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Design and Construction of Multifunctional Upholstered Furniture from *Cocos nucifera* (Coconut) for a University Hall of Residence

Dizajn i izrada višenamjenskoga ojastrućenog namještaja od drva kokosove palme (*Cocos nucifera*) za sveučilišni studentski dom

ORIGINAL SCIENTIFIC PAPER

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ABSTRACT • Due to limitation of space in university residence halls, need for multifunctional furniture that promotes space utilisation, flexibility and convenience for user(s) has increased compared to single-function furniture that is costly and occupies more space. This study aimed to design and construct a multifunctional upholstered furniture unit from *Cocos nucifera* (coconut) for a university hall of residence. Specifically, it investigates the composition of a single unit that combines all functions of a bed, chair and drawer to achieve improved spatial efficiency, ergonomics and functional versatility. The study adopted Research and Development (R&D) research design involving information gathering, planning, prototyping development, testing and product refinement. Coconut timber, fabricated iron-framework, upholstery materials and transformation mechanisms were utilised in the construction of the prototype. Fourteen participants were involved in the preliminary evaluation which comprised assessment of space availability and usability survey. Descriptive statistics, reliability analysis, normality tests and Spearman rank correlation analysis were used to analyse data. Results revealed that the multifunctional furniture occupied significantly less space (182 cm × 26 cm × 29 cm) compared to single-function furniture arrangements (267 cm × 90 cm × 81 cm). The reliability analysis indicated acceptable internal consistency of ergonomic performance ($\alpha = 0.721$) and space-saving effectiveness ($\alpha = 0.785$). A significant positive correlation was found between space-saving performance and ergonomic performance ($r_s = 0.654, p < 0.05$). Cost analysis further indicated a higher cost of 52.3 % of single-function furniture as against the developed multifunctional furniture. Hence, this study presents a new approach to provide an affordable ergonomic, space-saving multifunctional upholstered furniture using *Cocos nucifera*.

KEYWORDS: *Cocos nucifera*; design and construction; multifunctional; upholstered furniture

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SAŽETAK • Zbog ograničenog prostora u studentskim domovima povećala se potreba za višenamjenskim namještajem koji pridonosi boljoj iskorištenosti prostora, fleksibilnosti i praktičnosti za korisnike u usporedbi s jednonamjenskim namještajem koji je skup i zauzima više mjesta. Cilj ovog istraživanja bio je dizajnirati i izraditi višenamjenski ojasučen namještaj od drva kokosove palme (*Cocos nucifera*) za sveučilišni studentski dom. Konkretno, istraživao je sastav jedne jedinice koja objedinjuje sve funkcije kreveta, stolice i ladičara kako bi se postigla veća prostorna iskoristivost, bolja ergonomska svojstva i funkcionalna svestranost namještaja. U radu je primijenjen istraživačko-razvojni (R&D) pristup koji je obuhvatio prikupljanje informacija, planiranje, izradu prototipa, ispitivanje i doradu proizvoda. U izradi prototipa upotrijebljeno je drvo kokosove palme, izrađeni su željezni okvir, materijali za ojasučenje i mehanizmi za transformaciju. U preliminarnoj evaluaciji, koja je obuhvatala procjenu raspoloživog prostora i anketu o upotrebljivosti namještaja, sudjelovalo je četrnaest ispitanika. Za analizu podataka primijenjeni su deskriptivna statistika, analiza pouzdanosti, testovi normalnosti i Spearmanova analiza korelacijskog ranga. Rezultati su pokazali da je višenamjenski namještaj zauzeo znatno manje prostora ($182\text{ cm} \times 26\text{ cm} \times 29\text{ cm}$) u usporedbi s jednonamjenskim namještajem ($267\text{ cm} \times 90\text{ cm} \times 81\text{ cm}$). Analiza pouzdanosti pokazala je prihvatljivu unutarnju konzistentnost ergonomskih svojstava ($\alpha = 0,721$) i učinkovitost uštede prostora ($\alpha = 0,785$). Utvrđena je značajna pozitivna korelacija između učinkovitosti uštede prostora i ergonomskih svojstava ($r_s = 0,654$, $p < 0,05$). Analiza troškova dodatno je potvrdila da je jednonamjenski namještaj 52,3 % skuplji od razvijenoga višenamjenskoga namještaja. Stoga je rad primjer novog pristupa osiguranju pristupačnoga, ergonomskoga i višenamjenskoga ojasučenog namještaja kojim se štedi prostor, uz upotrebu drva kokosove palme (*Cocos nucifera*).

KLJUČNE RIJEČI: *Cocos nucifera*; dizajn i konstrukcija; višenamjenski ojasučen namještaj

1 INTRODUCTION

1. UVOD

In spatial design, saving space is important to optimise energy usage and thermal and visual comfort especially for tiny homes that emphasise smaller spaces for more sustainable lifestyles. Flexible and efficient, foldable, modular, space-saving and/or multifunctional equipment or furniture may considerably reduce the environmental impact of low-spaced dwellings (Oyewole *et al.*, 2010; Bonvoisin *et al.*, 2016; Lim and Ng, 2021). One of the trends of modern-day furniture design is multifunctional furniture items (Lim and Ng, 2021). Over 90 % of people in the densest populated cities live in small buildings or flats due to lack of space (Knauf, 2015). Thus, when multifunctionality is accounted for in the design of a furniture piece paired with ergonomics and anthropometric considerations, it can become less bulky and thus portable as well as convenient to use in small spaces.

The rate at which Nigerian institutions invest in construction of hall of residence, in part to fulfil the third cardinal function of establishing a university, which is to provide community service, is on a high side. For any hall of residence to achieve an optimum efficiency, the type and design of furniture to be adopted is one of the key components that needs proper attention. A multifunctional upholstered furniture in the context of this study is a single unit with functionality of bed, chair and drawer in smart design comprise of safety, comfort, ease of use, productivity/ performance and aesthetics. Upholstery-making, however, is the craft of designing practical cushioned or padded sitting furniture for homes and offices. Upholstery furniture

making simply requires the expertise in designing upholstery patterns, skills in using the hand tools to shape wood in building carcasses that fit a platform for sitting and backing; webbing with specific felts of strength, cording the edges of the carcass for aesthetics purposes; padding with foam materials for comfort and covering with fabrics for beauty and style (Utuk *et al.*, 2019). Wood is the main raw material of the furniture industry, and it mainly consumes natural resources from forests (Lins *et al.*, 2020).

