Convertible Desk/Couch

E-Team 29

4 Students

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Original Ideas and Selection
Our team's original list of ideas that we came up with was

1. A device to align and zip a zipper
2. A self-stabilizing pen/pencil for someone with a tremor
3. A flower box that automatically plants and waters flowers
4. A bike attachment that uses the motion of the bicycle to power an electronic device charger
5. A retractable extension cord
6. A solar-powered charger for an electric skateboard
7. A device that can tie shoes
8. Gloves to relieve stress on the hands of people in massage therapy school
9. A device to lock a skateboard to a bike rack
10. A desk that converts into a couch

After meeting with Professor Niku, we decided to design a desk that converts into a couch for college students who may not have room for both a desk and a couch in their rooms.

Problem Analysis

After deciding on our idea, we analyzed our problem to identify the requirements our design should fulfill. Here are the questions we considered:

1. Should it sit multiple people?
   The solution should comfortably seat at least two people, similar to a typical couch.
2. How much desk space is needed?
   There should be enough room for a college student to do their schoolwork, ideally with space for a computer and for writing.
3. How should the furniture be converted from one form to another?
   The furniture should be able to be converted from a desk to a couch by hand, without tools or a lengthy process. As well as easily converting the height of the furniture back and forth, so that the seat of the couch is not the same height as the surface of the desk.
4. Does the desk need to be cleared to convert the furniture?
   There should be areas that don't need to be cleared in order for the desk to be converted to furniture, but a large portion of the desk area will need to be cleared.
5. Should the user be able to sit on the device and use the workspace at the same time?
   No, as this would likely require the device to be too large for the average college student's living space.
6. How much space should it take up?
   It should take up less space than having both a couch and a desk.
7. Should there be drawers or other types of storage?
   Yes, there should be some drawers or other types of storage space.

Final Problem Definition

After analyzing our problem, we created a formalized final problem definition as follows:

> Our team will design a piece of furniture that can be easily converted from a desk into a couch and vice versa. Our main population target is college students. So, the furniture must be smaller than the combined size of a separate desk and a couch. For accessibility, the furniture will be easy to convert between the two modes. The desk mode will have enough space for schoolwork, while the couch mode will be comfortable and accommodate at least two people. Some areas of the desk will remain when converted into couch mode, so that the desk does not need to be completely cleared each time it is converted. There will also be some built-in storage.

Idea Development

After finalizing our problem definition, we identified several mechanisms to convert a desk into a couch.

Idea 1

The first idea that arose had the surface of the desk able to rotate in order to turn into a couch, and a gear system that would raise the surface up and down, making the height of both the desk and the couch adjustable.

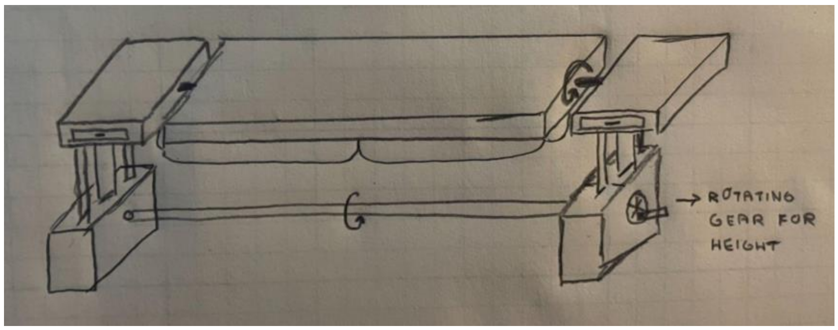


Figure 1: Idea 1

Idea 2

Another idea that arose had a main surface that moved up and down to serve as both the desk surface and the seat of the couch, while the backrest of the couch remained static. In Figure 2, it is shown that the top portion of the piece, in say desk mode, needs to be completely pulled off to turn it over into couch mode.

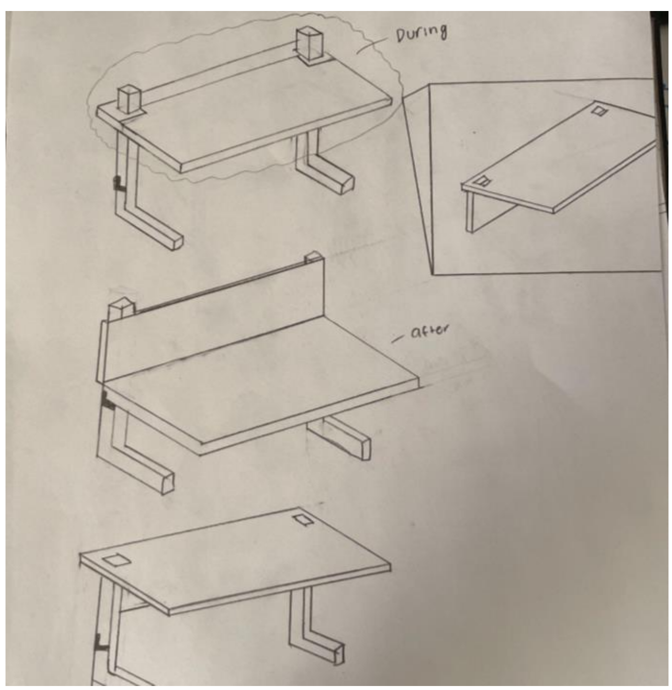


Figure 2: Idea 2

Idea 3

We also had an idea: the couch and desk were one solid body that would rotate and slide up and down within a slot to create a desk mode and a couch mode. A locking mechanism was suggested that would twist or fold out of the side supports to stabilize the body in couch or desk mode.

