FALL 2020

PRODUCT DESIGN SPECIFICATION

PREPARED BY

ASCEND

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ABOUT ASCEND: MEET THE TEAM

WE ARE ASCEND

A team of designers and engineers with a vision for people to ascend to an increased state of work-related productivity while staying in touch with nature

The following report details the design process over the extent of the MAE 4340/4341 Innovative Product Design via Digital Manufacturing Fall 2020 semester. Team members equally divided work between themselves and collaborated for many sections. Names and pictures are included below:

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1 PRODUCT DESCRIPTION EXECUTIVE SUMMARY

1.1. Product Name

1.2. Basic Functions

1.3. Special Features

1.4. Key Performance Targets

1.5. Service Environment Conditions

1.6. Prediction of Misuse Cases

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1.1 PRODUCT NAME

Our product is an innovative chair-desk-backpack combination called VenturePak. Through this product, we aim to make working outdoors more comfortable, accessible, and enjoyable for all.

1.2 BASIC FUNCTIONS

The VenturePak serves as a compact backpack combined with a foldable chair and a desk. This product:

- Allows the user to carry all their work materials safely wherever they go.
- Serves as a portable yet sturdy chair that can be used anywhere.
- Contains a detachable desk that can be brought along and used as a workstation, or left behind if the user does not require it.
- Offers the user a portable workspace which can be used outside in nature, allowing them to connect with the outdoors.

1.3 SPECIAL FEATURES

The VenturePak has been thoughtfully designed, and has the following features that ensure the users' comfort and enhance their productivity:

- Lightweight and compact design for ease of portability.
- Sturdy yet ergonomic chair design to ensure safety and comfort.
- Detachable desk to afford flexibility to the user.
- Adjustable desk height to make the product accessible for different users.
- Padded back and straps for comfort while carrying.

1.4 KEY PERFORMANCE TARGETS

The VenturePak meets the following key performance targets:

- Unfolding the VenturePak into the chair configuration and assembling the desk must not take more than 20 seconds.
- VenturePak must be able to support 400lbs, which is twice the weight of an average-sized adult.
- The chair and desk must be stable during use, even in uneven outdoor terrain.
- The telescoping legs of the desk must not retract during use.
- The backpack must be strong enough to carry the weight of the user's materials in addition to the weight of the collapsed chair frame and desk.

1.5 SERVICE ENVIRONMENT CONDITIONS

The VenturePak is intended to be used outdoors in nature, but can be used anywhere the user would like to work. VenturePak is designed for use in a variety of locations, including but not limited to parks, backyards, camping grounds, hiking trails and office complexes.

The chair and desk legs for the VenturePak are serviceable at different terrains, including damp, uneven surfaces as seen in parks and open fields, sandy grounds at beaches or hard indoor flooring.

The VenturePak backpack is water-resistant and can keep the contents inside dry for short periods during rains, though exposure to rain for over 30 minutes is not recommended. The aluminum frame of the chair, legs and table legs are not expected to undergo corrosion from expected short-term moisture exposure, and not expected to expand or contract due to temperature changes by amounts that would affect performance. The product is suitable for all temperatures and climates where it is possible to be outdoors for prolonged periods.

The VenturePak is expected to be stored indoors when not in use for long periods of time, away from direct sunlight to prevent color fading.

1.6 PREDICTION OF MISUSE CASES

Although the VenturePak has been designed to provide a comfortable user experience in a variety of situations, the following misuse cases have been identified:

- A user exceeding the safe weight limit for either the chair or the desk of the VenturePak
- VenturePak being used on very steep inclines where the product can tip forward or slip
- Not fully opening the legs when converting the VenturePak into its chair configuration, causing the legs to close up on themselves as the user sits down.
- Not securing the desk legs' locking mechanism before beginning work, causing them to collapse upon load application.
- Not properly stowing the collapsed chair legs, causing the fabric flap of the backpack getting caught in the frame and being unable to be zippered shut.
- Not properly attaching the collapsed desk to the chair frame when converting to backpack mode, causing the desk to become unsecured while the backpack is being carried.

1.7 PICTURES OF CONCEPT

Fig. 1.7.1. Isometric view of VenturePak

Fig. 1.7.2. VenturePak with side fabric hidden to show the collapsed chair and desk assembly

Fig. 1.7.3. Fully deployed VenturePak in the outdoors

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FIELDWORK AND RESEARCH

2.1. Empathy field work

2.2. Analytical Hierarchy Process

2.3. Conjoint Analysis

2.1 EMPATHY FIELDWORK

Before developing a product, we conducted empathy fieldwork to see how people are affected by social distancing. We conducted interviews, observed environments, and immersed ourselves in social distancing by mimicking the behaviors of different age groups. We noticed that people enjoyed outdoor seating at restaurants as a compromise for being outside while also social distancing. Other interesting trends included that teachers had a more difficult time adjusting to online classes while engaging with unmotivated students. Similarly, students were more stressed as a result of classes shifting online and being indoors for significantly more time. Overall, we realized that there was a fear of going to work indoors in a crowded place, but everyone still would benefit from a change of scenery.

We then unpacked our findings shown in Figure 2.1.1. by creating seven common categories that all of our needs, insights, and surprises fit into. We also created subcategories within each category to better analyze our findings. We then connected data points through tensions, contradictions, consistencies, synergies, and confusion.

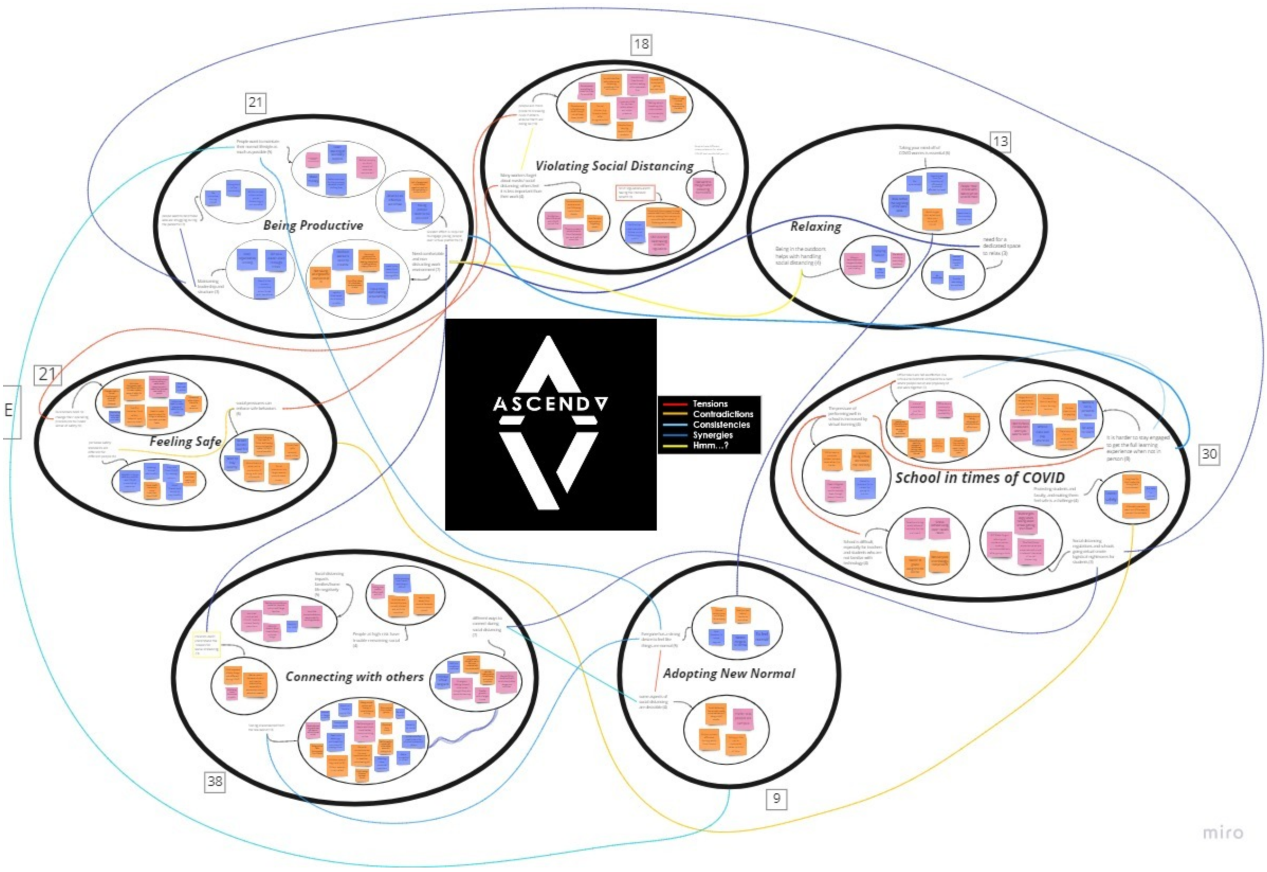


Figure 2.1.1. Unpacking empathy fieldwork

We unpacked the data by portraying our data points in a donut-arrangement to easier see the percentage-weight of each category, shown in Figure 2.1.2. Our largest categories were "connecting with others" and "school in times of COVID". This fieldwork may have been influenced by our personal experiences at school since March 2020. Within the categories, our biggest subcategories were feeling disconnected from the real world and a desire to feel like everything is normal. To address this unease, we decided that we wanted a product that would be used in the outdoors while complying with social distancing. Due to the empathy field work, we decided to create a product that would promote productivity while allowing people to enjoy the outdoors.

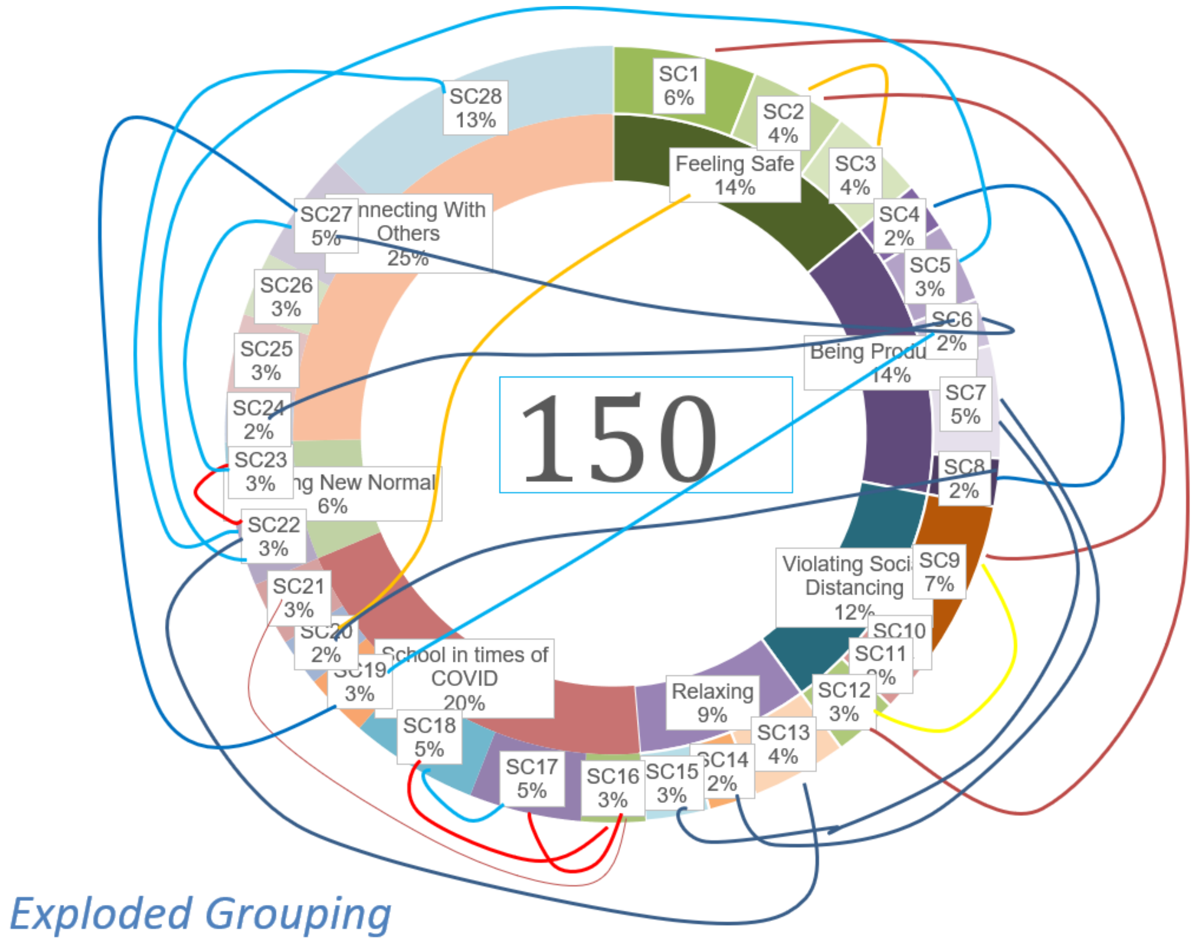


Figure 2.1.2. Donut of Empathy Fieldwork Categories

2.2 ANALYTICAL HIERARCHY PROCESS

The analytical hierarchy process is a tool used to quantify our empathy fieldwork results by analyzing the relative importance of each of the categories for the product. As a group, we decided on the relative importance of a category compared to another. This allowed us to determine if our own opinions were consistent when comparing both categories.

In Figure 2.2.1., our inputs were based on what we believed to be more important and how much more important the category was. If we believed that a column on the left was more important than the top row, we gave it an odd number from 1-9. If it is less important, we gave it a fractional number from 1/3 - 1/9.

