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MATHEMATICAL MODELING AND DESIGN OPTIMIZATION OF AN ADJUSTABLE STANDING DESK FOR ERGONOMIC HOME OFFICE USE

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Abstract

This study addresses the Ergonomic challenges faced by individuals working from home due to insufficiently supportive furniture, which contributes to discomfort, poor posture, and health complications. The aim was to develop a cost-effective, adjustable standing desk design that enhances user comfort by increasing height and workspace area while ensuring stability, postural support, and health benefits.

A mathematical modeling approach was employed to analyze the stability, strength, and functional performance of the standing desk. The design specifications included achieving a height of at least 45 cm, a workspace area of 4000 cm2 or greater, and sufficient stability to support 50 pounds of weight, all while maintaining a total cost below $250. Several conceptual designs were considered using a decision-making matrix, with the final design developed using SolidWorks software to model key mechanical components. The model was verified using numerical analysis, including torque calculations for stability assessment.

The final design achieved a maximum height of 50.64 cm and a workspace area of 7600 cm2, both exceeding the specified requirements. Stability was verified through torque calculations at the points of structural support, demonstrating that the design could counteract applied forces effectively. An assessment of aesthetic appeal, based *on a user survey, indicated an 87% satisfaction rate. The total estimated cost $173.4 met the budgetary constraint, leaving room for additional manufacturing expenses.*

The results demonstrate that the proposed adjustable standing desk meets all functional, non-functional, and cost constraints, offering a viable ergonomic solution for home office settings. Recommendations are provided for improving use convenience and manufacturability in potential future production stages.

Keywords: Adjustable Standing Desk, Ergonomic Design, Mathematical Modeling, Stability Analysis, Design Optimization, Solid Work Modeling

Nomenclature

T the torque (Nm),

$F_{\perp}$ the perpendicular force,

r is the moment arm.

I. Introduction

Work-from-home regulations resulted in an immediate change with many individuals utilizing household furniture as part of a temporary home office. Insufficient ergonomic support provided by this setup and longer hours spent working result in poor posture and cause discomfort which inhibits productivity and can incur medical expenses due to health issues developing (Providence) [XII]. Existing standing desks that are designed for a home setting offer limited space, therefore, a more practical solution had to be found. This research was embarked upon as it affected a group member who experienced continuous pain and doctor visits yet was unable to find a simple design that aided with posture and could be adjusted to suit their needs at a reasonable cost.

In recent years, ergonomic design in office and educational furniture has gained increasing attention due to its significant impact on health, productivity, and overall well-being. Ergonomically designed furniture, particularly adjustable standing desks, has been shown to reduce sedentary behavior, enhance focus, and mitigate the risk of developing chronic health conditions like cardiovascular disease and musculoskeletal disorders (Chrisman, M., and Ye, S.,)[V]. The rise in sedentary lifestyles, particularly in educational settings where students sit for prolonged periods, has spurred the need for furniture solutions that promote movement and flexibility, such as height-adjustable desks.

Parametric furniture design offers another innovative approach, allowing for flexibility in form and function through the use of advanced design tools. (Fariz, Fesa Putra Kristianto line and Zain Amarta)[VI] emphasized the use of the Finite Element Method (FEM) in analyzing stress and deformation in furniture, specifically for parametric TV tables. This method enables the assessment of the structural integrity of furniture under varying loads, ensuring both aesthetic appeal and functional reliability (Fariz, Fesa Putra Kristianto line and Zain Amarta)[VI]. Such computational techniques are crucial for designing furniture that can withstand different use cases without compromising on user comfort or durability.

In parallel, studies by (Barcellos, Ekaterina Emmanuil Inglesis, and Galdenoro Botura) [IV] have highlighted the importance of integrating design methodologies with engineering practices, focusing on the balance between user-centered design and structural efficiency. This interdisciplinary approach ensures that products like adjustable desks are both practical and ergonomically sound. The combination of advanced computational methods with user-focused design processes leads to furniture that not only supports physical health but also enhances cognitive performance and productivity (Barcellos, Ekaterina Emmanuil Inglesis, and Galdenoro Botura) [IV].

In the realm of height-adjustable table design, both ergonomics and cost-efficiency are critical factors, especially as remote work and study have become more prevalent. (Sai and PatelC.H)[XIV] developed an affordable solution, optimizing height-adjustable tables by focusing on material selection and cost-effective mechanisms like aluminum frames and linear actuators. Their approach ensures both comfort and accessibility for students and professionals working from home during the pandemic. By leveraging tools such as Autodesk Fusion 360, the design's components were optimized for functionality and pricing.

Ergonomic design plays a pivotal role in reducing musculoskeletal issues, particularly for students who spend extended hours working on laptops. (Jafarvand)[VIII] redesigned a folding ergonomic laptop desk aimed at improving posture and minimizing discomfort for college students.

By measuring the anthropometric dimensions of students and incorporating adjustable features such as desk height and inclination, they ensured the desk's compatibility with diverse body types. This approach highlights the importance of user-centered design in developing products that support health and productivity in academic environments.