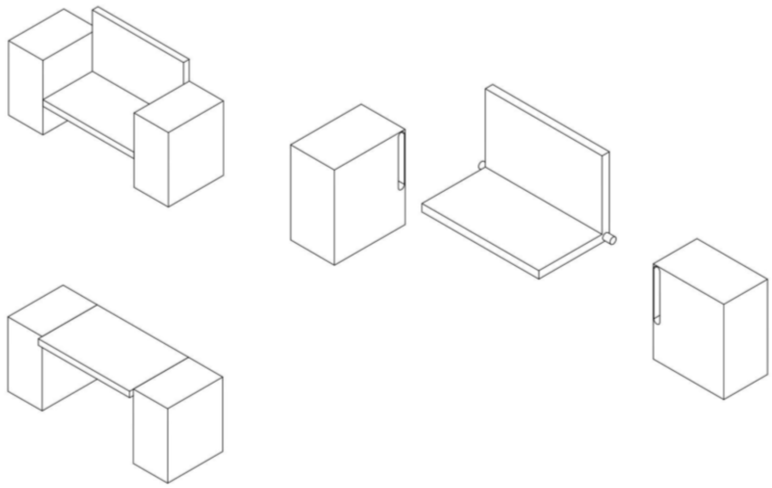


Figure 3: Idea 3

Idea 4

We also considered a design that would rotate similarly, but with the body of the couch and desk cut in half, so you could sit on the couch and use the desk at the same time.

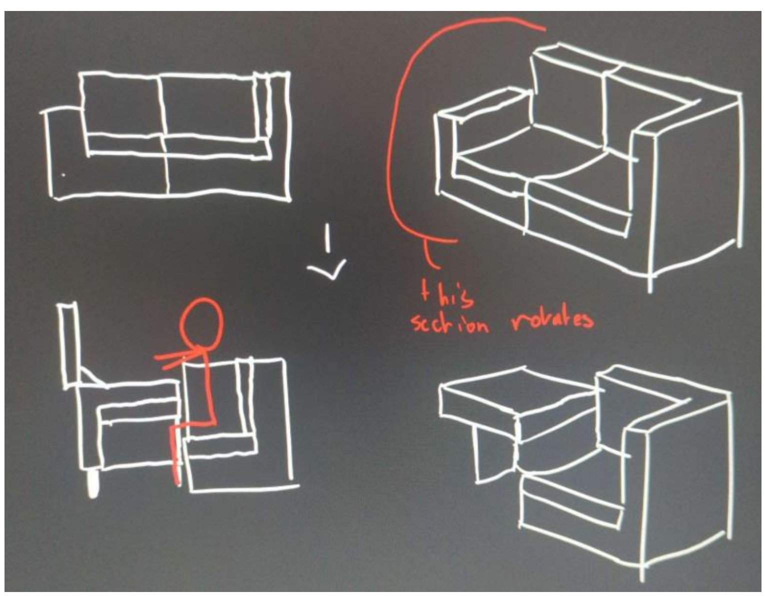


Figure 4: Idea 4

Idea 5

We wanted to create a design with a more elegant transformation, so rather than rotating, our next design would use a track along the shape of the couch and desk profiles to hold sliding wooden slats.

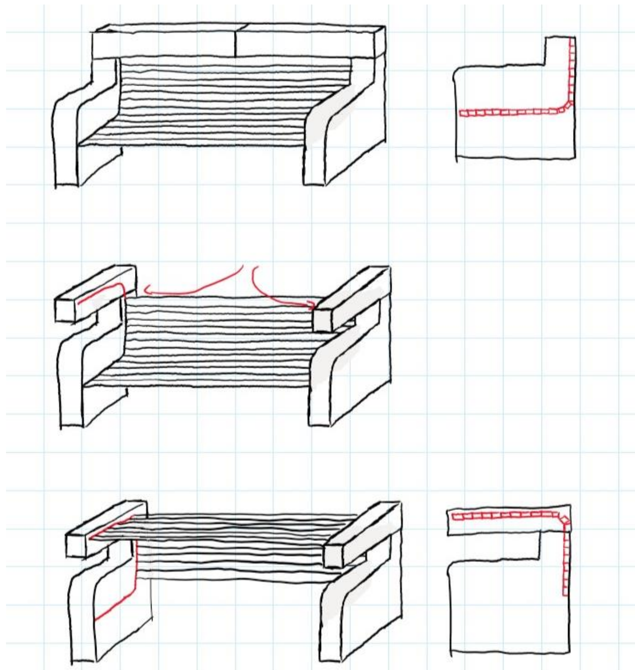


Figure 5: Idea 5

Idea 6

This design stemmed from multiple offshoots, including one with a footrest that would have drawers for extra storage.

