Design Project:

Bed Desk for Ergonomics Improvement

ME 234-01

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June 10, 2020

Introduction

This project challenges ergonomic risk factors for a bed workspace. I decided to tackle this problem because my sister was starting to develop bad posture and experience neck strains from doing schoolwork on her bed. Hopefully, the solution will benefit those who don't have access to the comfort of a traditional workspace. In this document, I will discuss the research conducted, address the problem statement, and state the design criteria and constraints.

Background/Stakeholder Research

My sister, Laura, currently does not have access to her own proper workspace, so she has been attending school virtually from her bed. She hunches over her laptop, neck bent towards the screen for a closer look. After questioning her about the comfort of her workspace, she responded, "I usually sit in the middle of the bed and bend my body over my laptop. Unfortunately, when I wake up, my back feels sore. Now, my posture has gotten worse." Furthermore, she mentioned disliking direct contact between the laptop and her legs. I reached a conclusion that Laura hoped to fix her posture with an improved makeshift workspace and preferred an elevated surface design.

Next, I researched existing products and patents for designs that addressed her needs:

"Folding Lap Desk, laptop desk, Breakfast Table, Bed Table, Serving Tray." Amazon. https://www.amazon.com/Folding-laptop-Breakfast-Table-Serving/dp/B01NBTRGDH/ref=sr_1_8?dchild=1&keywords=bed+desk&qid=1590190712&s=office-products&sr=1-8. Accessed 21 May 2020.

This existing product addresses the stakeholder's needs because of its structure. The side panels are solid and strong, due to the plastic material, and support the top flat table surface. However, the black plastic may be unaesthetic to the eye, and this product seems to be intended for younger children who want to store items beneath the desktop.

"KLIPSK Bed tray, white" Ikea. https://www.ikea.com/us/en/p/klipsk-bed-tray-white-00258882/?gclid=CjwKCAjw8J32BRBCEiwApQEKgadISMfaHh0ravDielLvX64nV6z-mgYyXVdo9nt4XswiZFkkm8xc5RoCOTAQAvD_BwE. Accessed 21 May 2020.

This design is simplistic and straightforward; it offers a stable flat surface that holds objects above the bed surface. Although this is a great design, it may not be effective for workspace needs due to a slight ridge along the rim. The rim could be uncomfortable for users who want a completely flat surface to write on, and cause discomfort as the rim presses into the user's arm.

"Adjustable 8 Position Laptop Tray Desk." Wayfair. https://www.wayfair.com/furniture/pdp/inbox-zero-adjustable-8-position-laptop-tray-desk-w003172146.html. Accessed 21 May 2020.

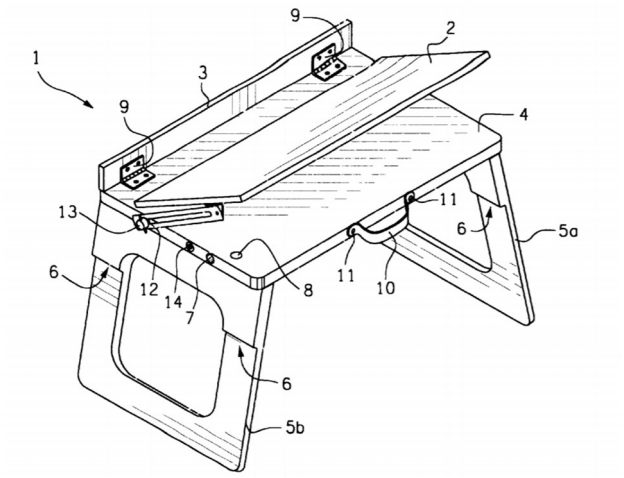
This design is a great way to incorporate angled elevation, which could lessen the user's neck strain. However, this design does not have legs and does not work well as a bed desk. This product will have to sit on the user's lap, making it uncomfortable and difficult to work as eyes are focused down.

"Berthiaume Bamboo Adjustable Laptop Tray." Wayfair. https://www.wayfair.com/furniture/pdp/symple-stuff-berthiaume-bamboo-adjustable-laptop-tray-w001403264.html. Accessed 21 May 2020.

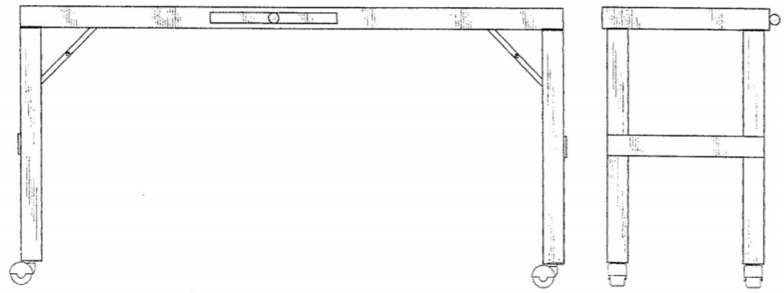
This existing product from Wayfair seems to have strong and sturdy table supports. It has great usability features, allowing a small table height and surface elevation adjustment. I would be concerned about the wired elevation adjustment component and how much load it can take.

"Laptop Desk for Bed, TaoTronics Lap Desks Bed Trays for Eating and Laptops Stand…" Amazon. https://www.amazon.com/TaoTronics-Foldable-Adjustable-Portable-Writing/dp/B07DJ5F15J. Accessed 21 May 2020.

This product has amazing usability features, such as the clips holding the laptop in place, as well as the height and elevation adjustment options. The device adjustments can be personalized to the user's preferences, allowing maximum comfort.



Drake, David C. Configurable Lapdesk. US 6044758, United States Patent and Trademark Office, 4 April 2000. Google Scholar. *https://patentimages.storage.googleapis.com/9e/f5/ba/5a7bddd7655ce2/US6044758.pdf*
This desk unit is convenient due to its portable nature, with folding legs and hinged boards.