Due to the increasing need for multifunctional furniture in small living spaces, particularly with the rise of home office work post-pandemic, (Viggiani, Maria FS and Silva, L. G.)[XVIII] designed an innovative desk to address ergonomic and spatial challenges. The desk incorporates adjustable features and multifunctionality, serving both as a workspace and a living room console. The project utilizes the Design Methodology for Innovation Generation to ensure a user-centered, space-saving solution for small homes, integrating features like height adjustability and built-in storage for better organization.

(Robertson and Michael J. O'Neill) [XIII] investigated the impact of an office ergonomics intervention, which included both workspace redesign and ergonomics training. The intervention aimed to reduce musculoskeletal discomfort and improve ergonomics knowledge among workers. Results showed significant improvements in ergonomic knowledge and a reduction in self-reported musculoskeletal discomfort for those who received both the new workspace and training, compared to those who only had workspace changes or no intervention.

(Verbeek) [XVII] evaluated the effectiveness of an instruction program designed to optimize office furniture adjustments based on individual body dimensions. The program focused on adjusting seat and desk height for improved posture. The study found that, while instruction led to statistically significant improvements in furniture adjustment, practical obstacles such as limited availability of footrests and desk adjustability hindered full adoption of the ideal sitting posture. This study concluded that more accessible adjustments and further research are necessary to enhance the effectiveness of ergonomic interventions.

The study assessed the mismatch between students' body dimensions and school furniture across primary, secondary, and university levels in Slovenia. Results showed a significant mismatch, particularly in desk and seat height, with primary school students being the most affected. The findings highlight the need for adjustable furniture to improve ergonomics and prevent musculoskeletal discomfort in educational environments (Loredan, Kaja Kastelic and Michael David Burnard) [IX].

The guide provides an extensive overview of ergonomic principles applied to office furniture design. It covers key topics such as anthropometry, workplace postures (sitting, standing, reaching), and common workplace motions. The document also discusses ergonomic guidelines for chairs, desks, and storage, with an emphasis on designing products that fit the diverse sizes and needs of users. Additionally, the guide highlights universal design considerations to accommodate individuals with disabilities, offering practical insights for creating inclusive and comfortable work environments (Scott Openshaw, Allsteel Erin Taylor, and Allsteel)[XV].

Research Objectives

• To assess the problem of discomfort while working from home and identify a set of requirements needed for a successful solution.
• To brainstorm ideas for solutions and develop multiple designs that meet the criteria.
• To assess the design concepts and select a final design which will be developed further to produce a viable final product which meets all updated specifications.

Need Statement

There is a need for a support system that increases the height of a workspace to facilitate standing and maximizes the working space area while costing less than $250.

Engineering Design Specification

The engineering design specification in Table 1 was determined at the start of the research to assess two functional requirements which were maximizing height and area, a non-functional requirement which was aesthetic appeal, and the constraint requirement of cost. This was updated as the research progressed to include the functional requirement of stability since it was deemed necessary for the design to work as intended. The values and verification methods were re-assessed to reflect more achievable goals that would still ensure a successful end product since testing of the final product could not be performed.

Table 1: Engineering Design Specification [XI,XVI]

Characteristic	Relation	Value	Units	Verification Method	Comments
Increases the height of the workspace to allow standing	>=	45	cm	Test	Measure the product at its tallest height in CAD.
Increases workspace area	>=	4000	cm2	Test	Measure product at the maximum surface area in CAD.
Sufficient Stability	>=	50	lbs.	Test	Perform calculations based on the center of mass determined in CAD.
Aesthetic Appeal	>	80	%	Test	Collect survey results from 30 people to assess the aesthetic appeal on a scale of 1-5 and take an average of the results.
Cost	<=	250	$	Analysis	Calculate the material cost for the design and estimate the labor costs required to create the product.

II. Conceptual Design

The design was subdivided into the three main functional requirements shown in Figure 1, and ideas were brainstormed for each function. This provided a few options for how the design could be approached and enabled design concepts to be generated based on the Morphological chart.

Conceptual Designs Considered

The first concept was arrived at using the analysis of technical systems as it resembled a scissor lift (as seen in Figure 2). The tabletop featured two main pieces that formed the original surface which could be moved apart to allow a third piece to be added between them for increased surface area. This would be supported underneath by a frame to which the legs are connected. The legs fit into grooves in the base and top plate both of which have a large surface area to promote stability and allow the legs to be opened or closed more depending on the height that the user wants to achieve.

