



## DEVELOPMENT OF A TRANSFORMABLE FURNITURE SYSTEM: FROM SHELVING UNIT TO FUNCTIONAL TABLETOP

<sup>1</sup>Awopetu, O. O., <sup>2</sup>Owoyemi, J. M., <sup>3</sup>Babatunde, T. P. and <sup>4</sup>Ojo, O. T.

<sup>1,3,4</sup>Mechanical Engineering Department, The Federal University of Technology, Akure, Ondo State, Nigeria  
<sup>2</sup>Forestry and Wood Technology Department, The Federal University of Technology, Akure, Ondo State, Nigeria  
Corresponding Author: [tolulope.babatunde@eksu.edu.ng](mailto:tolulope.babatunde@eksu.edu.ng)

Awopetu, O. O., Owoyemi, J. M., Babatunde, T. P. and Ojo, O. T. (2024): Development of a Transformable Furniture System: from Shelving Unit to Functional Tabletop. *Journal of Engineering and Engineering Technology* /18(1), 98-109

Received Date: 17.2.24

Accepted Date: 4.5.24

### Abstract

The standard dimension of building in the major cities and university environment has been compromised in order to take advantage of the steady increase in the population rate leading to high demand for housing in the city and university environment. The increasing desire for accommodation and the high cost of land have led to the appearance of small apartments that do not meet all uses. The circumstances of the small dimensional apartments create an opportunity for the development of transformable space-saving furniture that uses less space and provides dual functions. Based on the concept that the design must serve at least two forms of appearances and functions brings about the design of transformable book shelves to the table with a view to maximizing utility spaces in the student hostels. In this research, total available space ( $T_{AS}$ ) and useable space area ( $U_{AS}$ ) together with their percentages were determined from FUTA, EKSU, AFUED, and FPA students' hostels. Data obtained were analyzed for the useable space and average percentage of the hostels' available space. After a critical study of the useable area across the four institutions, it was deduced that the minimum useable area of  $0.83 \times 10^6 \text{ mm}^2$  was suitable for the design of a transformable shelve-to-table that works with the hostels of the institutions. Also, the ergonomic and anthropometric measurements of 80 students' height across the four institutions were computed for the 5<sup>th</sup>, 15<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, and 95<sup>th</sup> percentile, for the design of the platform/layer involved. The maximum and minimum positioning of the step boards were adopted for 75 percentile and 15 percentile which is equivalent to 1240 mm and 248 mm because of the limited usable space attained from the four selected institution student's hostels. This design model was done using AutoCAD software and static simulation was carried out using the Solidworks 2021 Simulation CAD software for stress analysis to verify the amount of load that could be supported by developing a prototype without failure in both shelve and table. Fabrication of transformable furniture was done using higher density fiberboard (HDF) of its full size 3600mm x 1200mm x 225mm. A pair of gas spring mechanisms were used to maintain its alignment positioning, stability, safely lifting, and counterbalancing weights in both shelve and table. The effectiveness of the research was justified by maintaining the horizontal platform in both shelve and table appearance to sustain any objects placed on any of its platforms/layers during the transformation without displacement from their original position.

**Keywords:** transformable, ergonomic, anthropometric, design, fabrication, furniture

### Introduction

It has become a way of life and common routine for the people living in the city and area of tertiary institutions to live in small apartments that do not meet all uses because the standard dimension has been compromised in order to take advantage of the steadily increase in the population rate, leading to high demand for housing which eventually contributed to the appearance of small apartments (Uysal, 2013).

The nature of the apartment reduces the chances of the occupant putting in place all necessary furniture and other materials due to the lack of space (Xu *et al.*, 2018). This brings about building space-saving management which can be best achieved by furniture

transformation (Husein, 2021). Furthermore, the circumstances of the small dimensional apartments create an opportunity for the development of transformable space-saving design based on the concept that the design must serve at least two forms of appearances and functions, that is, the ordinary appearance and transformed appearance (Shiyao, 2013; Zhou and Chen, 2018). According to Pirc *et al.*, (2021), functionality is the most relevant factor in the buying decision process, surpassing both quality and design (Gomex *et al.*, 2018). Nevertheless, the functionality of the furniture is paramount before a choice can be made in space saving (Pandhi, 2017). Therefore, multi-purpose and custom-made furniture suitable for space saving and management could solve the major