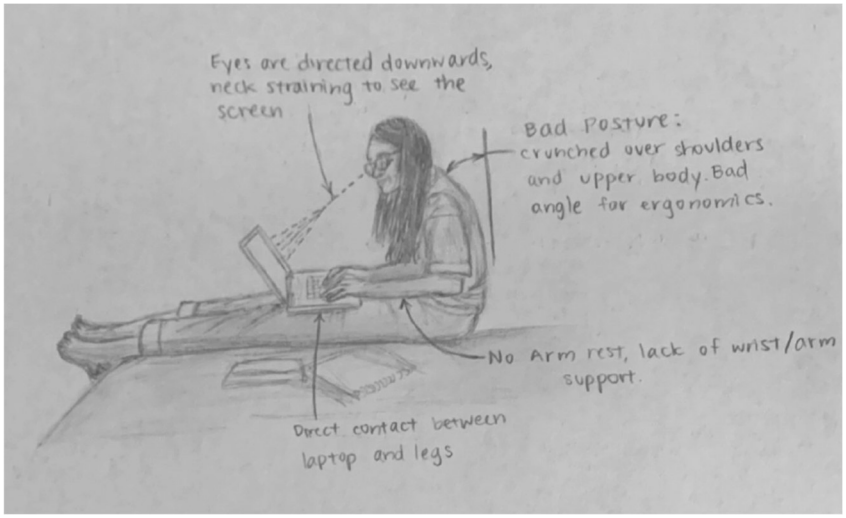
Richardson, Willie F. Bed Desk. US 372602, United States Patent and Trademark Office, 13 Aug. 1996. Google Scholar. *https://patentimages.storage.googleapis.com/57/a8/f0/4c0b5f2950d782/USD372602.pdf*
This simplistic design is straightforward to use. A flat surface and hinged legs allow the table to collapse into a smaller size for easy transportation.

After reviewing all existing solutions, I found many plausible designs. I learned that the most common table supports are flat, rectangular panels. I did not see any desks that sported the traditional four separate table bars, which might indicate they are too unstable on soft surfaces such as a bed.

To conclude, I researched articles to learn more about the concept of ergonomics in a workspace. One example of the ergonomic factors mentioned by *mayoclinic.org* was regarding monitor/screen placement; it was stated that the top of the monitor (laptop screen) “should be at or slightly below eye level.” (Office Ergonomics...) Although this article followed a desk and chair setup, I looked for issues I can address using a bed instead of a chair. In addition, I found that adjustable bed trays are the best elevated workspaces: “The feature of a perfect bed tray includes ease of adjustment, impeccable designs, durable construction, angular adjustment, and a built in fan for heat dissipation for your laptop.” (“6 Ergonomic Tips) I will try my best to utilize this research address these points during my design ideation.

Problem Description

Using the bed as a workspace can negatively affect one's posture and cause physical injuries. People who work on their beds and need an effective ergonomic workstation design may benefit from this project.



As seen in the photo above, physical complications will arise from working on a bed. My goal is to reduce ergonomic risk factors and improve working conditions at home by addressing the physical needs and complications of working on a bed.

Project Constraints and Criteria	Description
Aesthetic	Smooth and flat desk surface
Usability	Interactive: specifically, table height and surface elevation adjustments
Comfort	Amount of time that user can use the device without noticing discomfort
Safety	Amount of load device can take without collapsing, especially underneath weight of a laptop
Stability	Table will not noticeably wobble
Functionality	Desktop will not directly touch the user's legs

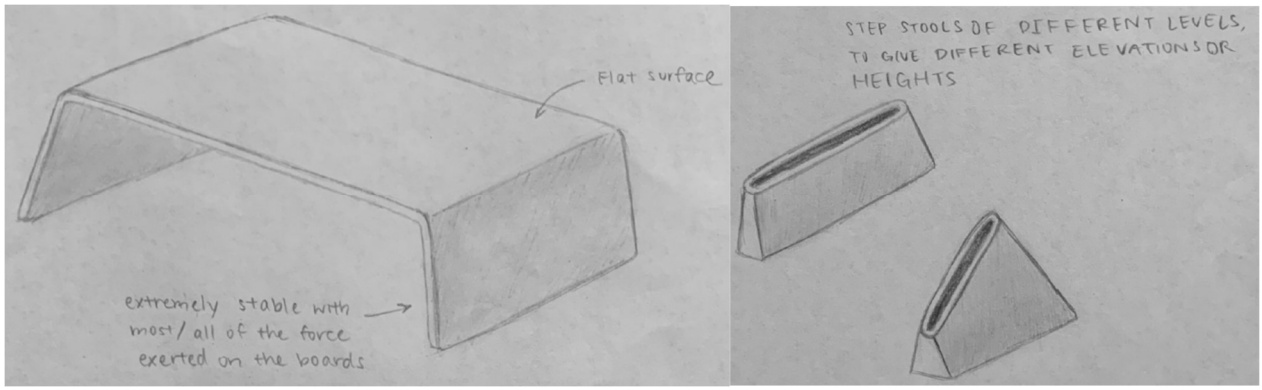
This table addresses the needs and constraints of this project. In addition, I came up with more criteria based off of the research conducted, such as table height and surface elevation adjustments.