	Being Productive	(Not) Violating Social Distancing	Relaxing	School in times of COVID	Adapting New Normal	Connecting with Others	Feeling Safe
Being Productive	1.00	0.20	3.00	3.00	0.14	0.33	0.14
(Not) Violating Social Distancing	7.00	1.00	0.14	5.00	0.11	7.00	0.20
Relaxing	1.00	0.20	1.00	0.14	0.14	0.20	0.20
School in times of COVID	3.00	0.33	0.20	1.00	0.14	7.00	0.11
Adapting New Normal	5.00	1.00	5.00	3.00	1.00	7.00	1.00
Connecting with Others	5.00	0.14	5.00	0.20	0.20	1.00	0.14
Feeling Safe	9.00	3.00	9.00	7.00	3.00	9.00	1.00
sum	31.00	5.88	23.34	19.34	4.74	31.53	2.80

Figure 2.2.1. Analytical Hierarchy Process Inputs

In Figure 2.1.2, our inputs were then normalized to convert each cell into percentages. The weighted column at the end indicates the importance value of each category. Being productive was 6.3%, not violating social distancing was 14%, relaxing was 3.2%, school in times over COVID was 7.2%, adapting to the new normal was 21%, connecting with others was 7%, and feeling safe was 40%. Feeling safe had the highest weighted value, portraying that above all else, our product had to promote the user's feeling of safety. The second highest category was adapting to the new normal, indicating that our product should conform to social distancing mandates.

	Being Productive	(Not) Violating Social Distancing	Relaxing	School in times of COVID	Adapting New Normal	Connecting with Others	Feeling Safe	weights
Being Productive	0.032	0.034	0.129	0.155	0.030	0.011	0.051	0.063
(Not) Violating Social Distancing	0.226	0.170	0.006	0.258	0.023	0.222	0.072	0.140
Relaxing	0.032	0.034	0.043	0.007	0.030	0.006	0.072	0.032
School in times of COVID	0.097	0.057	0.009	0.052	0.030	0.222	0.040	0.072
Adapting New Normal	0.161	0.170	0.214	0.155	0.211	0.222	0.358	0.213
Connecting with Others	0.161	0.024	0.214	0.010	0.042	0.032	0.051	0.076
Feeling Safe	0.290	0.511	0.386	0.362	0.633	0.285	0.358	0.403
sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

Figure 2.2.2. AHP Analysis

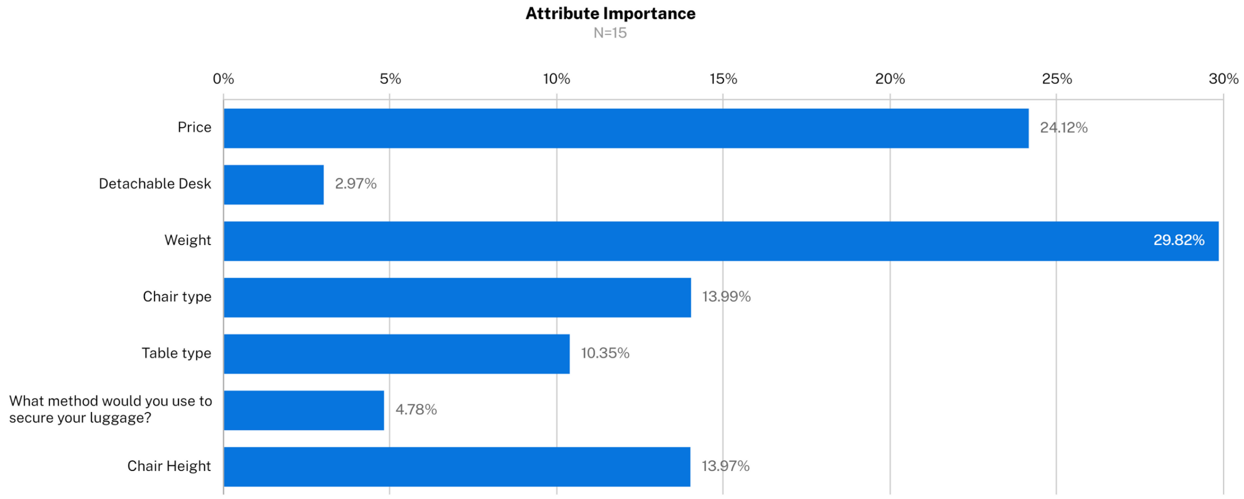
Our results showed that we were inconsistent with what we believed to be to be important. However, we all agreed that our highest categories were the most important to us also. Therefore we decided to focus on the main categories of feeling safe and adapting to the new normal. Using the Adaptive Hierarchy Process, we were able to confirm the importance of each of our categories from our empathy fieldwork.

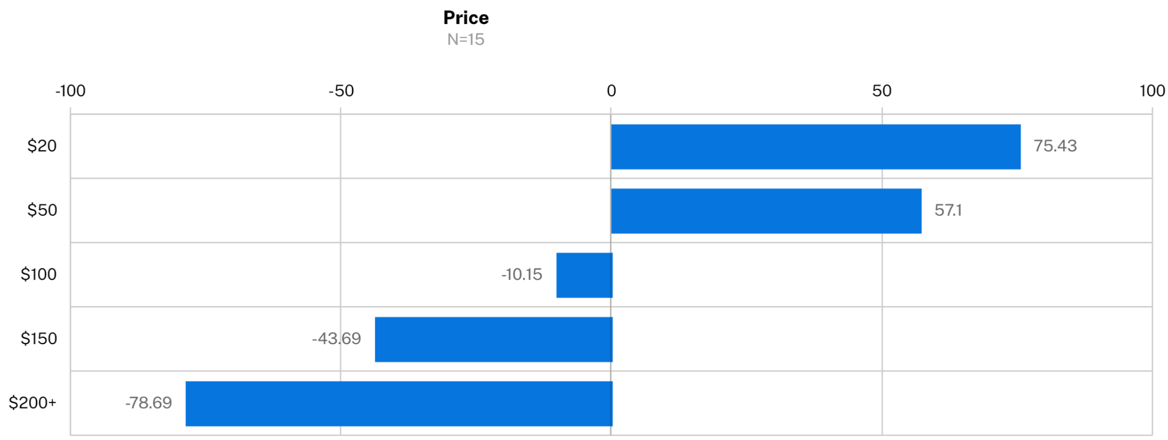
Weight sum vector	Criteria weights	Consistency Vector
0.52	0.09	5.88
1.59	0.23	6.89
0.26	0.23	1.13
0.92	0.08	11.04
1.98	0.08	25.77
0.69	0.21	3.21
3.51	0.08	45.61
	average consistency	14.22
	consistency index (I	1.20
	consistency ratio, C	0.83

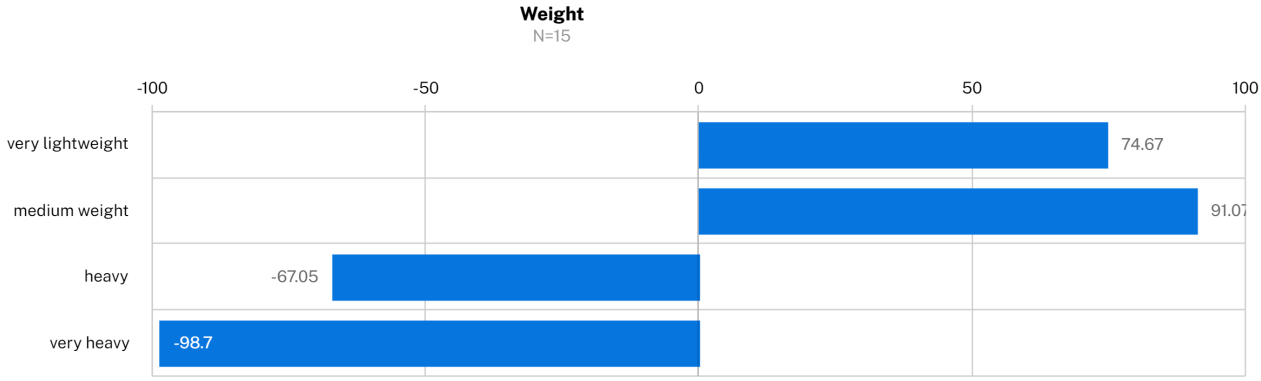
Figure 2.2.3. AHP Results

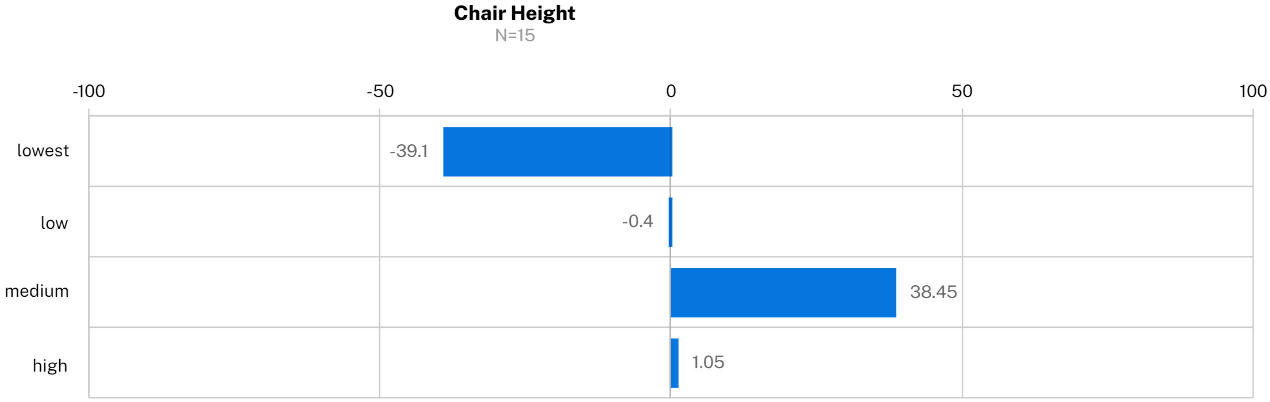
2.3 CONJOINT ANALYSIS

To figure out the most important aspects of our design, we distributed a user survey to all of the user testing participants to determine which product characteristics were favored. Using the Sawtooth software, we broke down our product by categories. From doing a conjoint analysis, our results in Figures 2.3.1-4 showed that price and weight were the most contended factors of our product. From the attribute importance, weight was the most important factor with close to 30%. Most preferred the device be the weight of a regular backpack, as the demand sharply dropped off as the weight approached that of a heavy army backpack. The second most important factor was price, as most people would purchase the product at a price point around $50, with the demand dropping off sharply at $100. A third factor would be chair height, in which users indicated a preference for the height to be that of a regular desk. There was largely negative feedback for the lowest chair height, which is sitting on the ground. Due to these considerations, we decided that decreasing the weight of the product would be our top priority while also using low-cost, inexpensive materials. We were also considering just having padding to sit on, but since most people wanted it to be at a normal height we kept the chair legs despite the heavier weight.







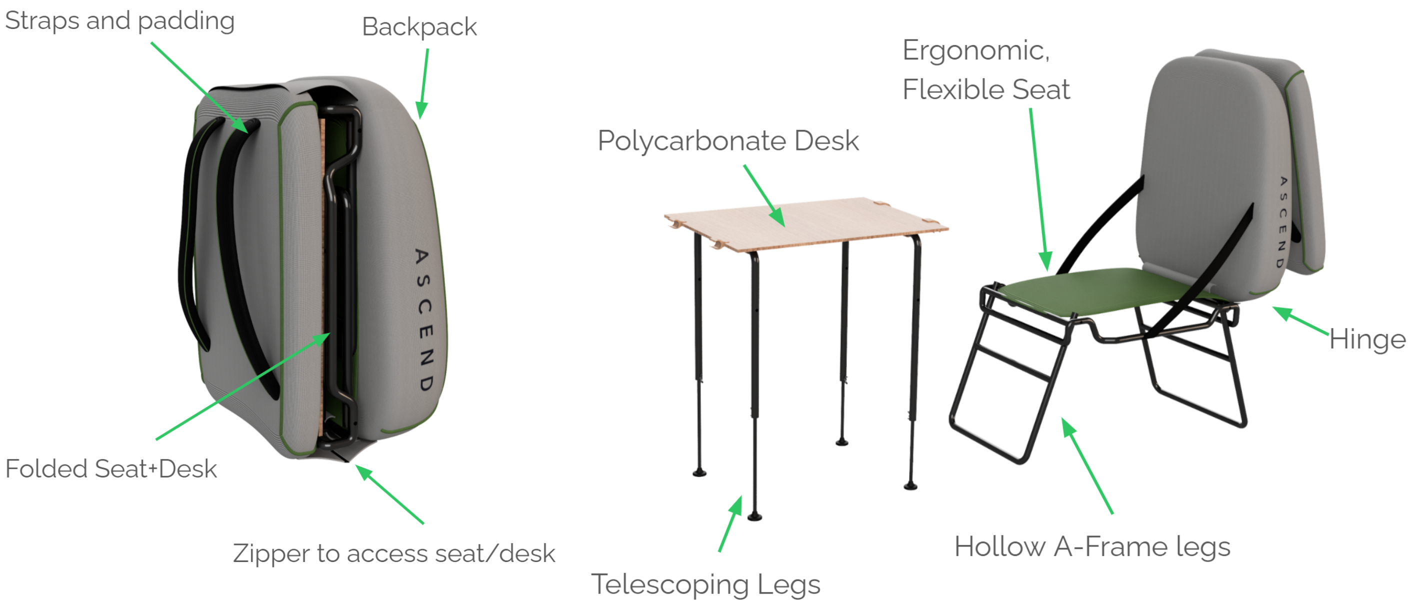


Figures 2.3.1-4. Conjoint Analysis Summary of Attribute Importance and Top Three Analysis

3 PHYSICAL DESCRIPTION

3.1. EMBODIMENT OF SOLUTION

Our VenturePak is created with simplicity and compactness in mind. The chair and desk components are separate from each other, making packing and unpacking easier. It is made out of lightweight materials for ease of transportation, and it also provides ample storage space for all of your study needs. There is padding along the bottom and back sides for cushioning and user comfort.



Figures 3.1.1-2. Final renderings of VenturePak.

The total mass of the VenturePak is estimated to be about 3.1 kg, of which the aluminum frame accounts for most of the mass. The desk and the fabric make up a significant portion of the rest of the mass while contributions from fasteners are fractional.