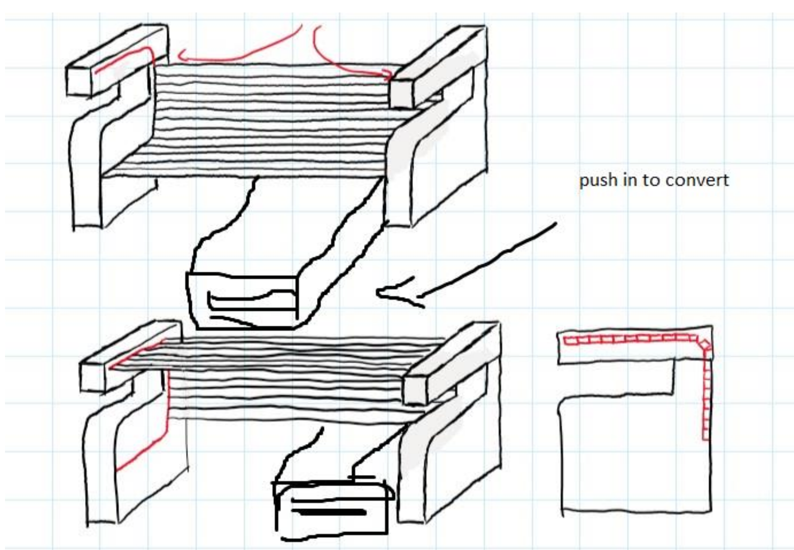


Figure 6: Idea 6

Idea 7

And one with an extended side to create room for extra storage.

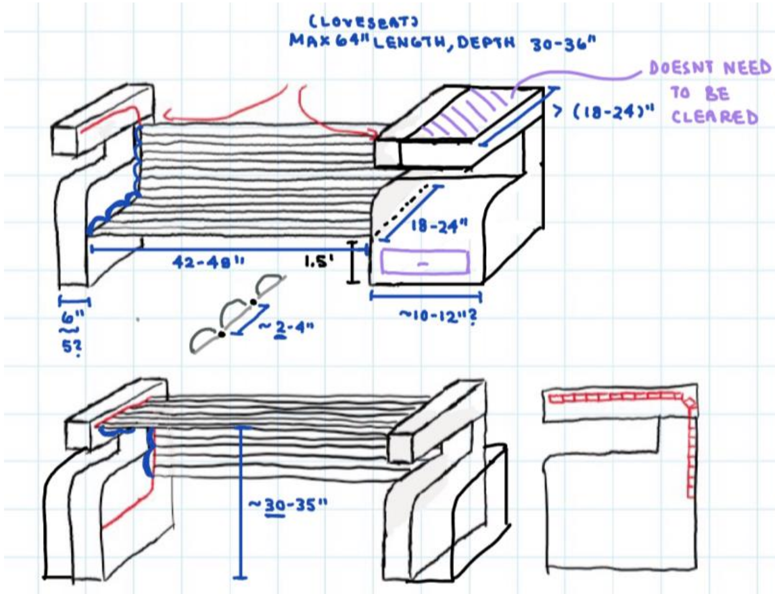


Figure 7: Idea 7

Idea 8

We also had one more design, more loosely based on this rail system, where the bottom part uses drawer slides in order to be collapsible.

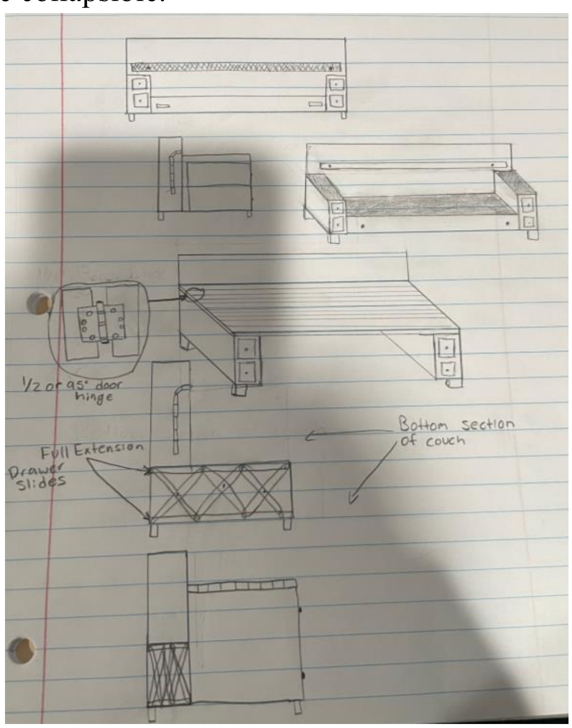


Figure 8: Idea 8

Idea Selection

After generating our ideas, we all got together and discussed what we like and dislike about each design. We liked how the height was so customizable for idea 1, but we knew that it would be heavy and tricky to design. We appreciated the simplicity of idea 2 but thought that the couch would be too uncomfortable. We liked how idea 3 rotated, but we thought that the aesthetics could be better and we were concerned with how we could create a secure locking system that wouldn't be too complicated to use. We thought it was really interesting that idea 4 would let you sit and use the device's workstation at the same time, but we were concerned that it would be hard to find a place for storage that wouldn't be flipped over. We really liked the aesthetics and transformation method of idea 5, but again, we were concerned with where we would find room for storage, which led to ideas 6 and 7.

Eventually, we narrowed it down to four final ideas.

- Idea 1: Where the height of the couch/desk could be changed using a gear system.
- Idea 3: Where the body of the couch/desk would rotate within and slide up and down a slot to move into different configurations.
- Idea 4: Where the desk/couch would be divided in half so that it could be fully or partially transformed.
- Idea 7: Where the desk/couch would be created by slats sliding up and down a rail system, and with one side extended to create room for storage.