Project Management

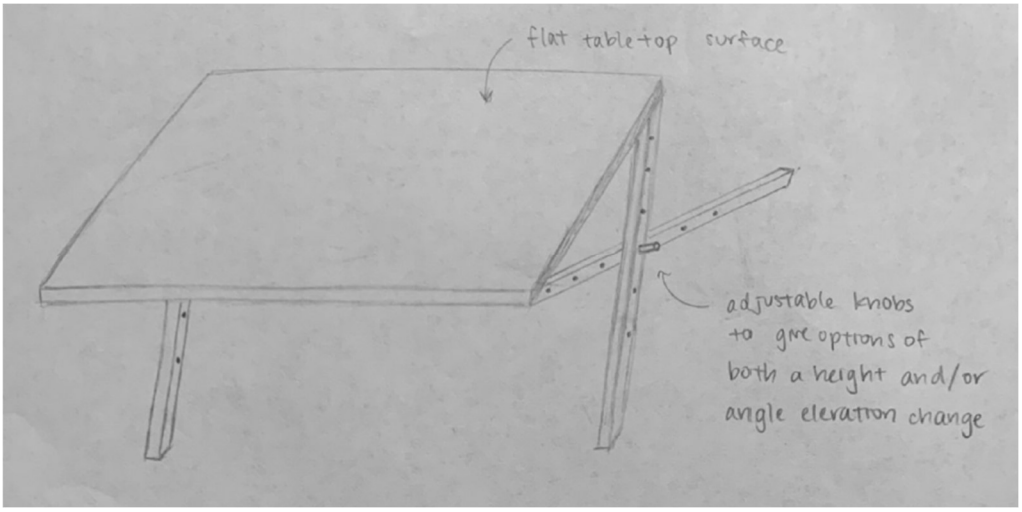
This project's deliverables and milestones include: SOW document, PDR report, a pitch video, and a concept prototype. See Appendix A.

Ideation

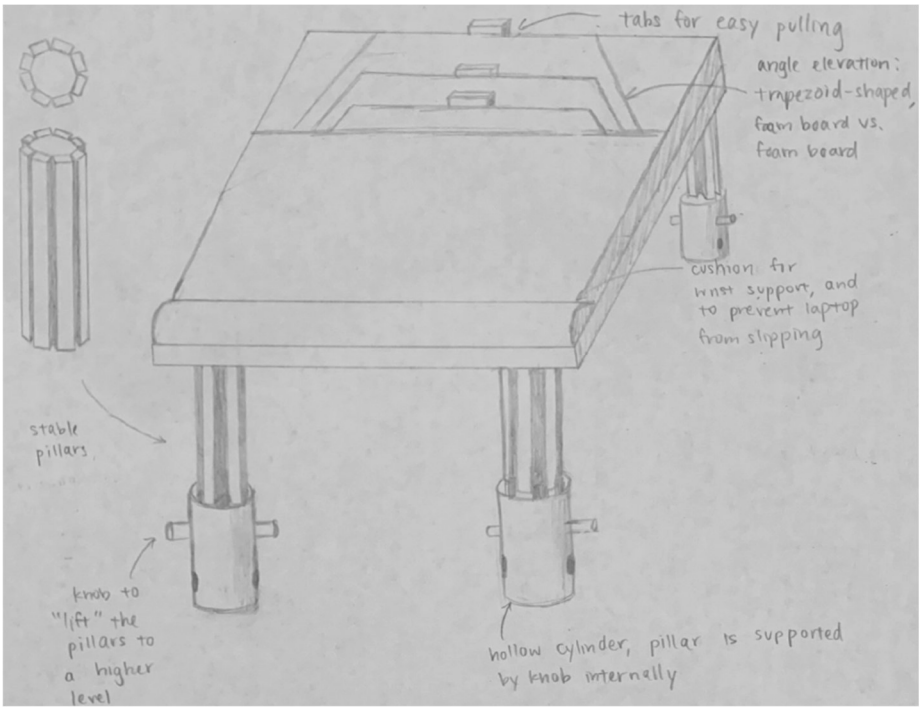
I utilized functional decomposition to come up with a general idea of bed table's typical functions and features, which helped me focus on a problem to address and ways solve it. During the process of ideation, I used varying ideation methods such as brain-walking, HMW, and analogies. Using these ideation techniques, I came up with at least 100 design ideas of varying shapes and features (See Appendix B). From those ideas, I sketched a few plausible final designs and my top five are displayed below:



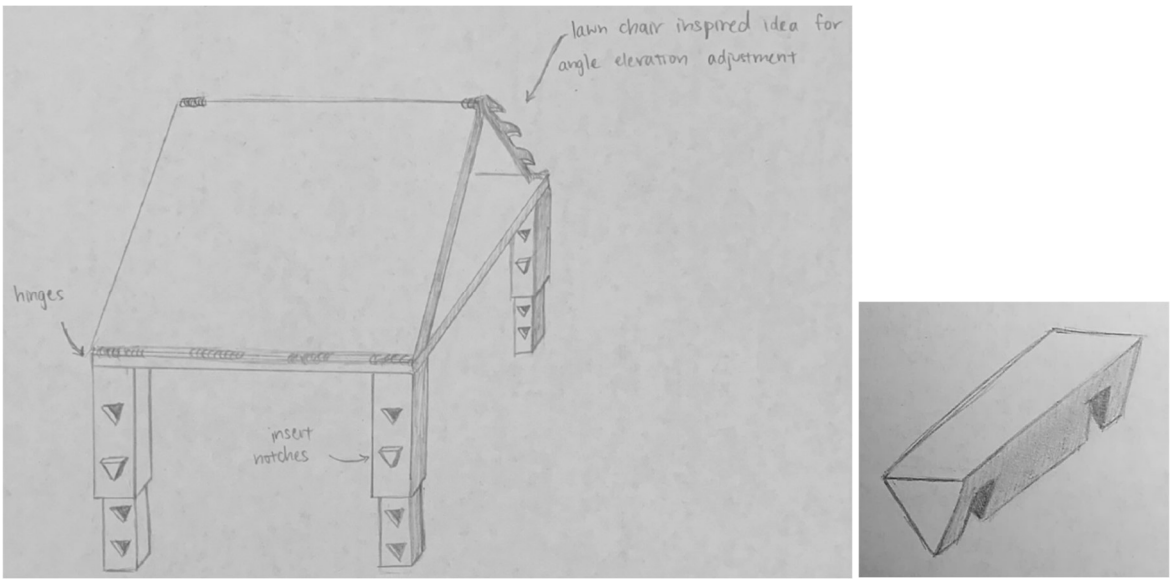
Sketch 1. For this design, I thought of ways to maximize simplicity and durability. However, the extra parts would be extremely inconvenient. It would be challenging to keep track of so many components.