The link below shows an animation of the bookbag unpacking and packing with the chair and table fully extending before nesting into the backpack. The back of the bookbag first unzips and flips over to the front. Then, the table detaches and the chair legs and table legs extend. This process is then reversed to show the packing process.

https://youtu.be/dKFpwiguSZw

PROTOTYPING

We started out with a paper prototype shown in Figure 3.1.3-6A. It had collapsible chair legs with a swivel desk. When prototyping in cardboard as seen in Figure 3.1.3-6B, we quickly realized that that design was not feasible due to the desk being cantilevered. The legs were kept relatively the same but bars going across the bottom were added for more support. We also made a usable prototype from existing products shown in Figure 3.1.3-6C with a metal folding chair, a bookbag, and a cardboard desk. For our final prototype in Figure 3.1.3-6D, we created chair legs with PVC pipes that can telescope outwards and also fit the support of the desk within the legs. The desk is supported on both sides and can be disconnected to enter and exit the chair.

(A)

(B)

(C)

(D)

Figures 3.1.3-6. Iterations of Physical Prototypes

Figures 3.1.7-8. Final Prototype

Our final prototype can be used both indoors and outdoors. The chair was made out of PVC pipes connected with quick release pins. This approach ensures the chair's structural rigidity while also being able to be quickly assembled and disassembled. The desk was supported on both sides, and it can be removed for easy access into and out of the chair. We used a camping chair for the padding and back support and a regular backpack to show the storage space that this bag can still hold. It could hold the weight of a person with some minor flexing and was appropriately sized for a smaller body frame.

3.2 MANUFACTURING

3.2.1 Material Selection

Backpack

Common fabrics suitable for outdoor use include nylon and polyester fabrics. Nylon fabric is extremely resistant to sun exposure, solvents, and oils, which is fitting for long-term outdoor use (such as for tarps), especially when coated in neoprene. Polyester fabrics are also UV, water, and mildew resistant. Though not as durable as nylon, polyester fabrics are weather resistant enough for the conditions the VenturePak will be exposed to and are very tear-resistant for less than half the price. This is the most common choice for hiking backpacks, and for these reasons, 600D polyester will be used for this product.

Frame and Legs

The primary materials considered for the frame and legs were composites (carbon fiber, fiberglass) and metal tubing. While composites would likely provide the highest strength-to-weight ratio, the complexity and high costs of the composite layup, baking, and tooling, as well as the comparatively slower production output rate led to the team focusing primarily on metal tubing. This choice is also commonly used in similar reference products such as outer-frame hiking backpacks and folding beach chairs.

Aluminum-6061 was selected for the final version of the product as it provides an excellent balance between being lightweight, strong, and low-cost. Other alternatives considered were Al-3003 and Al-5052, as these are the most common aluminum alloys used in tube bending (see the next section for info on this manufacturing process). However, 3003 is significantly lower-strength than 6061 (a yield strength of 185 MPa as compared with 276 MPa for Al-6061), and 5052 is not suited for low-radius bends near 90 degrees.

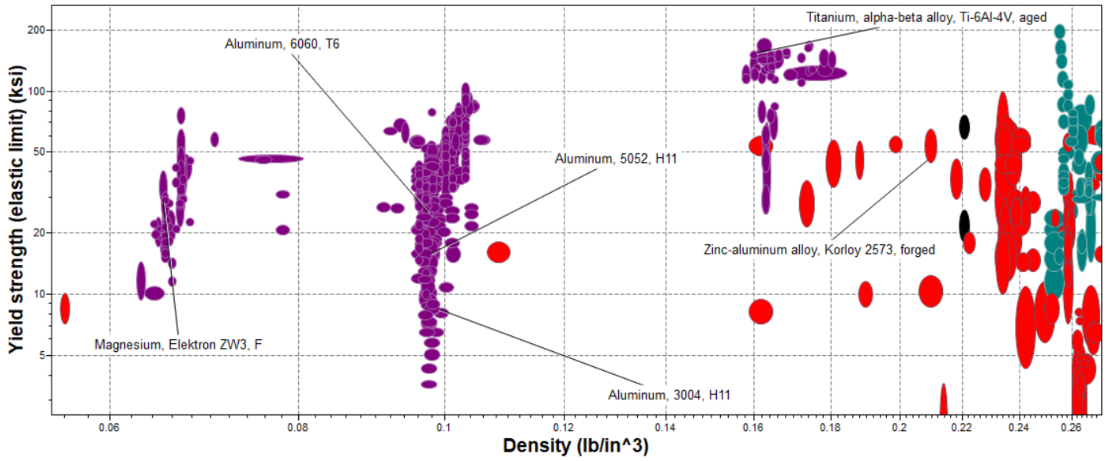


Figure 3.2.1.1. Yield strength vs density for material contenders for the frame and legs. Ashby charts were used to aid in selecting materials for our product. The components for which material selection was most important (with respect to strength, weight, and cost) were the frame, backpack fabric, and the desk.

Desk

For the desk, the driving characteristics for material selection were stiffness, strength, and weight. With metal being too heavy, and wood being limited in strength, polycarbonate became the leading material. Even though the carbon-fiber fill was greater in strength, the glass fill was half the price and would meet the strength requirements for a desk.

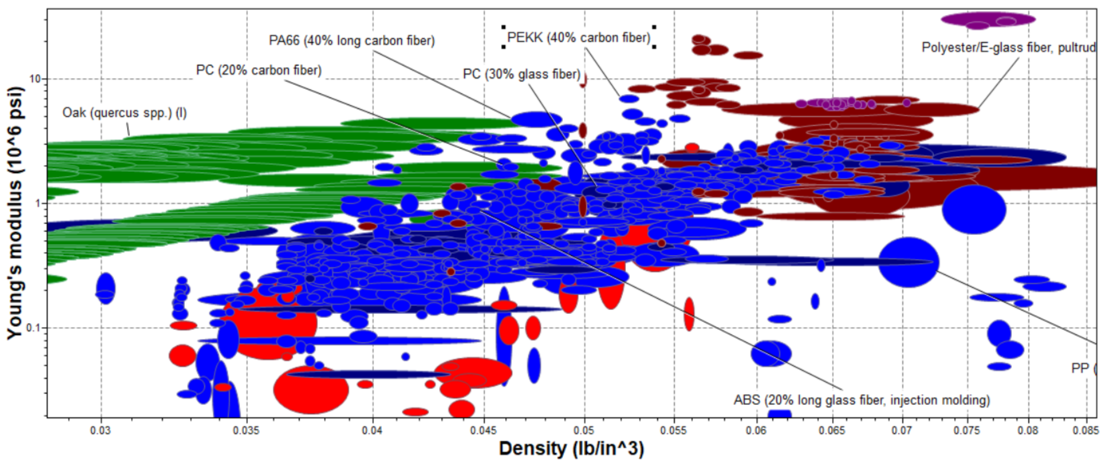


Figure 3.2.1.2. Young's Modulus vs Density for potential desk materials, including plastics, wood, and metals.

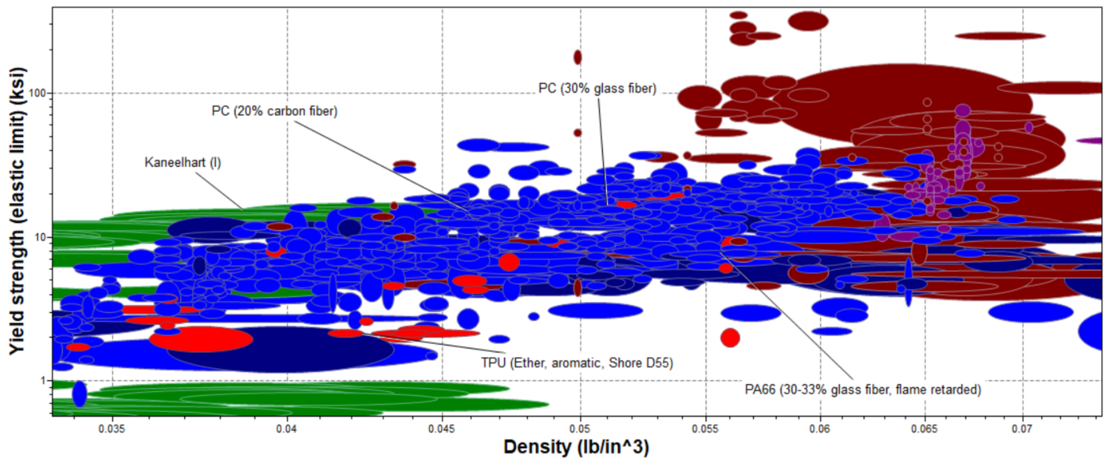


Figure 3.2.1.3. Yield Strength vs Density for potential desk materials, including plastics, wood, and metals.

3.2.2 Manufacturing Methods

Frame and Legs

The frame consists primarily of a single piece of ⅝" OD aluminum tubing which can be bent into the correct shape and pinned to close the final seam. While there are multiple types of tube bending processes, compression bending was selected due to being the simplest type of tube bending process, and this simplicity lends itself to a lower per-bend cost. This process is well-suited for complex multi-bend components like this, especially with the relatively small tube diameters this frame is made out of. Beach chairs tend to use this method as well. The main drawback of this is that it can "squish" the overall tube diameter at the inner corner of a tight-radius bend, inducing stress concentrations. Additional braces could be necessary to include because of this, particularly at the higher-loaded corners keeping the chair legs in place. Considering this with the alternative bending processes, draw bending requires more expensive tooling specific to the tube diameter and the bend radius. This would significantly increase manufacturing costs as the same bending tool would not be usable for every bend on the tube, or if a heavy-duty larger size of the bag is planned for future development, a new tube diameter would also mean significant additional investment in new tooling. Another alternative method, roll bending, is a slower process that is best suited for large bend radii - which is not applicable in this design.

For connecting the support tubes to the main frame component, welding was initially considered, but due to the high labor costs, this was replaced with flattening the ends of the tubes so they could be pinned to the frame.

Desk, and Clips

Manufacturing of the desk is very simple as this is primarily a polycarbonate sheet which can be cut with a bandsaw and finished with a light sanding and polish. This is then connected to the legs which are manufactured in the same process as the frame. The tube clips and clamps are available through third-parties such as McMaster, who are better-suited for producing standardized attachments for tubing at large-volumes. These will be fastened to the desk with epoxy because these will not be experiencing significant loading, and screws and bolts would interfere with the writing surface on the other side.

Backpack

Fabrication of the backpack involves cutting, sewing, printing, and coating the polyester fabric sheet. These sewn components will also be filled with various amounts of foam padding over the course of this process, especially the shoulder straps and back cushioning.

3.2.3 Manufacturing Costs and Bill of Materials

Frame/Legs

The frame is to be cut to size in house, then outsourced to be bent. The cost of bending depends on the number of bends, bend radius, holes, material, and the dimensions of the tubing. The China Synergy Manufacturing Group has an online calculator that was used to estimate the cost of these processes for each tube on the Venture Pack, giving a total of $8.54. Additionally, a total of 24.3 feet of Aluminum 6061 tubing with an outer diameter of ⅝ inches and inner diameter of 0.555 inches is needed. Online Metals offers the most competitive price of $67.30 for 25 feet of the desired tubing.

Backpack

Assuming $20 per hour for sewing operations, it is estimated that the total cost of labor per unit will be $20.00, given that the fabrication instructions are clear and optimized for time. Adding the manufacturing operations for the frame/leg and backpack, these will total $28.24.

The Bill of Materials below gives a full breakdown of the parts required, their costs, and adds in the cost of the manufacturing to give a total cost estimate for one unit of the Venture Pack. Note that all of these processes and material costs will be significantly reduced by manufacturing this in China instead of the US, as well as by purchasing stock material in bulk. The per-unit cost will decrease with scale as well.

Bill of Materials **Final Product (1 Unit, Retail)**				
Item	Vendor	Quantity	Unit Cost	Total Cost
Buckles for adjustable straps	McMaster	2	$7.14 / 25	$0.57
Adjustable straps	McMaster	3	$5.25 / 5	$3.15
Zipper	ZipperShipper	1	$1.99	$1.99
Zipper slider	ZipperShipper	3	$0.99	$2.97
Desk	McMaster	1	$9.59	$9.59
Aluminum Frame	Online Metals	1	$67.30	$67.30
Padding for straps, back, and bottom	Joann	1	$7.79	$7.79
Backpack Fabric	McMaster	1	$33.50	$33.50
Nylon Plastic Loop Clamp	McMaster	4	$13.60 / 100	$0.54
Plastic Routing Clamps	McMaster	4	$12.77 / 100	$0.51
Pins (for hinged legs)	McMaster	4	$7.38 / 25	$1.18
Manufacturing and fabrication	Details in report	1	$28.24	$28.54
Final Product Total				**$157.63**

Figure 3.2.3.1. Final Design Bill of Materials

Also included for comparison is the price of the physical prototype constructed during the testing phase of the project, below:

Bill of Materials **Prototype**				
Item	Vendor	Quantity	Unit Cost	Prototype Cost
PVC Pipe. Pipe size ½. 27/32" OD, 0.546" ID	McMaster	2	$9.80	$19.60
PVC Pipe. Pipe size ¾. 1-3/64" OD, 0.742"	McMaster	1	$7.20	$7.20
PVC Elbow T connectors	Home Depot	4	$1.34	$5.36
PVC 90 degree connector	Home Depot	2	$1.14	$2.28
Shoulder screw	McMaster	2	$1.56	$3.12
Locknuts	McMaster	2	$3.30 / 100	$0.07
Velcro	McMaster	1	$10.95 / 5	$2.19
Desk	McMaster	1	$11.97	$11.97
Duct Tape	McMaster	1	$12.80 / 20	$0.64
Backpack	Walmart	1	$29.97	$29.97
Seat. Stadium chair.	Coleman	1	$14.99	$14.99
Prototype Total				**$97.39**

Figure 3.2.3.2. Physical Prototype Bill of Materials

3.3 ENGINEERING CHARACTERISTICS AND PERFORMANCE METRICS FROM HOUSE OF QUALITY

Relationships

2	Strong Positive
1	Positive
	Neutral, Not Applicable
-1	Negative
-2	Strong Negative

	Engineering Characteristics	1	2	3	4	5	6	7	8	9	10
1	Stability of Legs										
2	Volume of Backpack										
3	Rigidity of Desk	1									
4	Ability to sustain adverse weather	1									
5	Seat Size		1								
6	Ease of Manufacturing			-1	-1						
7	Ease of Assembly			-1	-1						
8	System Durability	1		1	1	-1	-1				
9	Desk Mounting Complexity							-1			
10	Rigidity of Seat							1	1		
ID		1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10