problems associated with students in some of the most highly populated Colleges and Universities who live in small apartments, either within or outside the school because architects now base their design on maximizing the available spaces (Li, 2015; Husein, 2021). Moreover, an effort is gradually shifted to designing furniture that is transformable in nature which can serve dual or multiple uses without compromising the minimum allowable space for other purposes (Astonkar and Kherde, 2015; Estaji, 2017). Several works have been done on space management, these include; Shelf Mountable Tables (Ehrreich, 2017), Foldable Banquet Tables and Bench Set (Tsai, 2017), Pet Kennel Furniture (Rathman et al., 2019), Vertical Elevated Foldable Frame Table (Ng, 2014) but none of these had added a shelve transition nor addressed to be a solution to a specific institution. This therefore brings about the innovation of the development of transformable furniture shelve-to-table that will serve in more than one capacity at the same

time in the undergraduate and post-graduate school's hostels and apartments across the Colleges and Universities of selected schools. This study, therefore, is aimed at designing a small book shelve that could also be used for reading and dining purposes, with a view to maximizing utility space utilization in the student hostels.

**Materials and Method**

**Determination of the ergonomic and anthropometric data and usable space**

The ergonomic and anthropometric data of 80 concerned students between 16 to 40 years of age were obtained in their standing posture from the ground level for the purpose of design. The anthropometric measurement of 20 students' height per institution was taken to determine the average height of the shelve. Also, the percentile of the average height obtained for 5%, 15%, 25%, 50%, 75%, and 95% are shown in Table 1, to determine an appropriate positioning of the step boards.

**Table 1: Average of the Anthropometric measurement of student's height and their percentile**

THE INSTITUTIONS	STUDENT'S AVERAGE HEIGHT	5%	15%	25%	50%	75%	95%
FUTA	5.46	0.273	0.819	1.365	2.73	4.095	5.187
EKSU	5.52	0.276	0.828	1.38	2.76	4.14	5.244
AFUED	5.545	0.27725	0.83175	1.38625	2.7725	4.15875	5.26775
FPA	5.5	0.275	0.825	1.375	2.75	4.125	5.225
AVERAGE	5.50625	0.275313	0.825938	1.376563	2.753125	4.129688	5.230938

Likewise, the dimensions of rooms in eight students' hostels from four different schools: FUTA, EKSU, AFUED and FPA were taken to determine the available and useable space for furniture in the respective students' hostels. It was achieved by using Equations (1-4) (Tunay and Melemez, 2008; Uysal, 2024)

$$(T_{AS}) = (E_{AS}) - [(E_{AF}) + (O_{IA})] \tag{1}$$

$$(\%T_{AS}) = (T_{AS}) / (E_{AS}) \times 100\% \tag{2}$$

$$U_{AS} = T_{AS} - M_{ASW} \tag{3}$$

$$\%U_{AS} = U_{AS} / E_{AS} \times 100\% \tag{4}$$

Where:  $E_{AS}$  is the area of the entire room, is the area of the existing furniture,  $O_{is}$  is the area of other items,  $T_{AS}$  is the total available space  $U_{AS}$  is the useable space area and  $M_{ASW}$  is minimum walking space area. The  $T_{AS}$ ,  $U_{AS}$  and  $\% U_{AS}$  of the student's hostels in FUTA, EKSU, AFUED, and FPA, were determined by Equations (1-4) and shown in Tables 2( a-d), respectively.

**Table 2a: The Area of Useable Available Space and its Percentages in FUTA'S Hostel**

<b>NAME OF HOSTEL</b>	<b>T<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>M<sub>ASW</sub> (10<sup>6</sup>mm<sup>2</sup>)</b>	<b>U<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>E<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>%AUAS (10<sup>6</sup>mm<sup>2</sup>)</b>
<b>MKO B2</b>	6.647	5.760	0.887	17.280	5.133102
	6.590	5.760	0.830	17.280	4.803241
	6.677	5.760	0.917	17.280	5.306713
	6.667	5.760	0.907	17.280	5.248843
	6.678	5.760	0.918	17.280	5.312500
<b>MKO B3</b>	6.654	5.760	0.894	14.400	6.208333
	6.596	5.760	0.836	14.400	5.805556
	6.590	5.760	0.830	14.400	5.763889
	6.688	5.760	0.928	14.400	6.444444
	6.611	5.760	0.851	14.400	5.909722
<b>ADENIYI</b>	5.801	4.896	0.905	14.198	6.374137
	5.819	4.896	0.923	14.198	6.500916
	5.756	4.896	0.860	14.198	6.057191
	5.838	4.896	0.942	14.198	6.634737
	5.752	4.896	0.856	14.198	6.029018
<b>SCHOOL AREA</b>	4.470	3.600	0.870	9.000	9.666667
	4.481	3.600	0.881	9.000	9.788889
	4.491	3.600	0.891	9.000	9.900000
	4.488	3.600	0.888	9.000	9.866667
	4.472	3.600	0.872	9.000	9.688889

