AUTHOR:

Obed Persie Appiah-Kubi [a,1,*]
Evans Kwadwo Donkor [b,2]

[a]Department of Interior Design and Materials Technology, Faculty of Built and Natural Environment, Kumasi Technical University, Kumasi, 00233, Ghana.
[b]Sculpture Technology Department, Takoradi Technical University, Takoradi, 00233, Ghana.
[1]obed.appiah-kubi@kstu.edu.gh[*],
[2]evans.donkor@ttu.edu.gh.
*Corresponding author

ISSN 2584-0282
International Journal of Arts, Architecture & Design,
Vol. 4(1), January 2026

doi.org/10.62030/2026Janpaper7

Published: 30th Jan 2026

Received: 30th Sept 2025

Accepted: 24th Nov 2025

Designing for Vertical Needs: Creating a Ladder Chair for Ergonomic and Space-Saving Solutions

ABSTRACT

As creative and academic studio spaces grow increasingly constrained, the demand for multi-functional furniture solutions becomes more critical. This study focused on the design, fabrication, and evaluation of a multifunctional ladder chair that addresses vertical access and space-saving needs in Ghanaian educational and workshop environments. Employing a studio-based, practice-led methodology, the study combined the use of sustainable materials, anthropometric data, and hybrid production techniques to produce a user-centred product. The ladder chair was fabricated with mild steel and maple hardwood, merging metalworking and traditional woodworking processes to ensure structural integrity and ergonomic comfort. The assessment after the fabrication evaluated visual appeal, transformation ease, and load stability. Instructors, students and artisans' observational feedback was thematically analyzed, shedding light on material quality, functional intuitiveness, user safety, space optimization, and educational relevance. Users lauded the ease of the transformation mechanism, compact form, and strong material contrast, signifying the product's success in achieving functional and spatial objectives. The research reveals that efficient multifunctional furniture contributes to improved space utilization and learner engagement in TVET environments. Beyond its practical design purpose, the ladder chair stands as a meaningful instructional model for project-based learning. Implications emphasize the importance of adaptive furniture in supporting sustainable development, skills training, and institutional design innovation. The research recommends future exploration into modular designs, lightweight materials and broader user testing to improve inclusivity and scalability.

Keywords - Ergonomic design, Hybrid materials, Multifunctional furniture, Space efficiency, Sustainable design.

1. Introduction

As global urbanisation continues to reshape work and living spaces, the availability and affordability of interior landscapes are now critical concerns in planning and design (Prakash et al., 2022). As compact living becomes increasingly prevalent, it has brought about smaller flats, collaborative offices, and versatile learning areas, demanding a fresh interpretation of the –space dynamic. Amid this spatial evolution, the need for multifunctional, adaptable, and vertically efficient furniture has increased. Modern consumers and designers seek solutions that deliver multifunctionality within compact spaces, merging form, usability and comfort (Taifa & Desai, 2017).

Published by:
World University of Design

Among potential design responses, the ladder chair, a fusion of chair and stepladder functions, offers a particularly effective solution. This multifunctional piece offers regular seating and addresses vertical accessibility, which makes it mostly pertinent in settings where space limitations make it impossible to incorporate several independent furniture pieces. It can be used in a variety of settings, including offices, homes, studios, libraries and workshops. The ladder chair is more than just a gimmick; it belongs to a wider design paradigm focused on furniture that responds to changing spatial roles, vertical relationships, and bodily motion.

The concept of multifunctional furniture is not a new one. Secretaries, step-chairs and library ladders were examples of convertible furniture pieces used in aristocratic interiors during the 18th and 19th centuries that were designed to combine luxury and functionality (Thariq et al., 2010). Unlike these early examples, which stressed ornamentation and class distinction, modern interpretations prioritize comfort, functional efficiency and sustainability (Dittakavi Tarun et al., 2017). In today's context, furniture must transcend multifunctionality to embody safety, efficiency, and ergonomic accuracy based on human anthropometry, the systematic analysis of body measurements and posture.

As a result, ergonomics is now an important element of contemporary furniture design. A poorly designed furniture can lead to postural discomfort, exhaustion, and even chronic health issues like joint strain and lower back pain (Pain et al., 1996). Ignoring anthropometric diversity, including differences in limb proportions, stature or balance capacity, in the design of a ladder chair can heighten potential hazards. To ensure suitability for various user groups, critical design aspects such as riser height, tread width, seat depth, and support angles need customization. An ergonomically designed ladder chair promotes both safety and ease of access, efficiently utilising space in schools where frequent access to high storage areas is required (Ofield, 2025).