ID	Performance Criteria (or Measures) / Customer: Full Attribute/Goal/Add'l Info	Short Name	Relative Importance	Stability of Legs	Volume of Backpack	Rigidity of Desk	Ability to sustain adverse weather	Seat Size	Ease of Manufacturing	Ease of Assembly	System Durability	Desk Mounting Complexity	Rigidity of Seat
		Direction of Change ↑ ↓		↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
1	Ability for all 3 components to fold into backpack	Compactness	5.00		1					2		-1	
2	Weight	Weight	5.00	1							1		
3	Visual Appeal	Attractiveness	4.00					-1	-1			1	
4	Desk Size	Desk Size	2.00		1	-1		1					
5	Time to Assemble	Assembly Time	1.00							2		-1	
6	Ergonomics	Comfort	3.00					1	-1				-1
7	Affordability	Cost	5.00	-1		-1	-1			-1			

Customer Perception / Performance Scores

ID	Normalized & Unweighted: A(low)	A(high)	A(target)	B	C	D	E	Normalized & Weighted: A(low)	A(high)	A(target)	B	C	D	E
1	1	5	5	3	5	3	0	5.0	25.0	25.0	15.0	25.0	15.0	0.0
2	1	5	5	5	5	5	4	5.0	25.0	25.0	25.0	25.0	25.0	20.0
3	1	5	3	4	3	2	2	4.0	20.0	12.0	16.0	12.0	8.0	8.0
4	1	5	5	5	0	5	0	2.0	10.0	10.0	10.0	0.0	10.0	0.0
5	1	5	4	5	5	5	5	1.0	5.0	4.0	5.0	5.0	5.0	5.0
6	1	5	2	1	2	0	2	3.0	15.0	6.0	3.0	6.0	0.0	6.0
7	1	5	3	5	2	5	3	5.0	25.0	15.0	25.0	10.0	25.0	15.0
								25.0	**125.0**	**97.0**	**99.0**	**83.0**	**88.0**	**54.0**

Competitor Legend

	Competitor	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	Link
B	DESKIT	3	0	3	1	0	4	5	5.00	5.00	0	https://www.designboom.com/design/deskit-backpack-desk-prosoc-08-20-2019/
C	Zology Folding Camping Chair Stool Backpack	2	3	0	4	1	5	5	2	0	1	https://www.amazon.com/dp/B075L2J14B?tag=topluggagereviews-20&linkCode=ogi&th=1&psc=1
D	Aarambh Help Desk	5	5	5	5	5	5	5	5	5	5	https://www.thecoolist.com/aarambh-help-desk/
E	TravelChair Slacker Chair	4	0	0	5	2	3	4	4	0	2	https://www.amazon.com/TravelChair-Slacker-Chair-Folding-Tripod/dp/B0019N36B2/ref=as_li_ss_tl?ie=UTF8&linkCode=sl1&tag=workboot-20&link

Figure 3.3.1. Full QFD, or House of Quality, diagram. Also displayed full-size vertically on P.41

The Quality Functional Deployment (QFD) diagram, synonymous with House of Quality (HOQ), is a master-level systems engineering document that illustrates what aspects of the system are important to the customer and translates them into desired engineering characteristics for the product. The HOQ diagram is a method used to shape the engineering characteristics of a system to more closely match stakeholder wants and needs. HOQ processes are conducted before the design process begins but after the key performance parameters that define functional performance of the system have been identified. The goal of conducting a HOQ process is to determine based on stakeholder requirements what features a system should have or what changes should be made. It also reveals the relationships between various engineering characteristics of the system.

The top section of the HOQ diagram illustrates the impact that promoting one engineering characteristic in a design has on other aspects of the design. For example, the bottom-right most score of “1” in the top section signifies that an increase in system durability correlates to an increase in the rigidity of the seat. This quadrant also reveals that increasing the stability of the legs has a positive impact on the stability of the desk, as well as the system’s ability to sustain adverse weather, and the durability of the system. Furthermore, the system’s ease of manufacturing engineering characteristic, an element not of concern to the customer, is made more difficult by the system’s ability to sustain adverse weather conditions, as more complex materials are involved. The next section reveals how the needs of the customer connect to these engineering characteristics, and thus what the team should design the system towards.

	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	
1											Stability of Legs
2											Volume of Backpack
3	1										Rigidity of Desk
4	1										Ability to sustain adverse weather
5		1									Seat Size
6			-1	-1							Ease of Manufacturing
7			-1	-1							Ease of Assembly
8	1		1	1	-1	-1					System Durability
9							-1				Desk Mounting Complexity
10							1	1			Rigidity of Seat
ID	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	**Engineering Characteristics**

Figure 3.3.2. The engineering characteristics of the VenturePak

The left side of the HOQ reveals what criteria deliver value to the customer and the relative importance of each one. These criteria are derived from the conjoint analysis the team conducted. The most important factors are mass, cost, and the compactness of the folded system. Criteria that the customer did not prioritize in their feedback included the size of the desk and the time required to assemble the system. While these criteria should not be neglected, this information informs the Ascent team that the VenturePak should be geared to be compact, light, and low-cost, as informed by the conjoint analysis. The middle section of HOQ diagram, pictured in the bottom-right quadrant of the below image, reveals the relationship each performance criteria has with every engineering characteristic.

For example, the bottom-leftmost "1" in this quadrant reveals that making the system more affordable likely decreases the stability of the legs, since they will deflect more if they are made of less-stiff, less-expensive materials. Interesting trends include that the engineering team's ease of manufacturing is likely hindered by making the system more visually appealing or more ergonomic, as these attributes required curves or complex shapes to be manufactured into the design. Additionally, the rigidity of the desk is adversely impacted by the size of the desk, and is decreased by using less expensive materials.

	Relationships
2	Strong Positive
1	Positive
	Neutral, Not Applicable
-1	Negative
-2	Strong Negative

	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	
1											Stability of Legs
2											Volume of Backpack
3	1										Rigidity of Desk
4	1										Ability to sustain adverse weathe
5		1									Seat Size
6			-1	-1							Ease of Manufacturing
7			-1	-1							Ease of Assembly
8	1		1	1	-1	-1					System Dura
9							-1				Desk
10							1	1			F
ID	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	

	Performance Criteria (or Measures) / Customer	*Direction of Change* ↑ ↓	*Relative Importance*	Stability of Legs	Volume of Backpack	Rigidity of Desk	Ability to sustain adverse weather	Seat Size	Ease of Manufacturing	Ease of Assembly	System Durability	Desk Mounting Complexity	Rigidity of Seat
				↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
ID	*Full Attribute/Goal/Add'l Info*	*Short Name*											
1	Ability for all 3 components to fold into backpack	Compactness	5.00		1					2		-1	
2	Weight	Weight	5.00	1							1		
3	Visual Appeal	Attractiveness	4.00					-1	-1			1	
4	Desk Size	Desk Size	2.00		1	-1		1					
5	Time to Assemble	Assembly Time	1.00							2		-1	
6	Ergonomics	Comfort	3.00					1	-1				-1
7	Affordability	Cost	5.00	-1		-1	-1			-1			

Figure 3.3.3. Performance Criteria and Engineering Characteristics of VenturePak

3.4 TRIZ

10 key TRIZ contradictions were identified during the early design phases of the project, and the principles to solve this contradiction became an integral part of elements on the final design and prototypes. The following table gives examples of some of the solutions that made their way onto the designs over the course of the semester:

Contradiction	Principle Used	Solution on Product
Weight vs Volume	Parameter Change	The seat back supports and the seat only needs to be in tension, so fabric can be used instead of rigid elements. This also helps improve device complexity and ease of use
	Merging	The back-facing side of the backpack can also serve as the seat back when the chair is deployed. This also improves ease of access to materials inside the backpack: locating the bag behind the chair back was found to be the preferred location
	Merging	(Prototype) - Extended the diagonal chair legs to also serve as the support for the desk
Ease of operation vs device complexity	Equipotentiality	Use the weight of the user to keep the linkages on the chair legs locked in place
Ease of operation vs adaptability/versatility	Dynamics	Adjustable table height via telescoping components to allow the user to change this to suit their preference

Figure 3.4.1 TRIZ considerations

3.5 MECHANICAL ANALYSIS

To verify our design to ensure that our design will not break under loading, we conducted Finite Element (FEA) analysis on the chair frame and the table to ensure that all components have high safety factor greater than 2.0. Weights of 100 kg for the chair and 50 kg for the table were considered. Based on feedback from the final presentation, a next step would be to consider shear and stability loading cases, since we expect the user to induce side loading on the chair and desk. However, due to the quick turnaround between the final presentation and this report, we present only analysis conducted before the final presentation feedback was received.

Load Case 1: 1000 N of Force on Four Bars

The first loading case in Figure 3.5.1 is 1000 N on four bars of the chair where the person will most likely be supported with the chair legs at the bottom fixed. We received a safety factor of 1.46, but that was in the connector piece between the legs and the main frame. We then did a shear force calculation to confirm the results, and we saw that the screw going across has a much larger safety factor than what the results were giving us. We concluded that this was because the mesh was too coarse, as it was calculating the circular holes and shafts as polygons instead of a smooth surface. The next point of deformation is where the chair legs touch the main frame. We then decided that there will be a rubber padding on all four points of contact to minimize the risk of deformation.

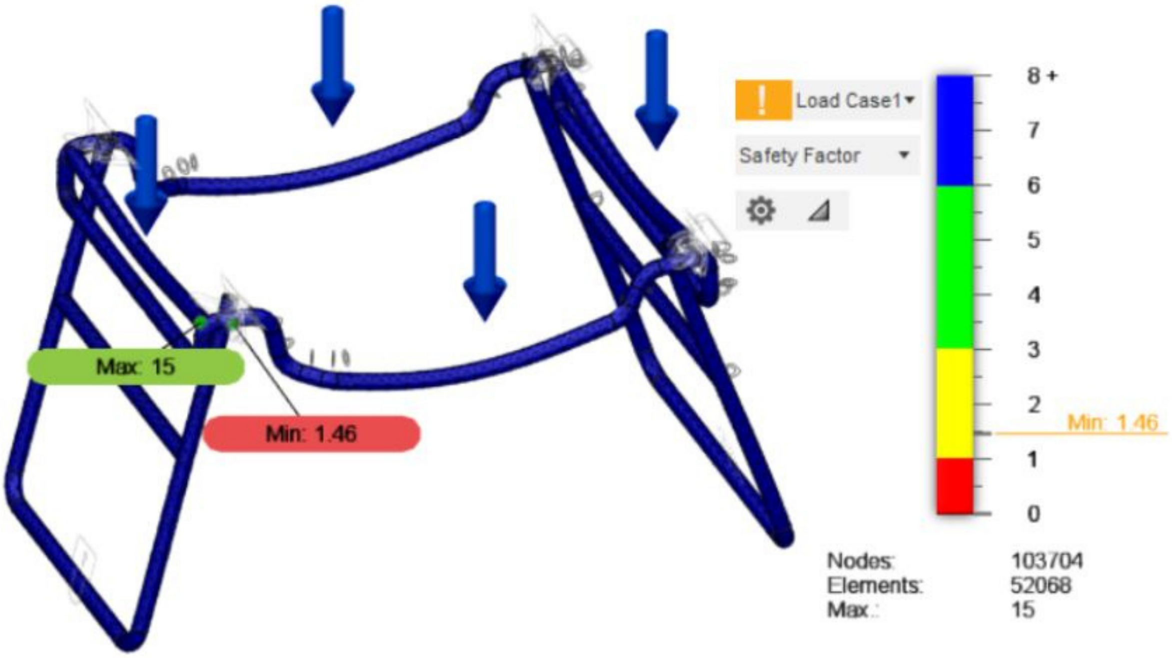
Screw Shear Stress Calculation:

Shaft diameter: 0.25 in = 0.00635 m, Yield Strength of Steel: 250 MPa

$\tau\_max = F/A = (1000\ N/4)/((0.00635m/2)^2)$

$\tau\_max = 7894100\ Pa = 7.9\ MPa$

S.F. = 250 MPa /7.89 MPa = **31.7**



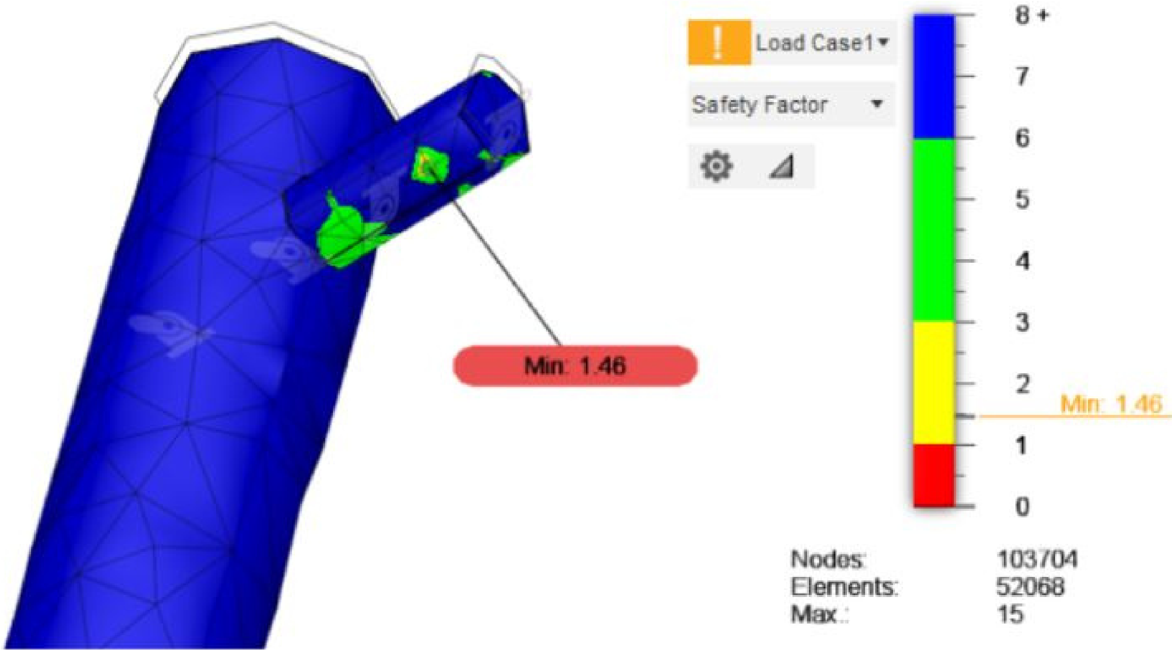


Figure 3.5.1. FEA of 1000 N on Chair

Load Case 2: Buckling in Chair

The second loading case in Figure 3.5.2. Downwards force was distributed over the four top bars of the frame. The simulation revealed that the first buckling condition in the legs will occur at 45775 N, second will happen at 71626 N, and third at 89748 N. However, since the chair will fail before seeing loads this high, there is no risk of the chair buckling.