Single-function furniture becomes wasted, and the multifunction process device maintains its utilisation for an extended timeframe since it has additional features and serves an expanded range of requirements (Andrews, 2021; Lim and Ng, 2021). In Nigeria, there are basically three categories of forests based on the type of vegetation within the country such as coastal mangrove and freshwater forest, tropical rainforest in the south humid zone and drier forest of the middle and north region (Salami and Balogun, 2016; Akinbami *et al.*, 2023; Ayeni *et al.*, 2023). Also, furniture is made with mainly two kinds of wood: naturally sourced solid wood and engineered wood. Solid wood is then categorised into two types: hardwood and softwood. Hardwood comes from deciduous trees that also produce seeds and are generally slower growing and often of a higher density than softwoods. They are used for high-end furniture decorative woodwork, desk, flooring among others. Examples are ash, beech, birch, cherry, oak, maple, walnut, mahogany, rosewood, teak and coconut trees.

The coconut tree (*Cocos nucifera*) is one of the most widely grown and important palms. However, in the case of furniture construction, the tree has been less

appealing compared with other hardwoods making it a generally accepted burning wood. Humans have been cultivating a wide range of coconut trees around the world. The average air dry and oven dry density of coconut stem is 400 and 460 kg/m³, respectively. The modulus of elasticity in bending (MOE) and the modulus of rupture in bending (MOR) values for air dry and oven dry conditions are 2374 and 2633 N/mm² and 27.30 and 30.44 N/mm². The compression strength parallel to grain and perpendicular to grain for air dry and oven dry conditions are 12.41 and 12.85 N/mm² and 9.28 and 9.64 N/mm², respectively (Rana, Das and Ashaduzzaman, 2015; Lamidi *et al.*, 2021). This validates the possibility to use the stem of *Cocos nucifera* for different structural purposes. The under-utilisation of this wood can be described as a colossal waste. Meanwhile, government attention has been drawn to wealth from waste. Therefore, this prompted the researchers' curiosity to reconsider the tree in constructing multifunctional furniture. Hence, the study has been made on design and construction of multifunctional upholstered furniture from *Cocos nucifera* (Coconut) for a university hall of residence.

1.1 Concept of multifunctional furniture

1.1. Koncept višenamjenskog namještaja

Most challenges encountered in small spaces can be solved through some smart solution approaches, like investment in multifunctional furniture and modular furniture as well as space design which can also contribute to enhancing the efficiency of small spaces (Estaji, 2017). Multifunctional furniture is referred to by many names: space-saving furniture, transformable furnishing and multifunctional furniture; design of a single piece that serves multiple activities or purposes at the same time. Such furniture has been manufactured and used for years but until now the significance of these multifunctional pieces has not been fully acknowledged (Canepa, 2017).

Multifunctional furniture denotes pieces of furniture that adjust with different applications by transforming spatial relationships of their pieces. Sometimes modification needs skill; such kinds of furniture can be quite costly as it adapts to different applications at the same time. Multifunctional items like foldable, stackable and transformable furniture are great solutions for maximizing small spaces (Farjami, 2014). Various types of such versatile furnishing are available on the market, for example, multipurpose furniture that can work as a table, chair, bookshelf and a wardrobe at the same time.

A university hall of residence is a shelter and home for its students; hence, it must provide conditions in which students feel comfort, wellbeing and live healthily (Gomes *et al.*, 2015). In residence halls,

where space is scarce, it is an issue how to fit basic furniture into cramped dormitories. Due to this spatial restriction, multifunctional furniture needs to be employed because neighbouring their living quarters people must adapt single quadrants for several tasks. Moreover, modern lifestyle trends promote efficiency while minimizing superfluity in everyday life and contribute to the increased desirability for flexible living solutions. With housing area becoming smaller, furniture that can offer maximum utility in the least space is increasingly preferred. This is where multifunctional furniture comes into play, as it combines uses into a single piece of furniture which provides optimal space efficiency.

1.2 Aim of paper

1.2. Cilj rada

The aim of this study is to design and construct a piece of multifunctional upholstered furniture from *Cocos nucifera* (Coconut) for a university hall of residence. Specifically, the study sought to design a furniture unit that integrates the functions of a bed, chair and drawer within a single structure in order to improve space utilisation and functionality in compact student dormitories.

2 MATERIALS AND METHODS

2. MATERIJALI I METODE

2.1 Research design

2.1. Dizajn istraživanja

The study adopted Research and Development (R&D) design. Research and development design is defined as an industry-based development model in which the findings of research are used to design new products and procedures, which are systematically tested in the field, evaluated and refined until they meet specified criteria of effectiveness, quality or similar standards (Cheng *et al.*, 2021; Gall *et al.*, 2007). Figure 1 depicts the flow of the entire design process entailed within the methodology, analysis, results and discussion.