After we selected these as our final design candidates, we used a decision matrix (Table 1) to determine our final design based on aesthetics, cost, ease of conversion, ease of assembly, lifespan, comfort, and weight.

Table 1: Decision Matrix

Characteristic	Idea 1	Idea 3	Idea 4	Idea 7
Aesthetics	1	-1	1	1
Cost	-1	1	1	1
Ease of Conversion	1	-1	1	1
Ease of Assembly	-1	-1	-1	1
Long Life	0	0	-1	-1
Comfort	-1	1	1	1
Weight	-1	0	0	1

Total	-2	-1	2	5

This led us to select idea 7 as our final solution. We decided to design a desk that would transform into a couch by sliding wooden slats through a rail system to create the couch's shape, with one side extended to provide a surface that won't be affected by transforming from one mode to another and to create room for storage.

Final Solution

Using Idea 7 shown in Figure 7 previously, we proceeded with a SolidWorks design. This design features pre-assembled slats with cushions on one side and a hard, flat surface on the other. The other components are two separate sides, the backing, and two headrests with pre-assembled spring-loaded locking mechanisms. A cup is involved in the images to show the static surface, which does not move during the transformation.

Shown in Figure 9 is the furniture in couch mode, where the headrests rotate back, and the slats expose the cushion surface on top. In Figure 10, the furniture is in desk mode with the headrests rotated forward. A more detailed description of the conversion from couch mode to desk mode is given in the transformation section.

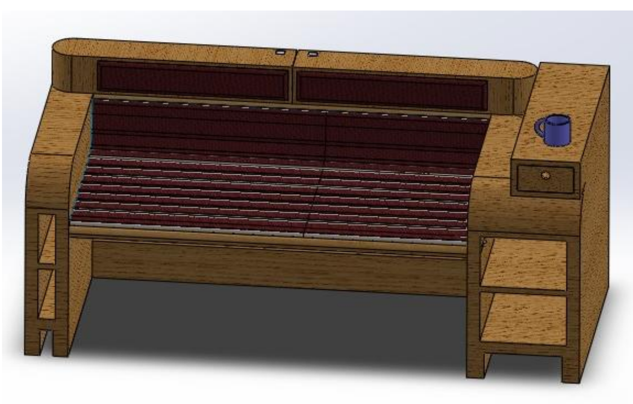


Figure 9: Couch Mode

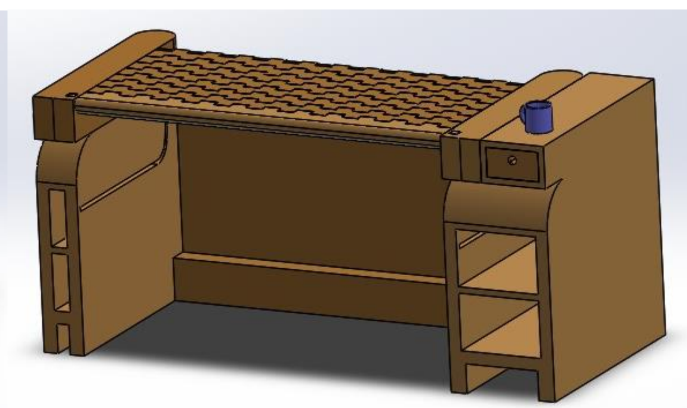


Figure 10: Desk Mode

Include slats layed out, mention that there is a customizable colored cover that fits over the cushion and slats.

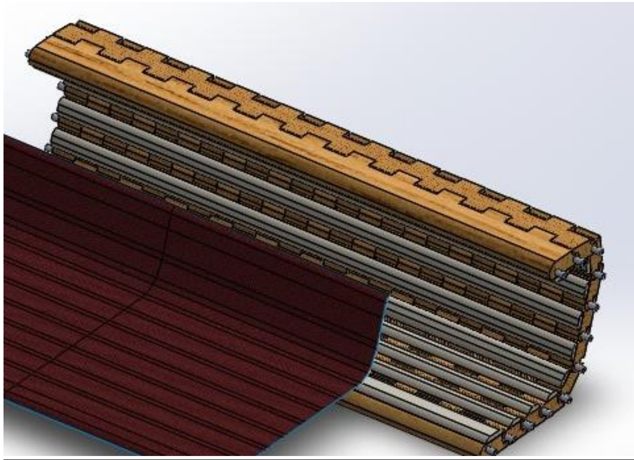


Figure 11: Slats, Cushions, and Cover

Assembly

The couch/desk comes in six main pieces, the two side supports, the back piece, the attached wooden slats that become the surface of the desk and couch, and the two rotating headrests. Assembly is done in a 3 step process:

Step 1

Insert the slats of the couch body into the rails of the two side supports in the couch configuration. Once these pieces are in place, connect the two side supports to the back piece. This will keep the main body of the couch/desk in place for the next step.

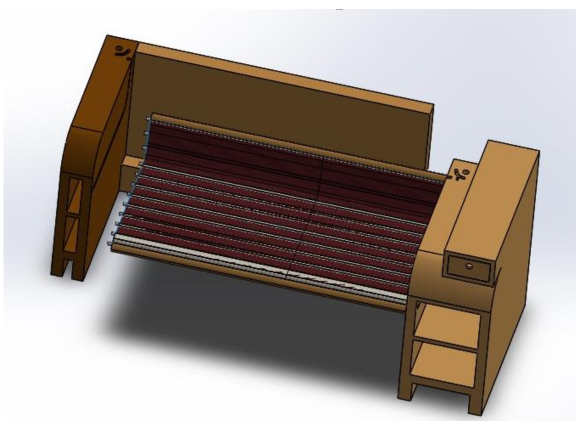


Figure 12:

Step 2

Reach inside the hollowed out area of the side support to access the rails that wooden slats slide through. From here, screw the provided mushroom caps onto the end of each slat.