**Table 2b: The Area of Useable Available Space and its Percentages in EKSU's Hostel**

<b>NAME OF HOSTEL</b>	<b>T<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>M<sub>ASW</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>U<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>E<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>%A<sub>UAS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>
<b>KUKU</b>	5.322	4.32	1.002	10.80	9.27777778
	5.243	4.32	0.923	10.80	8.54629630
	5.372	4.32	1.052	10.80	9.74074074
	5.252	4.32	0.932	10.80	8.62962963
	5.350	4.32	1.030	10.80	9.53703704
	5.379	4.32	1.059	10.80	9.80555556
	5.388	4.32	1.068	10.80	9.88888889
	5.442	4.32	1.122	10.80	10.3888889
	5.349	4.32	1.029	10.80	9.52777778
	5.400	4.32	1.080	10.80	10.0000000
<b>SCHOOL AREA</b>	4.098	3.24	0.858	8.10	10.5925926
	4.127	3.24	0.887	8.10	10.9506173
	4.223	3.24	0.983	8.10	12.1358025
	4.119	3.24	0.879	7.29	12.0576132
	4.076	3.24	0.836	7.29	11.4677641
	4.546	3.60	0.946	9.00	10.5111111
	4.523	3.60	0.923	9.00	10.2555556
	4.166	3.24	0.926	7.29	12.7023320
	4.117	3.24	0.877	7.29	12.0301783
	4.103	3.24	0.863	7.29	11.8381344

**Table 2c: The Area of Useable Available Space and its Percentages in AFUED'S Hostel**

<b>NAME OF HOSTEL</b>	<b>T<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>M<sub>AWS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>U<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>E<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>%A<sub>UAS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>
<b>OLOYO</b>	5.643	4.68	0.963	11.70	8.23077
	5.558	4.68	0.878	11.70	7.50427
	5.586	4.68	0.906	11.70	7.74359
	5.550	4.68	0.870	11.70	7.43590
	5.661	4.68	0.981	11.70	8.38462
	5.579	4.68	0.899	11.70	7.68376
	5.549	4.68	0.869	11.70	7.42735
	5.582	4.68	0.902	11.70	7.70940
	5.551	4.68	0.871	11.70	7.44444
	5.528	4.68	0.848	11.70	7.24786
<b>SCHOOL AREA</b>	4.843	3.96	0.883	9.90	8.91919
	4.136	3.24	0.896	8.10	11.06173
	4.107	3.24	0.867	8.10	10.70370
	4.170	3.24	0.930	8.10	11.48148
	4.474	3.60	0.874	9.00	9.71111
	4.494	3.60	0.894	9.00	9.93333
	4.584	3.60	0.984	9.00	10.93333
	4.117	3.24	0.877	7.29	12.03018
	4.095	3.24	0.855	7.29	11.72840
	4.071	3.24	0.831	7.29	11.39918

**Table 2.d: The Area of Useable Available Space and its Percentages in FPA's Hostel**

<b>NAME OF HOSTEL</b>	<b>T<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>M<sub>AWs</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>U<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>E<sub>AS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>	<b>%A<sub>UAS</sub> (10<sup>6</sup> mm<sup>2</sup>)</b>
<b>ABUJA</b>	5.347	4.32	1.027	10.80	9.50926
	5.284	4.32	0.964	10.80	8.92593
	5.263	4.32	0.943	10.80	8.73148
	5.191	4.32	0.871	10.80	8.06482
	5.389	4.32	1.069	10.80	9.89815
	5.305	4.32	0.985	10.80	9.12037
	5.347	4.32	1.027	10.80	9.50926
	5.262	4.32	0.942	10.80	8.72222
	5.325	4.32	1.005	10.80	9.30556
	5.159	4.32	0.839	10.80	7.76852
<b>SCHOOL AREA</b>	5.031	3.60	1.431	9.00	15.90000
	5.009	3.60	1.409	9.00	15.65556
	4.432	3.24	1.192	8.10	14.71605
	4.196	3.24	0.956	8.10	11.80247
	4.076	3.24	0.836	7.29	11.46776
	4.193	3.24	0.953	7.29	13.07270
	4.861	3.96	0.901	9.90	9.10101
	4.868	3.96	0.908	9.90	9.17173
4.224	3.24	0.984	7.29	13.49794	
4.234	3.24	0.994	7.29	13.63512	

**Design and Fabrication of the Transformable Furniture**

The detailed design drawing of the transformable furniture was done with the use of the Solidworks 2021

Simulation CAD software application. Figures (1-2) show the isometric view of the transformable shelve-table (shelf and table mode).

