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GNG2101[D] - Introduction to Product Development and Management

User Guide

Project Deliverable I

Group 2.4
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Abstract

The goal is to design a tablet holder for wheelchair trays. The application must be reliable, flexible and accessible. This report will provide readers the instructions on how all the subsystems were created and how they function. We also included numerous images, drawings and CAD models to capture the prototypes and thoroughly explained each subsystem. This document also represents the observations and documents collected while the final product was being made. It includes the design concepts that the team came up with, along with the comprehensive blueprint for how the product works. Additionally, it offers insights to any possible future developers that might want to replicate or improve the current prototype.

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1. Introduction

The purpose of this user manual is to inform anyone who is interested or has already purchased the tablet holder about the proper ways to use it. This document will cover ways to use the tablet holder, ways to maintain the tablet holder, possible improvements, and more. Our target audience is primarily children in wheelchairs, however, it will have to be assembled by an adult or care giver. After reading this user manual, you will have all the necessary information to utilise the device.

2. Prototype Creation

2.1 Prototype I

The first prototype was created on the most feedback and most intervention from our client. As seen in Deliverable A, our group came up with a list of information which was already known, and information we needed from our client to build and understand what would be needed in this prototype. Our group then formatted this information into a series of open-ended questions, and then took note of what responses we received during our first client meeting. Taking these notes from the meeting, we then went ahead with Deliverable B and documented the useful responses into interpreted needs, requirements and constraints, and metrics and target specifications. During this deliverable our group also researched similar products on the market for benchmarking, where we took several pieces of criteria and scored each product.

Moving on, we then took the criteria gathered in Deliverable B and applied it to Deliverable C where we each generated our own ideas for the product with diagrams and explanations. This then resulted in us using a similar criteria scheme as used in Deliverable B

to judge and rank each of the diagrams, and then come up with a conceptual design on CAD. Then coming up with our first physical prototype, our group met up in person to create a very basic prototype.

Figure 2.1: Prototype I

The first prototype was made with the intention to give a visual and physical representation of how the opening and closing mechanic would work at a very basic, fundamental level, while also allowing our group to see if the tablet tray's design would be compatible with the tablet and tablet holder. The first prototype was made with scrap material such as cardboard and tape, while having a majority of the focus put towards a simple motor and the coding required to make it move accordingly. An Arduino uno was used in this prototype along with a breadboard and easily removable wires so the prototype could easily be disassembled and reconstructed. Prototype I was made to be quarter scale, with half of the intended functionality as it moves up and down with one motor.

2.1 Prototype II

Moving onto Deliverable F, our group then assembled the second prototype. This prototype featured several design changes from the first, as we showed prototype I to the client and received further feedback, along with facing several difficulties and setbacks

between prototype I and II. The primary challenge we faced was making the second motor be able to slide the tablet holder form the back of the tray to the front, unlike the first motor which moved the tablet from up to down. We had originally planned for a sliding mechanic, however as we went ahead with physically making the prototype we found out that the sliding mechanism would not be compatible with the motors we had available. In search of an alternative way to move the tablet holder, we instead relied on a Scott-Russell Linkage.

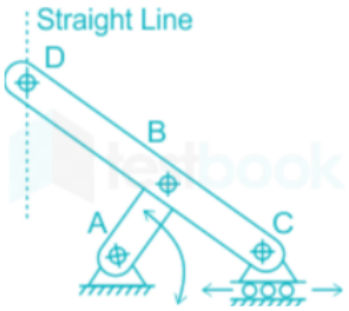


Figure 2.2: Scott-Russell Linkage

With Prototype II, we modified the Scott-Russell Linkage to better suit our prototype and the space we had to allow the sliding mechanism to work within the tray. After testing out the slider and having it work, we then went with creating the rest of the prototype.

Figure 2.3: Prototype II

Prototype II was created using lasercut ⅛ inch MDF sheets, along with part of the sliding mechanism being 3D printed. This prototype was made to be half scale, and to mostly demonstrate and test out the movement of our tablet holder horizontally, rather than the first

prototype which focused on the vertical up and down turning motion of the tablet holder. It was made without a top component to allow a better view of the mechanism within, and so it would be easier to make quick fixes when needed. This prototype also relied on an Arduino uno along with a breadboard.

