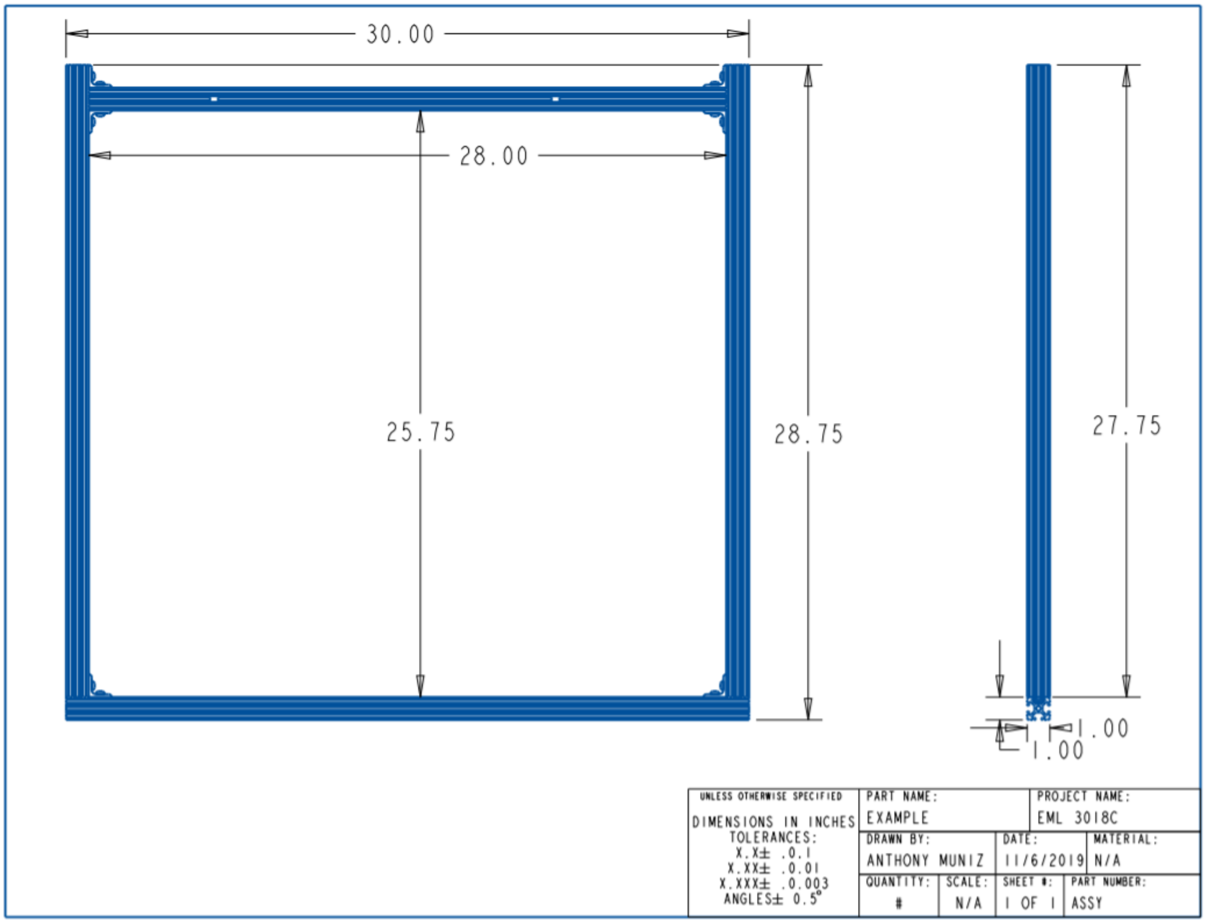
Troubleshooting

Issue	Solution(s)
Spring in scissor lift whiteboard mechanism has broken.	Whiteboard divider can be detached from the mechanism and spring replaced.
Gas spring is frozen.	Remove gas spring from assembly after removing whiteboard divider and provide lubrication. Otherwise, replace gas spring.
Shelf hinges no longer lock at their 90-degree extended position.	Remove tabletop from hinges and then remove hinge from leg.
Whiteboard stuck in down position.	It is possible one of the sliders has become wedged or broken. These can be replaced if disassembled
Table no longer rolls.	Check to make sure all wheel locks are off. If wheel is seized remove and lubricate. If this does not work replace the wheel.
Power receptacle no longer provides power.	Test receptacle with multimeter. Check main power outlet table is plugged into. Check wiring for pinches. If still no power replace broken receptacle.