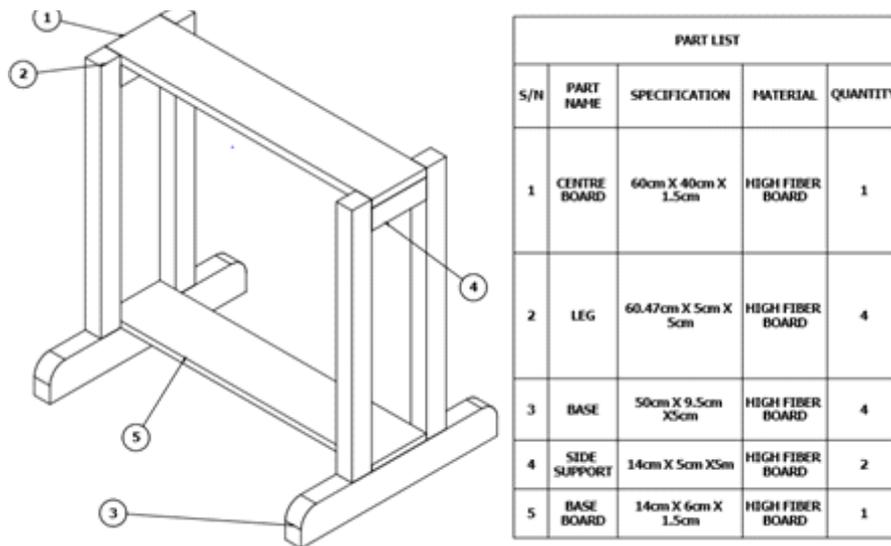


Figure 1: The isomeric view of the Leg details and arrangement

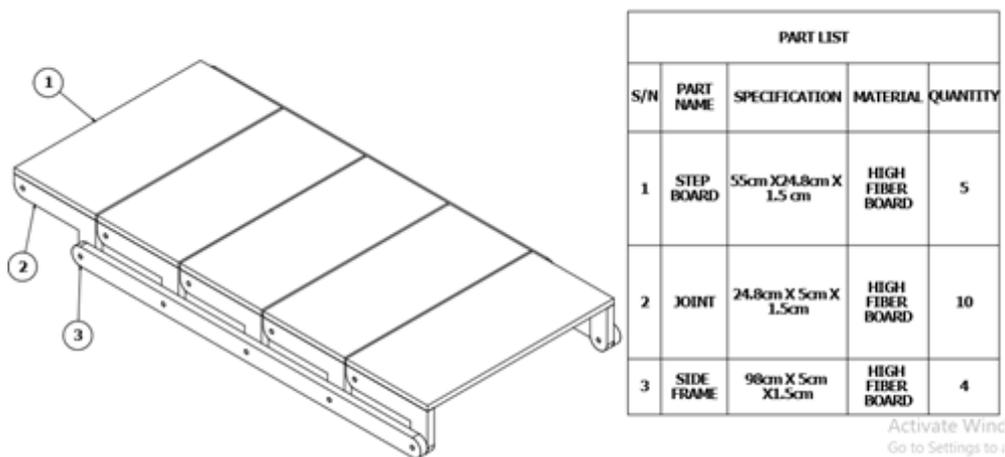


Figure 2: Isometric view of Step board details and arrangement

Higher Density Fibreboard (HDF), an engineered board produced from resin-bonded wood fibers under high pressure and heat was used in the fabrication of the designed model. Its full size of 3600mm x 1200mm x 225mm was marked out for the appropriate dimensions of the parts. It was cut into their respective shape and sizes with a barn saw machine. After which, it was fastened together by screws and washers with a screw fasten machine to form the respective transformable shelves. Also, the gas spring was used as a mechanism to maintain its

alignment positioning, stability, safely lifting, and counterbalancing weights in both shelves and table. The force exerted by the mechanism was determined by using Equation (5) (Tunay and Melemez, 2008)

$$F = WL/DN \tag{5}$$

Where: F is force in newton, W is the weight (load) in newton, L is the length of gas spring in meter, D is the diameter of gas spring in meter and N is the number of gas springs.

### Design Description

The design of the transformable shelf-to-table furniture was made on the following design description after which the available space and the anthropometric measurement of the student's height have been properly considered (Yoon and Yoon, 2019); Leg

details and arrangement shown in Figure 1 and Step board details and arrangement shown in Figure 2 were put together for the fabrication. The isometric view of developed transformable furniture: shelf-to-table is shown in Figures (3-4). Likewise, Figure 5 shows the exploded view of the shelf.