2.1 Prototype III

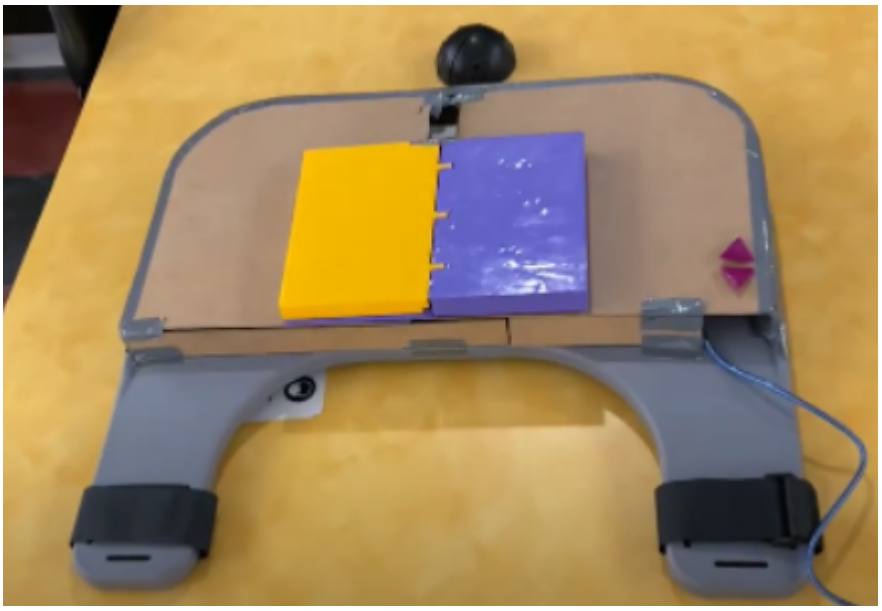
I 

Figure 2.4: Prototype III

Following another meeting with the client, Prototype III was finished. The final prototype was created using laser cutting technology for the base, side, and all MDF pieces, while the rest of the parts were created with CAD models and 3D printers or the parts were shipped in.

MDF was used in the final prototype due to how quick it was to gain access to and due to its affordability. It is also quite light and easy to use a laser cutter with, and can easily be replaced if there were any issues during the laser cutting or assembly. Other materials could be used in place of the MDF, such as fibreglass or acrylic sheets.

The tablet holder itself was 3D printed, however our group faced several difficulties with this material due to its weight. 3D printing a tablet holder with hollowed out insides

would be more efficient, or using another material such as a thinner more sturdy plastic or rubber.

The slider mechanism was made from laser cut MDF and stainless steel. The steel was used in place of MDF due to the MDF bar in the slider snapping, so it was not a planned material to be used. In the prototype, other materials such as more stainless steel for all the sliders or fibreglass. The material used for the sliders needs to be able to slide properly and not cause too much friction while sliding, while also being light. It also needs to be able to be cut accurately so the motor can attach into it properly.

For the electrical components of the tablet holder and tray, an arduino uno and soldered proto board were used. Due to lack of resources, our team had to use a scrap proto board which was burnt out on several points. A fresh protoboard which is purchased rather than second-hand would be more efficient and more reliable to use.

3. How to Use the Prototype

3.1 Set Up

The first step in using the tablet holder is setting it up. The kit comes with everything you need. That includes; 2 motors, an Arduino with wires, a protoboard, duct tape, 2 MDF side parts, 2 MDF side holders, ABS tablet holder, 4 inch ABS piece, 2 inch ABS piece, 3 inch ABS piece, ABS pins, 2 ABS buttons, batteries, and a battery pack. You will have to start by cutting out holes demonstrated in figure 3.1. The rectangular hole is for one of the 2 motors, make sure that the end of the motor with the rotating part is closer to the border of the tray. The two 1 inch holes are used to pass wires from the Arduino that will be placed underneath the tray to the protoboard that is on the surface of the tray. The other 1 inch hole is for the motor wire. Once the holes are made, you can insert the motor into the