Research and development model consists of ten primary stages:

- i. Research and information collection – literature review and needs analysis
- ii. Planning – product development planning
- iii. Developing the preliminary form of product – prototype creation
- iv. Preliminary field testing – small scale field testing
- v. Main product revision – revision based on preliminary testing
- vi. Main field testing – major field testing

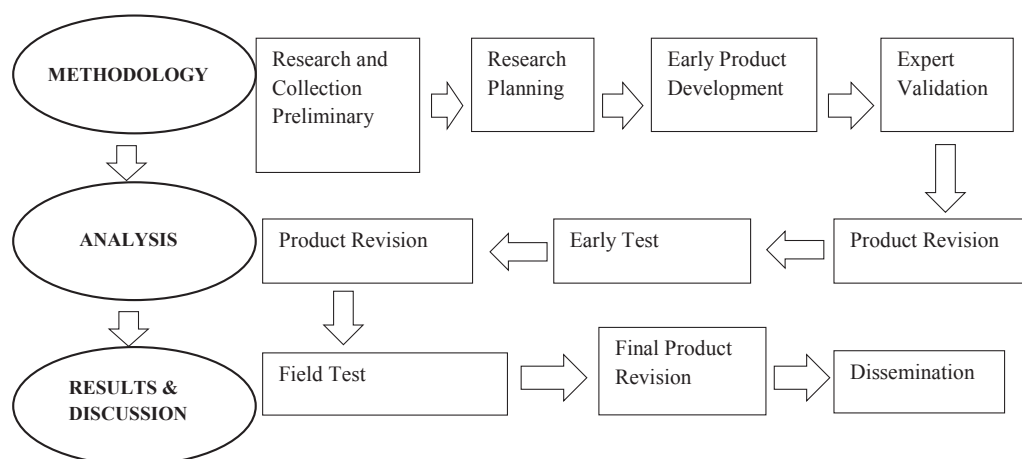


Figure 1 Research and development design process

Slika 1. Proces dizajna proizvoda i istraživanja

- vii. Operational product revision – subsequent refinement
- viii. Operational field testing – operational-scale testing
- ix. Final product revision – final refinement
- x. Dissemination and implementation – product dissemination and implementation

This model emphasises formative evaluation and repeated revision, making it particularly suitable for producing valid and reliable educational products. It has been extensively applied in the development of learning materials, media, curricula and instructional models.

2.2 Research and information collection

2.2. Istraživanje i prikupljanje informacija

Research and information collecting on multifunctional articles are essential in understanding the important features and functions that make such products effective and adaptable for modern use. Multifunctional articles are intended to provide two or more functions within a single unit as a means for increasing space utilisation, convenience, flexibility and cost effectiveness. The compactness, transformability traits, durability, ergonomic suitability and aesthetic appeal are key features underlying their insets into houses, institutions and commercial settings. A review of related literature, patent design and self-creative perspectives was conducted to collect materials that could be informative and representative on the selected themes allowing for a deeper comprehension.

Figures 2 – 9 show a few illustrative samples of some furniture that have been designed to enhance space and functionality. Figure 2 shows a multifunctional table with an integrated structure on which the user can perform various activities and user-controllable input functions (Furniture Design Magazine, 2022). Figure 3 shows an adaptive multifunctional furniture

chair that provides flexibility in support usage (IKEA Catalogue, 2023). Figure 4 depicts a multifunctional wardrobe with built-in storage and additional utility functions, while Figure 5 represents a multifunctional centre table aiming to merge the surface functionality with storage capacity (Furniture Design Magazine, 2022). A foldable bed-chair which tries to provide freedom of use and makes best use of limited space is shown in Figure 6 (Estaji, 2017). An example of an intervention in this area is shown in Figure 7, where a convertible storage furniture combining both seating and compartmentalised storage functions is provided for practical access to commonly used items and clothes, aiding item retrieval programming upon awakening smoothly with less physical effort involved (Gomes *et al.*, 2015). Figure 8 shows an example of a compact convertible furniture developed for relaxation and mobility as well as multipurpose use inside small areas (Mazlan *et al.*, 2021), whereas Figure 9 is an example of multifunctional study desk with shelves and storage that could serve both academics and residential purposes (IKEA Catalogue, 2023). Thus, these designs illustrate how multifunctional furniture can make it easier to utilise space in a residence hall effectively and to the user benefit.

2.3 Planning

2.3. Planiranje

Three tentative furniture concepts identified as Self-proposed Ideas A, B and C (Figure 10 – 12) were initially developed to explore different approaches for integrating the functions of a bed, chair and drawer within a single multifunctional furniture unit. Each concept possessed unique structural and functional characteristics aimed at improving space utilisation, transformability, ease of fabrication and user convenience. To determine the most suitable design for development, a subjected scoring process was conducted using selected evaluation criteria which included ease



Figure 2 Multifunctional table (Furniture Design Magazine, 2022)

Slika 2. Višenamjenski stol (Furniture Design Magazine, 2022.)



Figure 3 Multifunctional chair (IKEA Catalogue, 2023)

Slika 3. Višenamjenska sofa (IKEA Catalogue, 2023.)



Figure 4 Multifunctional wardrobe (Furniture Design Magazine, 2022)

Slika 4. Višenamjenski ormar (Furniture Design Magazine, 2022.)



Figure 5 Multifunctional centre table (IKEA Catalogue, 2023)

Slika 5. Višenamjenski središnji stol (IKEA Catalogue, 2023.)



Figure 6 Multifunctional bed (Estaji, 2017)

Slika 6. Višenamjenski krevet (Estaji, 2017.)



Figure 7 Multifunctional storage system (Gomes *et al.*, 2015)

Slika 7. Višenamjenski namještaj za odlaganje (Gomes *et al.*, 2015.)



Figure 8 Multifunctional chair (Mazlan *et al.*, 2021)

Slika 8. Višenamjenska stolica (Mazlan *et al.*, 2021.)



Figure 9 Multifunctional study desk (IKEA Catalogue, 2023)

Slika 9. Višenamjenski radni stol (IKEA Catalogue, 2023.)

