GNG2101[A]

Design Project User and Product Manual

Submitted by:

Table Tweakers AND A4.5

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1 Introduction

This User and Product Manual (UPM) serves as a comprehensive guide for parents of children with disabilities, particularly those with hindered motor skills, to adeptly utilize the Adjustable Play Table. It is a critical resource not only for immediate use but also for future reference in the event of modifications or enhancements. The manual is structured to provide clarity and simplicity, offering detailed insights into the setup, operation, and maintenance of the Adjustable Play Table. The document assumes predefined height standards, assures the availability of materials within budget constraints, and emphasizes user safety and satisfaction. It aligns with specific accessibility requirements and presupposes user-friendly controls to accommodate the client's unique needs. Please note that this manual is tailored with privacy considerations in mind, respecting the confidentiality of our client.

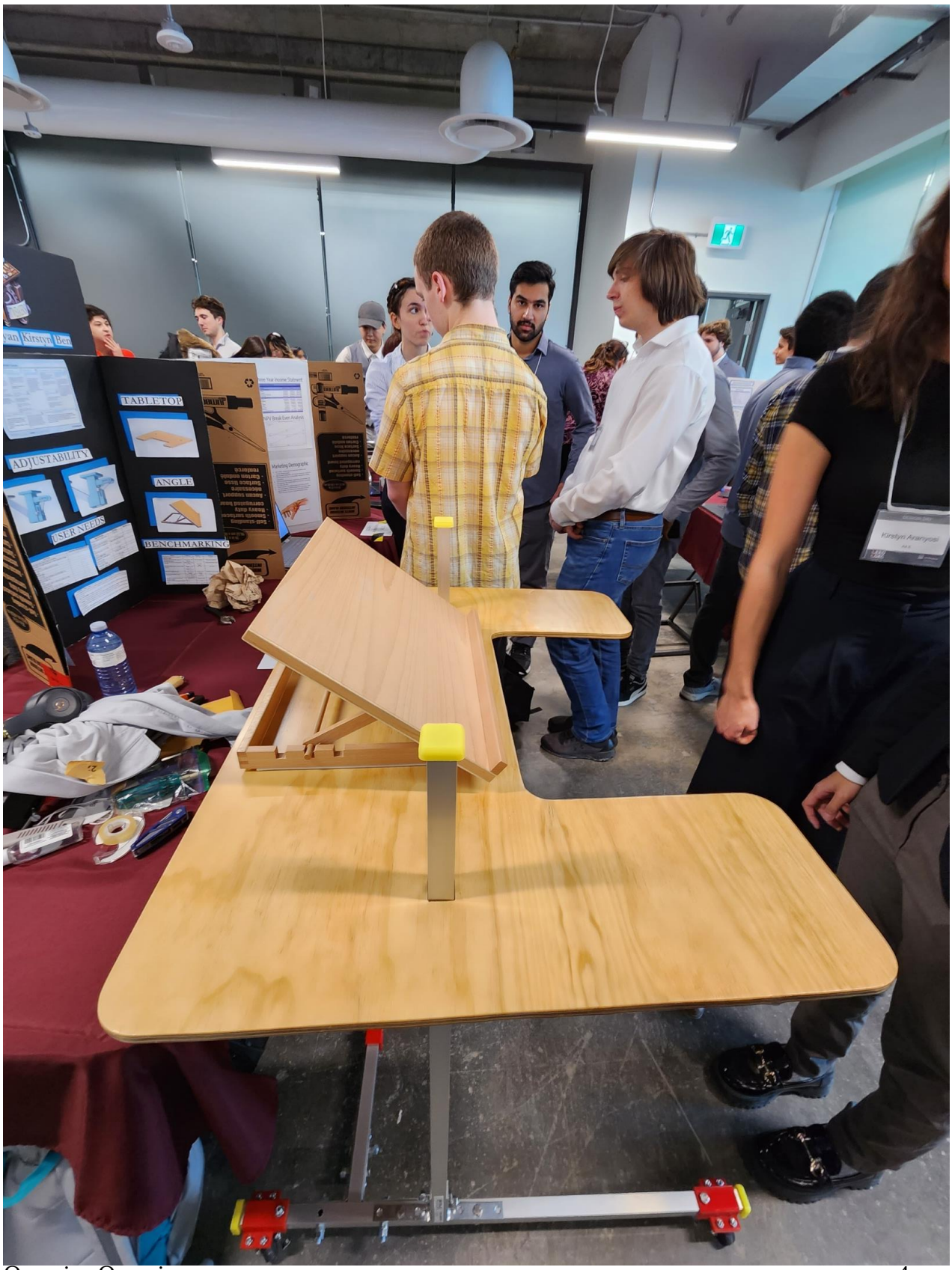
2 Overview

Our goal is to create a versatile and cost-effective table tailored for children with disabilities, particularly those with limited motor skills, capable of facilitating daily activities and wheelchair compatibility. The importance of meeting the distinctive needs of our client through an adaptable table is underscored by its profound influence on autonomy and daily routines. The primary challenge we address is the development of a device that seamlessly integrates with a wheelchair, and the focal point on adjustability is paramount. This emphasis directly links to the client's capacity to interact with the device seamlessly, rendering it a pivotal aspect of the project.

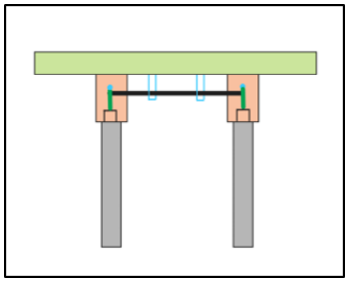
The fundamental needs of the user for the adjustable table are rooted in diverse requirements. Adjustability within height parameters is fundamental for promoting autonomy, safety, and long-term value. Portability ensures the table's versatility in various locations, both indoors and outdoors, supporting participation in diverse activities. Safety and durability are prioritized for daily use, while the versatility of surfaces ensures comfort in different environments.

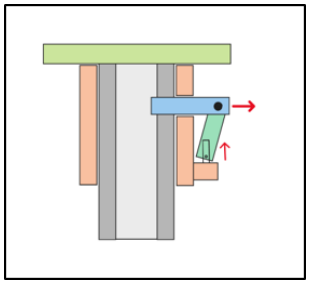