rectangular hole, make sure you secure it in place with the use of duct tape. Next, you will duct tape the Arduino to the bottom of the tray, right underneath the 2 holes so that the wires can pass through. Make sure that you duct tape the battery pack next to the Arduino, as seen in figure 3.2. You will then place the protoboard on the right side of the tray as seen in figure 3.3. Make sure that none of the wires are bent, this will prevent any performance issues. You can now assemble the scotts russell mechanism. This is done by placing the one end of the 3 inch ABS piece to the motor. You can attach one end of the 4 inch ABS piece to the other end of the 3 inch ABS piece. Finally, attach the 2 inch ABS piece to the end of the 4 inch ABS piece. The mechanism should look similar to the mechanism in figure 3.4. You will connect all the ABS pieces with the abs pins. Place the second motor onto the 2 inch ABS piece as seen in figure 3.3. Once the scotts russell mechanism is set up, make sure that you place two pieces of MDF on both sides of the 2 inch ABS piece. These MDF pieces should be parallel to each other and in the centre of the board. This will allow the scotts russell mechanism to slide properly. Once this step is done, begin placing the MDF side holders on the surface of the board. They should be placed on both sides of the board and duct taped, similar to figure 3.5. This will hold up the MDF side parts. Now, you must attach the ABS tablet holder to the motor with the use of the connector. The connector will already be placed on the ABS tablet holder. The connector snuggly fits into the groves of the motor. Make sure when you connect the tablet holder to the motor, it is lying flat (position 1). Once the tablet holder is connected, you can place the two side parts onto the side part holders to create the second layer and cover up the wires. Make sure you leave a 1 inch slit open in the middle when putting the side parts on, this will allow the tablet holder to move forwards and backwards. Also, make sure to put the side holder with the holes on the right side of the tray, the holes are for the buttons. The result should look like figure 3.7. Make sure you duct tape the outside of the side holders to the tray for extra security. You can also add extra MDF to

support the side holders. Leave a gap on the right side of the board, this is so that you can tape the buttons to the bottom of the side holder. The buttons should be sticking through the MDF side part. You can then glue the ABS buttons onto the buttons. One facing up, and one facing down. You can now use the tablet holder.