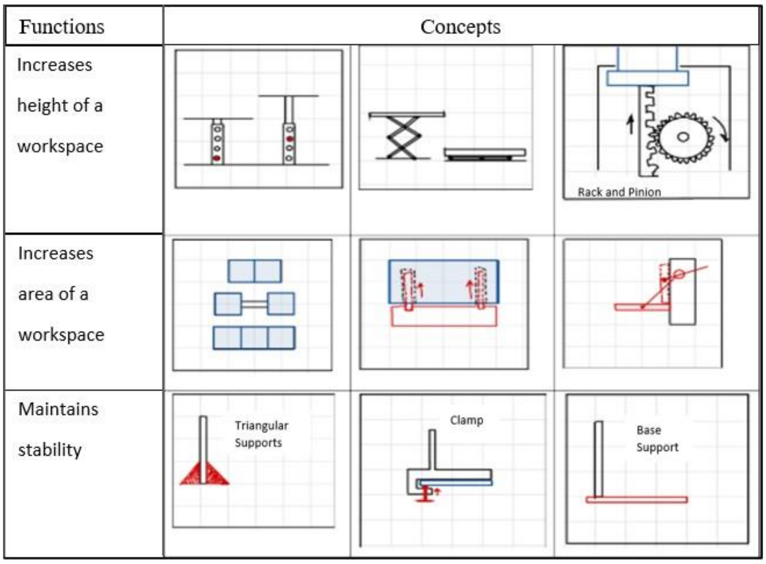

Fig. 1: Morphological Chart illustrating potential solutions.

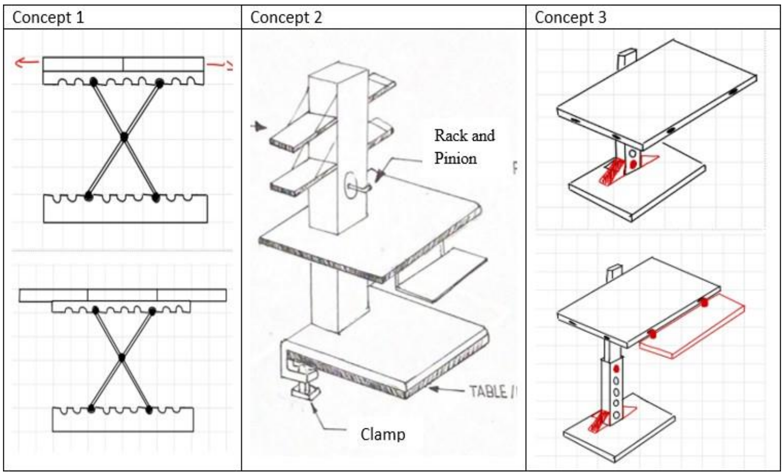

Fig. 2: Illustrations of more complete concepts with finer details.

The second concept in Figure 2 utilized the analysis of natural systems by observing a tree. The design had a main tabletop, retractable shelves or "branches" and an attachment that could be folded down to increase surface area. A rack and pinion design formed the 'trunk' and allowed the height to be adjusted while a clamp at the base of the design secures the design to a desk to increase stability.

The third concept was arrived at through brainstorming and implementing a design that resembled a puzzle. Additional attachments for the tabletop had pins which could be locked into grooves in the main tabletop like interlocking puzzle pieces to increase workspace area. The stem of the design allows an inner stem to be moved out of the larger, outer stem similar to a telescoping device and is locked into place with a bolt. The stability was increased by adding triangular supports where the stem and base plate connect in the third concept (seen in Figure 2).

Decision-Making Matrix

Based on the decision-making matrix in Table 2 each of the three concepts' performance in six key areas was assessed. Concept 1 (shown in Figure 2) was selected as the datum and all columns were zeroed for reference such that a score of +1 is better than the datum and -1 is deemed not as favorable as the option in the datum. In the areas of height adjustability, ergonomics, and safety, both concepts 2 and 3 were given a score of +1 indicating that more ideal solutions were presented as compared to concept 1. Both these designs made increasing the height easier as they are adjusted using the stem and do not need to be reassembled as required in Concept 1. This gives a wider range of adjustments which improves ergonomics as it can better cater to a user's needs. The safety aspect is also linked as reconfiguring the top and base plate in concept 1 can result in damage to the user if a piece falls or if the grooves are not locked in properly. Concepts 2 and 3 remove this concern since no large parts need to be moved.

Table 2: Decision-making matrix for design concepts.

Criteria	Datum: Concept1	Concept 2	Concept 3
Height adjustability	0	+1	+1
Maximizes workspace area	0	-1	0
Ergonomics	0	+1	+1
Safety	0	+1	+1
Stability	0	-1	0
Cost	0	-1	+1
Total	0	+1	+1

The ideas for maximizing workspace area and stability in concepts 2 and 3 were rated -1 and 0 respectively. In concept 2, the increase in area does not offer a continuous surface which makes it less ideal than the datum whereas in concept 3, the puzzle piece idea is just as practical as the datum. Stability in concept 2 just uses a large base but the legs are not properly supported unlike in concepts 1 and 3 where the stems utilize a similar idea and have additional supports at the base rather than just a large base plate. In the area of cost, concept 2 was rated -1 as it featured a more complex design with many parts thus requiring more material and would be difficult to manufacture as compared to the simplicity of concept 1. Concept 3 received a score of +1 which is better than the datum since it was realized that the cost of metal legs and a frame that allows the tabletop to slide apart in concept 1 may be more difficult to manufacture and increase material cost as compared to the parts required for concept 3 which are much simpler and consist of more basic parts.

The overall results gave a total score of zero for concept two which is the same as the datum whereas concept three earned a score of +4 which indicated that it was the best solution based on the decision-making matrix.