Our product distinguishes itself by addressing a unique aspect that sets our table apart from others in the market. Unlike existing adjustable tables, our design offers a remarkable minimum height of 1 foot, providing a level of accessibility and functionality not commonly found. Furthermore, many adjustable tables available are associated with high costs, often ranging in the hundreds or thousands of dollars. In contrast, our product is designed to be budget-friendly, allowing for construction within a reasonable budget of $100. This key differentiation makes our table not only innovative in its design but also significantly more affordable for a broader user base.


Lauren
Aryan
Kirstyn
Ben
FRAMEWORK
ADJUSTABILITY
USER NEEDS
TABLETOP
ANGLE


TABLETOP
ADJUSTABILITY
ANGLE
USER NEEDS
BENCHMARKING

Our table design features an H-shaped base frame with adjustable square shaft legs using a pin system for stability. To simplify height adjustments, a user-friendly handle is incorporated beneath the table, eliminating the need for manual pin insertion. This design balances simplicity and effectiveness, utilizing a combination of 3D printed and metal components.





2.1 Conventions

If applicable, describe any stylistic and command syntax conventions used within this document. For example, when an action is required on the part of the reader, it is indicated by a line beginning with the word 'Action'.

2.2 Cautions & Warnings

Before using the Adjustable Play Table prototype, please be aware of the following cautions and warnings to ensure a safe and optimal experience:

1. Height Adjustment Caution: The table is designed to be adjustable to accommodate various heights. However, users should exercise caution when adjusting the height, especially if there are obstacles or fragile items on the table.
2. Pin Mechanism Handling: The table utilizes a pin system for height adjustment. Be cautious when handling the pins. Do not attempt to adjust the height without securely locking the pins in place.
3. Handle Operation: The handle located under the table is used to release the pin mechanism. Users should operate the handle with care, ensuring it is fully engaged before releasing to prevent sudden movements.
4. User Supervision: If children or individuals with specific needs will be using the table, adult supervision is advised, especially during height adjustments.
5. Materials and Construction: Some parts of the prototype are made from 3D-printed components, and metal beams. Avoid applying excessive force or placing heavy objects on the table.