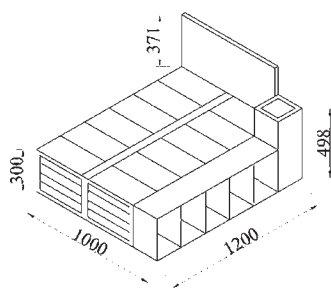


Figure 10 Self-proposed idea A

Slika 10. Vlastito dizajnersko rješenje A

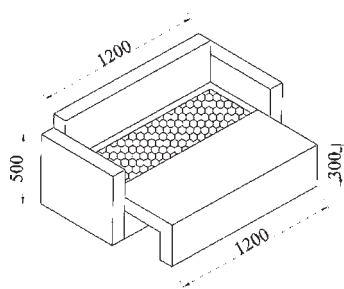


Figure 11 Self-proposed idea B

Slika 11. Vlastito dizajnersko rješenje B

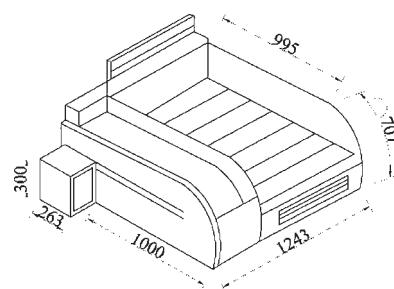


Figure 12 Self-proposed idea C

Slika 12. Vlastito dizajnersko rješenje C

of transformation, multifunctionality, ease of fabrication and space-saving effectiveness (Cheng *et al.*, 2021). Each criterion was assigned equal weighting, and the proposed concepts were rated using a five-point scale. The weighted scores obtained from the evaluation revealed that Self-proposed Idea B achieved the highest overall score and was therefore selected as the final design concept for further development and construction (Table 1).

2.4 Working drawing for self-proposed Idea B

2.4. Tehnički crtež vlastite dizajnerske ideje B

Based on the scoring, Self-proposed Idea B was chosen as the best design concept, thus allowing for

the development of a working drawing. It contains necessary visual and dimensional information for the construction and assembly of the multifunctional furniture. To facilitate a comprehensive understanding of the design, the drawing was sectioned according to each functional configuration, namely the chair position (Figure 13), drawer position (Figure 14) and bed position (Figure 15). For each function, plan, side and pictorial views were presented to clearly depict the dimensions, form and operational features of the furniture. In addition, an exploded view (Figure 16) was included to illustrate the individual components, assembly sequence and interconnections within the structure.

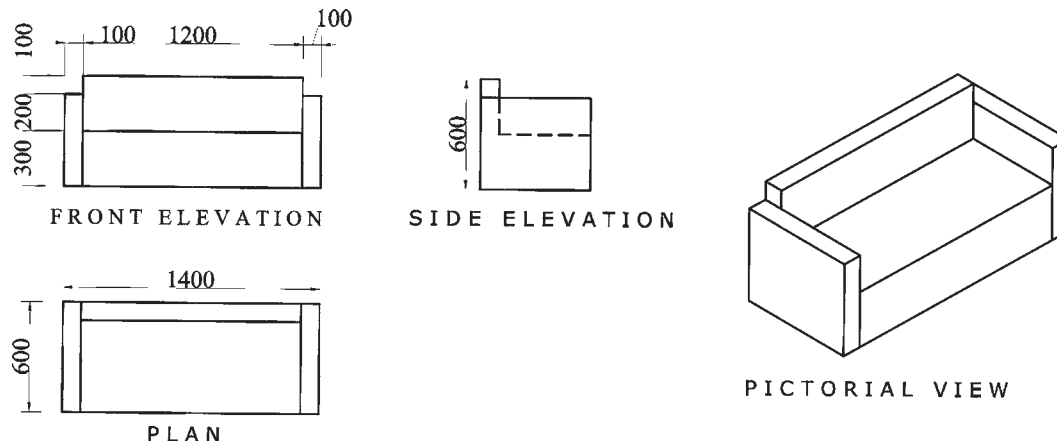


Figure 13 Multifunctional furniture in chair position

Slika 13. Višenamjenski namještaj u funkciji naslonjača

Table 1 Self-proposed idea A, B and C table of scoring

Tablica 1. Tablica vrednovanja vlastitih dizajnerskih rješenja A, B i C

Selection criteria Kriteriji vrednovanja	Weight, % Ponder, %	Self-proposed ideas / Vlastita dizajnerska rješenja					
		A		B		C	
		R	WS	R	WS	R	WS
Ease of transformation / jednostavnost transformacije	25	4	0.8	5	1.0	4	0.9
Multifunctionality / multifunkcionalnost	25	5	1.2	5	1.2	4	0.8
Ease of fabrication / jednostavnost proizvodnje	25	3	0.6	4	1.2	3	0.6
Space-saving / ušteda prostora	25	3	0.6	5	0.8	4	1.2
Total score / ukupan broj bodova		3.2		4.2		3.5	
Rank / poredak		3		1		2	

Note: R – Rating; WS – Weighted score; Rating scale: 5-excellent, 4-good, 3-neutral, 2-poor, 1-worst

Napomena: R – ocjena; WS – ponderirana ocjena; ljestvica ocjenjivanja: 5 – izvrsno, 4 – dobro, 3 – neutralno, 2 – loše, 1 – najgore