III. Mechanical Design

To create a model from the third concept in SolidWorks, the three functional requirements and additional auxiliary functions were separated according to the different parts of the desk that would fulfill them. The ergonomic advantages of the design were also integrated into the modeling process, ensuring the desk could accommodate users of different heights and facilitate optimal posture. The dimensions and materials of these parts were then determined based on the conceptual sketch such that each requirement was appropriately met.

Functions

Basic Functions

Three basic functions were identified and taken into consideration when designing each part of the table. The first basic function was for the design to increase the height from the main table to the design's tabletop to at least 45cm. To achieve this, the base of the table was designed with an outer stem, and a smaller inner stem was separately designed to fit inside of it. This telescoping concept allowed the inner stem, which was attached to the tabletop, to move laterally such that the total height of the table could reach 45 cm. This was later verified using the measurement tool in SolidWorks.

The second basic function was to provide a workspace area of at least 4000 cm2. To do this, the main tabletop was dimensioned to provide this area, with a width of 50 cm and a length of 80 cm. To further increase the area, slots were created in the main tabletop and three extension pieces were separately designed. Pegs that were angled downwards were extruded such that they fit into the slots of the main tabletop and would rely on both a tighter fit and gravity to remain in place. This function was also verified in CAD using the measurement tool.

The final basic function was to ensure sufficient stability. To meet this function, triangular supports between the tabletop and the inner stem, as well as the base and the outer

stem were added to allow for an even force distribution and prevent the tabletop or stem from bending in the case of an uneven lateral or horizontal force. A thin metal plate slightly smaller than the main tabletop was added for extra stiffness as well. Finally, a c-clamp was incorporated into the base and the c-clamp screw had a larger surface area so that the design could be securely attached to a surface and the risk of tipping was minimized. This function was tested by using the center of mass in CAD and torque calculations.

Auxiliary Functions

The design had two auxiliary functions, the first being a proper locking mechanism for the inner and outer stems. This mechanism was designed as a bolt and nut system and was incorporated by designing one hole that went through the outer stem, and multiple holes through the inner stem of the same size. To lock this system in place, a chosen hole in the inner stem was lined up with the hole in the outer stem, and the bolt was inserted through both holes. Then, the entire system was secured by screwing the nut onto the threaded part of the bolt.

The second auxiliary function was for the inner stem to move out of the outer stem with ease. This was achieved by using a clearance between the inner and outer stems that was large enough to prevent major friction between these parts, but small enough so that the stems would remain upright. The stems were also hollowed out, which made the entire desk much lighter, and less force would be needed to lift the inner stem and adjust the height.

Layout

SolidWorks Design

Upon the completion of each separate part, a SolidWorks assembly was created, and the components were mated to ensure a proper fit between every design, as shown in Figure 3.

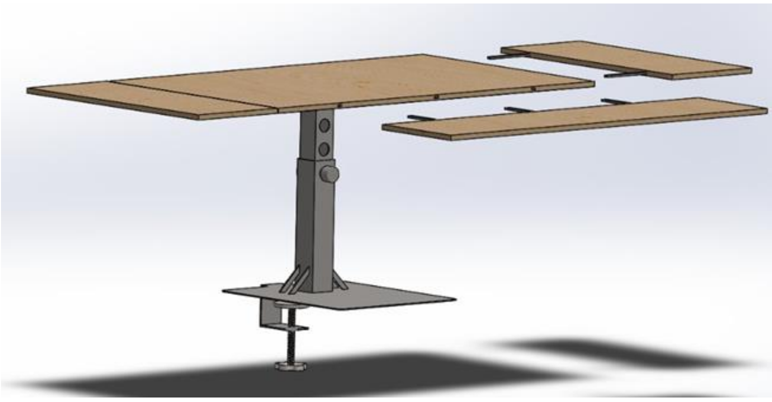

Fig. 3. An isometric view of the final SolidWorks assembly.

The tabletop extensions were configured to show what they would look like when attached to the main tabletop, as well as how the pegs and slots lined up before being attached. This configuration made use of the middle hole in the inner stem to lock the design in place.

Triangular supports at the base were made as two separate metal parts on three sides of the outer stem.

The c-clamp mechanism was built into the base of the design with a bent metal piece and threaded hole, as shown in Figure 4. The c-clamp screw, also shown in Figure 4, had a relatively large radius to enable stability and reduce potential damage to the surface on which the design would be attached. The handle of the screw featured indents so that users would have a better grip rotating the screw.

The alignment of the outer and inner stems allowed for the proper use of the locking mechanism, which is seen in Figure 5. Once the holes were aligned, the bolt was inserted until the head made contact with the outer stem. Then, the nut was screwed onto the threaded portion of the bolt, on the opposite side of the outer stem to prevent the bolt from falling out and thus locking the stems in place at the desired height.