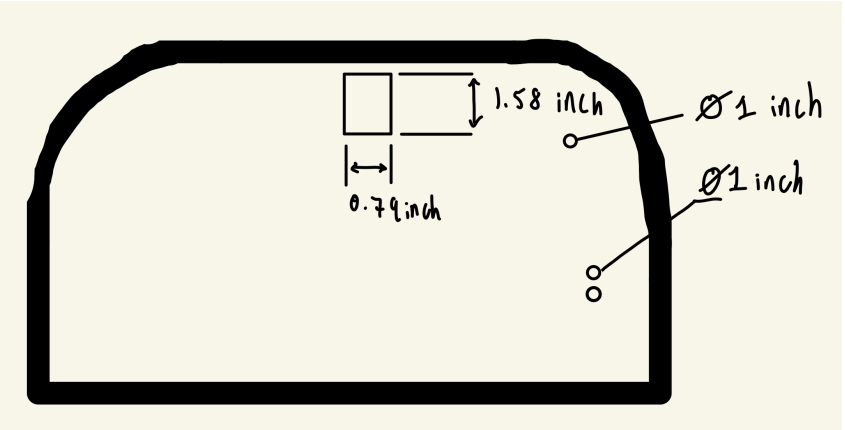


Figure 3.1, Hole Placement

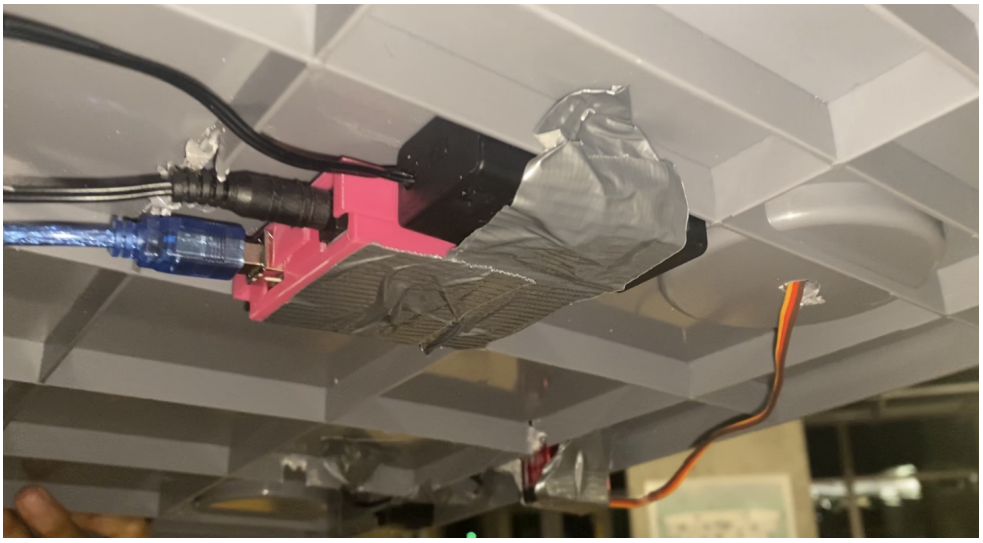


Figure 3.2, Arduino and Battery Pack

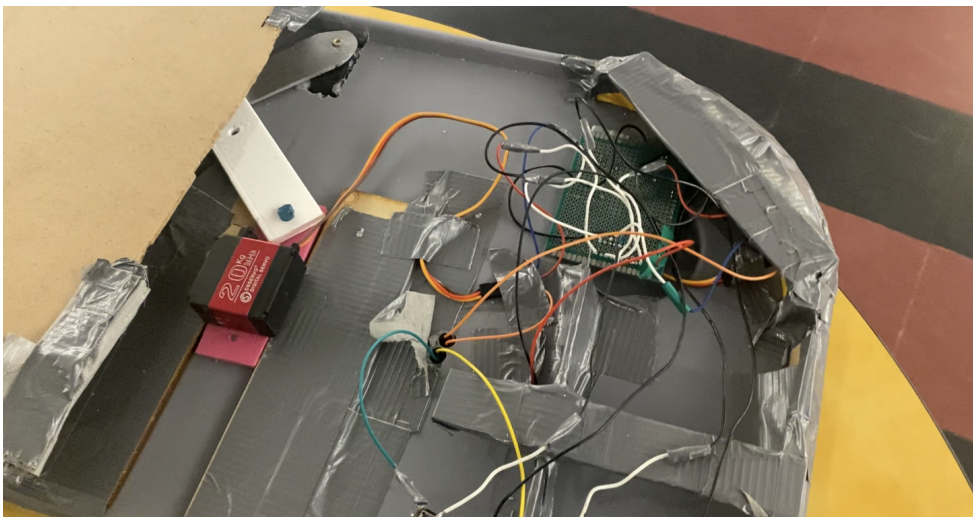


Figure 3.3, Protoboard placement

Figure 3.4, Scotts Russell Mechanism

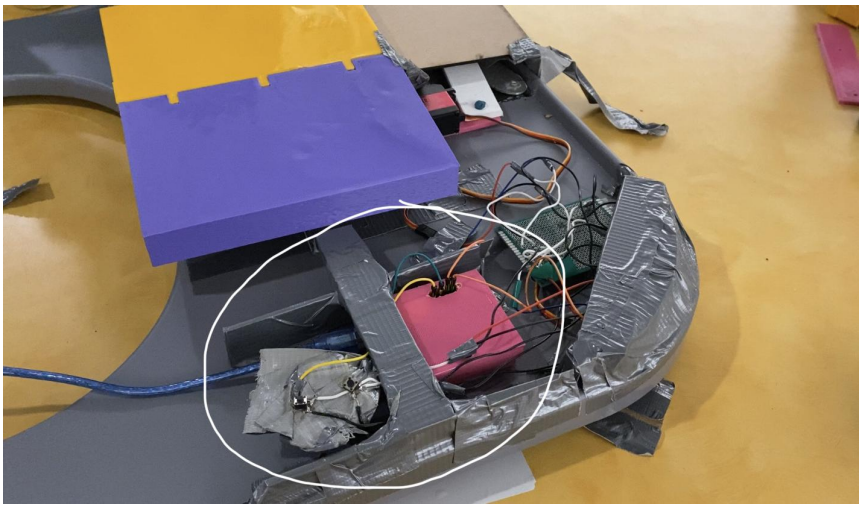


Figure 3.5, Side Holder

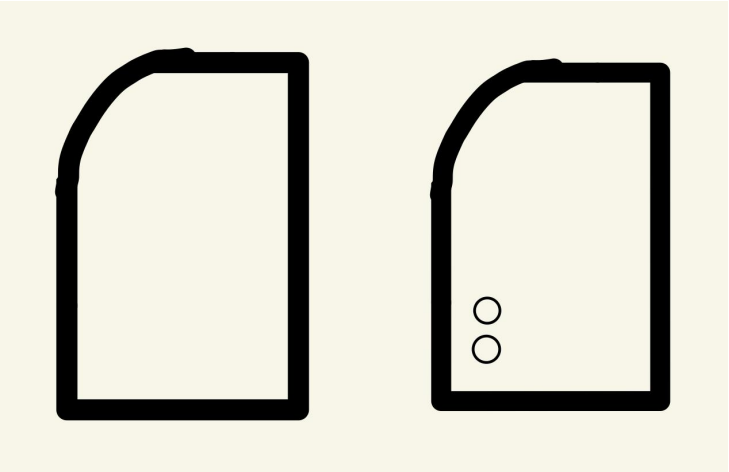


Figure 3.6, Side parts

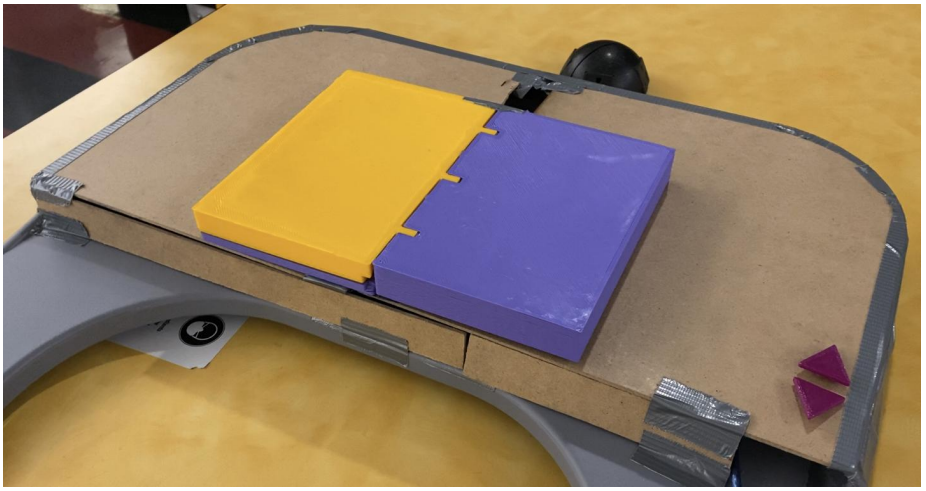


Figure 3.7, Final result

3.2 Using the Tablet Holder

Now that you have set up the tablet holder, you are ready to use it. It is quite simple. The tablet holder comes with 5 preset positions. These preset positions can be cycled through by pressing the up and down buttons. The first position will always be the tablet holder at a 0° angle. The second position opens the tablet holder to a 135° angle. The third position moves the tablet holder up closer to the user. The fourth position rotates the tablet holder to a 180° angle. The fifth position moves the tablet holder back to a 135° angle and to the end of the tray. Once the button is pressed after the fifth position, it resets the tablet holder back to the first position.