Appendix E: Engineering Drawings

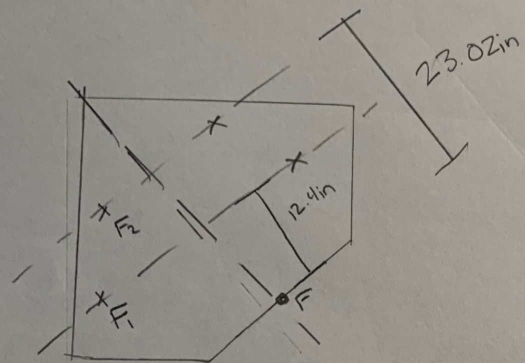



30.00
1.00
2.40
28.00
28.75
UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES:
X.X± .0.1
X.XX± .0.01
X.XXX± .0.003
ANGLES± 0.5°
PART NAME:
Leg 1
PROJECT NAME:
MeWee Table
DRAWN BY:
ANTHONY MUNIZ
DATE:
03/11/20
MATERIAL:
AL 2020
QUANTITY:
1
SCALE:
N/A
SHEET #:
1 OF 1
PART NUMBER:
ASSY


30.00
28.00
25.75
28.75
27.75
1.00
1.00
UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES:
X.X± .0.1
X.XX± .0.01
X.XXX± .0.003
ANGLES± 0.5°
PART NAME:
EXAMPLE
PROJECT NAME:
EML 3018C
DRAWN BY:
ANTHONY MUNIZ
DATE:
11/6/2019
MATERIAL:
N/A
QUANTITY:
#
SCALE:
N/A
SHEET #:
1 OF 1
PART NUMBER:
ASSY

Appendix F: Calculations

Force



$$F_{y,max} = F_1 + F_2$$

$$F_1 = F_2\left(\frac{23.02in}{12.4in}\right)$$

$$F_{y,max} = F_1 + \left(\frac{12.4in}{23.02in}\right)F_1$$

$$F_{1,max} = 375lbf$$

$$F_{y,max} = 375lbf + \left(\frac{12.4in}{23.02in}\right)375lbf$$

$$F_{y,max} = 580.2lbf$$

Appendix G: Risk Assessment

Risk assessment document scans begin on the following page.

Project Hazard Assessment Worksheet				
PI/instructor: Dr. McConomy	Phone #: 850-410-6624	Dept.: ME	Start Date: 09-10-19	Revision number: 1
Project: CRI MeWee Table			Location(s): FAMU-FSU College of Engineering	
Team member(s): Alec Ellis, Kyle Innis, Anthony Muniz, Rieley O'Brien, Lauren Smith			Phone #: 772-341-7859	Email: ace16e@my.fsu.edu

Experiment Steps	Location	Person assigned	Identify hazards or potential failure points	Control method	PPE	List proper method of hazardous waste disposal, if any.	Residual Risk	Specific rules based on the residual risk
CAD prototype/physical prototype our design	FAMU-FSU College of Engineering	Anthony, Alec	- Slips, trips, falls	Engineering control	N/A	N/A	HAZARD:1 CONSEQ: negligible Residual: Low	Safety controls are planned by both the worker and supervisor. Proceed with supervisor authorization.
Select and order materials for design	FAMU-FSU College of Engineering	Lauren, Kyle	N/A	N/A	N/A	N/A	HAZARD:1 CONSEQ: negligible Residual: Low	Safety controls are planned by both the worker and supervisor. Proceed with supervisor authorization.
Machining of necessary materials	FAMU-FSU College of Engineering	Rieley, (others if needed)	(if done by group members) - Physical - Entangled by	Engineering control	Gloves, safety glasses	N/A	HAZARD:3 CONSEQ: minor Residual: Low Med	Safety controls are planned by both the worker and supervisor. A second worker must be in place before work can proceed (buddy system). Proceed with supervisor authorization.
Design construction	FAMU-FSU College of Engineering	Alec, Anthony, Kyle, Lauren, Rieley	- Physical - Slips, trips, falls	Administrative control	Safety glasses, closed toe shoes	N/A	HAZARD:3 CONSEQ: minor Residual: Low Med	Safety controls are planned by both the worker and supervisor. A second worker must be in place before work can proceed (buddy system). Proceed with supervisor authorization.
Design testing and revision	FAMU-FSU College of Engineering	Alec, Anthony, Kyle, Lauren, Rieley	- Physical - Slips, trips, falls	Administrative control	Safety glasses	N/A	HAZARD:2 CONSEQ: negligible Residual: Low	Safety controls are planned by both the worker and supervisor. Proceed with supervisor authorization.