Figure 13: Mushroom Caps Aligned with Slats

Step 3: Headrests

Insert the rotating headrests into the tops of the side supports. The top of each side support would ideally have interference fit bearings that the headrests are fit into, for a smooth rotation. Once these are in place, the couch is ready to be converted.

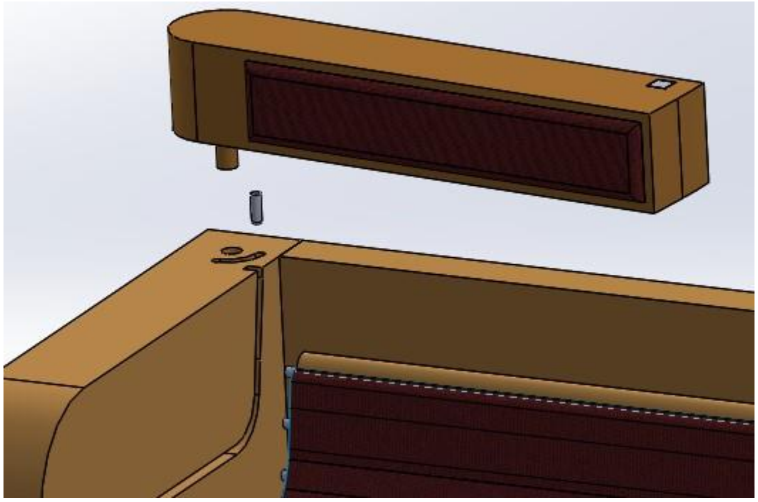


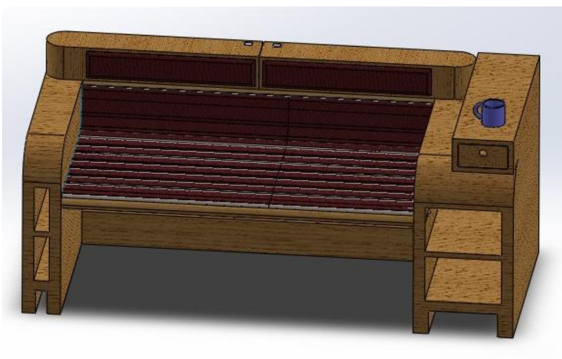
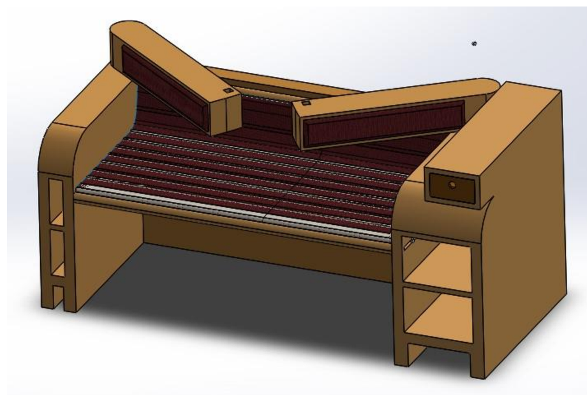
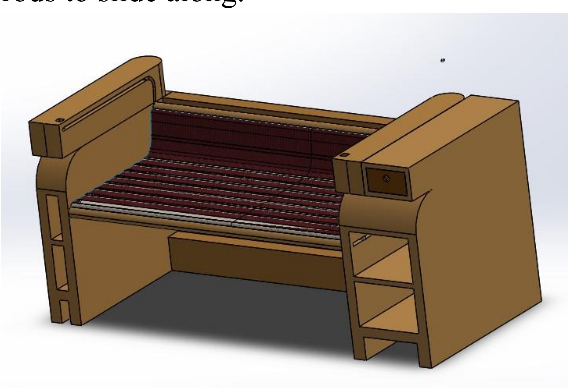
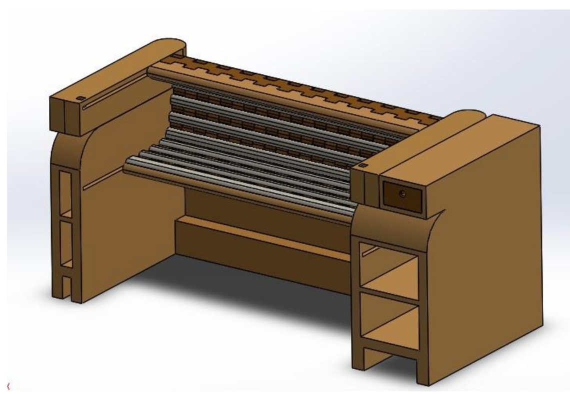
Figure 14: Headrest Installation