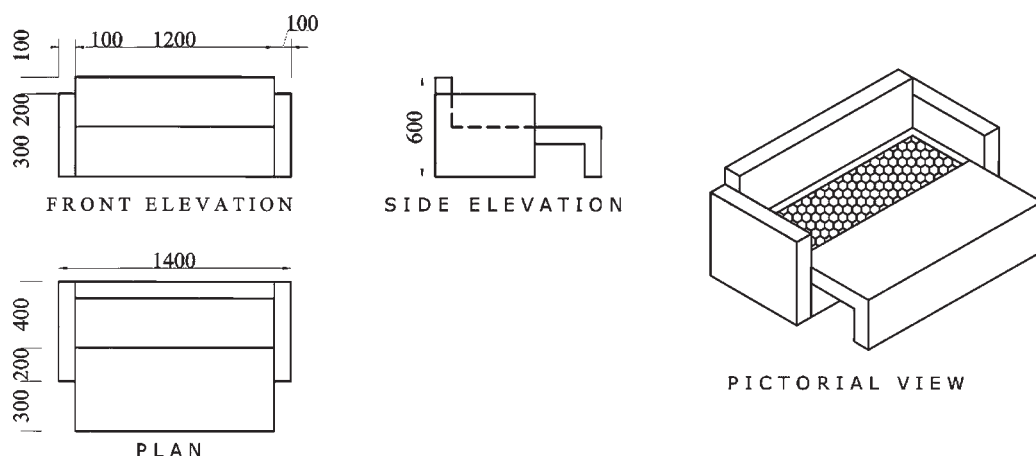


Figure 14 Multifunctional furniture in drawer position

Slika 14. Višenamjenski namještaj u funkciji ladice

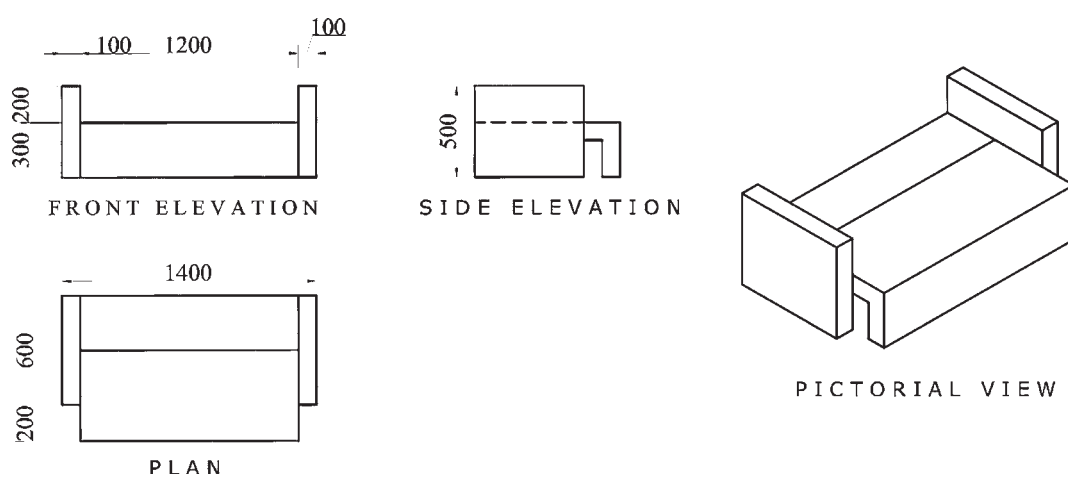


Figure 15 Multifunctional furniture in bed position

Slika 15. Višenamjenski namještaj u funkciji kreveta

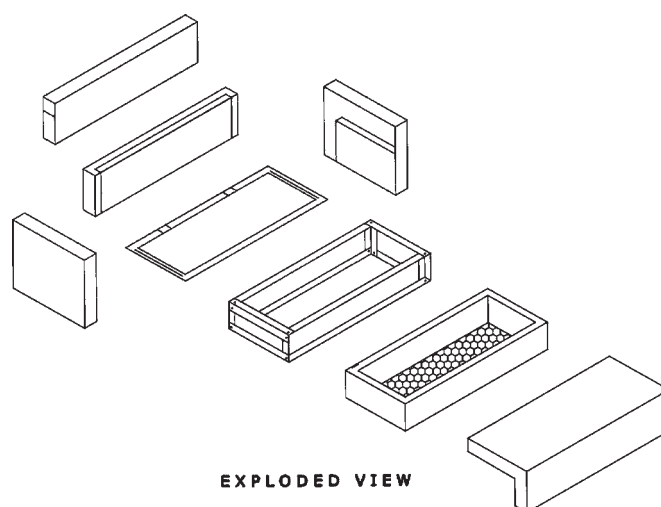


Figure 16 Exploded view of the developed multifunctional furniture

Slika 16. Prikaz rastavljenoga razvijenog višenamjenskog namještaja

2.5 Preparation of coconut timber

2.5. Priprema drva kokosove palme

The primary wood material used in this furniture is coconut timber derived from *Cocos nucifera*. Coconut trees were collected from Fashola town located in the Oyo West Local Government Area of Oyo State, Nigeria, along the Oyo – Iseyin Road. It is situated in the South-West geopolitical zone of the country, with coordinates approximately at 6.8333° N and 3.2833° E. The sampled trees were 50 – 60 years old, fairly



Figure 17 Coconut trunks
Slika 17. Debla kokosove palme



Figure 18 Conversion of coconut timber
Slika 18. Prerada drva kokosove palme



Figure 20 Bolts and nuts
Slika 20. Vijci i matice

straight and free from defects (Figure 17). These coconut trunks were converted into pieces with dimensions of 100 mm (width) × 25 mm (thickness) × 1000 mm (length) at a nearby sawmill (Figure 18). After conversion, the boards were air-seasoned to reduce the moisture content of wood (Figure 19).

2.6 Metal fasteners and hardware

2.6. Metalni spojni elementi

Timber contains various metal fasteners for putting the pieces of furniture together and fixing it on wooden panels with the iron frames. These range from bolts, nuts, screws and washers to metal brackets (Figure 20 and 21). Hardware pieces make sure that the furniture structure is proper and stable while in practical use.

2.7 Transformation mechanisms

2.7. Okov

This has to do with specific characteristics that the furniture needs to have in order to fulfil its design purpose. The furniture will include hierarchical or convertible items, which can serve multiple purposes without taking up too much ground area. The fixture was combined with a foldable mechanism (butterfly hinges) for



Figure 19 Seasoning of coconut timber
Slika 19. Sušenje drva kokosove palme

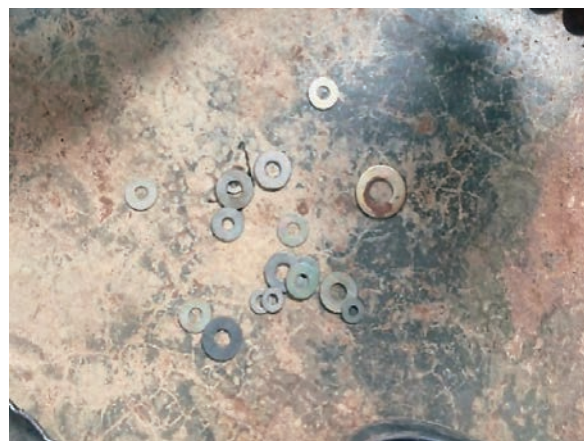


Figure 21 Washers
Slika 21. Podložne pločice



Figure 22 3D butterfly hinges
Slika 22. 3D leptir-spojnice



Figure 23 Drawer runner
Slika 23. Vodilica ladice

converting a chair to bed and a sliding mechanism (drawer runner) for providing storage compartments for personal belongings (Figure 22 and 23). All of the features are well defined in a way that ensures that the end design is practical and convenient for students.