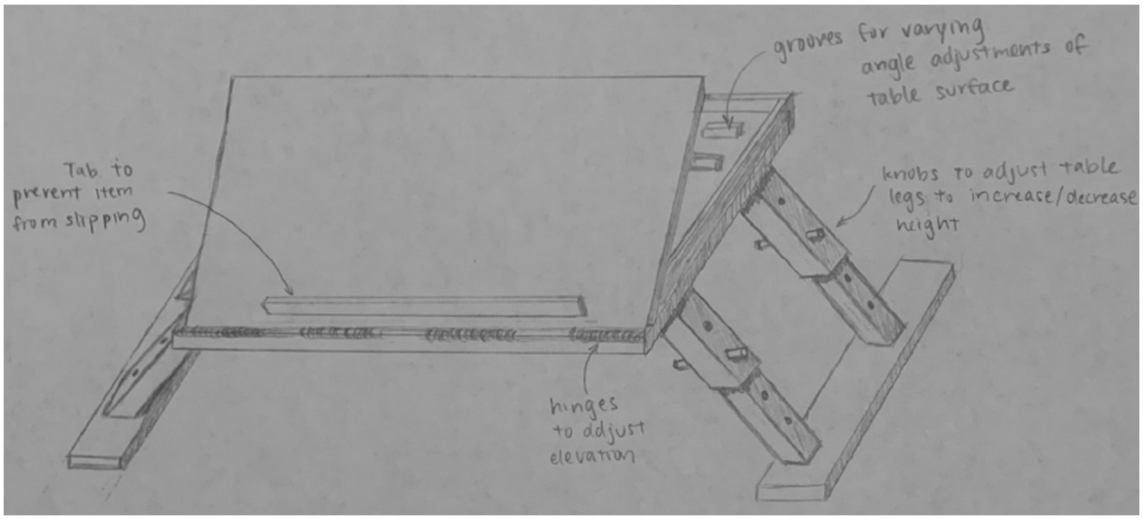
Sketch 2. After determining adjustment features were an important part of this project, I was inspired during my brain-walking and analogy method. Although I came up with a mechanism to maximize convenience, the amount of load on the table legs may be uneven and cause the table to collapse.



Sketch 3. I wanted to tackle aesthetics and stability in this design with the strength and beauty of symmetrical, cylindrical foam table legs. I also wanted to think of a different way to offer angle elevation adjustments. However, I was worried that the force exerted on the height adjustment knobs in the hollow leg cylinders might be too large.



Sketch 4. This design looks simplistic and aesthetic. It also offered the most angle elevation features, inspired by the lawn chairs at Cal Poly. I was unsure about the usability of this design, because the notches at the on the legs may be difficult to interact with. I intended for the user to insert the tab (right side sketch) into the notch and push down to lock it in place, but it's not very self-explanatory.



Sketch 5. This was my top choice because it maximizes functionality, usability, and aesthetics. This design's mechanisms seemed to be the best in terms of usability, and the support board at the bottom of the legs allows the table structure to stand evenly. The main concern I had was the stability of this design, because the table legs are slanted at an angle to maximize the user's leg space.

Idea Selection

Although I had many concerns for each design idea, I tested them by building model prototypes. Most, if not all, of my concerns were confirmed after assessing the mechanisms. With the prototypes in mind, I created pairwise comparison charts and decision matrices (shown below) to further narrow down my ideas.

		A	B	C	D	E
Durability	A	-	B	C	D	E
Functionality	B	-	-	B	D	BE
Usability	C	-	-	-	D	C
Safety	D	-	-	-	-	E
Adjustability	E	-	-	-	-	-

Results (Ranked in order from highest to lowest)

Functionality: 3
Safety: 3
Adjustability: 3
Usability: 2
Durability: 0

Functionality: 27%
Safety: 27%
Adjustability: 27%
Usability: 18%
Durability: 1%

Pairwise Comparison Chart. The results showed that the top three criteria needed to maximize functionality, safety, and adjustability. This eliminated sketch #2's design idea due to the instability of the legs, which jeopardized the safety factor. In addition, durability was the lowest ranked, and therefore, the idea in sketch #1 was also eliminated since its intentions was to maximize durability and simplicity.

Functionality: reduces ergonomic risks, amount of time user can use the device without noticing discomfort
Safety: table will not collapse on user
Adjustability: amount of options for table height and table surface angle elevation
Usability: smooth and flat desk surface, not wobbly
Durability: amount of weight/load this design can take

		Designs									
		# 1: Angle elevation tabletop surface		# 2: Table leg height adjustment: Knob insert/lock mechanism		# 3: Table legs at 30 degree angles with rectangular base		# 4: Table legs height adjustment: Toothpick insert, through all		# 5: Table legs height adjustment: tab insert	
Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Functionality	0.27	5	1.35	4	1.08	3	0.81	5	1.35	5	1.35
Safety	0.27	3	0.81	3	0.81	5	1.35	3	0.81	2	0.54
Adjustability	0.27	5	1.35	4	1.08	1	0.27	5	1.35	5	1.35
Usability	0.18	4	0.72	1	0.18	5	0.90	5	0.90	4	0.72
Durability	0.01	2	0.02	3	0.03	4	0.04	3	0.03	1	0.01
Total			4.25		3.18		3.37		4.44		3.97
Rank			2		5		4		1		3

Results (*Ranked from highest to lowest)*:

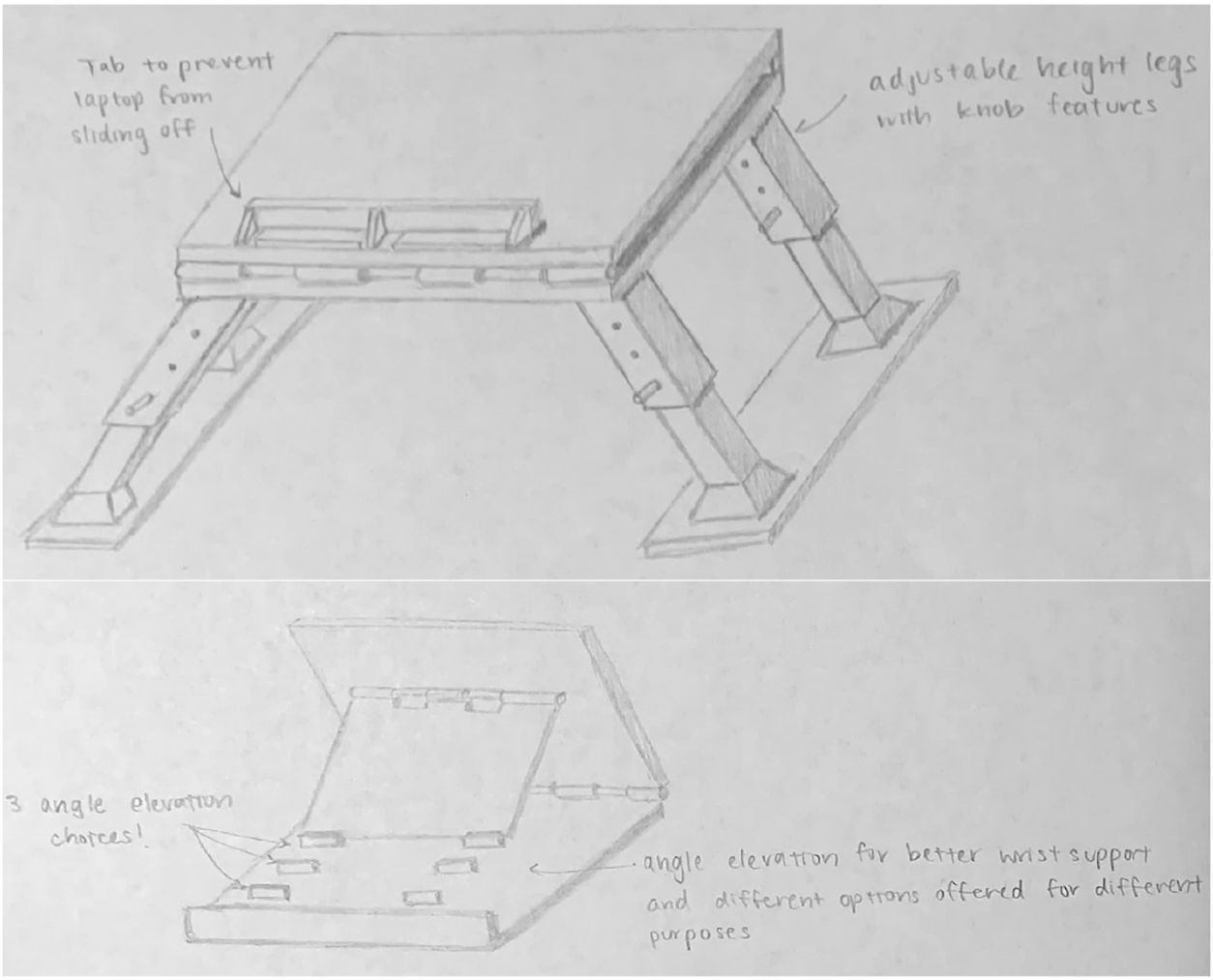
1. Design concept # 4: Table legs height adjustment: Toothpick insert, through all
2. Design concept # 1: Angle elevation tabletop surface
3. Design concept # 5: Table legs height adjustment: tab insert
4. Design concept # 3: Table legs at 30 degree angles with rectangular base
5. Design concept # 2: Table leg height adjustment: Knob insert/lock mechanism

Decision Matrix. After prototyping, I grasped a better idea of how the mechanisms and features addressed these criteria. Seeing that the knob/tab insert and lock mechanism ranked last, I decided to eliminate the idea in sketch #4 due to its complexity. In addition, the toothpick insert through all mechanism was ranked higher than the tab insert mechanism when taking table height adjustments into consideration. I chose to go with the toothpick insert mechanism to maximize safety and eliminated the idea in sketch #3.

After ranking all criteria and applying their weights to the five prototype models, I eliminated all design idea sketches except for sketch #5. I also asked my sister to interact with each prototype and used her feedback to determine each designs' usability, which confirmed my concerns for each eliminated sketch. Additionally, I consulted my groupmates, who offered advice on how to make my structure more stable. In conclusion, I choose the design in sketch #5 and decided to incorporate additional components to increase its stability.