Principal investigator(s)/ instructor PHA: I have reviewed and approved the PHA worksheet.

Name	Signature	Date	Name	Signature	Date

Team members: I certify that I have reviewed the PHA worksheet, am aware of the hazards, and will ensure the control measures are followed.

Name	Signature	Date	Name	Signature	Date
Alec Ellis	Alec Ellis	11/14/19	Anthony Muniz	A. Muniz	11/14/19
Ricley O'Brien	Ricley O'Brien	11/14/19	Lauren Smith	L. Smith	11/14/19
Kyle Innis	Kyle Innis	11/14/19			

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DEFINITIONS:

Hazard: Any situation, object, or behavior that exists, or that can potentially cause ill health, injury, loss or property damage e.g. electricity, chemicals, biohazard materials, sharp objects, noise, wet floor, etc. OSHA defines hazards as *"any source of potential damage, harm or adverse health effects on something or someone"*. A list of hazard types and examples are provided in appendix A.

Hazard control: Hazard control refers to workplace measures to eliminate/minimize adverse health effects, injury, loss, and property damage. Hazard control practices are often categorized into following three groups (priority as listed):

1. **Engineering control:** physical modifications to a process, equipment, or installation of a barrier into a system to minimize worker exposure to a hazard. Examples are ventilation (fume hood, biological safety cabinet), containment (glove box, sealed containers, barriers), substitution/elimination (consider less hazardous alternative materials), process controls (safety valves, gauges, temperature sensor, regulators, alarms, monitors, electrical grounding and bonding), etc.
2. **Administrative control:** changes in work procedures to reduce exposure and mitigate hazards. Examples are reducing scale of process (micro-scale experiments), reducing time of personal exposure to process, providing training on proper techniques, writing safety policies, supervision, requesting experts to perform the task, etc.
3. **Personal protective equipment (PPE):** equipment worn to minimize exposure to hazards. Examples are gloves, safety glasses, goggles, steel toe shoes, earplugs or muffs, hard hats, respirators, vests, full body suits, laboratory coats, etc.

Team member(s): Everyone who works on the project (i.e. grads, undergrads, postdocs, etc.). The primary contact must be listed first and provide phone number and email for contact.

Safety representative: Each laboratory is encouraged to have a safety representative, preferably a graduate student, in order to facilitate the implementation of the safety expectations in the laboratory. Duties include (but are not limited to):

- Act as a point of contact between the laboratory members and the college safety committee members.
- Ensure laboratory members are following the safety rules.
- Conduct periodic safety inspection of the laboratory.
- Schedule laboratory clean up dates with the laboratory members.
- Request for hazardous waste pick up.

Residual risk: Residual Risk Assessment Matrix are used to determine project's risk level. The hazard assessment matrix (table 1) and the residual risk assessment matrix (table2) are used to identify the residual risk category.
The instructions to use hazard assessment matrix (table 1) are listed below:

1. Define the workers familiarity level to perform the task and the complexity of the task.
2. Find the value associated with familiarity/complexity (1 – 5) and enter value next to: HAZARD on the PHA worksheet.

Table 1. Hazard assessment matrix.

		Complexity		
		Simple	Moderate	Difficult
Familiarity Level	Very Familiar	1	2	3
	Somewhat Familiar	2	3	4
	Unfamiliar	3	4	5

The instructions to use residual risk assessment matrix (table 2) are listed below:

1. Identify the row associated with the familiarity/complexity value (1 – 5).
2. Identify the consequences and enter value next to: CONSEQ on the PHA worksheet. Consequences are determined by defining what would happen in a worst case scenario if controls fail.
   a. Negligible: minor injury resulting in basic first aid treatment that can be provided on site.
   b. Minor: minor injury resulting in advanced first aid treatment administered by a physician.
   c. Moderate: injuries that require treatment above first aid but do not require hospitalization.
   d. Significant: severe injuries requiring hospitalization.
   e. Severe: death or permanent disability.
3. Find the residual risk value associated with assessed hazard/consequences: Low –Low Med – Med– Med High – High.
4. Enter value next to: RESIDUAL on the PHA worksheet.