2.8 Upholstery materials

2.8. Materijali za ojašćenje

Some areas of the design encompass utilizing upholstery materials to induce comfort and aesthetics into the furniture. High-density foam was used as cushioning material for seating surfaces and backrests (Figure 24). Upholstery fabric covered the foam for a soft and comfortable feel (Figure 25). Furniture design technique was enhanced within the developed multifunctional furniture by merging upholstery materials, where ergonomic comfort, structural support, durability and aesthetic level of quality score were improved. The upholstery system was composed of padded foam and covering fabric applied to the seat, backrest and touch surfaces of the furniture. Material selection was based on factors such as user comfort, load bearing capacity, deformation resistance, durability and extended usability in a university hall of residence.



Figure 24 High-density polyurethane foam
Slika 24. Poliuretanska spužva velike gustoće



Figure 25 Polyester upholstery fabric
Slika 25. Poliesterska tkanina za ojašćenje

The high-density polyurethane foam was chosen as the padding material for its capacity to provide sufficient body support and distribute pressure properly while sitting and reclining. The foam in this study had a density of 35 kg/m³ and a stiffness value of 4.5 kPa, which were regarded as ideal for medium-duty furniture applications that require both comfort and dimensional stability (Figure 24). The chosen values of foam properties were satisfactory for limiting over-compression while maximizing resilience and more generally for prolonging the service life of upholstered elements under repeated use conditions.

The foam was enveloped with polyester upholstery fabric with the grammage of 320 g/m² (Figure 25). It was chosen for its texture, tensile strength, abrasion resistance, ease of maintenance/cleaning properties among others. The upholstery fabric not only provided a soft and comfortable surface but also enhanced the visual appearance and overall finishing quality of the furniture developed. The combination of high-density foam and durable upholstery fabric was therefore considered suitable for multifunctional furniture intended for intensive use in university hostel environments.



Figure 26 Fabricated iron
Slika 26. Obradeni željezni element



Figure 27 Fabricated iron
Slika 27. Spojeni željezni elementi

2.9 Fabricated iron for structural framework

2.9. Obradeni željezni elementi za nosivu konstrukciju

The main support structure of the furniture is made from fabricated iron. Angle irons are cut, welded and shaped together into a stiff supporting frame for the wooden panels and upholstery components (Figure 26 and 27). So, the iron frame gives additional strength for stability and load-bearing capacity, especially used in furniture like beds that support the sleeping function and sofas that support seating as well as compartment functionality.

3 PROJECT IMPLEMENTATION

3. PROVEDBA PROJEKTA

The project implementation phase involved the systematic transformation of the developed concept into a functional multifunctional upholstered furniture unit designed for use in a university hall of residence. This phase was about iteration and developing the design intentions to a point where it can be practically built, selecting materials for different parts of the furniture, as well as assembling these materials step by step. Emphasis was placed on integrating the chair, drawer and bed functions within a single compact framework while ensuring structural stability, ergonomic suitability and efficient space utilisation. Folding, sliding and conversion mechanisms were continuously refined throughout the implementation process to optimise operational smoothness, increase durability and provide better user safety. In addition, careful attention was given to joint placement, upholstery integration and dimensional accuracy to ensure that the final product achieved both functional adaptability and aesthetic coherence.

3.1 Concept development

3.1. Razrada koncepta

This demonstrated the fundamental functional features of the furniture, such as folding, sliding or

converting between different uses. This stage allows designers to examine the practicality, structural stability and aesthetic qualities of the design before subjecting it to user evaluation (Figure 28 – 32). The concept development phase involved the systematic translation of the preliminary furniture idea into a functional multifunctional prototype capable of integrating chair, drawer and bed functions within a single compact structure. This stage was essential for assessing the operational feasibility, structural behaviour, transformation efficiency, ergonomic suitability and aesthetic characteristics of the proposed furniture prior to final fabrication. An iterative design approach was adopted throughout the development process, allowing progressive modifications and refinements to improve functional performance, user convenience and spatial efficiency. Particular attention was given to dimensional coordination, load distribution, mechanical transformation, structural stability and material compatibility during the various stages of development.

To give a better insight into how the idea of furniture can change and evolve into an actual working model, stages of development can be seen in Figures 28-32. These stages show how the structural framework, transformation mechanisms, upholstery support system and final functional assembly of the developed furniture have been successively refined. Illustrated in Figure 28, Development Stage A shows the initial design structure for the furniture idea. At this point the main supporting members and dimensional arrangement was set out to give the furniture overall shape, balance and load-bearing arrangement. Anthropometric considerations relating to sitting and reclining dimensions were incorporated to ensure user comfort and functionality. Development Stage B, Figure 29, shows how the mechanical transformation system was integrated into the structural framework. At this stage, mobile and adjustable parts required to transform the furniture between chair, drawer and bed positions were



Figure 28 Development stage A
Slika 28. Faza razvoja A



Figure 29 Development stage B
Slika 29. Faza razvoja B



Figure 30 Development stage C
Slika 30. Faza razvoja C



Figure 31 Development stage D
Slika 31. Faza razvoja D

implemented. Folding and sliding mechanisms were also added to allow for smooth transformation while reducing load on the structure during operation. Also, the placement of joints, hinges and connecting parts was adjusted to give it more flexibility, durability and make use easier but safer. The furniture structure at the later development stage C including upholstery support systems, reinforcement members and storage components is shown in Figure 30. Further structural changes were made not only to improve rigidity but also to ease the use and functionality. Reinforcement components were placed in critical load-bearing areas to reduce deformation and enhance structural performance at service loading situations. Ergonomic considerations such as seating posture, body support, and accessibility of storage compartments were also evaluated and integrated into the design.