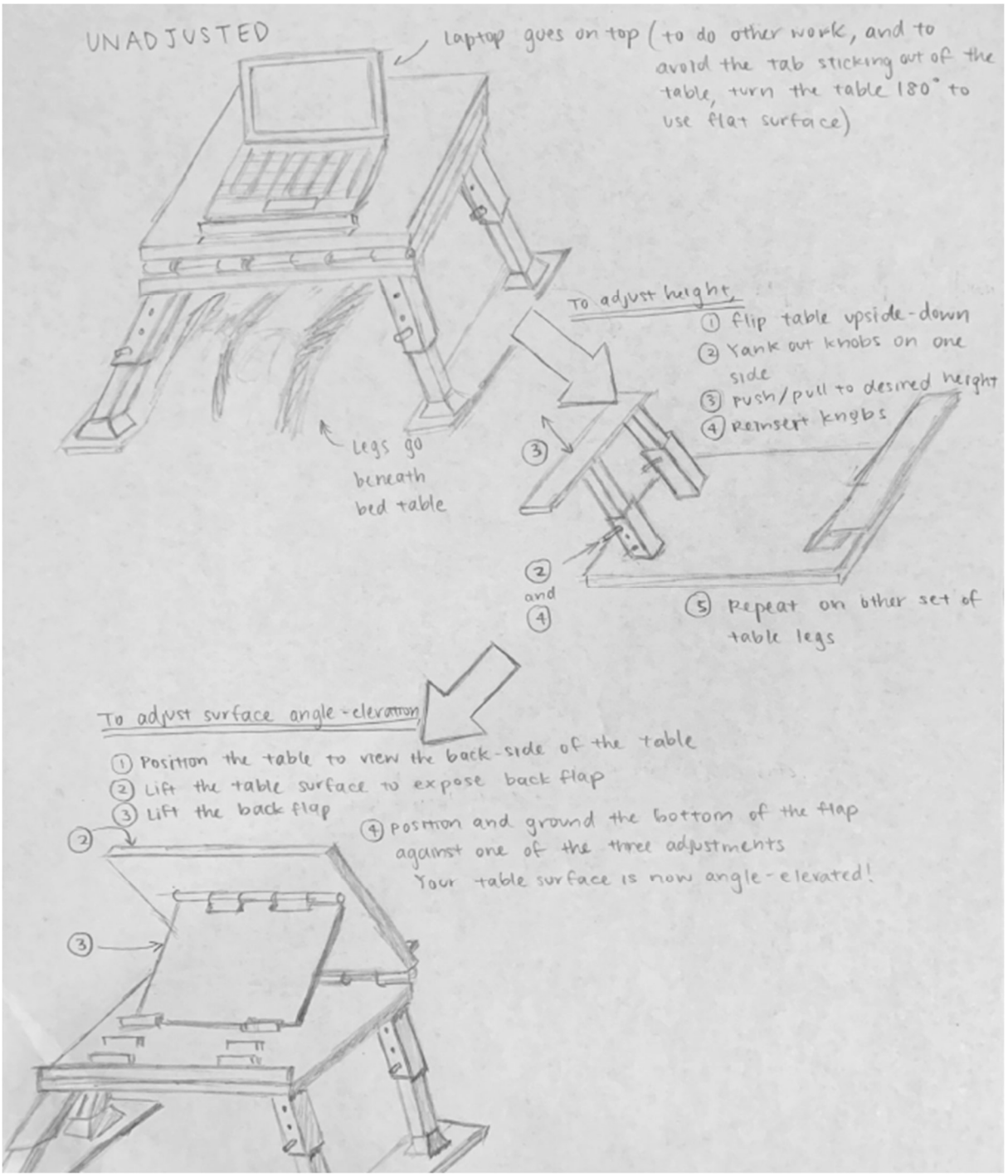
Implementation

My chosen concept has two adjustment features: table surface angle elevation and table height elevation. These adjustments will improve the ergonomics of the users' bed workspace by maximizing comfort and preventing physical injuries.



Annotated sketch of Final Design. As mentioned previously, this design's main features include the adjustment mechanisms with three elevation choices each. The design also features a long, horizontal tab to prevent the laptop from sliding off when the angle elevation mechanism is being used. Two horizontal support boards at the bottom helps the table stand flat against the bed to increase durability. In addition, the hinges allow a smooth rotation for the table-top and back flap.

With this concept, the user can work on their laptop and perform tasks at a comfortable eye level, which reduces neck strain and prevents bad posture. In return, the user's productivity and efficiency will increase in their workspace.



Final Design Storyboard. This design's application allows the user to do work as if it were a typical desk. To use the height elevation adjustment, the user must remove all items from the table surface and flip the table upside-down. Focusing on one side, pull out the table knobs and push/pull to the desired height. Reinsert the knobs in their respective holes and repeat on the other side. To use the angle elevation adjustment, the user has to lift the table-top and expose the mechanism underneath. Second, the user should position themselves/the table to find the backflap connected to the table-top. Next, the user must rotate that backflap and position the bottom of it against the tabs.

I designed this table in hopes of the user understanding basic movements of pushing and pulling objects, in addition to recognizing the adjustment mechanisms. If this product is not used as intended, it could collapse and jeopardize the user's safety.

When I presented the final prototype to my sister, she was amazed at the sleek and clean look. She was satisfied with the functionality of it and started using it instantly. Below, I will show the demonstration model and address its features.

Photo of demonstration model. In this photo, you can see the bed table sitting on the bed. The symmetry of this table adds onto the aesthetic, along with the neutral colors of white, brown, and a little bit of black. The materials used were foamboard, thin cardboard, pencils, and chopsticks. The wood in chopsticks is very sturdy, so it offered strength in upholding the foamboard legs. As seen above, there is a tab on the tabletop to prevent objects from sliding off once the angle elevation is being used. The tab is supported by fillets to keep it at a right angle and to prevent bending from the weight distributed on top. These two features ensure safety/product liability and functionality. In addition, the table legs are angled to address human factors by offering plenty of leg space for the user.

Photo of demonstration model's angle elevation feature. The above photo displays the hinges, tabs, and backflap involved in the angle adjustment function. Again, the symmetrical features and neutral colors add onto the aesthetic.

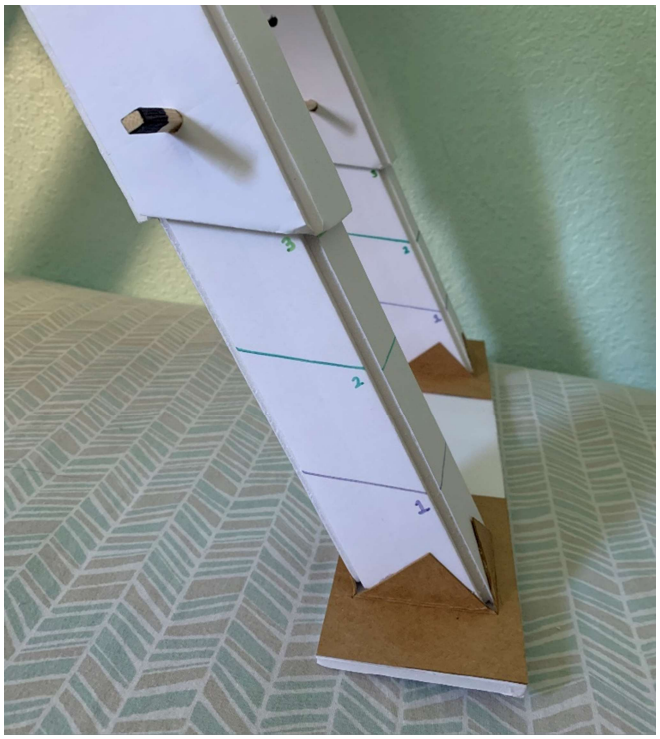


Photo of demonstration model's height elevation feature. This photo is a close-up of the height elevation being adjusted to its highest level. I chose to color code and number each level to help the user understand the function. This contributes to the usability of the product by giving the user feedback with each increasing level. In addition, this photo shows the bottom of the table legs. I tried to ensure stability and safety by using thin cardboard to enforce each table leg to stay at its intended angle (60^{o} from horizontal).