3 Building The Table

3.1 Materials

The following materials are needed to assemble the table:

- 8 brackets
- 2 long 42” aluminum beams with pins
- 2, 3-feet long beams
- 2, 1-foot beams
- 22 3/8” bolts, 1.5” long
- 40 3/8” nuts
- 16 ¼" bolts, 3/4” long
- 16 ¼" nuts
- 4 3/8” washers
- Tabletop with Supports and Components attached
- 2 Caster Wheels
- 2 Locking Caster Wheels
- 4 Wheel Adapters
- Connecting Adapter
- 6 Squishy Caps

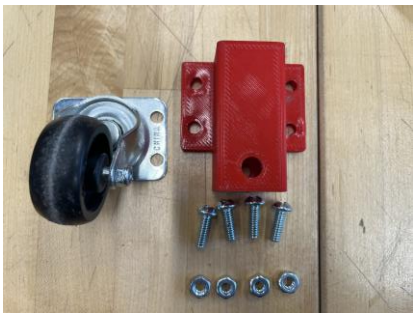
3.2 Tools For Assembly

The following tools are required/suggested for assembly:

- Wrench
- Plyers
- Robertson Head Screwdriver
- Mallet

3.3 Assembly

To assemble the table, follow the steps bellow:



1) Attach the wheel adapters to the 4 caster wheels using the 1/4” bolts. Ensure the bolts are facing away from the wheel so the bolts do not inhibit the wheel’s movement. Use the wrench and pliers to tighten the bolts.

2) Attach 2 brackets to either side of each one-foot beam with 3/8” bolts and nuts. Attach the brackets to the end with the two holes. Ensure the bolts are tight and attach 2 nuts to fasten the bolts.

3) Next attach 2 brackets to either side of each 42” beams with 3/8” bolts. Ensure the brackets are attached at the end with the two lone holes, and not the end with multiple holes going down the beam. Ensure the bolts are tight and attach 2 nuts to fasten the bolts.

4) Now attach the 2 two free wheels (already attached with the adapter) to the lone hole located at the end of each 3-foot pole. Ensure this is the end with only one hole, as the other end has multiple holes. The nut should be on the top side of the beam, facing away from the wheel.

5) Next attach the two locking wheels the same fashion as step 4, but on the other end of the 3-foot beams. Ensure they are the same way up.

6) Attach the 42” beams to the top of the 3-foot beams. This is parallel to the wheels. Ensure the bolts are double nutted and tightened to ensure the table is secure and strong.

7) To complete the leg assemblies, add a 1-foot beams to each of the 3-foot beams. These should be attached to the side with no brackets and should be perpendicular to the 42” beam. As well ensure for each of the legs, the 1-foot beams are attached so that the two assemblies mirror each other. This means one is attached to the

right side, and the other to the left. This may also require loosening of other brackets to fit the bolts inside. Then tightening.

8) Now take this time to tighten any bolts and nuts to ensure the table is secure.
9) Next attach the two table legs together using the connecting adapter and the two 1-foot beam ends. Use washers between all surfaces so as not to damage the plastic.

10) Carefully place the tabletop onto of the 42’ beams, then use the handle to adjust the height. Be careful to place the beams in the table holes and line it up correctly. For the table to move down/up the table legs, the handle must be pulled to retract the pins.
11) Lastly add the 6 squishy caps to each end of the aluminum tubing.

4 Using the System

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the table.

4.1 Adjustable Play Table

This section provides an overview of the main functions and features of the Adjustable Table System. Detailed instructions for each function are provided in the subsequent subsections.

4.1.1 Subsystem 1: Frame

The frame can be disassembled using a wrench and plyers to improve portability. As well squishy caps can be added to the ends of the beams to prevent the user from cutting themselves on the sharp edges.

4.1.2 Subsystem 2: Tabletop

The tabletop is coated in a varnish which means its more durable an waterproof. This means it can be cleaned and can be used for eating and painting. There are rounded edges as well as a cutout for the user to be more immersed in the tabletop.

4.1.3 Adjustable Mechanism

To adjust the height of the table, pull up on the grey PCV pipe underneath the tabletop. It’s suggested you grab it with both hands, with one at each end. Pull until you hear a clicking sound on both ends of the table. Then adjust the table to the desired height. Then release the handle and wiggle the tabletop so the pins lock into place.

4.1.4 Wheels

The wheels can be removed by unscrewing the bolts and sliding off the adapters. The wheels can be removed from the adapter by unscrewing the 4 connecting bolts. Lastly the wheels can be locked by pushing the lever located on the back two wheels. This will then prevent the wheels from rotating. To unlock, push the level the other way and pull it up.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

The Adjustable Play Table prototype is designed to minimize error messages and behaviors. However, in the event of encountering any unexpected issues, users may observe the following:

1.

   Error Behavior: Tabletop Movement Restricted.

   Possible Cause: One of the pins may be stuck or not fully released.

   Corrective Action: Check both pins to ensure they are fully released before attempting to adjust the height.

2.

   Error Behavior: Tabletop does not stay in the desired height position.