Development Stage D, presented in Figure 31, represents the advanced assembly before finalizing the end form of the furniture. At this point, the structural frame, mechanisms, upholstery and storage systems were combined into a single multifunctional unit. Functional evaluation was carried out to determine transformation efficiency, operational convenience,

structural stability and aesthetic quality. The furniture was redesigned, including minor changes related to dimensional alignment and finishing details for better performance. The final outcome of the concept development process is presented in Figure 32; it shows the completed multifunctional upholstered furniture in bed position. The developed prototype demonstrates the successful integration of seating, storage and sleeping functions within a single furniture unit designed spe-



Figure 32 Developed multifunctional furniture in bed position
Slika 32. Razvijeni višenamjenski namještaj u funkciji kreveta

cifically for compact living environments such as university residence halls. The concept development process therefore validates the practicality of multifunctional furniture systems in improving space management, functional adaptability and user convenience within restricted residential spaces.

3.2 Test plan: Space availability

3.2. Plan ispitivanja: iskoristivost prostora

This is performed to compare the area occupied by three single-function furniture pieces (bed, chair and drawer) and the developed multifunctional furniture. The furniture items with single function are grouped in one space area, then researchers move on to measure the occupied area. Researchers then put the proposed invention at a different space and measure how much of the space it occupies. The data are then recorded for comparative analysis.

3.3 Test plan: Usability survey and feedback

3.3. Plan ispitivanja: anketa o upotrebljivosti i povratne informacije

The participants for this study included fourteen (14) users who were briefed on how to fill out a questionnaire consisting of variables such as ergonomic performance and space-saving effectiveness. The questionnaire items were based on constructs adapted from Davis (1989) and the items about space saving effectiveness were drawn from Husein (2020). For this study, a seven-point Likert scale was adopted as it is more precise, reliable and simple to use than other scales, and provides better reflection on the interviewee's true evaluation.

4 ANALYSIS PLAN

4. PLAN ANALIZE

The data generated were analysed by comparing the corresponding area occupied in case of single functional furniture with the area occupied in case of developed multifunctional furniture. IBM SPSS Statistics version 21 was used to analyse ergonomic performance and space saving effectiveness data, including descriptive, reliability, normality and Spearman's correlation analyses.

5 RESULTS AND DISCUSSION

5. REZULTATI I RASPRAVA

5.1 Results for space availability

5.1. Rezultati iskoristivosti prostora

The results for space availability are shown in Table 2, where the measures of a single-function furniture dimensions and the dimensions of developed multifunctional furniture (cm) are expressed as length $\times$ width $\times$ height ($L \times W \times H$). Storage space required for the single function furniture arrangement was (237 cm $\times$ 26 cm $\times$ 42 cm), which was larger compared to the storage space required for multifunctional furniture (182 cm $\times$ 26 cm $\times$ 29 cm).

5.2 Results for usability survey and feedback – Descriptive analysis

5.2. Rezultati ankete o upotrebljivosti i povratne informacije – deskriptivna analiza

Results presented in Table 3 revealed that most respondents were 21 to 25 years old (64.3 %), then between 18-20 years old (28.6 %) and lastly, only a small percentage came from ages of 26-30 years old (7.1 %). Results also showed that there was a higher percentage (64.3 %) of male respondents as compared to female gender (35.7 %). The participants (30.5 %) agreed that the proposed invention does a good job ergonomically but 59.7 % of them strongly agreed that the invention is ergonomic. Most of the respondents (81.4 %) indicated strongly agree and only 18.6 % indicated agree in response to functionality as space-saver furniture.

5.3 Reliability and normality analysis

5.3. Analiza pouzdanosti i normalnosti

The reliability of the instrument was evaluated using the Cronbach's alpha coefficient. Data from Table 4 indicted that the internal consistency of the survey instrument was acceptable ($\alpha > 0.6$) for all the variables.

According to Table 5, the distribution of the questionnaire data does not statistically significant differ from a normal distribution ($p > 0.05$), as evidenced by the Shapiro-Wilk and Kolmogorov-Smirnov tests of normality. The data were analysed with the Spearman's rank correlation test (non-parametric analysis). This

Table 2 Result on space availability
Tablica 2. Rezultati iskoristivosti prostora

	Item / Element	Length, width and height, cm Dužina, širina i visina, cm ($L \times W \times H$)
Single-function furniture, cm Jednofunkcijski namještaj, cm	Bed / krevet	190 $\times$ 90 $\times$ 50
	Chair / stolica	42 $\times$ 45 $\times$ 81
	Drawer / ladičar	35 $\times$ 40 $\times$ 55
	All items / svi elementi	267 $\times$ 90 $\times$ 81
Developed multifunctional furniture, cm Razvijeni višenamjenski namještaj, cm		182 $\times$ 26 $\times$ 29

Table 3 Participant demographics by age and gender (No. of Participants = 14)**Tablica 3.** Demografska obilježja ispitanika prema dobi i spolu (broj ispitanika: 14)

S/N Red. br.	Items Stavka	Level (with scale) Razina (skala)	No. of scores Frekvencija odgovora	Mean Srednja vrijednost	Standard deviation Standardna devijacija
1	Age dob	1: 18 – 20 years old	4 (28.6 %)	4.52	0.312
		2: 21 – 25 years old	9 (64.3 %)		
		3: 26 – 30 years old	1 (7.1 %)		
2	Gender spol	1: Male	9 (64.3 %)	2.70	0.467
		2: Female	5 (35.7 %)		
3	Ergonomic performance (11 items) <i>ergonomska svojstva</i> (11 stavki)	1: Strongly disagree	0	4.32	0.264
		2: Disagree	10 (6.5 %)		
		3: Somewhat disagree	5 (3.3 %)		
		4: Neutral	0		
		5: Somewhat agree	0		
		6: Agree	47 (30.5 %)		
		7: Strongly agree	92 (59.7 %)		
4	Space-saving effectiveness (5 items) <i>učinkovitost uštede prostora</i> (5 stavki)	1: Strongly disagree	0	3.81	0.401
		2: Disagree	0		
		3: Somewhat disagree	0		
		4: Neutral	0		
		5: Somewhat agree	0		
		6: Agree	13 (18.6 %)		
		7: Strongly agree	57 (81.4 %)		

Table 4 Cronbach's alpha values for survey instrument**Tablica 4.** Vrijednosti Cronbachova alfa-koeficijenta za anketni upitnik

S/N Red. br.	Variable / Varijabla	Cronbach's alpha (α) Cronbachov alfa-koeficijent (α)	No. of items Broj stavki
1	Ergonomic performance (EP) / <i>ergonomska svojstva</i>	0.721	11
2	Space-saving effectiveness (S) / <i>učinkovitost uštede prostora</i>	0.785	5

test measures the strength and direction of association between two ranked variables. The full distribution of Spearman's rho is derived for small samples and would be suitable for the survey data analysis of this study.