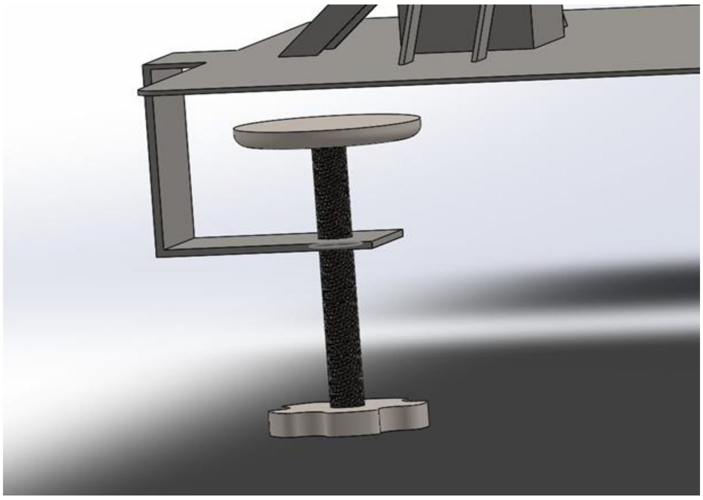

Fig. 4. A close-up of the C-clamp and C-clamp screw.

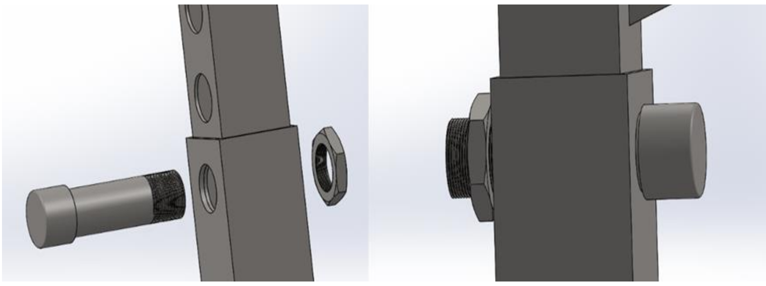

Fig. 5. A close-up of the aligned holes in two stems (left), as well as the bolt and nut that secure the system in place (right).

A small plate was included in the design of the stem for two purposes: the first was to allow for the triangular supports to be attached to the stem, which is seen in Figure 6. The second was to attach the stem and supports to the bigger plate and tabletop.

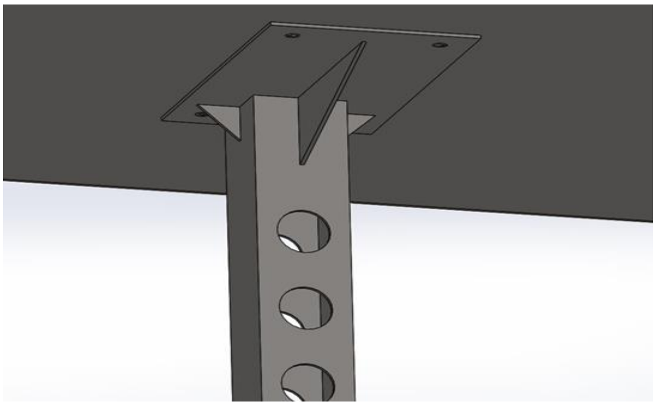

Fig. 6. A close-up of the inner stem and three of its five holes, the triangular supports attached to a smaller plate, and the larger plate attached using screws..

Four screws, also seen in Figure 6, were used for the attachment of the stem to the tabletop, as they were dimensioned to go through the smaller plate, larger plate, and the wood.

Material Selection

During the selection of materials, it was decided that the metal selected should be ductile and tough to prevent sudden failure. These properties as well as formability influence the amount of work the materials need and thus the manufacture costs. Cost and accessibility were also important to meet our constraint requirement, however, the aesthetic appeal and textures are prioritized since it is a part of the user's home and a non-functional requirement.

Material interactions are also considered for example, using screws in wood introduces stress therefore we must select materials that can withstand this. The stiffness of the tabletop and stem is also a necessity since they must support a load without bending. Density is also noted as a lightweight design that is preferred to allow the user to move it with ease. The main considerations were examined, and the selections were made (based on Table 3).

Table 3: Material Selection Chart with specified factors. Green rows are the final material selections.[I, II, III, VII, X, XI, XII, XVI, and XIX]

Part	Material	Density (g/cm^3)	Strength / Weight Ratio	Ductility (% Elongation)	Price ($ USD)	Other comments
Tabletop/Attachments	Maple Wood	0.55	36.7	N/A	16.1/bf	Modern aesthetic, decent strength, and price range
Tabletop/Attachments	MDF	0.8	45.0	N/A	4.5/bf	Disregarded due to water damage

						vulnerability
Tabletop/Attachments	Bamboo Plywood	0.70	57.1	N/A	45.3/bf	Very expensive and high-quality
Stem/Base/Clamps/Rods	AISI 304 Stainless Steel	7.80	112.8	25.5	2000/ton	Very high strength and expensive
Stem/Base/Clamps/Rods	ASTM A210 Medium Carbon Steel	7.90	63.9	34.0	500/ton	Decent stiffness properties, much more affordable
Stem/Base/Clamps/Rods	3003 Aluminum	2.80	62.5	14.6	2500/ton	Very lightweight with sufficient

Manufacturing Considerations

Due to the use of mixed materials and relatively unique parts, such as the stem and base, some manufacturers may focus on furniture made of one material (Inc.) [VII]. The production of this table will require both metal and wooden parts to be made and assembled. The triangular supports found in the base and between the stem and tabletop will need to be welded. Holes will need to be drilled into the inner stem, outer stem, and the base where the c-clamp is fixed – this hole will also need to be threaded. The wooden tabletop will need to be cut to size and appropriate rectangular holes will need to be cut into the sides with a downward slope such that the extensions do not fall out. The stem, metal plate, and main tabletop are going to be attached using eight screws, so holes dimensioned to be smaller than the body of the screws and larger than their heads will need to be drilled into the metal parts.