   Possible Cause: Pins may not be securely locked in place.

   Corrective Action: When adjusting the height, ensure both pins securely lock in the desired position.

3.

   Error Behavior: Bolts don’t fit in the holes when assembling.

   Possible Cause: Holes may be slightly off, in manufacturing.

   Corrective Action: Loosen other bolts for the bracket before putting the new bracket in, then tighten.

5.2 Special Considerations

While using the Adjustable Play Table, users should be aware of the following special considerations:

Caution: Avoid applying excessive force when adjusting the height if one of the pins is still locked. This may lead to pin breakage.

5.3 Maintenance

To ensure the long-term functionality of the prototype, regular maintenance is recommended:

Check for loose components or signs of wear periodically (pins, other 3D printed parts, & wheels).

5.4 Support

In case of emergency or the need for system support, users can contact our support team at *Table Tweakers*. For identified problems or inquiries, please follow these steps:

Email our support team at btait006@uottawa.ca, karan093@uottawa.ca, lhong093@uottawa.ca, &/or apand046@uottawa.ca.
Provide a detailed description of the issue, including any error behaviors seen.
Our support team will respond promptly with instructions for resolution or further assistance.

By following these guidelines, users can troubleshoot common issues, perform routine maintenance, and access reliable support for the Adjustable Play Table prototype.

6 Product Documentation

6.1 BOM (Bill of Materials)

Price ($CAD)	Part Name	Part Usage Description	Quantity	Links
$24.08	Caster Wheels	Wheels of the table, so they can move & also lock	1 Package x 4 wheels	https://www.amazon.ca/Houseable s-Locking-Capacity-Threaded-Furniture/dp/B0725W3MY6?source= ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=A1T1PCXZCQWDN5
$32.58	Plywood	Tabletop	1	https://www.homedepot.ca/product/3-8-inch-4-ftx8-ft-standard-spruc e-plywood/1000173237
$32.38	Aluminium Square Tubing	Legs of the Table	2	https://www.homedepot.ca/product/alexandria-moulding-1-inch-x-1inch-x-8-ft-metal-square-tube-in-satin-clear/1000675506
$2.73/foot	Aluminum rods	Used for lever mechanism	One 3 feet	https://millenniumalloys.ca/produ ct/ar061-6061-t6-aluminum-rod-0 -75in-diameter/
$13.94	Filament - PLA	Lever mechanism, caps	N/A	MakerSpace: https://filaments.ca/products/pva-f ilament-natural-1-75mm
$2.72	Nuts and Bolts	Securing table	12	From Home/ MakerLab
Total Cost:	$100.08 including free materials (Total: 113.90 including taxes)			

6.2 Subsystem 1: Frame

BOM for Frame Subsystem

Price ($CAD)	Part Name	Part Usage Description	Quantity	Links
$32.38	Aluminum Square Tubing	Legs of the Table	2	Home Depot
$2.72	Nuts and Bolts	Securing table	12	From Home/ MakerLab

The frame serves as the skeleton of the table, providing structural integrity and support. It was built using aluminum beams due to aluminum's strength-to-weight ratio, corrosion resistance, and ease of machining.

Design Considerations and Calculations:

- Calculated the load-bearing requirements to ensure the frame can support the expected weight without deformation.
- Determined the optimal size and number of beams to balance stability and material efficiency.
- Engineered the placement of holes for adjustability and assembly, considering the mechanical stress distribution.

Materials and Feasibility:

- Aluminum was chosen for its durability and lightness; however, alternatives like steel (for higher strength) or wood (for cost-effectiveness) could be considered, although they may alter the weight and machining process.

6.2.1 Equipment List

Machinery

Mill	• Make holes in the aluminum beams (legs)
Drill Press	• Make holes in brackets
Band Saw	• Cut aluminum beams to length
Hand-held drill	Used to drill through 3D printed materials
Wrench	ed to tighten bolts in assembly/ disassembly
Pliers	Used to tighten bolts in assembly/disassembly
De-burring tool	• Used to deburr all drilled holes
File	• Used to file down sharp, cut metal edges

6.2.2 Instructions

1. Cut aluminum beams to desired length with bandsaw
2. File down cut edges
3. Align mill and set up aluminum beams in the machine
4. Drill holes in identical increments; repeat for two legs
5. Mark all holes where bolts will go; drill holes
6. Deburr all holes to remove sharp edges
7. Mark hole locations on brackets; set up in drill press and drill
8. Deburr and file holes
9. In combination with 3D printed parts, assemble the frame with bolts, washers, and nuts, making sure to tighten all nuts with a wrench and pliers

6.3 Subsystem 2: Tabletop

BOM for Tabletop Subsystem

Price ($CAD)	Part Name	Part Usage Description	Quantity	Links
$32.58	Plywood	Tabletop	1	Home Depot

The tabletop is the primary user interface of the table, requiring careful consideration of ergonomics and aesthetics.