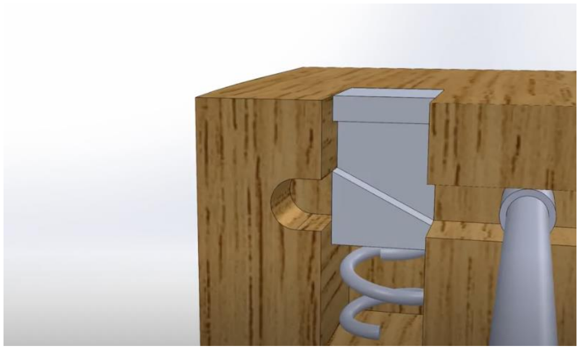
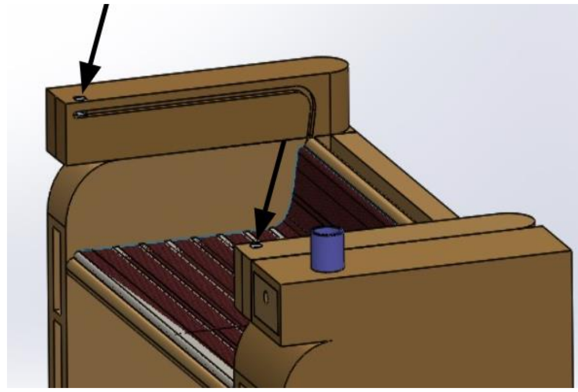
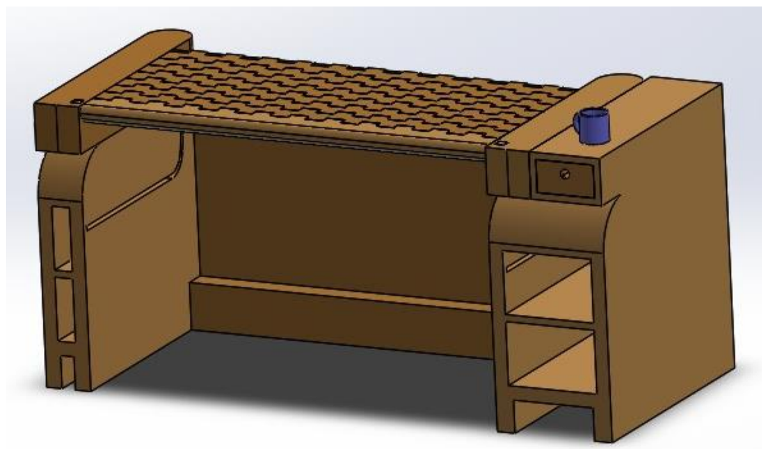
Our target consumer is college students, so we tried to simplify assembly as much as possible. We wanted our user to be able to easily assemble their furniture in a reasonable amount of time, without any specialized knowledge or tools.

Transformation

In order to transform from couch mode into desk mode and vice versa, the user simply rotates the headrests outwards so they align with the side supports. This creates a pathway through which the slats that make up the body of the couch/desk can slide through. The user then slides the slats up and out to create the shape of the desk, and a spring loaded mechanism locks them into place. To return to couch mode, the user will push down both buttons located on the headrests to release the slats and allow them to slide back into couch position. The headrests are then rotated back into alignment with the back of the couch. This process can be shown in Table 2 below.

Table 2

View 1: Initial Position Example 	View 2: Moving the headrests outwards by rotating both. 
View 3: Headrests have moved 90 degrees outwards, connecting the pathway for the rods to slide along. 	View 4: The slats with rods are now able to be pulled upwards along the pathway. 

<table>
<tr><td>View 5: The first rod secures the slats into desk mode by locking into place via a locking mechanism on each side of the desk shown with arrows in the Figure #
 </td></tr>
<tr><td>View 6: Final position example.
The slats are locked into position.
</td></tr>
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The desk shown in View 6 in Table 2 can be turned back into a couch by repeating this process shown in the table, but backwards.

Locking Mechanism - Assembly Between Modes

Figure 15 shows the locking mechanism integrated into the headrest, consisting of a button and a spring. When the leading slat is pulled up to form the desk, the roller that guides it will depress the button. When the slats are pulled up and fully forward, the button will return to its original position, securing the roller rod in place.

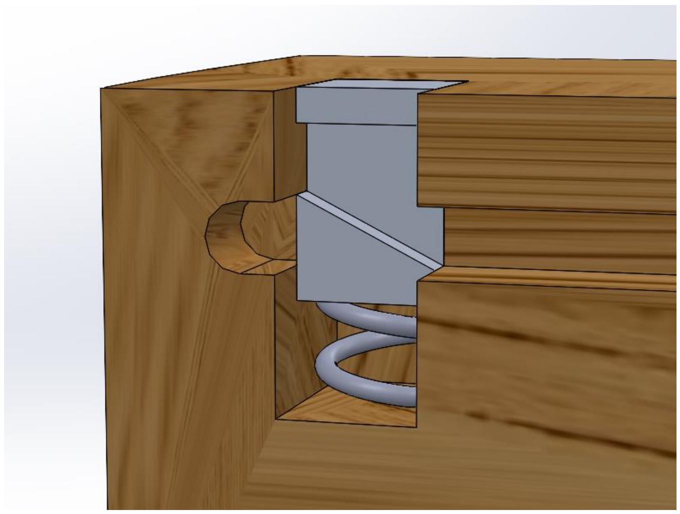

Figure 15: locking mechanism

Human Centered Design

Throughout our entire design process, we've tried to prioritize our user's experience and comfort by simplifying assembly, creating a design that is easy to convert from one mode to another, that doesn't sacrifice the functionality of an independent couch or desk, and that looks good as well.