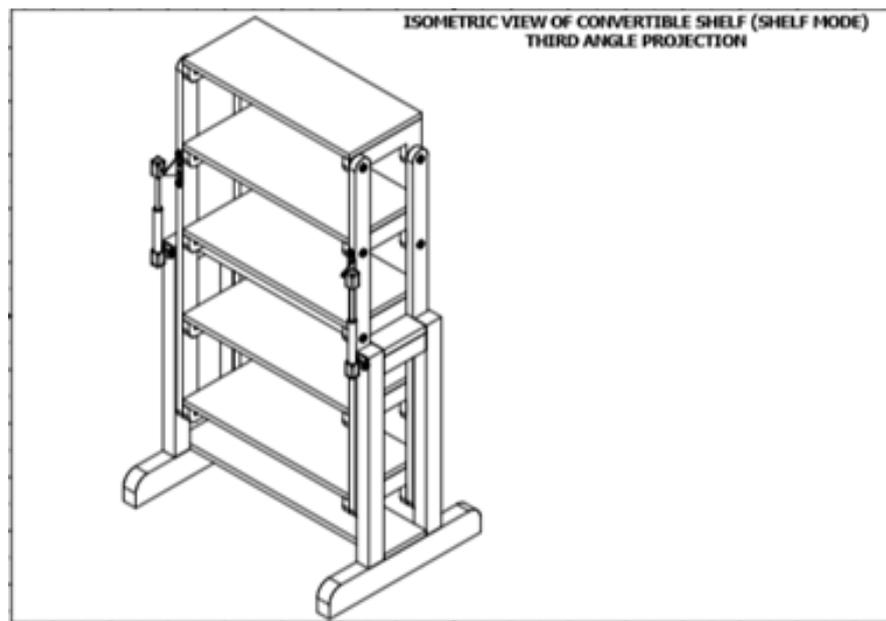


Figure: 3 isometric view of transformable furniture-shelve appearance

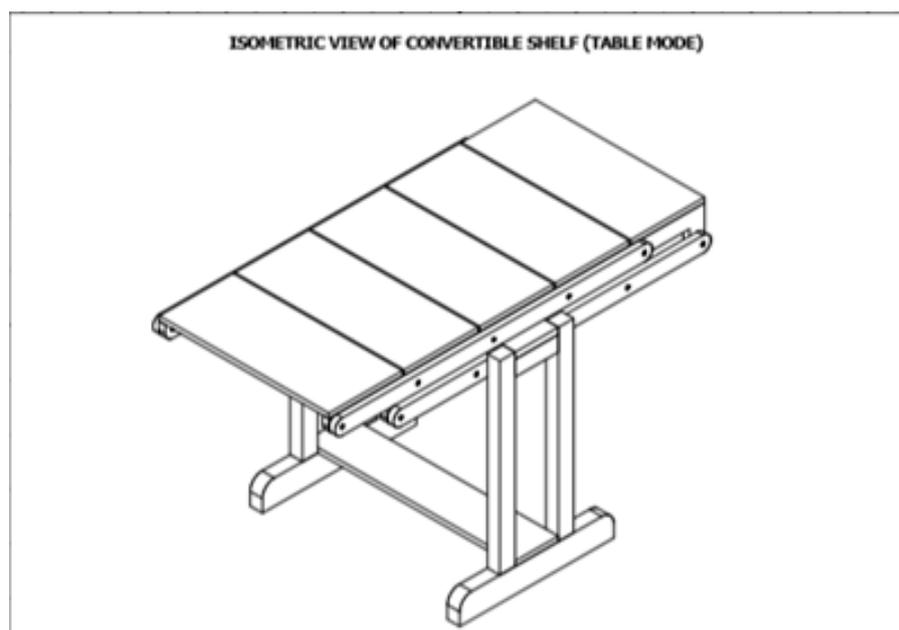
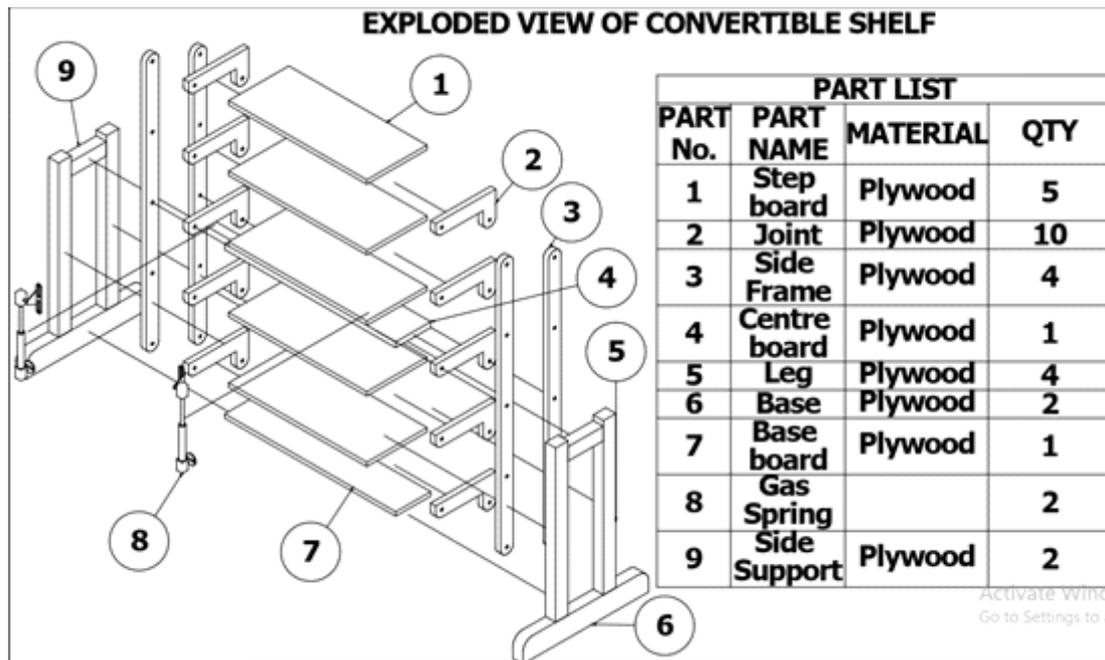