4. How to Maintain the Prototype

The prototype was designed for kids with disabilities and therefore a key design criterion was the ease of maintenance. This ensured that users of the product are able to maintain greater independence which was the prototype's main goal that was stressed by the client. The product can be regularly cleaned using any cleaning product that would be acceptable for ABS plastic. This general cleaning is not necessary for functionality and can be done based on user preference. The power source for the system is two 9V batteries with both connectors on the top that are connected to battery packs secured to the bottom of the tray. When the power begins to run low the open and close function of the tray will begin to slow. When this occurs flip the tray over and remove the battery pack cover of the pack that is on the right side when the tray is flipped. Then replace the battery in this pack with a 9V battery. If the slide back and forth mechanism begins to slow, complete the same process but to the battery pack that is on the left side when the tray is flipped. If the motors begin to stick simply apply a light lubricant to the portion of the motor that connects it to the sliders of the arm depending on the specific motor you are dealing with. Since all electronic components are soldered they are permanent and difficult to damage, also making them impractical to fix if they do break. The velcro that attaches the tray to the wheelchair will wear with use and will need to be occasionally removed and replaced. Replacements can be ordered from Amazon or Walmart and will fit the same as the removed velcro. Any other non-electronic components were custom-made by our team and can be ordered directly from us.

5. Possible Modifications and Improvements

For the purpose of this section in the report, every section speaks to possible improvements that we would have implemented if we had more time and resources. Essentially, they speak to what our ideal product would have looked like.

5.1 Motors

As seen in Section 2.2 (Prototype II), our sliding mechanism was implemented using a stepper motor. Programming a stepper motor on the Arduino IDE was quite challenging for us so we opted to switch the motor used in that mechanism in our final prototype. However, this wasn't the best decision since the rotational mechanism on a stepper motor is very different from that of a servo motor and we had already 3D printed our parts according to the stepper motor. Given more resources, we would switch to a stepper motor for ease of hardware use even though the software side is a little more complicated.

Other than the motor type replacement, we would also add another motor to the open and close mechanism. In our current iteration, we have 1 servo motor that performs the function of opening the tablet. While this is adequate at this step in our design process, a future suggestion would be to have a servo motor on either side of the base of the tablet holder to add extra steadiness and weight capacity.

5.2 Materials & Height Difference

In our ideal final product, we were hoping to be able to 3D print the entire top surface of the tray. However 3D printing is a quite time-consuming process and we hit many obstacles while trying to print the few parts that we did. In addition to that, MDF acted as a good temporary substitute for the product that we were hoping to create.

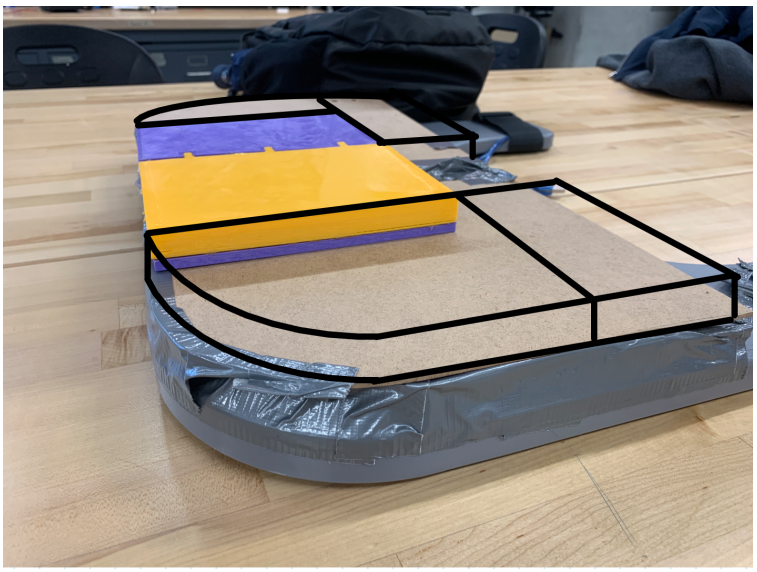


Figure 5.2) Flat Surface for Tablet Holder

Given more time and resources, we would ideally have a flat level surface for the top of the tablet holder that can actually act as a table for any potential users. It would look like Figure 5.2, with an even surface that is 3D printed.