We felt that if the process of converting our furniture from a couch to a desk and vice versa was too complicated or took too long, the user would be hesitant to switch back and forth frequently and would tend to keep their furniture in one mode or the other most of the time. This is why we came up with so many different ideas for how the furniture would be converted; we wanted to ensure that the conversion process would never be inconvenient enough to discourage the user from changing modes.

Another aspect of our design that we felt was extremely important was that the user should not have to sacrifice comfort for the convenience of convertible furniture. That is, the couch mode of our design should be as comfortable as a normal couch, and the desk mode should be as comfortable as a normal desk. We measured a variety of couches and desks to determine acceptable ranges for the height and depth of the desk surface and the height and depth of the couch seat (see Figures 16 and 17 on the next page for exact dimensions). One of the reasons we liked the design we selected more than many of our other designs was that the rails that the wooden slats slide through to define the shape of the couch would allow the body of the couch/desk to change shape, so we could have a comfortably shaped couch without having to accept an oddly shaped desk.

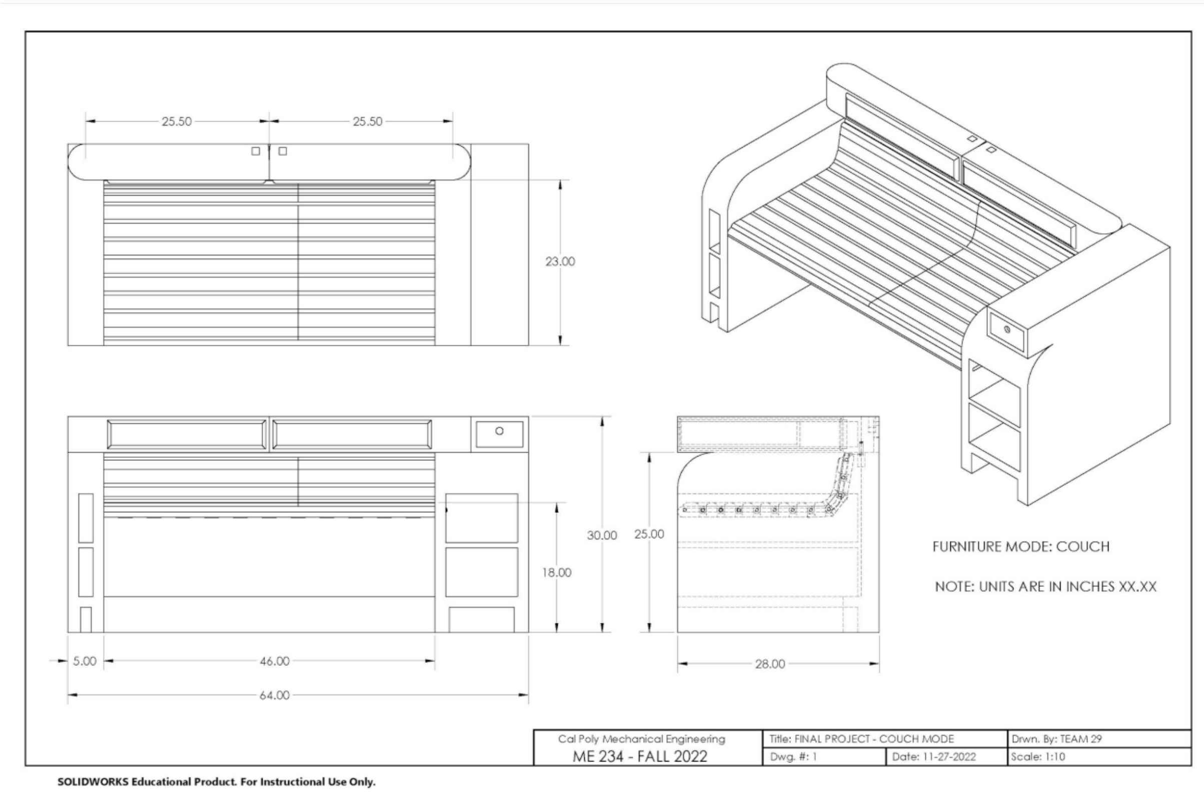

Figure 16: Dimensions in Couch Mode

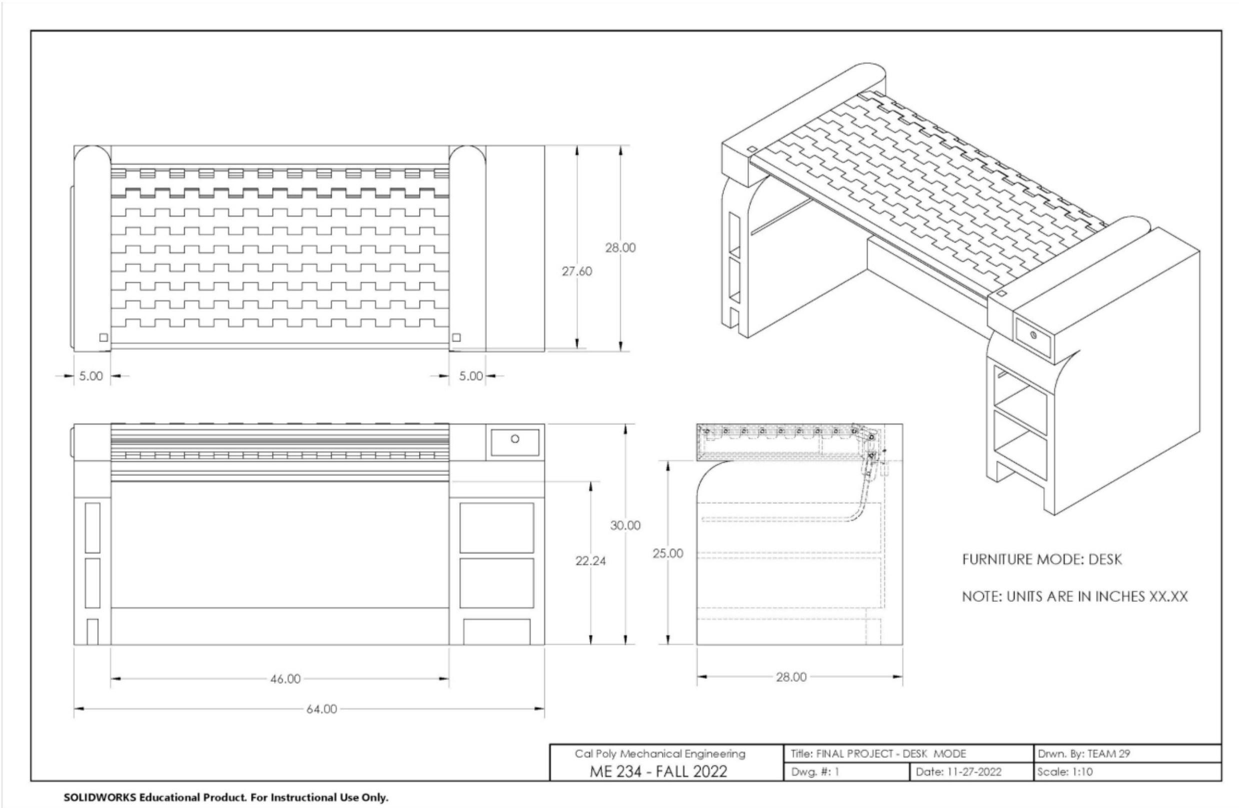

Figure 17: Dimensions in Desk Mode

While we focused heavily on functionality when generating ideas, another reason we liked this design was its aesthetics. We feel this design looks good in both couch and desk modes, and the conversion method is simple and elegant. This design would surely be a unique addition to any room and spur a lot of conversation.

Cost Breakdown:

The furniture piece is made up of four different materials. The cost breakdown is shown in Table 3 below. To find the cost of each material, we had to do some calculations. We determined the volume of each material using the mass properties displayed in SolidWorks. The weight of each material is then found by multiplying its volume by a generic density. The cost of each material is then found by multiplying the weight by the material's price per pound, which are also generic values.

Table 3

Material	Volume (ft^3)	Density (lb/ft^3)	Weight (lb)	Price per Pound ($\$ / lb$)	Cost ($$$)
Wood (Cedar)	8.63	23	198.49	1.5	297.74
Steel	0.04	489	19.56	0.42	8.22
Foam	0.21	4	0.84 lbs	24	20.16
Fabric	0.00031	201.6	0.0625	64	4
		Total Weight:	218.95 lb	Total Cost:	$330.12