Based on Table 6, it was found that space-saving effectiveness strongly, positively and significantly correlated with ergonomic performance ($r_s = 0.645$, $p < 0.05$).

5.4 Cost analysis

5.4. Analiza troškova

Table 7 shows the material costs needed to produce a unit of the developed multifunctional furniture, while

Table 8 indicates the cost price of each piece of furniture. The sales cost per unit was estimated at Nigeria Naira (₦) and it revealed that the total cost for the three single furniture units was about 52.3 % higher than the material cost for the developed multifunctional furniture.

5.5 Discussion

5.5. Rasprava

The developed multifunctional furniture requires considerably less space ($182 \times 26 \times 29$ cm) than classical single function furniture with dimensions of $267 \times 90 \times 81$ cm, which proves its usability in the confined

Table 5 Kolmogorov-Smirnov and Shapiro-Wilk tests of normality**Tablica 5.** Kolmogorov-Smirnovljev i Shapiro-Wilkov test normalnosti distribucije

Variables / Varijabla	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df*	P	Statistic	df*	p
Ergonomic performance (EP) / <i>ergonomska svojstva</i>	0.311	13	0.200	0.737	13	0.289
Space-saving effectiveness (S) / <i>učinkovitost uštede prostora</i>	0.243	13	0.200	0.845	13	0.461

* df – Degree of freedom / stupnjevi slobode

Table 6 Correlation between space-saving effectiveness and ergonomic performance**Tablica 6.** Korelacija između učinkovitosti uštede prostora i ergonomske svojstava

Variable relationship / Odnos među varijablama	r_s^*	p
Space-saving effectiveness and ergonomic performance <i>učinkovitost uštede prostora i ergonomska svojstva</i>	0.654	0.011
N	14	

* r_s – Correlation coefficient for Spearman's test / Spearmanov koeficijent korelacije

Table 7 Sales cost of the material per unit of multifunctional furniture**Tablica 7.** Trošak materijala po jedinici proizvoda za višenamjenski namještaj

S/N Red. br.	Material / Materijal	Unit Jedinica	Price Cijena, ₦
1	Coconut wood <i>drvo kokosove palme</i>	1	82,250
2	½" Plywood <i>furnirska ploča, 12 mm</i>	2	46,300
3	Iron angle / <i>željezni okvir</i>	1	67,300
4	Hinges / <i>spojnice</i>	1	2,500
5	Washer / <i>podložne pločice</i>	5	1,200
6	Screws / <i>vijci</i>	5	2,700
7	Bolts and nuts / <i>vijci i matice</i>	6	4,150
8	Drawer runner <i>vodilice ladice</i>	1	7,000
9	Foam / <i>poliuretanska pjena</i>	1	62,100
10	Fabric / <i>tkanina</i>	1	31,200
11	Labour / <i>rad</i>		12,500
	Total / <i>ukupno</i>		319,450

Table 8 Sales cost of a single furniture**Tablica 8.** Prodajna cijena jednog komada namještaja

S/N Red. br.	Description / Opis	Unit Jedinica	Price Cijena, ₦
1	Bed / <i>krevet</i>	1	375,200
2	Chair / <i>stolica</i>	1	87,150
3	Drawer / <i>ladičar</i>	1	24,300
	Total / <i>ukupno</i>		486,650

space of a university hall of residence. By embedding transformation functions such as bed, chair and drawer into one body significantly improved its spatial efficiency and functional performance. Moreover, these pieces of furniture showed desirable traits including built-in storage space, aesthetic appeal and adaptability to answer the challenges that enable optimal use of the living space. Thus, doubtlessly these results underpin the claim of Cheng *et al.*, (2021) and Husein (2021) who suggested that multifunctional furniture is a practical solution for environments that are limited in space and financially oriented because users can increase utilisation without extra furniture. Likewise, Canepa (2017) and Rajan *et al.*, (2019) indicated that multifunctional furniture design is especially beneficial for users having limited budgets. The results of this study are also in line with previous research on multifunctional furniture design (Mazlan *et al.*, 2021; Pricillia and Mutiara, 2021), which identified storage integration, transformability and spatial compatibility as major performance indicators for compact living space.

The results indicated that enhancements of furniture space optimisations were associated with greater comfort, utility and more positive ergonomic assessments. The outcomes indicated that multifunctional

furniture designed to facilitate efficient spatial utilisation could improve convenience for users and functional operation in small living spaces at the same time. This observation supports the position of Estaji (2017) and Vlaovic *et al.*, (2022) who argue that sustainable and flexible interior spaces require furniture designs that provide multiple functionalities with spatial requirements adaptable to the changing demands. This finding is also in agreement with that of Mazlan *et al.* (2021) and Vlaovic *et al.*, (2022) who concluded that flexibility, adaptability and efficient spatial configuration were the most significant influencing factors of usability and ergonomic satisfaction in multifunctional furniture systems.

6 CONCLUSIONS

6. ZAKLJUČAK

The findings of this study demonstrated the successful development of multifunctional upholstered furniture integrating bed, chair and drawer functions from *Cocos nucifera* timber for use in space-constrained environments. The novelty of the study lies in the effective combination of multifunctionality, ergonomic suitability and space optimisation within a single furniture unit produced from coconut timber. The developed furniture exhibited satisfactory ergonomic compatibility and enhanced user comfort, confirming its suitability for a contemporary university hall of residence.

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