IV. Verification of Design

The characteristics outlined in Table 1 (engineering design specification) were chosen specifically such that they could be verified without the need for the actual construction of the product. These qualities were verified through various tests of CAD and surveying, as well as a cost analysis. First, the height of the design was required to reach at least 45cm. This was verified through a test method of basic quantitative measurements of the height from the base to the top of the design when the stem is fully compressed and extended on SolidWorks. At its shortest configuration, the height of the design was 32.16cm, but due to the adjustability of the design the tallest height was measured to be 50.56cm, which met this functional requirement.

The second characteristic was that the workspace area needed to be at least 4000 cm2. This was verified by a test method where the surface area of the main tabletop and extensions were measured in SolidWorks. The area of the main tabletop was measured to be exactly 4000 cm2, while the total area with the extensions was found to be 7600 cm2 which exceeded the minimum value; thus, the functional requirement was met.

Furthermore, the ergonomic impact of height adjustability was analyzed. The results indicated that allowing users to alternate between sitting and standing positions reduces spinal compression. Which contributes to overall musculoskeletal health.

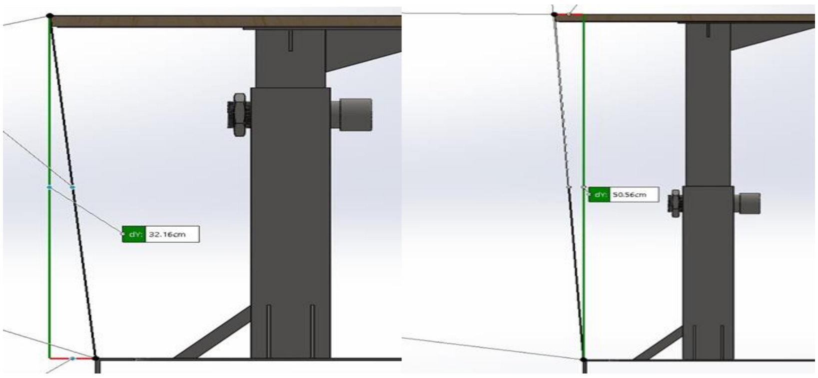

Fig. 7. The vertical height of the design at its shortest (left) and tallest (right) configurations, measured in SolidWorks.

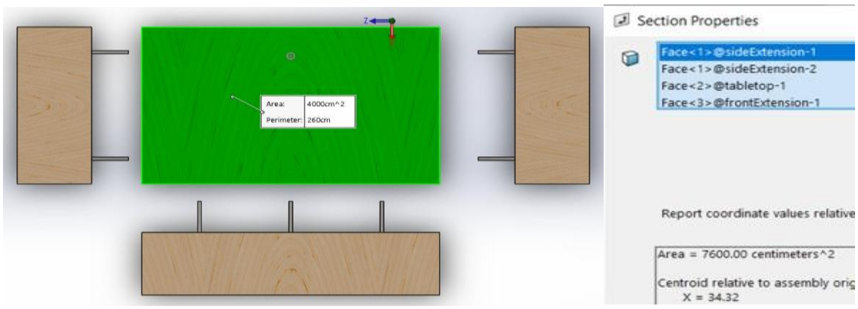

Fig. 8. SolidWorks surface area measurements excluding the tabletop extensions (left) and the total surface area of the design (right) measured using the Section Properties feature in SolidWorks.

Third, the stability of the design was verified through calculations based on applying a force near the front of the tabletop concerning the center of mass as the fulcrum and the distance between the points as the moment arm. The essential torque calculation used is shown in Equation (1).

$$T = F_{\perp} * r \tag{1}$$

Where

T: the torque (Nm),

$F_{\perp}$: the perpendicular force

and r is the moment arm.

The same calculation was applied to the bottom base and a torque of 348.57 Nm at the top and 109.30 Nm at the base was calculated, both of which values can be easily counteracted by the metal diagonal supports. An estimated applied force of about 500N was used in both calculations. The specific values can be seen in Figure 9 and the calculations are shown in the Appendix. The addition of a c-clamp was also a precautionary step to prevent the desk from tipping if excessive force was applied to the edge of the desk in case.