Figure: 4: isometric view of transformable furniture-table appearance



**Figure: 5: Exploded view of transformable furniture-shelf appearance**Description of the developed furniture

The developed transformable furniture; shelf-to-table has rectangular shaped frames made of high-density wood fiber which consists of different part frames joined by a screwing process and another component is a gas spring. This has two major arrangement parts, leg details arrangement and step board details arrangement. The shelf-to-table in its ordinary appearance shown in Plate 1 serves as a shelf and in its transformed appearance shown in Plate 2 as a table, that is when it is slid down through manual operation with the gas spring support for weight balance.



Plate 2: Table - transformed appearance of the developed furniture



Plate 1: Shelf - the ordinary appearance of the developed furniture

**Results and Discussion**

After a critical study of the useable area across the four institutions, it was deduced that the minimum useable area  $0.83 \times 10^6 \text{ mm}^2$  was suitable for the design of a transformable shelf-to-table that works with the hostels of the institutions. The minimum useable area of  $0.83 \times 10^6 \text{ mm}^2$  is the maximum area for the design. Furthermore, the maximum and minimum positioning of the step boards were adopted for 75 percentile and 15 percentile which is equivalent to 1240 mm and 248 mm because of the minimum usable space attained from the four institutions (FUTA, EKSU, AFUED, and FPA) student's hostels. The 75 percentile and 15 percentile ranges were achieved using Equation 6, while the interval between each of the step boards was found by Equation 7.

$$R = \text{Max. \%tile} - \text{Min. \%tile} \text{ (Uysal, 2024)} \quad (6)$$

Where R is the Range, Max. %tile is the Maximum percentile and Min. %tile is the Minimum percentile  
R is the Range, Max. %tile is the Maximum percentile and Min. %tile is the Minimum percentile

$$R = 1240 \text{ mm} - 248 \text{ mm} = 992 \text{ mm}$$

$$I_{SB} = R/4. \text{ (Uysal, 2024)} \quad (7)$$

Where  $I_{SB}$  is the Interval between each of the step boards  
 $I_{SB} = 992 \text{ mm}/4 = 238 \text{ mm}$

### Load Analysis of the Transformable Furniture Shelf to Table

The results generated from the simulation of stress and deformation induced on a transformable furniture shelve-to-table, when a static load of 120 N was applied on each step board of the furniture was analyzed. The analysis was done on the furniture when it was in its table form and shelf form respectively. Static simulation was carried out using the Solidworks 2021 Simulation CAD software.

### Design Consideration

The following were put into consideration in this analysis:

- i. Acceleration due to gravity is  $9.8 \text{ m/s}^2$
- ii. Each step board was large enough to

accommodate 3 textbooks each weighing 40 N, (The Weight of Engineering Mathematics Textbook by K. A. Stroud), thus making a total load of 120 N on each level.

- iii. The load on the furniture was statically applied and uniformly distributed across the top surface of each level of the step board.

### Discussion

The results of the analysis for stress are presented and discussed in this section.

### Stress Analysis

The stress distribution on the transformable shelve-to-table due to the load applied at the top is shown in Figure 6, while it is in table form. Here, the legs and the frame form the load-bearing structure of the transformable furniture. The stress distribution also showed that the front and rear of the table undergone the highest level of stress. However, the balance of the system in this state was maintained by the table at the center.