Photo of demonstration model's table leg fillet support. In this photo, fillets are displayed to support the table leg(s). In previous photos, we saw that the table legs are attached at an angle. These fillets keep the table legs rigid and keep them from flexing. This will ensure safety, as the fillets prevent the overall table from collapsing. In addition, this ensures functionality since the fillets hold the table legs at their intended angle, and in return, the table surface stays horizontal.

The user can customize and utilize the adjustment features to fit their needs and purposes. This bed desk is not for those who prefer working in a traditional desk and chair workspace. It might also contribute to exclusion for people with disabilities, especially for those who are paralyzed in the upper half of their body. On the other hand, this design is for people who don't have access to a traditional workspace or prefer to work in the comfort of their beds.

Conclusion

My final project addresses the lack of ergonomics in my customer's bed workspace by improving posture and preventing muscle strain. I believe the final design is a creative solution to the problem because I am bringing the ergonomics of using a desk to customers working in bed. After seeing my sister interact with this design, I saw that her wrist is above her elbows, which is not ergonomic according to *mayoclinic.org.* (Office Ergonomics...) This design tackled bad posture and relieved neck strain, but some discomfort was still present. In the future, I would like to include a lower leveled surface and suggest a separate keyboard and mouse to maximize the user's comfort.

Works Cited:

"Adjustable 8 Position Laptop Tray Desk." Wayfair. https://www.wayfair.com/furniture/pdp/inbox-zero-adjustable-8-position-laptop-tray-desk-w003172146.html. Accessed 21 May 2020.

"Berthiaume Bamboo Adjustable Laptop Tray." Wayfair. https://www.wayfair.com/furniture/pdp/symple-stuff-berthiaume-bamboo-adjustable-laptop-tray-w001403264.html. Accessed 21 May 2020.

Drake, David C. Configurable Lapdesk. US 6044758, United States Patent and Trademark Office, 4 April 2000. *Google Scholar.* https://patentimages.storage.googleapis.com/9e/f5/ba/5a7bddd7655ce2/US6044758.pdf

"Folding Lap Desk, laptop desk, Breakfast Table, Bed Table, Serving Tray." Amazon. https://www.amazon.com/Folding-laptop-Breakfast-Table-Serving/dp/B01NBTRGDH/ref=sr_1_8?dchild=1&keywords=bed+desk&qid=1590190712&s=office-products&sr=1-8. Accessed 21 May 2020.

"KLIPSK Bed tray, white" Ikea. https://www.ikea.com/us/en/p/klipsk-bed-tray-white-00258882/?gclid=CjwKCAjw8J32BRBCEiwApQEKgadISMfaHh0ravDielLvX64nV6z-mgYyXVdo9nt4XswiZFkkm8xc5RoCOTAQAvD_BwE. Accessed 21 May 2020.

"Laptop Desk for Bed, TaoTronics Lap Desks Bed Trays for Eating and Laptops Stand…" Amazon. https://www.amazon.com/TaoTronics-Foldable-Adjustable-Portable-Writing/dp/B07DJ5F15J. Accessed 21 May 2020.

"Office Ergonomics: Your How-to Guide." Mayo Clinic, Mayo Foundation for Medical Education and Research, 27 Apr. 2019, www.mayoclinic.org/healthy-lifestyle/adult-health/in-depth/office-ergonomics/art-20046169.

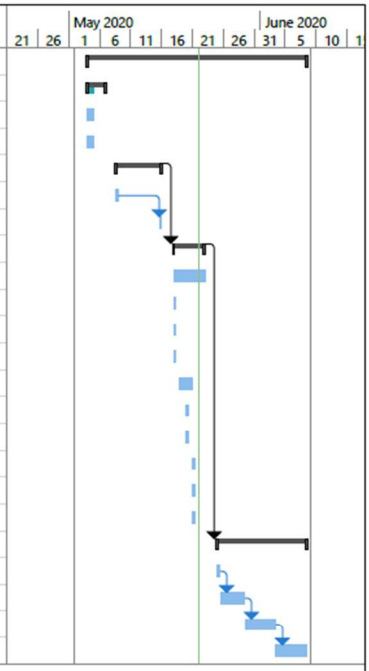
Richardson, Willie F. Bed Desk. US 372602, United States Patent and Trademark Office, 13 Aug. 1996. *Google Scholar.* https://patentimages.storage.googleapis.com/57/a8/f0/4c0b5f2950d782/USD372602.pdf

"6 Ergonomic Tips for Working Comfortably in Bed." Domestications Bedding & Home Living, 26 Mar. 2018, https://domesticationsbedding.com/6-ergonomic-tips-for-working-comfortably-in-bed/.