The side structures, back, slats, and headrests are made of cedar. We decided to use cedar wood for our table because, while it is strong, it is on the lighter side. Cedar wood density runs about 23 (lb/ft^3), which is nice because our desk uses quite a lot of wood. The total price of cedar wood for our project came to be $330.12. The price of the wood materials is slightly higher than we hoped, but we expect to reduce the cost by at least one-third after finding a commercial supplier.

The slats contain steel rods, which connect them to one another. The rods extend beyond each side of the slats so that they can be placed into the empty pathways along each inner side of the desk. The furniture piece also includes locking mechanisms with springs and some pins, all made of steel. We decided to use steel because of its durability, as aluminum is cheaper but softer. The metal rods will be holding all the stress when people sit on the furniture in couch mode. Our total cost of steel came out to a mere $8.22.

On one side of each slat's surface is a cushion made of foam and fabric. The foam for the structure was selected based on how stiff yet comfortable it is. With the foam market ranging from about 1.5lb/(ft^3) to 8lb/(ft^3), we chose an in-between value of 4lb/(ft^3), so as to provide support but also for compression and comfort. The total price of the foam comes out to be $20.16.

Our total cost is $330.12. Given that this piece of furniture combines a couch and a desk, we feel the price is fair.

Weight Analysis:

The weight of the furniture was also an important consideration. This structure must be strong enough to support bodies, but not too heavy so it cannot be moved around easily. Referring to Table 3 again, our total weight is 218.95 lb. Similar to the cost analysis, we feel this weight is acceptable regarding the utility of this piece of furniture.

Conclusion:

Our piece of furniture easily transforms between the two modes we want, couch and desk. The sides come with pre-assembled storage shelves and one drawer. The headrests also come with pre-assembled internal components. Lastly, the slats, the pins connecting them, and the cushions come folded and preassembled. The desk mode has enough space to do schoolwork, put your legs underneath, and keep a portion of it stationary. The couch mode is comfortable and can accommodate at least two people. With our target audience being college students, cost, weight, and ease of assembly were strongly considered. This piece has emerged from the human-centered design process. It is what we had hoped for and more. Although as life evolves, so must our designs. As future engineers, we will continue our pursuit of optimization in our everyday lives, drawing on the lessons learned in this course and the design project.