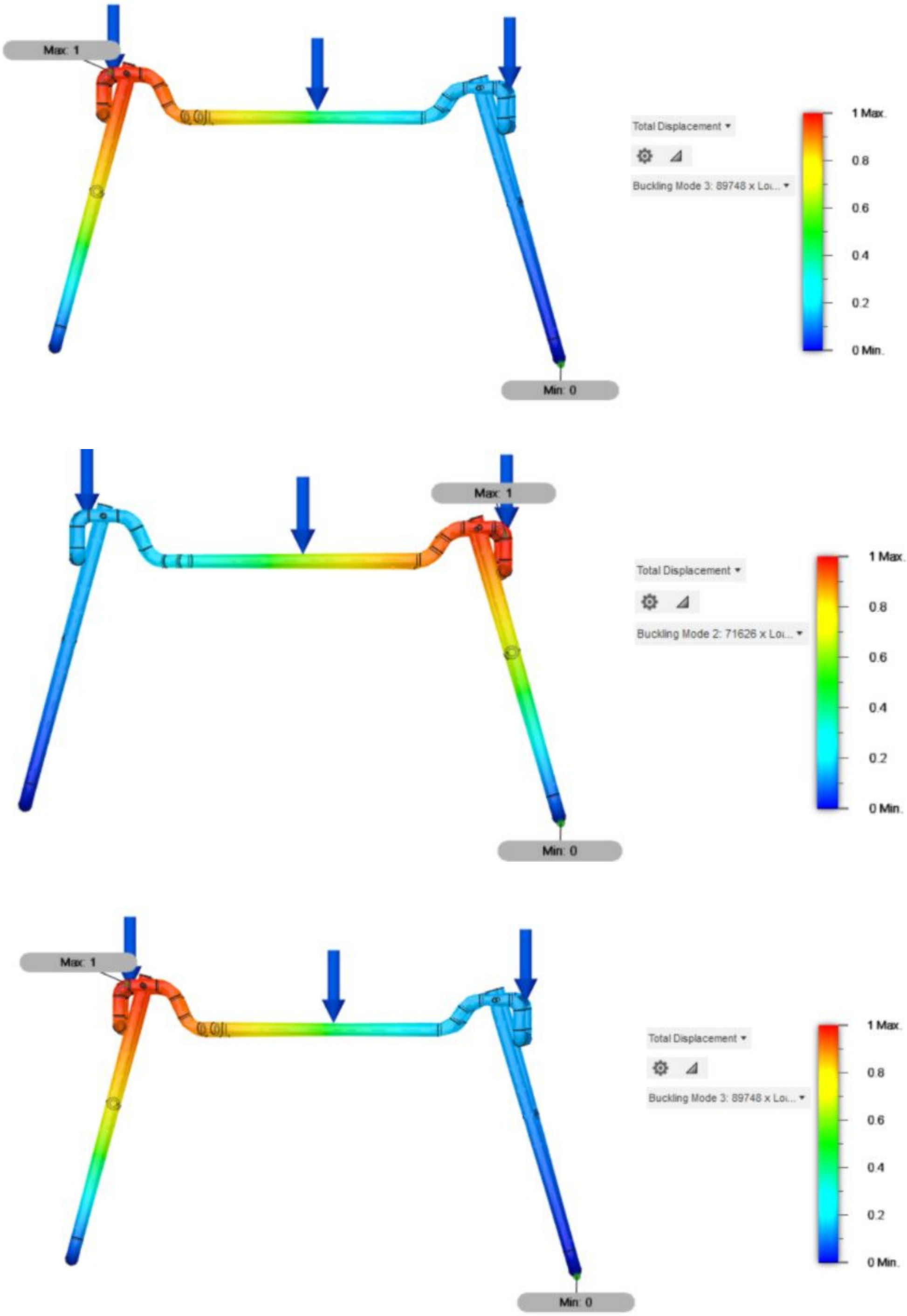


Figure 3.5.2. FEA Buckling Analysis chair

Load Case 3: 500 N of force on Top of Table

The third loading case in Figure 3.5.3 is a force of 500 N on top of the table with the chair legs at the end supported. There is a minimum safety factor of 6.89 happening at the hole with a connector screw going through, but is it still a large enough safety factor to not be concerned since the table does not have to hold as much weight.

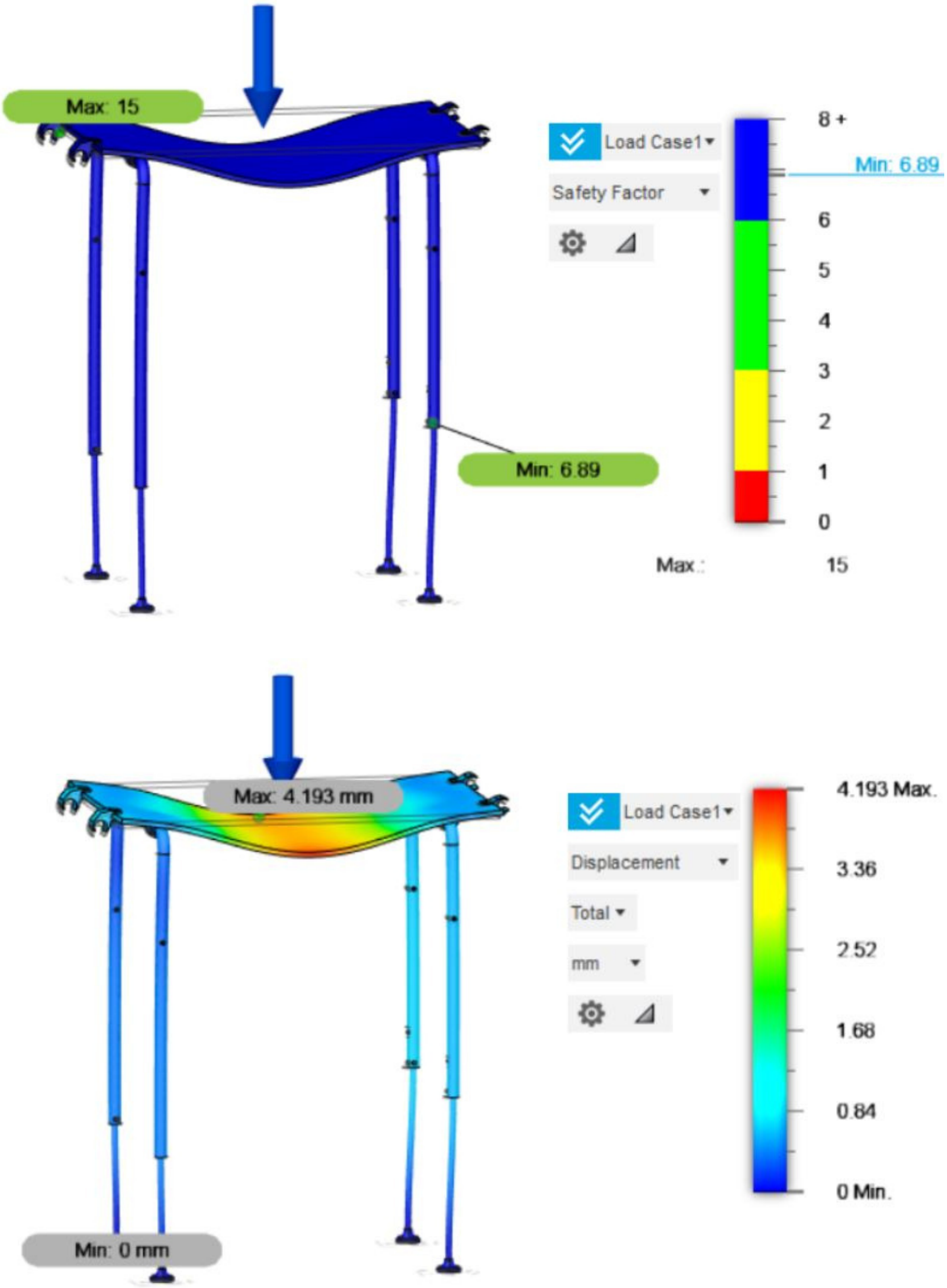


Figure 3.5.3. FEA Analysis of 500 N on Table

Load Case 4: Buckling of Table

The fourth loading condition in Figure 4.5.4 is the table buckling. As with loading case 2, the simulation reveals how many times the magnitude of the inputted force needs to be multiplied by in order to cause the system to fail in buckling. The first buckling case will happen with 11383 N of force, the second at 11608 N, and third at 17005 N. Since the table will not see loads this high, buckling is not a concern.

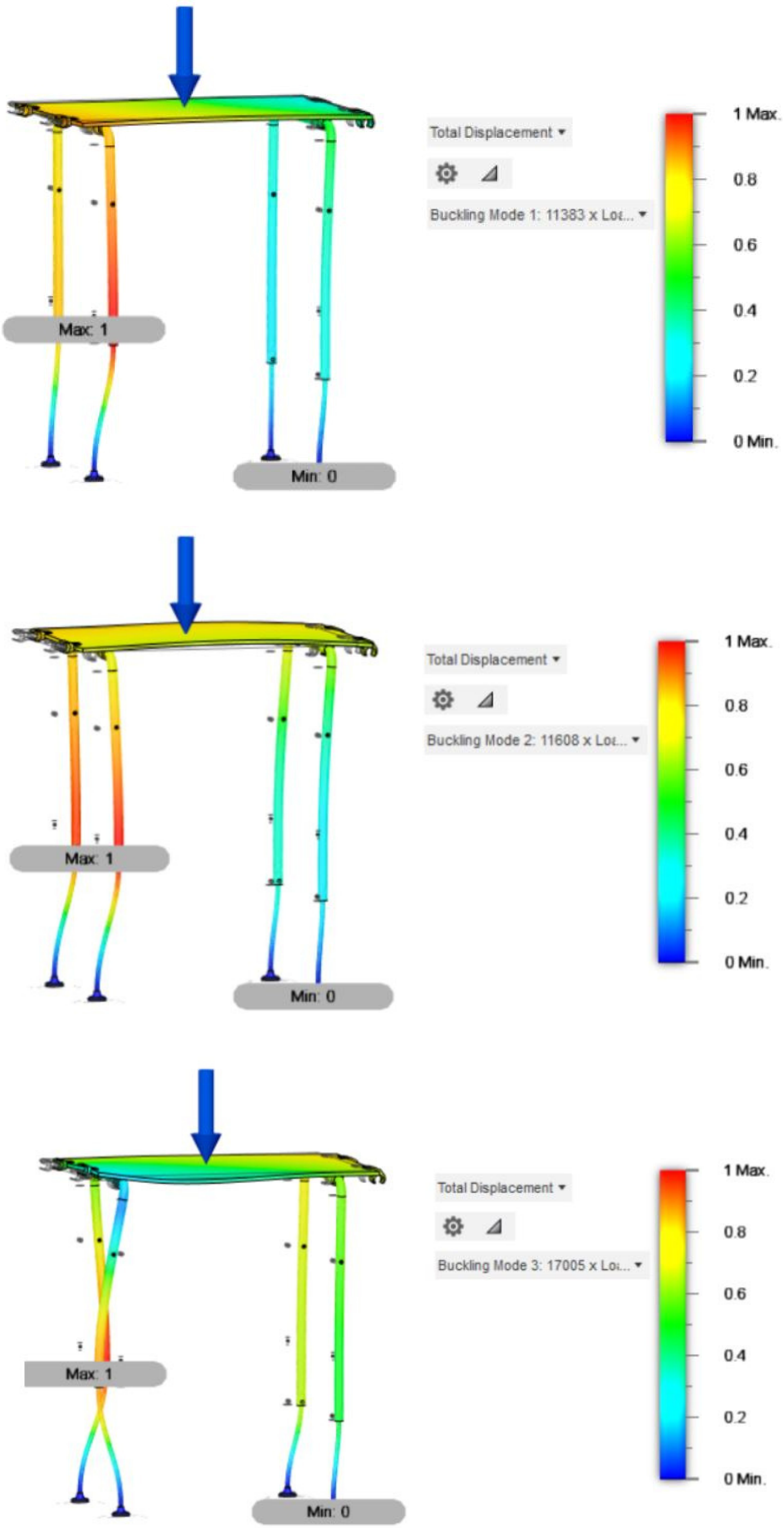


Figure 3.5.4. FEA Buckling Analysis of Table

4 MARKET IDENTIFICATION

4.1 TARGET MARKET

Our target market is students and working professionals, specifically those with an affinity for the outdoors or a desire for a change in their monotonous routine. As our empathy fieldwork indicated, students feel unengaged in their online classes and as a result struggle to stay afloat in their coursework. Moreover, due to COVID-19 precautions, students are not using public indoor work spaces, for fear of potential exposure. As a result, people spend more time at home than ever. Through further research and discussion, our team found that students and professionals who are cooped up at home eventually experience fatigue and an overall decrease in productivity.

Additionally, we are also targeting educational institutions. Over the past year, elementary schools, high schools, and universities across the world have struggled immensely with transitioning their coursework online. Our product would not only permit students to work alone, but it would also allow classes to easily resume while maintaining social distancing guidelines in the outdoors.