Appendices:

Appendix A. Gantt Chart

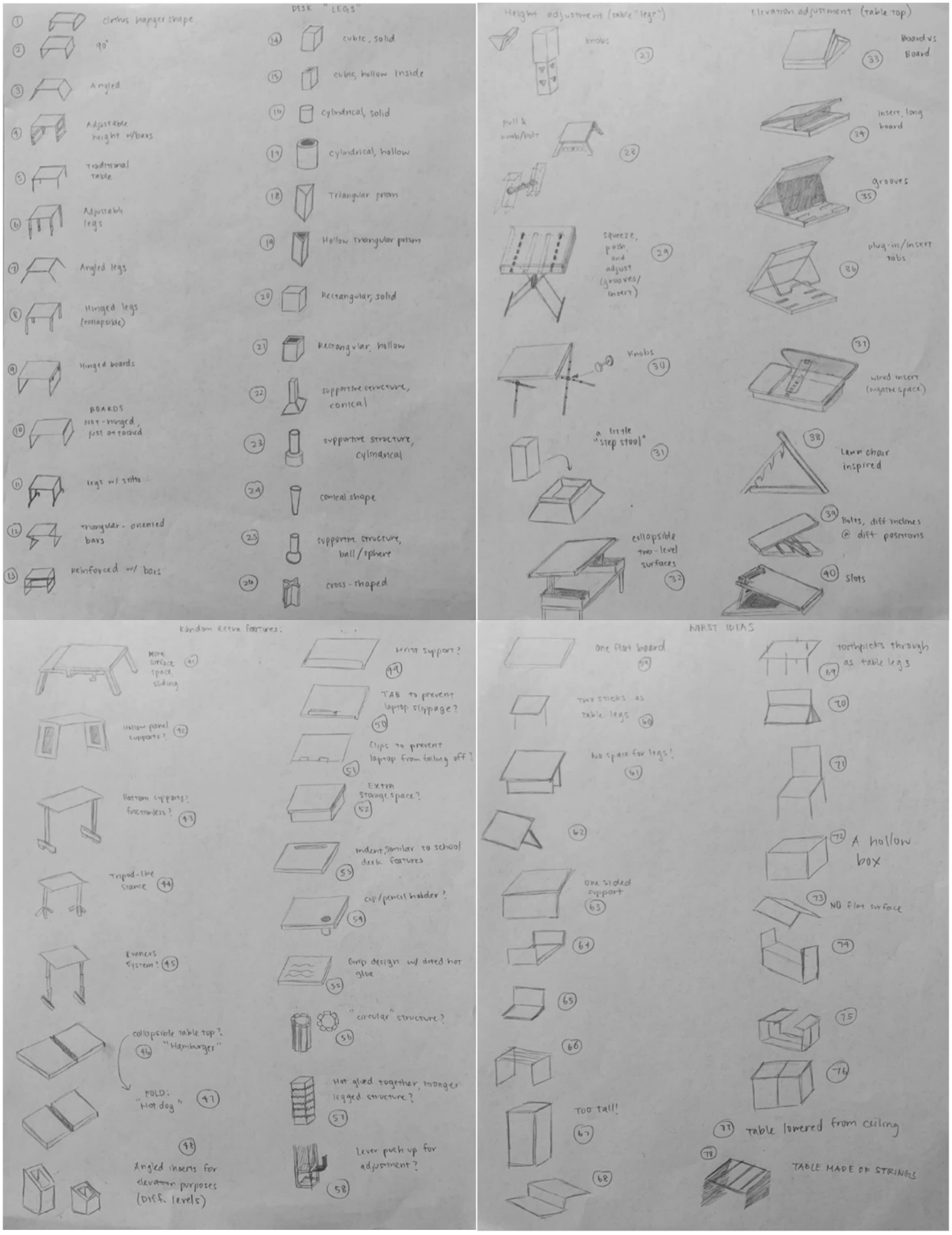
ID	Task Name	Duration	Start	Finish
1	**Bed Desk Design with Elevation Feature**	**25.5 days**	**5/4**	**6/8**
2	**Compile Ideation Kit**	**3 days**	**5/4**	**5/6**
3	Obtain/find craft items	1 day	5/4	5/4
4	Purchase critical items if needed	1 day	5/4	5/4
5	**Create a Problem Statement**	**5.25 days**	**5/8**	**5/15**
6	Make three needs statements	2 hrs	5/8	5/8
7	Choose/alter one into a problem statement	1 hr	5/15	5/15
8	**Deliverable Submission: Scope of Work**	**5 days**	**5/18**	**5/22**
9	Sketch 100 project design ideas	1 wk	5/18	5/22
10	Create a title page	5 mins	5/18	5/18
11	Write an introduction paragraph	1 hr	5/18	5/18
12	Refine the problem statement	20 mins	5/18	5/18
13	Conduct background research	2 days	5/19	5/20
14	Create a brief summary of the need & stakeholder(s)	2 hrs	5/20	5/20
15	Create a table of project constraints and criteria	2 hrs	5/20	5/20
16	Write a conclusion to summarize the SOW	2 hrs	5/21	5/21
17	Complete a works cited page	1 hr	5/21	5/21
18	Create a "Gantt chart"	3 hrs	5/21	5/21
19	**Deliverable Submission: Preliminary Design Review**	**10.5 days**	**5/25**	**6/8**
20	Create a pairwise comparison and decision matrix	4 hrs	5/25	5/25
21	Create five ideation models and submit for feedback	4 days	5/25	5/29
22	Incorporating feedback, build a "Concept Prototype"	3 days	5/29	6/3
23	Create a video pitching the design	3 days	6/3	6/8



Project: Bed Desk
Date: 5/22/20

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

Appendix B. 100 Design Ideas



Stronger structure ideas

Rectangular structures beneath table top (79) OR Triangular, (80) Trapezoidal (81)

RIBBING toothpick inside (82)

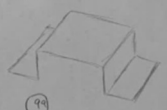
- LOTS OF FOAM (83)
- TRUSSES (84)
- INCORPORATE CIRCLES (85)
- DUCT TAPE (86)
- THICK SUPPORTS (87)
- ADD BENDS (88)
- WOODEN DOWELS (89)
- Fillers (90)

(91) Reinforcements

- DO STATICS? (92)
- STRING (93)
- CONSIDER opposing forces in structure (94)
- UTILIZE STRENGTH OF HOT GLUE (95)
- UTILIZE WEIGHT OF LAPTOP TO DESIGN ADVANTAGE (96)
- DIY SCREWS (97)

← bent corners

(98)



(99)

(100)