5.3 Cover for slider

The sliding mechanism has a gap in the middle so that the slider can move up and down the surface of the tray freely. A judge on Design Day (March 2022) questioned what would happen if something fell between the cracks. This is a very valid question since our primary target audience is essentially school children.

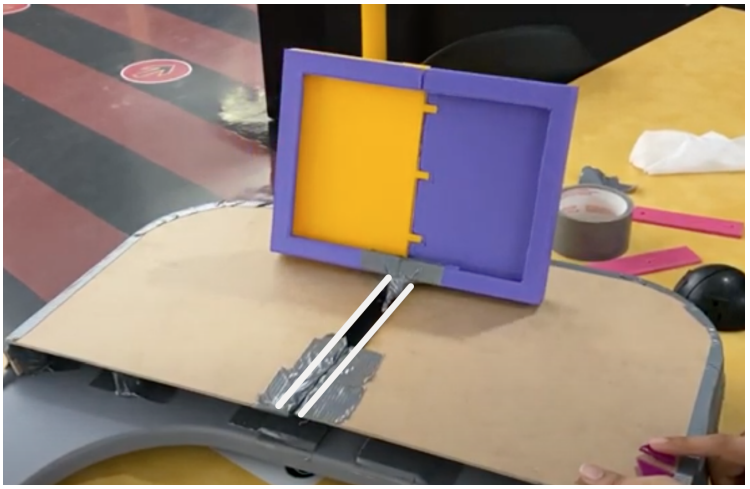


Figure 5.3) Sliding Mechanism Cover

A solution to this would be to use gap covers over the white lines shown in Figure 5.3, they are typically made out of silicone or rubber. This would allow the material to be flexible enough to allow the slider to move freely but also rigid enough to create a solid cover while the slider is not in use.

5.4 Safety Mechanisms

Our current product did not take safety into consideration since the prototypes were almost entirely functionality-based. We did, however, come up with a few ideas on how to make the product safer and more child friendly.

Figure 5.4) Potential Safety Mechanism Implementation

As seen in the figure shown above, there are 2 main mechanisms in mind to increase the safety of this product to make sure it passes safety standards. Firstly, a soft, padded material would be placed along every white boundary. This would be done just in case a child happens to get their hand stuck in the crevice of the tablet holder. Having the buffer material would eliminate any possibility of pain. Secondly, we would add an ultrasonic sensor where the pink

circle is shown. This would ensure that the tablet holder wouldn't close if there happen to be any obstructions in its path.

5.5 Different Components

For our prototype, we were given a budget of $100. Due to the monetary constraints, we weren't able to purchase entirely new components for our product and because of this some of the components were faulty or wouldn't run the way they were supposed to. The main issue here was the protoboard, which we had to desolder before use and this unfortunately did end up frying some of the circuit so it required a substantial amount of troubleshooting. Another big problem was that one of the tactile button switches that we soldered into our circuit began to malfunction and kept functioning as though it was constantly being pressed. We did face the same problem while we were in the initial prototyping stage but that was easily dealt with since we just replaced the button. This caused many issues since it wouldn't function the way it was meant to. I believe completely new and possibly certified components would help us in fixing this problem.

6. Conclusion

In conclusion, this deliverable will supply the user of the wheelchair tablet holder with the necessary knowledge of how to start, operate, power off and maintain the product. It also mentions any potential modifications that the user could think about adding in the future. The creation of the prototype is covered to show the user the thought process behind the product and demonstrate why certain possible features may have not been included. The user guide as a whole ensures that the user is able to use the product to its maximum capacity in a safe manner.

7. Appendices

7.1 Code

The code that we uploaded to the Arduino is included here:

https://github.com/shambhavi000/D2.4-Tablet-Holder-for-Wheelchair-Tray/blob/main/FinalPrototype

7.2 Design Files

All necessary design files (including this one) have been uploaded to our Makerepo:

https://makerepo.com/shambhavi/1170.tablet-holder-for-wheelchair-tray-d24