Design Considerations and Calculations:

- Selected materials that balance durability with a pleasant tactile feel.
- Designed for ease of cleaning and maintenance.
- Incorporated cutouts and fillets for cable management and user comfort.

Materials and Feasibility:

- Plywood was chosen for its versatility and cost-effectiveness, finished with varnish for durability. Alternatives like MDF could be cheaper but less durable, while hardwoods offer greater longevity but at higher costs.

6.3.1 Equipment List

Sawhorses	• (optional) Used to prop the tabletop up for cutting

Jigsaw	• Used to make the cutouts and fillets on the table
Sandpaper	• Used to sand down cut surfaces of the table
Cloth	• Used to apply and wipe off varnish on tabletop

6.3.2 Instructions

10. Place plywood on sawhorses
11. Mark plywood with outermost dimensions for the table; cut into a rectangle with jigsaw
12. Mark plywood with cut-out dimensions; cut with jigsaw
13. Mark all radii; cut with jigsaw
14. Mark square holes for aluminum beams; iteratively cut with jigsaw
15. Sand down all cut surfaces
16. Apply several coats of varnish, making sure to follow the product instructions

6.4 Subsystem 3: Adjustable Mechanism

BOM for Adjustable Mechanism Subsystem

Price ($CAD)	Part Name	Part Usage Description	Quantity	Links
$2.73/foot	Aluminum rod	Used for lever mechanism	One 3 foot	Millennium Alloys
$9.72	Filament - PLA	Lever mechanism, caps	463g	MakerSpace

The adjustability mechanism is central to the table's functionality, allowing for height variation.

Design Considerations and Calculations:

- Engineered for smooth operation across the table's range of motion.
- Stress-tested the 3D printed components to ensure they can withstand repeated use.
- Calculated the force required by the user to adjust the table, aiming for ease of use.

Materials and Feasibility:

- Utilized 3D printed parts for complex geometries, with the possibility of using metal parts for increased durability in future iterations.

6.4.1 Equipment List

3D Printer	• Used for printing body, pins, PVC support, caps, and support piece
0.4 Nozzle	• Used for the 3D printer extrusion for smaller parts (e.g. slider, pin long, end cap for pin, end cap, spring pin, pin for holding up table)
0.8 Nozzle	• Used for the 3D printer extrusion for larger parts (e.g. body, support, support frames for connecting rod)

6.4.2 Instructions

1. Download the STL files provided
2. Open or Download UltiMaker Cura 3D printer slicer
3. Upload each file individually; however, ensure that there are two copies of each file in the slicer to ensure that there are two equal parts for each side
4. Make sure that are supports on each build to avoid failure; when dealing with smaller pieces ensure that you change the nozzle if you are only working with one printer
5. Once all parts are printed assemble them focusing on the large parts connecting the

supports, then move on to the pin mechanism- inserting the large pin into the hole, add the slider piece connected them with the long pins then capping them off

6. Attach the springs into the slotted holes at the bottom of the main adjustable and add them to the long pin, making sure to cap them off
7. Now connect the pin for holding up the table into the PVC pipe and glue it into place
8. Attach the pin into the pin to hold up the table and glue accordingly
9. Place the adjustable mechanism body flat side down onto the table and glue aligning with the insert on the table

6.5 Subsystem 4: Wheel

BOM for Wheel Subsystem

Price ($CAD)	Part Name	Part Usage Description	Quantity	Links
$24.08	Caster Wheels	Wheels of the table, so they can move & also lock	1 Package x 4 wheels	Amazon
$4.22	Filament - PLA	Lever mechanism, caps	201g	MakerSpace

Wheels add mobility to the table, a critical feature for users who need to move their workspace.

Design Considerations and Calculations:

- Selected caster wheels for easy movement in all directions.
- Ensured the wheel assembly could carry the table's full loaded weight without failure.