The maximum stress on the table due to the 120N load applied on each level was  $2.312 \text{ MN/m}^2$ . This value is less than the yield strength of the material used to fabricate the frame ( $5.65 \times 10^6 \text{ N/m}^2$ ). This means that the frame structure of the table can bear the stresses induced on it without buckling

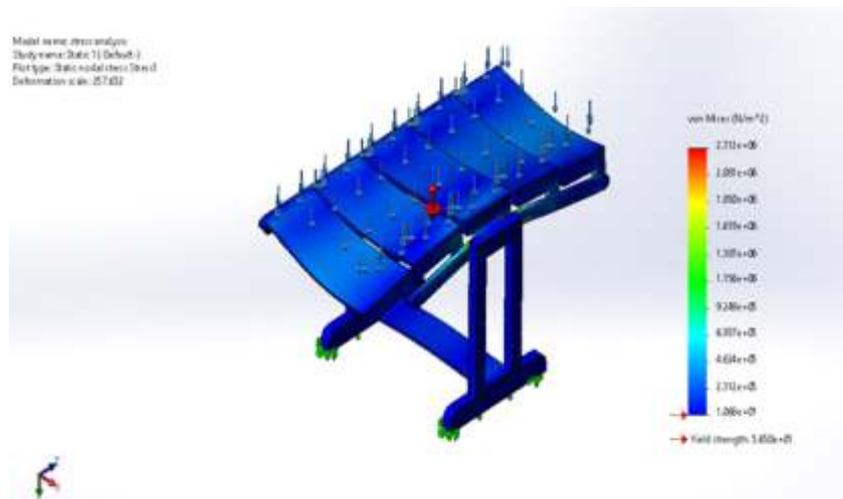


Figure 6: Stress analysis results on table form of the transformable furniture

### The Stress Analysis on the shelve

The stress distribution on the transformable shelve-to-table furniture due to the load applied at the top of each step board is shown in Figure 7, while it is in shelve form. In the analysis, the legs and the frame form the load-bearing structure of the shelve and the stress distribution showed that the center of each step board experienced the highest level of stress. However, the balance of the system at this state was maintained by the shelve at the center of gravity.

The maximum stress on the shelve due to the 120N load applied on each level was  $1.037 \text{ MN/m}^2$ . This value is less than the yield strength of the material used to fabricate the frame ( $5.6 \times 10^6 \text{ N/m}^2$ ). This means that the frame structure of the shelve can bear the stresses induced on it without buckling. To compare the performance of the developed transformable furniture in the two forms, it was confirmed that the shelf position offered more load-bearing advantage and performance when compared with its table form.

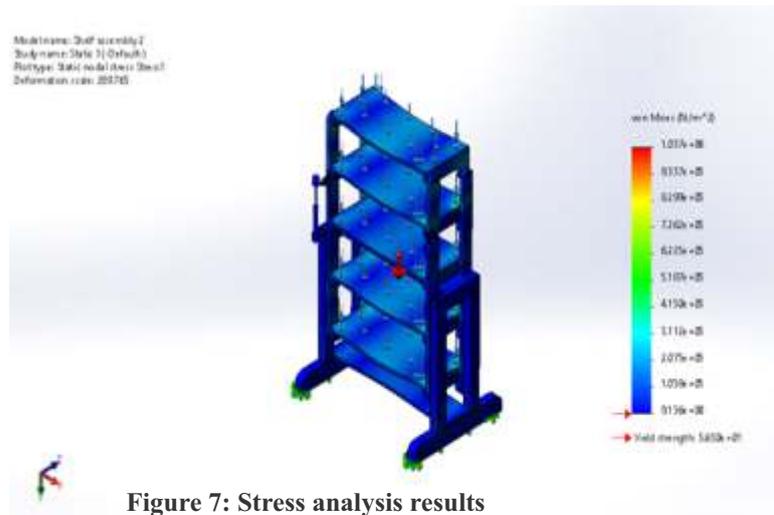


Figure 7: Stress analysis results

**The performance evaluation of the designed transformation shelf to table**

The performance evaluation was carried out on;

- i. the designed prototype of the developed shelf-to-table was verified for 100 N, and 120 N load per step platform to establish load that could be supported by the design prototype without failure in both shelf and table mode. This is shown in Plate 3 and Plate 4.
- ii. the designed prototype of the developed shelf-to-table, to verify and establish that the load maintained the same position on the step platform

during its transition from shelf-to-table and vice versa. This was observed for 30°, 45° and 60° to affirm that every object remains in its state of rest, throughout the period of transition. This is shown in Plate 5 and Plate 6.

- iii. the prototype established that its transition from shelf to table is perfectly achieved
- iv. its examined at MKO B2 and MKO B3 FUTA’S hostel and the aim of the project is achieved.