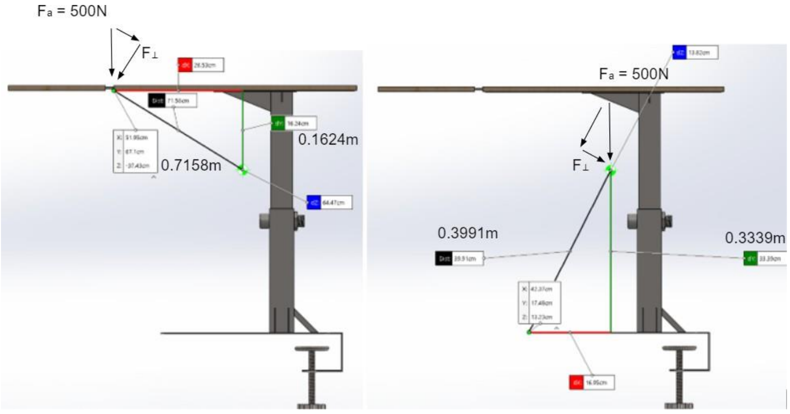

Fig. 9. Diagram of relevant forces and measurements used to calculate the torque.

Aesthetic appeal was ensured by creating a survey and collecting the results based on solely how the design looks and the satisfaction on a scale of 1-5. A sample size of 30 people was considered suitable, as it was a sufficient amount to represent the general public though not too much that would make it increasingly difficult due to the lack of a physical product. As can be seen from the pie chart in Figure 10 indicated that 87% of people were completely or mostly satisfied, thus the non-functional requirement was met.

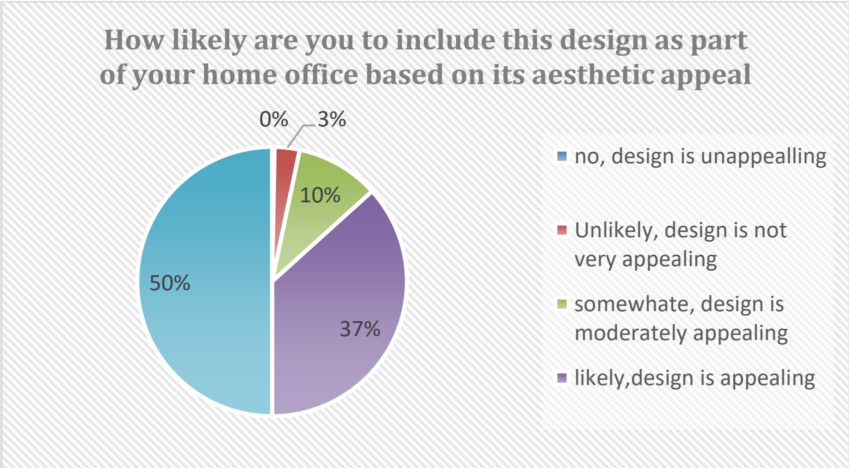

Fig. 10. A pie chart depicting the results of the data collected through a survey.

The cost constraint of not exceeding $250 required the estimation of labor costs and material costs were determined based on selections made earlier. The verification method for this was analysis based on the total material cost calculated from the volume of material needed through SolidWorks and the cost per volume or mass of the relevant materials. A calculated total material cost was $173.40, and these calculations are shown in the Appendix. The design meets these criteria since an attempt was made to select readily available materials which would be less expensive. The design was also minimalistic to reduce the material needed as well as to be simple to manufacture and assemble.

V. Conclusion

The problem of lack of ergonomic support was identified and the objectives were to assess the problem and identify a set of requirements needed for a successful solution, brainstorm ideas develop multiple designs that meet the criteria to assess the concepts, and select a final design to produce a viable final product which met all updated specifications. The problem was evaluated, and the engineering design specification was developed to reflect the functional requirements of increasing the height of the design to at least 45 cm increasing the workspace area to greater than 4000 cm2, and ensuring stability to support at least 50 pounds of weight. The non-functional requirement was ensuring the aesthetic appeal with a minimum of 80% satisfaction rate and the constraint requirement was ensuring that the design cost is less than $250 overall.

Three concepts were developed using a morphological chart and by utilizing a decision-making matrix, Concepts One and Two earned a score of 0 while Concept Three had a score of +4 based on the areas of height adjustability, maximizing area, ergonomics, safety, stability, and cost. The third concept was selected as the final design and a SolidWorks model was created and updated, together with the Engineering Design Specifications as the project progressed and improvements were made. The verification of the design was done according to these updated specifications.

Measurements of maximum height and the maximum surface area were taken and found to be 50.64 cm and 7600 cm2 respectively thus meeting the functional requirements. The stability of the design was verified through calculations of torque exerted on the sections where the stem and tabletop meet and was found to have a torque of 348.57 Nm at the top and 109.30 Nm at the base thus it was concluded that the supports were capable of holding up to 50 lbs. The aesthetic appeal of the design was assessed by a sample group and the survey results indicated an 87% satisfaction rate and reflected no fully negative reviews. The total material cost based on material selections was $173.40 which allowed room for other expenses thus the cost constraint was met. According to the Engineering Design Specification, the concept was selected and developed to attain a viable end product and all project objectives were completed successfully.