Materials and Feasibility:

- Chose durable materials for the wheel adapters, with the option to use metal casters for environments with heavier use

6.5.1 Equipment List

3D Printer	• Used for printing caster wheel adapter
0.8 Nozzle	• Nozzle type for efficient printing for adapter
Hand Drill	• Used to create exact holes for caster wheels to fit on the system

6.5.2 Instructions

1. **Download the file for the adapter and upload it to UltiMaker Cura's 3D printing software**
2. Ensure the settings are set to nozzle 0.8 and have supports on
3. Print the file then remove supports ensuring there's no extra filament left
4. Connect the caster wheel to the bottom of the adapter ensuring that it lines up and draw four holes where the screws would go
5. Drill each hole ensuring to clamp the piece in place to avoid slipping
6. Screw four bolts into each hole connecting them with a respective nut
7. Attach each adapter to each leg, now screw all bolts and nuts into place to connect the entire adapter

6.6 Testing & Validation

Wheels

Rolling Friction Test: Measure the force required to start and maintain the movement of the table across different surfaces (carpet, tile, etc.).
Stability Test: Test the table's stability while being moved with a load on top to ensure it does not tip over.

Durability Test: Subject the wheels to a long-distance rolling test to simulate months of use in a brief time.

Results for Wheels:
Friction coefficients for different surfaces.
Maximum safe speed and load for movement without tipping.
Distance until wheel failure or performance degradation.

Frame
Load Test: Place increasing weights on the table to test the frame's load capacity.
Fatigue Test: Repeatedly apply and remove the load to assess the frame's resistance to fatigue.
Torsion Test: Apply torsional force to test the frame's resistance to twisting.
Results for Frame:

Maximum load capacity before permanent deformation.
Number of load cycles sustained before signs of fatigue.
Degree of torsional force the frame can withstand without bending.

Adjustability Mechanism

Range of Motion Test: Verify that the adjustability mechanism can move through its entire intended range smoothly.
Speed of Adjustment Test: Time the duration required to adjust from the minimum to the maximum height.
Repeatability Test: Conduct multiple adjustments to check for consistency in movement and any signs of wear.
Results for Adjustability Mechanism:

Range of height adjustment measured in inches or centimeters.
Average time taken for height adjustments.
Number of cycles completed before the mechanism shows wear or inconsistency.

Tabletop

Surface Durability Test: Assess the tabletop's resistance to scratches, heat, and stains.
Load Distribution Test: Evaluate how well the tabletop can distribute a load without warping.
Impact Test: Drop various objects from a height to test the tabletop's resistance to impact.

Results for Tabletop:

Durability ratings against common forms of damage.

Maximum weight distributed without warping.

Impact resistance level without cracking or chipping.

Issues or Special Requirements for Sustained Usage:

- **Maintenance Schedule**: Establish a regular maintenance routine for the moving parts, especially the adjustability mechanism and wheels.
- **Weight Limitations**: Clearly label the maximum load capacity to prevent overloading and potential frame damage.
- **Environmental Considerations**: Provide guidelines for the environmental conditions in which the table can be used without compromising its materials or mechanisms.

7 Conclusions and Recommendations for Future Work

Throughout the course of developing the adjustable table prototype, the team garnered invaluable insights and identified strategic avenues for future exploration. Regular interactions with clients proved to be a treasure trove of information, affirming that understanding user requirements directly from the clientele is essential for a design that truly meets their needs. The team honed their practical skills, navigating the intricacies of milling, the precision of 3D printing, and the art of woodworking—each process contributing uniquely to the prototype's development. These skills highlight the need for team versatility and the advantage of cross-functional expertise in product design.

The structured use of project management tools, specifically Wrike, was instrumental in orchestrating the project's workflow, displaying the benefits of systematic planning and tracking. The clarity of project deliverables became a roadmap for progress, advocating for a well-defined, iterative approach that accommodates for regular feedback and incremental improvements.

Looking to the future, with more time at hand, the focus would be directed toward extensive durability testing to ensure the table withstands the rigors of daily use. Incorporating user feedback would become a cyclical part of the design refinement process, ensuring that the product evolves in alignment with user preferences and needs. Features that were initially deferred due to time constraints, like advanced adjustment mechanisms, would be revisited. These would offer enhanced ergonomics and user-friendliness, potentially revolutionizing the table's market appeal. Portability features, such as foldability or lighter materials, would also be on the agenda, aimed at making the table more versatile in a variety of settings. Additionally, safety features, especially those safeguarding against accidents in diverse environments, would be developed further, marking the product as suitable for a wider audience, including children.

The project was a lesson in balancing immediate objectives with long-term vision, laying a solid foundation upon which future teams can build more refined, user-centered, and innovative table designs.