Plate 3: Verification of 120 N load



Plate 5: Design prototype at 45°



Plate 4: Verification of 120 N load



Plate 6: Design prototype at 60°

## Conclusion

In this work, transformable furniture: shelve-to-table has been developed. Solidworks 2021 simulation CAD software was used for detailed design analysis and simulation of shelve-to-table, and vice versa. Anthropometrics was used in the design of suitable transformable furniture shelve-to-table for the purpose of space management to optimize the use of available space in small apartments, especially the student hostels across the four tertiary institutions. The 15 percentile and 75 percentile of anthropometric measurement of students' height were used for the minimum and maximum height of the shelve and a maximum usable space area of  $0.829 \times 10^6 \text{ mm}^2$  was considered. This developed transformable shelve-to-table also established the following facts;

- i. the shelve was able to convert to a table and maintain a horizontal platform while transforming to a table and vice versa
- ii. the transformable furniture: shelve-to-table added more aesthetic to the room, as it is also a noble idea for furniture furniture-affiliated challenge in a limited space.
- iii. every platform could withstand the maximum load of 120 N without deformation
- iv. the transformable furniture: shelve-to-table was able to justify the available space in the hostels, based on a 4-foot minimum standard walking space and standard space that furniture could cover in an apartment.

## Reference

- Astonkar, D. V. and Kherde, S. M. (2021): Design and development of multipurpose, space-saving seating arrangements using ergonomics. *Int. J. Eng. Res. Appl.* 2015, 7–12. Available online: [https://www.ijera.com/special\\_issue/NCERT-Nov-2015/0712.pdf](https://www.ijera.com/special_issue/NCERT-Nov-2015/0712.pdf) (accessed on 4 July 2021).
- Ehrreich, J. A., Damm, C. M. and David, R. L. (2017): Foldable Table. U.S. Patent No US9770097B2, 26 September 2017.
- Estaji, H. (2017): A Review of Flexibility and Adaptability in Housing Design. *Journal of Contemporary Architecture*, 4:37-49.
- Gómez-Carmona, O., Casado-Mansilla, D. and López-de-Ipiña, D. (2018): Multifunctional Interactive Furniture for Smart Cities. *In the 12th International Conference on Ubiquitous Computing and Ambient Intelligence*, Punta Cana, Dominican Republic
- Husein, H. A. (2021): Multifunctional Furniture as a Smart Solution for Small Spaces for the Case of Zaniary Towers Apartments in Erbil City, Iraq. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 12(1): 1-11.
- Li, H., Hu, R., Alhashim, I. and Zhang, H. (2015): Foldabilizing furniture. *ACM Trans. Graph.* 34(90):1-12
- Ng, K. C. (2014): Vertically Elevated Foldable Frame. U.S. Patent No US8763537B2, 1 July 2014.
- Pandhi, N. (2017): Designing Furniture for Small Spaces, in Connection with Human Wellbeing. Department of Design, Norwegian University of Science and Technology, Norway. Technical report.
- Pirc, B. A., Manja, K.K., Tihana, V. and Petra, G. (2021): Monitoring Consumer Purchasing Behavior for Wood Furniture before and during the COVID-19 Pandemic, *Forests*. 12(7):873-890
- Rathman, B. and Rathman, B. (2018): Pet Kennel Furniture. U.S. Patent No USD821038S1, 19 June 2018.
- Shiyao, W. (2013): An Analysis of Transformable Space Saving Furniture. Faculty of Forestry, University of British, Columbia. Wood 493.
- Tsai, F. (2017): Foldable Banquet Table and Bench Set. U.S. Patent No US20170340100A1, 30 November 2017.
- Tunay, M. and Melemez, K. (2008): An analysis of biomechanical and anthropometric parameters on classroom furniture design. *Afr. J. Biotechnol.* 7, 1081–1086.
- Uysal M. (2014): The Health Risks of Small Apartments. The Atlantic. Furniture Design and Product Development Principles Considering End-of-life Options and Design for Environment Strategies. Master's Thesis, Purdue University, West Lafayette, IN, USA, Pp 1-95
- Xu, X.; Luo, F.; Wang, W.; Hong, T. and Fu, X. (2018): Performance-Based Evaluation of Courtyard Design in China's Cold-Winter Hot Summer Climate Regions. *Sustainability*. 10:3950-3969
- Yoon, I.S. and Yoon, J.C. (2019): Foldable Desk with Foldable Chair. U.S. Patent No US10201223B2, 12 February 2019.
- Zhou, J. and Chen, X. (2018): Convertible Furniture Design. *Computer and Graphics*. 70:165–175.