4.1.1. Market Size

To better estimate our market size, we are assuming that VenturePak is only being sold in the United States. Being that we are targeting students and working professionals, we will include people from the ages of 10-40. This was done to include middle to high school students, college students, and young working professionals. According to the U.S. Census, there are approximately 131 million people who fall within this age bracket in the United States (Bureau 2020). There are approximately 67 million people in the working professionals category, which for this activity will be assumed to be from the ages of 25-40. According to a recent survey, 40 percent of people are not working, which brings our number down to 40 million people. Additionally, only 40 percent of people work at a desk job, leading us to believe that the market for working professionals is 24 million people ("Standing or Walking" 2017). For the student market, there are approximately 20 million people in college in the U.S. and 37 million in middle and high school, totalling to 57 million students in school. This brings the approximate market size to 81 million people.

While this market may currently be 81 million people, there is expected growth as well. Universities experience a substantial increase in enrollment following recessions. During a difficult job market, individuals tend to go back to school and seek to develop their skills. Following the 2008 Recession, enrollment in higher education rose by 11.5%, with previous recessions such as those in 1990 and 2001 indicating the similar results. As enrollment increases, the consumer base for our product will as well.

4.2 CONSUMER BEHAVIOR

4.2.1. Sociological Research

The market for VenturePak continues to grow during the pandemic, from our target user to larger institutions, VenturePak has an opportunity for immense consumer growth as evidenced by recent economic events.

In terms of the typical user, sixty-four percent of Americans changed their spending habits during the pandemic (Leonhardt 2020). The fourth largest change in spending was seen in Education, with a seventeen percent increase since last year. As COVID infection numbers continue to rise, it is likely that educational spending will continue to increase, sparking individuals to invest more in proper work space amenities and supplies. Additionally, much of the workforce began working remotely during the pandemic and nearly 48 percent of people prefer to continue doing so. The typical remote employee wants the opportunity to work from anywhere, and VenturePak would enable them to do so.

In terms of educational institutions, many schools reopened for in-person instruction at the start of the academic year. However, according to the American Academy of Pediatrics and the Children's Hospital Association, the amount of children infected with COVID-19 rose dramatically by 14% within the first two weeks of instruction ("Coronavirus..." 2020). As infection numbers rise, schools have to rethink their instruction strategy, which may include outdoor instruction.

4.2.2.Historical solutions to stated problem

The public safety and mental health problems we face during the COVID-19 pandemic are unlike any others we have faced since the 1918 Spanish Flu. However, the issue of spending too much time indoors is not unique to the pandemic. Before the pandemic, on average, users spent 90 percent of their time indoors. However, as a result of the pandemic that number has only increased (Buchholz 2020). As time indoors increases, negative health outcomes do as well. Increased amounts of time spent indoors has a direct negative impact on people's mental health, sleep regulation, and immune system strength (Frank 2020). These negative effects will not only have long lasting health repercussions, but may also affect a user's ability to stave off COVID-19. As history has dictated, there have been no real solutions to this problem, as our time spent indoors was only increasing before the pandemic. There have been programs to help offices and schools get outside for a short amount of time, but no permanent solutions. Moreover, people have created "outdoor offices," however they typically consist of a clear enclosure outside, and are not very different from the typical shed. This solution, while it does create a change in routine and scenery, is no longer viable during the pandemic. VenturePak is a step in the right direction to encourage users to spend more time outdoors while still following distancing guidelines.

4.3 HOUSE OF QUALITY - COMPETITOR ANALYSIS

The House of Quality or QFD diagram discussed in section 3, also allows product designers to objectively compare their product to leading competitors in terms of the performance characteristics valued by the customer. As discussed above, the conjoint analysis revealed that mass, cost, and compactness of the device were drivers behind the design. Those customer preferences are reflected in the performance criteria weighing scale.

The market analysis process revealed a number of key competitors both domestic and abroad that directly or indirectly would compete with VenturePak. One is the DESKIT, a small backpack-desk combination put to market by a small India-based startup, PROSEC. The design features a desk that is attached to a backpack via a zipper, and can be deployed outwards and is supported by two cross legs. Per the product's website, this product is geared only towards young Indian schoolchildren. Further, it does not incorporate a seat or any ergonomic considerations into the design. Thus, while the product shares some common functionalities with the VenturePak, they are largely geared towards different target markets. In the HOQ, the DESKIT scores similarly to the VenturePak, as they function similarly minus the seat.

Another backpack-chair combination is the Ziology Folding Camping Chair Stool Backpack, which is readily available on Amazon. The Ziology pack features a backpack with a pair of legs that fold outwards into a cross pattern. The user sits on top of the backpack-frame combination. While also geared towards the market of people wishing to relax or be productive outside, the Ziology package features no desk or back rest, as ergonomics are sacrificed in favor of durability.

The Aarmbh Help Desk is another low-cost solution out of India designed with the goal of solving the country's problem of there being a severe shortage of desks. Designed to be made out of folded cardboard, the device functions as either a desk or a backpack depending on how it is folded. The Help Desk is pitched as a low-cost, mass-produced solution that offers a basic platform for studying that millions of students in India lack. Due to its materials, the Help Desk has a short lifespan, likely no longer than a year. It also is geared only towards children, and features no seat. As with the DESKIT, this product meets several customer needs very well, such as being light and cheap, however would not succeed among our customer base due to its lack of durability.

The TravelChair Slacker Chair features a simple triangularly shaped seat supported by tripod legs, and is available on Amazon at a competitive price. Despite being geared towards relaxing and being productive outdoors, the design features no seat back or desk, and overall does not incorporate ergonomic features in the design. In part due to the limited functionalities the device offers, it is sold at the low cost of $21.99 on US markets. As a result of its design limitations, the design scores poorly against the customer performance criteria.

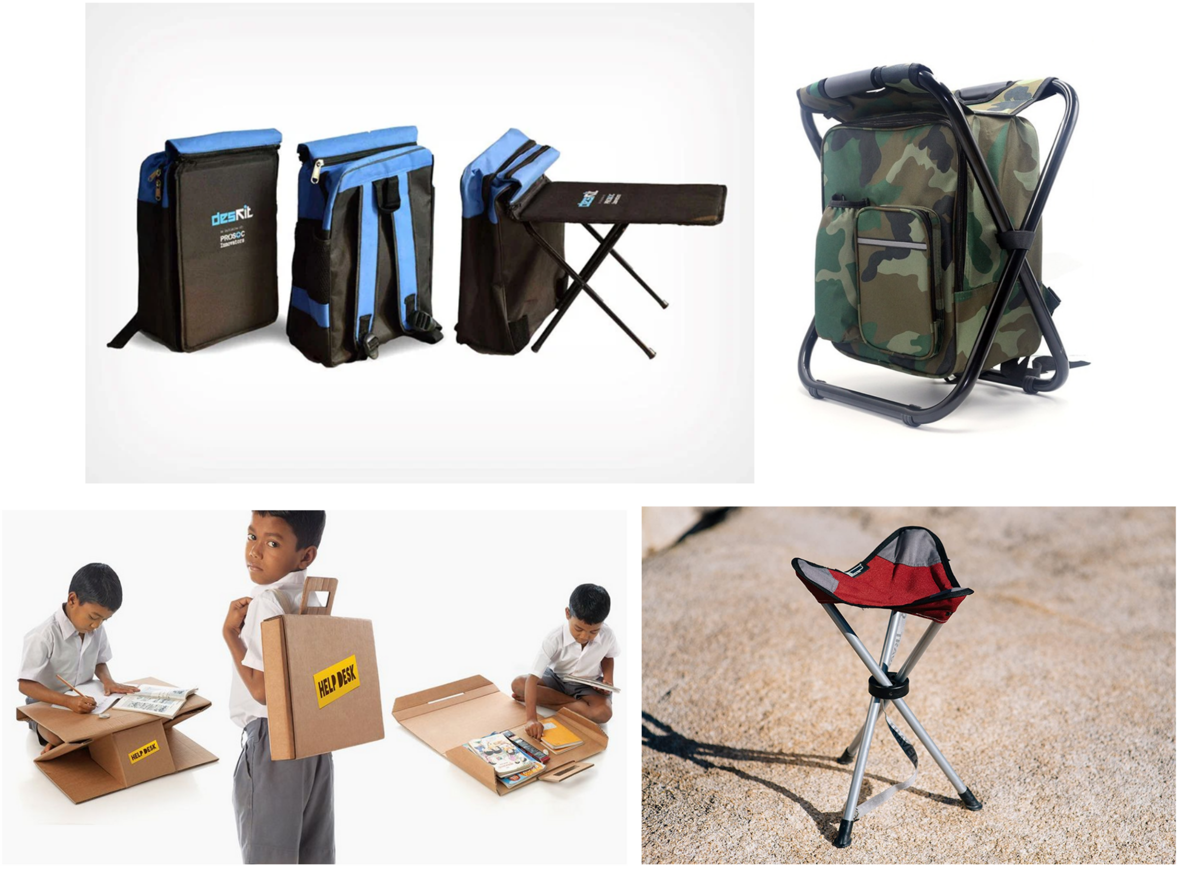


Figure 4.1.1. The PROSEC (top-left), Ziology (top-right), Aarmbh (bottom-left), and TravelChair (bottom-right) products, respectively

Relationships

2	Strong Positive
1	Positive
	Neutral, Not Applicable
-1	Negative
-2	Strong Negative

	Engineering Characteristics	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10
1	Stability of Legs										
2	Volume of Backpack										
3	Rigidity of Desk	1									
4	Ability to sustain adverse weather	1									
5	Seat Size		1								
6	Ease of Manufacturing			-1	-1						
7	Ease of Assembly			-1	-1						
8	System Durability	1		1	1	-1	-1				
9	Desk Mounting Complexity							-1			
10	Rigidity of Seat							1	1		

Performance Criteria (or Measures) / Customer

ID	Full Attribute/Goal/Add'l Info	Short Name	Relative Importance	Stability of Legs ↑	Volume of Backpack ↑	Rigidity of Desk ↑	Ability to sustain adverse weather ↑	Seat Size ↑	Ease of Manufacturing ↑	Ease of Assembly ↑	System Durability ↑	Desk Mounting Complexity ↑	Rigidity of Seat ↑
		Direction of Change ↑ ↓		↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
1	Ability for all 3 components to fold into backpack	Compactness	5.00		1					2		-1	
2	Weight	Weight	5.00	1							1		
3	Visual Appeal	Attractiveness	4.00					-1	-1			1	
4	Desk Size	Desk Size	2.00		1	-1		1					
5	Time to Assemble	Assembly Time	1.00							2		-1	
6	Ergonomics	Comfort	3.00					1	-1				-1
7	Affordability	Cost	5.00	-1		-1	-1			-1			

Customer Perception / Performance Scores

ID	Short Name	Normalized & Unweighted A(low)	A(high)	A(target)	B	C	D	E	Normalized & Weighted A(low)	A(high)	A(target)	B	C	D	E
1	Compactness	1	5	5	3	5	3	0	5.0	25.0	25.0	15.0	25.0	15.0	0.0
2	Weight	1	5	5	5	5	5	4	5.0	25.0	25.0	25.0	25.0	25.0	20.0
3	Attractiveness	1	5	3	4	3	2	2	4.0	20.0	12.0	16.0	12.0	8.0	8.0
4	Desk Size	1	5	5	5	0	5	0	2.0	10.0	10.0	10.0	0.0	10.0	0.0
5	Assembly Time	1	5	4	5	5	5	5	1.0	5.0	4.0	5.0	5.0	5.0	5.0
6	Comfort	1	5	2	1	2	0	2	3.0	15.0	6.0	3.0	6.0	0.0	6.0
7	Cost	1	5	3	5	2	5	3	5.0	25.0	15.0	25.0	10.0	25.0	15.0
									25.0	**125.0**	**97.0**	**99.0**	**83.0**	**88.0**	**54.0**

Competitor Legend

	Competitor	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10	Link
B	DESKIT	3	0	3	1	0	4	5	5.00	5.00	0	https://www.designboom.com/design/deskit-backpack-desk-prosoc-08-20-2019/
C	Zology Folding Camping Chair Stool Backpack	2	3	0	4	1	5	5	2	0	1	https://www.amazon.com/dp/B075L2J14B?tag=topluggagereviews-20&linkCode=ogi&th=1&psc=1
D	Aarambh Help Desk	5	5	5	5	5	5	5	5	5	5	https://www.thecoolist.com/aarambh-help-desk/
E	TravelChair Slacker Chair	4	0	0	5	2	3	4	4	0	2	https://www.amazon.com/TravelChair-Slacker-Chair-Folding-Tripod/dp/B0019N36B2/ref=as_li_ss_tl?ie=UTF8&linkCode=sl1&tag=workboot-20&link

Figure 4.1.2. Competitor Analysis per the QFD

5

FINANCIAL REQUIREMENTS

5.1. Financial Summary

5.2. Bass Model

5.3. Pricing Policy

5.4. Capital Investments

5.5. Warranties

5.1 FINANCIAL SUMMARY

	Initial	2021	2022	2023	2024	2025
		Year				
Sales	$ -	$ 89,990.00	$ 899,900.00	$ 1,799,800.00	$ 2,249,750.00	$ 2,699,700.00
Gross Margin	$ -	$ 44,995.00	$ 449,950.00	$ 899,900.00	$ 1,124,875.00	$ 1,349,850.00
Salaries	$ -	$ (455,000.00)	$ (455,000.00)	$ (455,000.00)	$ (455,000.00)	$ (455,000.00)
Capital	$ (14,955.00)	$ (1,017.99)	$ (1,017.99)	$ (1,017.99)	$ (1,017.99)	$ (1,017.99)
Rent	$ -	$ (66,000.00)	$ (66,000.00)	$ (66,000.00)	$ (66,000.00)	$ (66,000.00)
Operating Profit	$ -	$ (477,022.99)	$ (72,067.99)	$ 377,882.01	$ 602,857.01	$ 827,832.01
Account Balance	$ (14,955.00)	$ (491,977.99)	$ (564,045.98)	$ (186,163.97)	$ 416,693.04	$ 1,244,525.05

Parameters	Value
Annual Salary	$ 65,000.00
Staff	7
Unit Price	$ 89.99
Profit Margin	50%
Annual Rent	$ 66,000.00

Expected sales/year	
2021	1000
2022	10000
2023	20000
2024	25000
2025	30000

Capital				
	Quantity	Cost/unit	Total	Cost/year
Compression bender	$ 3.00	$ 2,000.00	$ 6,000.00	
Bandsaw	$ 2.00	$ 300.00	$ 600.00	
Tube punch/press	$ 1.00	$ 600.00	$ 600.00	
Hole saw/ tube notcher	$ 1.00	$ 60.00	$ 60.00	
Sewing machine	$ 10.00	$ 300.00	$ 3,000.00	
Fabric cutting machine	$ 2.00	$ 1,000.00	$ 2,000.00	
Fabric screen printing tooling	$ 10.00	$ 30.00	$ 300.00	
Assorted tools	$ 1.00	$ 500.00	$ 500.00	
Prototyping materials			$ -	$ 1,000.00
Website hosting	$ 1.00	$ 1,895.00	$ 1,895.00	$ 17.99
Total initial capital investment:				$ 14,955.00
Yearly capital cost:				$ 1,017.99

Figure 5.1.1. Financial Summary

5.2 BASS MODEL

In order to create a Bass Model for the VenturePak, products with similar characteristics whose p and q values had been calculated were analyzed. P is the coefficient of innovation, which represents the probability of the product being adopted in time t. The coefficient of innovation is independent of prior adoptions, and strong marketing correlates with a high p value. Q is the coefficient of imitation, which is the probability of adoption based on social influence. The coefficient of imitation is dependent on prior adoptions, and a successful product correlates with a high q value. The characteristics of portability, compactability, and productivity were used to identify analogous products to the VenturePak.