VI. Recommendations

The design met all necessary criteria however, certain aspects could be improved going forward to make the design more user-friendly. It was noted that the bolt and nut used to secure the stem may be more difficult to adjust than anticipated therefore, options such as a ball lock pin can be explored. The materials' selection can also be revisited in more detail before the manufacturing stage, based on advice regarding the machining and fabrication of certain metal parts. It is considered that if this design is to be produced, the manufacturer can be consulted to ensure that the current design meets their requirements and adjustments can be made accordingly.

Further iterations include the testing of ergonomic effectiveness through user trial and real-world stress testing to validate its long-term health benefits. Additional physical testing, including stress analysis and load bearing test, should be performed to strengthen the dependence of simulation findings.

Conflict of Interest:

There was no relevant conflict of interest regarding this paper.

References

I. Alloy, Iron. Marketfrom.com, 2020, https://www.makeitfrom.com/material-properties/ASTM-A210-Medium-Carbon-Steel.

II. Alloy, Iron. *Marketfrom.com*, 30 May 2020, https://www.makeitfrom.com/material-properties/AISI-304-S30400-Stainless-Steel.

III. Aluminum, Alloy of. Marketfrom.com, n.d., https://www.makeitfrom.com/material-properties/3003-AlMn1Cu-3.0517-A93003-Aluminum.

IV. Barcellos, Ekaterina Emmanuil Inglesis, and Galdenoro Botura. "Design Process: Metodologia De Interação Entre Design E Engenharia Como Vetor De Inovação." *Blucher Design Proceedings*, vol. 2, no. 9, 2016, pp. 1307-1317. 10.11606/gtp.v14i2.137709

V. Chrisman, et al. "Assessing Sitting and Standing in College Students Using Height-Adjustable Desks." Health Education Journal, vol. 9, no. 6, 2020, pp. 735-744. 10.1177/0017896920901837

VI. Fariz, Nuthqy, et al. "Analysis of Stress and Deformation in Parametric Furniture Using the Finite Element Method." E3S Web of Conferences, vol. 465, 2023. 10.1051/e3sconf/202346502032

VII. Engineered IT Inc. "Furniture and Related Product Manufacturing." Haz-Map, n.d., https://haz-map.com/Industries/2034.

VIII. Jafarvand, Mojtaba, et al. "Redesign and Fabrication of a Folding Ergonomic Laptop Desk for College Students." Journal of Health Sciences & Surveillance System, vol. 10, no. 4, 2022, pp. 471-479. 10.30476/jhsss.2021.92035.1294

IX. Loredan, Nastja Podrekar, et al. "Ergonomic Evaluation of School Furniture in Slovenia: From Primary School to University." Work, vol. 73, no. 1, 2022, pp. 229-245. DOI:10.3233/WOR-210487

X. Marketfrom.com. "Wood Based Material." Marketfrom.com, 30 May 2020, https://www.makeitfrom.com/material-properties/Bamboo-Plywood.

XI. "Material Properties: Price of Medium Carbon Steel." Material Properties, 2020, https://material-properties.org/what-is-price-of-medium-carbon-steel-definition.

XII. Providence. "Working from Home and Lower Back Pain: Ergonomics and Exercise to the Rescue." Providence Blog, 6 Nov. 2020, https://blog.providence.org/blog/working-from-home-and-lower-back-pain-ergonomics-and-exercise-to-the-rescue.

XIII. Robertson, Michelle M., and Michael J. O'Neill. "Reducing Musculoskeletal Discomfort: Effects of an Office Ergonomics Workplace and Training Intervention." International Journal of Occupational Safety and Ergonomics, vol. 9, no. 4, 2003, pp. 491-502. 10.1080/10803548.2003.11076585

XIV. Sai Tarun Reddy, and C. H. Patel. "Optimized Design, Analysis of Affordable Height-Adjustable Table." JETIR, vol. 8, no. 5, 2021, https://www.jetir.org/papers/JETIR2105109.pdf.

XV. Openshaw, Scott, Erin Taylor, and Allsteel. Ergonomics and Design: A Reference Guide. Allsteel Inc., 2006. https://ehs.oregonstate.edu/sites/ehs.oregonstate.edu/files/pdf/ergo/ergonomicsanddesignreferenceguidewhitepaper.pdf

XVI. Engineering Toolbox. "Wood Panel and Structure Timber Products." Engineering Toolbox, n.d., https://www.engineeringtoolbox.com/timber-mechanical-properties-d_1789.html.

XVII. Verbeek, J. "The Use of Adjustable Furniture: Evaluation of an Instruction Programme for Office Workers." Applied Ergonomics, vol. 22, no. 3, 1991, pp. 179-184. 10.1016/0003-6870(91)90157-d

XVIII. Viggiani, et al. "Multifunctional Home Office Desk Design for Small Residential Environments." Revista de Ciencia y Tecnología, 2024, pp. 35-44. 10.36995/j.recyt.2024.41.005

XIX. Vermont Wood Studios. "Wood Maple: Color, Grain & Other Characteristics." Vermont Wood Studios, n.d., https://vermontwoodsstudios.com/content/maple-wood.