Table 2. Residual risk assessment matrix.

Assessed Hazard Level	**Consequences**				
	Negligible	Minor	Moderate	Significant	Severe
5	Low Med	Medium	Med High	High	High
4	Low	Low Med	Medium	Med High	High
3	Low	Low Med	Medium	Med High	Med High
2	Low	Low Med	Low Med	Medium	Medium
1	Low	Low	Low Med	Low Med	Medium

Specific rules for each category of the residual risk:

Low:
- Safety controls are planned by both the worker and supervisor.
- Proceed with supervisor authorization.

Low Med:
- Safety controls are planned by both the worker and supervisor.

- A second worker must be in place before work can proceed (buddy system).
- Proceed with supervisor authorization.

Med:

- After approval by the PI, a copy must be sent to the Safety Committee.
- A written Project Hazard Control is required and must be approved by the PI before proceeding. A copy must be sent to the Safety Committee.
- A second worker must be in place before work can proceed (buddy system).
- Limit the number of authorized workers in the hazard area.

Med High:

- After approval by the PI, the Safety Committee and/or EHS must review and approve the completed PHA.
- A written Project Hazard Control is required and must be approved by the PI and the Safety Committee before proceeding.
- Two qualified workers must be in place before work can proceed.
- Limit the number of authorized workers in the hazard area.

High:

- The activity will not be performed. The activity must be redesigned to fall in a lower hazard category.

Appendix A: Hazard types and examples

Types of Hazard	**Example**
Physical hazards	Wet floors, loose electrical cables objects protruding in walkways or doorways
Ergonomic hazards	Lifting heavy objects Stretching the body Twisting the body Poor desk seating
Psychological hazards	Heights, loud sounds, tunnels, bright lights
Environmental hazards	Room temperature, ventilation contaminated air, photocopiers, some office plants acids
Hazardous substances	Alkalis solvents
Biological hazards	Hepatitis B, new strain influenza
Radiation hazards	Electric welding flashes Sunburn
Chemical hazards	Effects on central nervous system, lungs, digestive system, circulatory system, skin, reproductive system. Short term (acute) effects such as burns, rashes, irritation, feeling unwell, coma and death. Long term (chronic) effects such as mutagenic (affects cell structure), carcinogenic (cancer), teratogenic (reproductive effect), dermatitis of the skin, and occupational asthma and lung damage.
Noise	High levels of industrial noise will cause irritation in the short term, and industrial deafness in the long term.
Temperature	Personal comfort is best between temperatures of 16°C and 30°C, better between 21°C and 26°C. Working outside these temperature ranges: may lead to becoming chilled, even hypothermia (deep body cooling) in the colder temperatures, and may lead to dehydration, cramps, heat exhaustion, and hyperthermia (heat stroke) in the warmer temperatures.
Being struck by	This hazard could be a projectile, moving object or material. The health effect could be lacerations, bruising, breaks, eye injuries, and possibly death.

Crushed by	A typical example of this hazard is tractor rollover. Death is usually the result
Entangled by	Becoming entangled in machinery. Effects could be crushing, lacerations, bruising, breaks amputation and death.
High energy sources	Explosions, high pressure gases, liquids and dusts, fires, electricity and sources such as lasers can all have serious effects on the body, even death.
Vibration	Vibration can affect the human body in the hand arm with `white-finger' or Raynaud's Syndrome, and the whole body with motion sickness, giddiness, damage to bones and audits, blood pressure and nervous system problems.
Slips, trips and falls	A very common workplace hazard from tripping on floors, falling off structures or down stairs, and slipping on spills.
Radiation	Radiation can have serious health effects. Skin cancer, other cancers, sterility, birth deformities, blood changes, skin burns, and eye damage are examples.
Physical	Excessive effort, poor posture and repetition can all lead to muscular pain, tendon damage and deterioration to bones and related structures
Psychological	Stress, anxiety, tiredness, poor concentration, headaches, back pain and heart disease can be the health effects
Biological	More common in the health, food and agricultural industries. Effects such as infectious disease, rashes and allergic response.