The Bass Model was used to calculate the number of adoptions at multiple instances in time, and the equations used to predict the number of adoptions can be read in figure 5.3.2. below. The model used for our product assumes 250,000 adopters, and uses coefficient of innovation and coefficient of imitation values from the table provided in Principles of Marketing Engineering and Analytics Second Edition by Gary Lilien and Arnaud Rangaswamy. Figure 5.3.3. shows differences in adoption between two types of products: (1) a product that is compact and portable and (2) a product that is used for work. For portable or more compact products such as a room AC, digital watch, and cell phone, there will be an increase in adoption later in time than for a product that is used for work, like a home PC. The cumulative adoption curve in figure 5.3.4. is helpful in visualizing the total number of sales over time. As a middle ground between the two types of products that are compact/portable and work related, the VenturePak adoption curve will most closely resemble that of the digital watch, where relatively early adoption and then a decrease in adoption thereafter is observed.

Bass Model Forecasting Equations

$$f(t) = p + [q - p]F(t) - q[F(t)]^2$$

Where $F(t) = \frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{(p+q)t}}$

M = potential market (ultimate number of adopters)
p = coefficient of innovation
q = coefficient of imitation
F(t) = portion of M that have adopted by time t
f(t) = probability of adoption by time t

Figure 5.2.2. Bass Model Equations: These equations were used in conjunction with the coefficients of innovation and imitation acquired through research to create the adoption curves in figures 5.2.3. & 5.2.4.

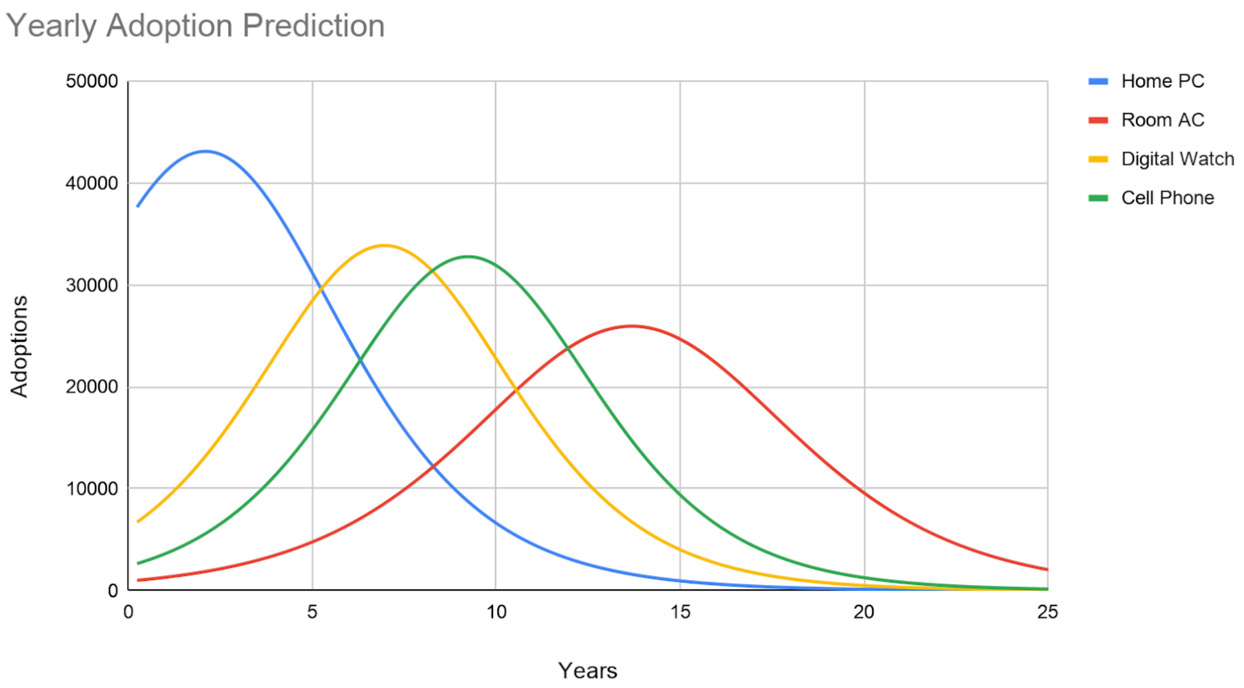


Figure 5.2.3. Yearly Adoption Prediction Curve: A yearly adoption prediction was calculated for a Home PC, Room AC, Digital Watch, and Cell Phone. The VenturePak most closely resembles a function in between that of the home PC and of the digital watch.

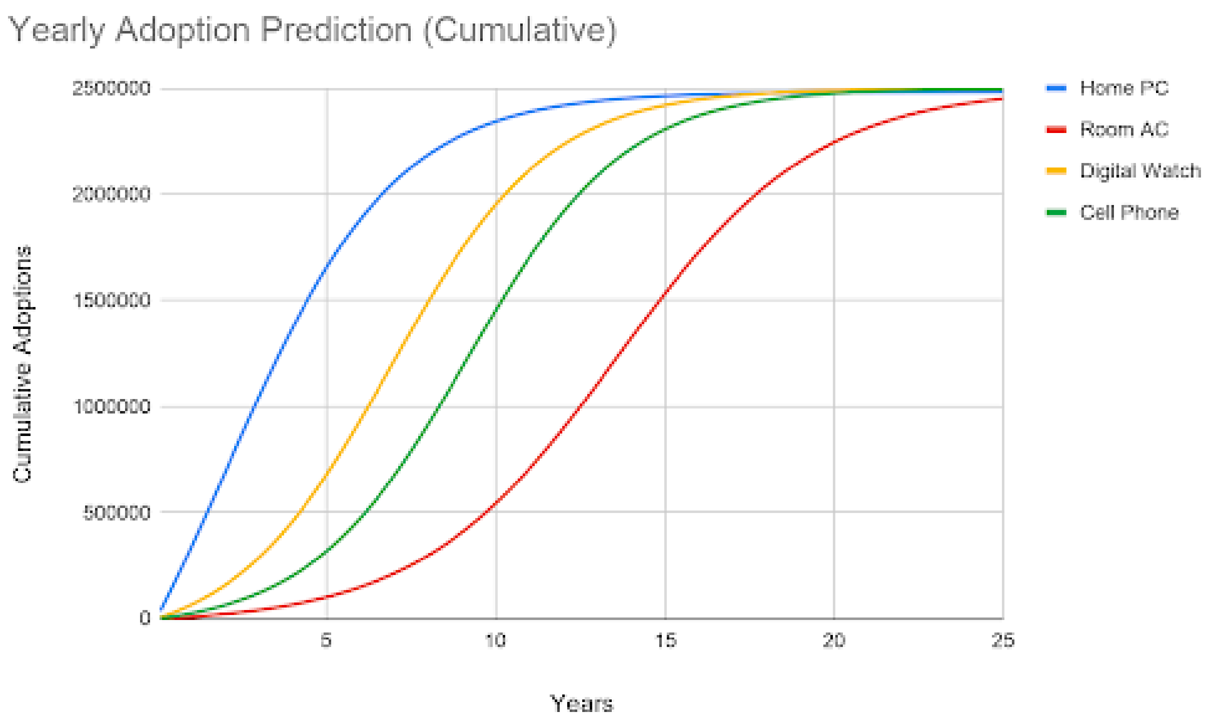


Figure 5.2.4. Cumulative Yearly Adoption Prediction Curve: A cumulative yearly adoption prediction was calculated for a Home PC, Room AC, Digital Watch, and Cell Phone.The VenturePak most closely resembles a function in between that of the home PC and of the digital watch.

5.3 PRICING POLICY

The target price for this product is $89.99.

Returning to the conjoint analysis, the trends with pricing indicated the sharpest decline in consumer demand after the price hit $100. This target price is set to avoid this decline, while maintaining as much of a profit margin as possible.

The primary issue currently is that from the manufacturing estimates, a single unit would cost $157.63 to make. It's important to note that this pricing involves purchasing materials at retail in the United States, and manufacturing at a limited scale. With an initial investment in tooling and a proper manufacturing facility in a country with lower labor cost, and purchasing materials in bulk, it's expected that the per-unit cost will be approximately $30-50 USD, yielding a profit margin of approximately 45-65%. If this per-unit cost is on the lower side of estimates, additional studies should be performed to see if lowering the target price of the product will increase consumer demand enough to increase gross revenue.

Comparing this with some reference products,
Kelty Tioga 5500 Classic External Frame Backpack, $188.95 (via Amazon)
Coleman Aluminum Camping Chair with Side Table, $54.44 (via Amazon).

While the high price of the Kelty backpack seems to indicate that the target price could be higher, this product serves a different market - hikers who are more concerned about performance and reliability for difficult excursions and are willing to pay more for this. The Coleman camping chair is for more casual use, and the price is significantly lower.

5.4 CAPITAL INVESTMENT

Based on the financial summary, an initial investment of at least $565,000 will be necessary to get operations started with the full team on payroll, and this does not yet account for physical capital purchases.

Payroll is a major investment sink and it may be optimal to run the company with a reduced staff at least for the first few years. Running at a staff of 3 would decrease the initial investment significantly to $232,000.

The annual cost for rent was estimated using a per-square-foot monthly cost of $1.10 and a warehouse size of 5000 square feet. For the website, ascendproducts.com is available on GoDaddy for $1895 + $17.99/year. Working with an outside investor or firm would very much be preferred to avoid taking out a loan from a bank.

5.5 WARRANTIES

The VenturePack will come with a 2-year limited warranty covering manufacturing defects in materials and workmanship. If any component breaks within this timeframe under "normal use", we will repair or fully replace the product. Pictures of the damage and proof of purchase is required. If damage occurs outside of the warranty terms or timeframe, Ascend will ship a replacement part which can be purchased on request.

6 LEGAL REQUIREMENTS

6.1. Safety & Environmental Regulations

6.2. Potential Liability Issues

- 6.2.1. Failure Mode and Effect Analysis

6.3. Intellectual Property Considerations

- 6.3.1. Patent Opportunities
- 6.3.2. Trade secrets
- 6.3.3. Trademark Opportunities

6.1 SAFETY & ENVIRONMENTAL REGULATIONS

The VenturePak must abide by all standard safety and environmental regulations that pertain to furniture such as chairs and desks, as well as those for worn garments. The Consumer Product Safety Act ensures that products do not impose any un-assumed risk on their users. The Act establishes safety standards as well as methods for customers to understand the safe use of a product. For this reason, potentially harmful features such as bolts are fastened to the VenturePak using a torque gun, and the mechanisms that facilitate the deployment of the chair and desk are indicated by removable sticker arrows, helping ensure safe and proper usage. Further, the backpack and chair components of the device must adhere to the Flammable Fabrics Act (FFA). This requires that the fabrics can not ignite via an ignition source such as a cigarette, and for the Ascend team to conduct a test and document that the device meets these standards.

6.2 POTENTIAL LIABILITY

To ensure users are using the VenturePak as the designers intended, and protect the team from liability concerns, the team must abide by the Federal Trade Commission Act. This regulation dictates that the product must convey all necessary information for proper use, and take measures to ensure that misuse is avoided. Various failure modes, as well as how they are mitigated, are documented below.

6.2.1. Prediction of Misuse Cases

A proper Failure Modes and Effects Analysis (FMEA) was conducted for the device. Under FMEA analysis, failure modes are not only identified but also are given ratings on severity and likelihood scales. The product of these ratings establishes the importance of the risk relative to others. The fact that the user is trusting the VenturePak to hold their entire body weight amplifies the importance of ensuring the mechanical integrity and resilience of the system. Misuse of the device or any mechanical failures within the system could lead to injury.

Two failure modes involving mechanical failures within the system were identified, and potential corrective actions laid out. The first catastrophic failure is the legs of the chair breaking under the weight of the user. This would result in the user falling to the ground and leaving them prone to bodily injury. This could be caused by the joints in the legs not being strong enough. While the product is considered broken by this failure mode, the user could fasten the connection back in place, however this is not an anticipated use case. To mitigate this failure mode, aluminum tubing was chosen for the chair frame and FEA as conducted on the frame system.

The second catastrophic failure mode is one of the straps that connects the chair seat to the backpack breaking. As the strap provides rigidity to the system in the form of tension, and prevents the backpack from falling backwards, strap failure would cause the user to fall backwards out of the chair, potentially landing on their head or shoulder. This entails a great deal of bodily risk and could be caused by wear and tear on the straps reducing their mechanical integrity. While the straps could be sewn together by the user, the system is considered broken from this failure. To ensure the straps are of good quality, the VenturePak will source straps from only ISO 9001 certified suppliers, and select straps rated for customers weighing twice the advertised weight limit of the VenturePak.

Two lower priority failure modes that hinder the performance of the system are the zipper snagging and the seat fabric tearing. The zipper opening the device is a prerequisite condition for system operation, and thus if the zipper gets stuck on a loose strand of fabric, it delays the deployment of the seat. The user must force the zipper through or wiggle it until the fabric is released. Should the problem persist, the user may choose to cut the fabric to free it. As a countermeasure, no fabric flaps will be included near the zipper. Another failure mode that does not impact the functionality of the device but impacts the key customer performance of appearance is the fabric of the seat tearing and exposing the padding of the seat to the environment. This is likely to occur near the end of the product's life cycle and is accelerated by leaving the VenturePak exposed to the elements for long periods of time. As a result of this, the product is less appealing to the customer.

Another unintended use case of the device resulting in a failure of performance would be the aluminum chair legs impaling the user or dropping onto their foot, potentially resulting in injury. To ensure this does not happen, the feet of the legs are blunt, as are all corners found on the device. Another failure mode is the chair straining the back of the user. This could occur after extended use, and is very much dependent on the posture of the user and the duration they use the device. Ergonomics is the corrective measure here, with the shoulder straps of the VenturePak and shape of the seat being designed to distribute weight across the body as much as possible.

Failure Mode #	Failure Mode	Failure Effects	Possible Cause	Failure Effects Severity	Occurrence Likelihood	Risk Priority Number (RPN) (=severity * occurrence	Risk Criticality (Corrective Action Priority)	Corrective Action
F.1	Chair breaks under weight of user	User is thrown to ground. Backpack may fall on user. User is prone to bodily injury	Connection between chair frame and deployable seat is not strong enough	5	1	5	MED	User may chose to sew connector back together, but the product is considered broken. Structural stability and integrity of device will be simulated in an FEA program before deployment
F.2	Straps connecting backpack to seat frame break	Back rest becomes unconstrained and falls backwards. User is prone to bodily injury	The quality of the straps deteriotating from being stored in inclement weather for extended periods of time	5	2	10	HIGH	User may chose to fasten or sew the broken strap together, but the product is considered broken. Calculation will be performed to determine the thickness and material for the strap required.
F.3	Zipper to deploy seat snags	User is unable to deploy the seat and seat frame portions of the device	Fabric getting caught in the zipper itself	2	3	6	LOW	The user must force the zipper through, or wiggle it until the fabric is released. Should the problem persist, the user may choose to cut the fabric to free it. As a countermeasure, no fabric flaps will be included near the zipper.
F.4	Seat fabric rips	The visual appeal of the product decreases. The internal padding of the seat is exposed to the enviornment	Wear and tear thinning the fabric, likely towards the end of the product life cycle	1	3	3	LOW	The user may chose to sew the gap, or cover it with duct tape. This failure mode will not impact the function of the system. A fabric will be selected that is specified to last at least the duration of the product lfe cycle.
F.5	User is impaled by fastener or chair legs	Bodily injury to user or injury to eye.	Device falling on or being thrown at user	5	1	5	LOW	The device shall be designed with blunt corners, and fasteners shall be affixed via a torque gun, such that they cannot loosen and become free.
F.6	Backpack weight strains back of user	The user may experience dull or sharp back pain	System is excessively heavy	2	3	6	MED	The shoulder straps of the backpack shall be designed to conform to the shoulders of the user. The weight of the device will be pressed into the lower back of the user, to avoid straining the user's back

Figure 6.2.1.1. Failure Modes & Effects Analysis

Of the many features and functionalities on the VenturePak, some are conceptually protected by United States patents as intellectual property. As a system that is a combination of three household items - a desk, backpack, and chair, a number of patents exist that protect these subsystems individually, or the interface between two. Protected technologies and concepts require a fee to adopt and incorporate. Other features are unprotected, as their patents have expired. A number of key features are discussed below.

Chair Related Patents

Three patents were identified to be of similar construction to our device. Patent US7118172B1 protects the concept of a general seat frame which has legs underneath the backpack to support it and folds and nests into the backpack. In terms of the configuration of the deployed legs, patent US5409291A protects the concept of having the legs form an A-shaped frame, but is expired. Patent USRE39022E1 protects the idea of having the back leg frame fold parallel and adjacent to one another against the backpack frame, but is also expired. From the expiration of these patents, as well as the limited scope of the first one, the current iteration of the VenturePak's folding seat frame, which places the chair supporting legs forward of the backpack, does not infringe on any intellectual property rights.

Straps Related Patents

The strap featured on the VenturePak is a technology that will have to be licensed, or a fee paid. There are two strap features on the device, one for the backpack straps and one connecting the deployed seat frame to the back rest, which provides rigidity during deployment. Patent US6345862B1 is an active patent that protects shoulder straps affixed to a solid seat frame. For the straps that connect the backrest and the deployed seat, Patent US5303975A claimed intellectual property on the design. It recently expired, however Patent US5819999A was filed quickly after and protects a similar angled strap design. However, the VenturePak features straps that run from the back rest to the chair frame, not to the seat. Thus, the proposed design does not infringe on the intellectual property protected by current patents.

Desk Related Patents

Two patents were found with technologies related to our desk design. One is US9242733B2, which is expired and patents the idea of supporting a desk with telescoping legs. Another is US10588402B2, an active piece of intellectual property regarding the concept of the desk folding into a larger backpack frame assembly. Due to the standalone nature of the desk design, and the fact that the telescoping patent is expired, the current version of the desk component of the VenturePak can be considered novel and not infringe on any intellectual property rights.

Patents Relevant to VenturePak		
Patent Number	Patent Name	Issue Date
US9242733B2	Tray Table with Articulating Support	18 July 2013
US7118172B1	Backpack Chair	10 Dec 2004
US6345862B1	Convertible Backpack Chair	1 Mar 2003
USRE39022E1	Backpack Chair	19 Jan 1999
US5303975A	Convertible Backpack Chair	24 Jan 1992
US5819999A	Combination Backpack and Chair	17 Mar 1995
US5409291A	Combined Chair and Backpack	6 August 1993
US10588402B2	Portable Collapsible	22 Aug 2007

6.2.1.1. Table of patents relative VenturePak

6.3.1. Patent Opportunities

A utility patent safeguards a device's key functionalities and how it is used. Utility patents give product designers the right to produce and sell a design. On the contrary, a design patent products the unique visual appearance of a device and protects from copyright infringement. As outlined in the above section, aspects of the design such as the chair frame, strap orientation, and desk are considered novel, and do not feature previously patented technologies. Thus, the team's approach is two-fold: pursue independent utility patents for the chair frame, strap configuration, and desk designs, and a design patent for the overall design. The design patent will ensure that the product cannot be copied once it enters the market, whereas the utility patent protects for twenty years the way the mechanical mechanisms were implemented on the device.

6.3.2. Trade Secrets

To have in our possession trade secrets, the Ascend team would have had to develop internal processes or knowledge which adds value to the device but is not readily available to the general public. This is not the case for the Ascend team, as the design of the device is the conglomeration of many different simple mechanical mechanisms. The configuration of these mechanisms is unique and calls for the patents reference in the above section. However, they do not qualify as trade secrets.

6.3.3. Trademark Opportunities

The team will trademark its name and logos. While there are several companies named "Ascend", our team distinguishes itself through its logo featuring a two-dimensional mountainscape design behind the word. The same is true for the "VenturePak" and its logo, featuring an abstract backpack in the same style of our company logo. The team's trademark includes the green-colored theme, as well as an alternative navy blue backdrop. All are featured below.

7

ENVIRONMENTAL TARGETS

7.1 ENVIRONMENTAL IMPACT ON PRODUCTION AND END OF LIFE

The main disadvantage for reliable and expendable products is that we are disposing them at increasing rates, and the environment is suffering as a result. Considering this, we went for a more environmentally friendly route of product design.

For our main frame of our product, we decided to use aluminum tubing. This allows for the majority of our product to be considered for recycling. Also, our desk will be made out of a polycarbonate sheet. These sheets can be easily recycled and remade into a new material, which makes it a better alternative to other materials that may not be as easily recycled. However, when these polycarbonate microplastics are cut, it produces small particles that could cause irritation to the skin and eye; if inhaled, it could cause lung tissue damage, which could also cause inflammation. As a result, manufacturers have internal safety protocols to protect their workers.

If low quality epoxy comes into contact with substances such as water, it could release some toxins. However, our epoxy will be completely polymerized during manufacturing stages, so it should not be a problem even in the long run.

During our manufacturing process, we use aluminum for our frame and legs. Aluminum manufacturing will have the most adverse effect on the environment due to its refining and smelting process, which releases greenhouse gases. Additionally, working with pure aluminum ore entails a huge amount of energy input, which is typically sourced from coal.

8 FINAL TIMELINE AND FUTURE PLANS

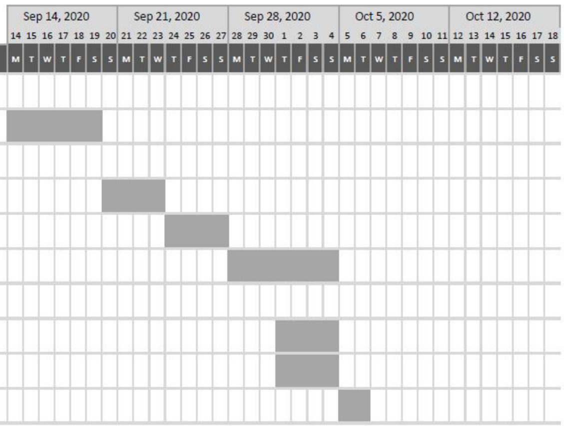
MAE 4340 Gantt Chart

Ascend

9/13/2020

1

TASK	PROGRESS	START	END
Empathize			
Empathy Fieldwork	100%	9/13/20	9/19/20
Define			
Unpack Fieldwork (Capture Emotional Data)	100%	9/20/20	9/23/20
Group and Subgroup Emotional Data	100%	9/24/20	9/27/20
Model Emotional Data (Flow of Thoughts, Personas, HMW Capabilities Diagram)	100%	9/28/20	10/4/20
Ideate			
Brainstorming Sessions	100%	10/1/20	10/4/20
Design Space Tradeoff Diagrams	100%	10/1/20	10/4/20
Concept Sketches	100%	10/5/20	10/6/20



MAE 4340 Gantt Chart

Ascend

9/13/2020

6

TASK	PROGRESS	START	END
Prototype			
Design Zero Brainstorming	100%	10/17/20	10/20/20
Design Zero Prototype Assembly	100%	10/21/20	10/21/20
Test			
Design Zero User Testing	100%	10/22/20	10/28/20
Brainstorm Ideas from User Testing Feedback	100%	10/28/20	11/1/20
Iterate			
Brainstorm for Design One	100%	11/1/20	11/8/20
CAD Iterations for Design One	100%	11/1/20	11/3/20
Finalize CAD Prototype for Design One	100%	11/4/20	11/8/20
Order Parts and Assemble Prototype One	100%	11/9/20	11/19/20
Prototype One User Testing	100%	11/20/20	12/8/20

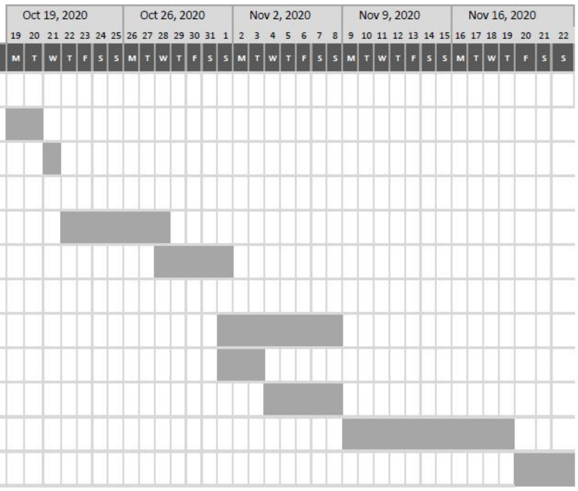


Figure 8.1 GANTT Chart

Section	Task	Date Completed
Empathize	Empathy Fieldwork	September 19, 2020
Define	Unpacking Fieldwork	September 23, 2020
	Group and Model Emotional Data	September 27, 2020
Ideate	Brainstorming Sessions	October 4, 2020
	Concept Sketches	October 6, 2020
Prototype	Design Zero Brainstorming	October 20, 2020
	Design Zero Prototype Assembly	October 21, 2020
Test	Design Zero User Testing	October 28, 2020
	Brainstorm Ideas from User Testing Feedback	November 1, 2020
Iterate	CAD Iterations for Design 1	November 3, 2020
	Brainstorm for Design 1	November 8, 2020
	Finalize CAD Prototype for Design 1	November 8, 2020
	Order Parts and Assemble Prototype 1	November 19, 2020
	Prototype 1 User Testing	December 8, 2020

Gate Review #1	10/07/20
Gate Review #2	11/11/20

Figure 8.2. Project Timeline with Gate Review Dates

8.1 FUTURE TIMELINE

Our plan is to continue to improve VenturePak, making it easier to use. To do so, we must conduct more usability testing to improve our product. This would include conducting more interviews and walkthroughs with potential customers, then redesigning based on those insights. We want to hear our users' perspective on the product; their comments would inform future design decisions. From there we want to drive down our manufacturing costs to lower our price point, making VenturePak more affordable for the modern student. After refining our design, we would then move on to gaining funding, by entering competitions like Big Idea or creating a GoFundMe page to bring our product to the world. Beyond that, we would like to pursue the patents discussed in section six, form an LLC, and expand our company to better suit our needs. Later on, we would want to partner with a backpack company who could market our backpack and help VenturePak be featured in stores across the country. At the end of the day, we hope to change the way people work, by changing where they work.

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