The fabrication of such adaptive furniture is further reinforced by sustainable design principles. Issues related to material sourcing, lifecycle assessment, and product disposal are drawing greater attention to the global design industry. Consequently, the use of locally available, biodegradable, and renewable materials such as bamboo, engineered boards, and reclaimed wood is gaining increasing popularity (Yang & Zhang, 2023). These materials support the principles of the circular economy while reducing their environmental footprint. Integrating such materials carries significant socioeconomic implications in Ghana and other developing countries, fostering local value chains, and promoting indigenous. Practically, the study adds to sustainable design practice by providing a locally adaptable solution that enhances safety, spatial efficiency, and material utilisation in both institutional and domestic environments. This relevance to real-world furniture production and TVET application reinforces its value for policy, training, and industry adoption.

The design and construction of ladder chairs can be utilised as a project-based learning activity in TVET, giving students a chance to practise design thinking, woodworking techniques, and ergonomic analysis in a practical setting (Pongo et al., 2014; Usman & Tyabo, 2013; Famiwole et al., 2012). This approach aligns with global trends in TVET pedagogy that emphasize problem-solving, experiential learning, and industry relevance. In addition, it connects conceptual understanding with real-world outcomes, allowing students to design solutions that balance utility and aesthetics. Theoretically, the study extends discourse in ergonomic furniture design by linking anthropometric principles to multifunctional design theory, offering insights into how vertical access and human-centered design can be synthesised within small-space environments. Methodologically, the research integrates user needs assessment, anthropometric measurement, and design prototyping to generate empirically grounded design data; an approach that strengthens its academic robustness and reproducibility.

Despite these advantages, the ladder chair remains underexplored in academic literature. The ladder chair is frequently disregarded as a specialised design intervention in space-efficient furniture studies because they typically focus on foldable items, modular systems, or wall-mounted units (Sathishranganathan et al., 2019; Bai et al., 2024). Therefore, by investigating the design, development, and assessment of a ladder chair that is ergonomically responsive, sustainably made, and suitable for institutional settings, this study fills a crucial gap.

The study, which is based on anthropometric analysis, user needs assessment, and design prototyping, suggests a model that is useful in real-world applications and advances academic discussions in the domains of furniture innovation, interior architecture, and product design. The availability of interior space has become a crucial concern in Ghana, as global urbanisation transforms living and working environments. This reflects a broader philosophical shift in interior environments (Pongo et al., 2014). In order to solve vertical accessibility and space limitations in educational and workshop settings, there has been a sharp increase in demand for multipurpose, flexible furniture, like the ladder chair. The objective of this research is to create and assess a sustainable, ergonomic ladder chair that promotes TVET pedagogy and increases spatial efficiency. It is expected that the outcomes will strengthen TVET pedagogy, influence design innovation, and encourage continued exploration of versatile furniture solutions.

2. Literature Review

2.1 Historical Context and Evolution of Ladder Chairs

Throughout history, furniture has mirrored the evolution of society, culture, and technology. The ladder chair, an evolution of the traditional ladder-back chair characterised by horizontal slats resembling a ladder, emerged as a product of necessity and creativity. The ladder-back chair, which emerged in medieval Europe and became widespread in 17th-century England, exemplified durability, simplicity, and ease of manufacture (Niedderer & Reilly, 2010). Its design became a fixture in colonial American households, aligning with the modest aesthetic values of Protestant homes during the Reformation. Over time, decorative enhancements were introduced, marking a gradual shift toward the integration of function and aesthetics.Referred to as the Franklin chair after Benjamin Franklin, who is commonly credited with its creation, the step chair signified a notable evolution. This design transformed perceptions of multifunctional furniture by incorporating a folding mechanism that enabled the chair to convert into a compact set of steps (Ulrich et al., 2020). Its multifunctional nature offered a practical solution to the challenge of vertical access in confined spaces, and its adaptability continues to inspire contemporary reinterpretations of ladder chair designs.The ladder chair has garnered growing attention within modern design circles due to its ergonomic benefits, space-conscious design, and enduring historical importance. Zemp et al. (2015) state that furniture that adjusts to space limitations without compromising comfort or style is becoming more and more popular among academics and businesses. As a result, modular, convertible furniture systems, of which the ladder chair is a striking example, have attracted renewed attention.

2.2 Multi-Functionality and Adaptive Design in Furniture

Multifunctionality has become a key component of both residential and commercial furniture design as urban living areas get smaller and user needs change. Furniture designed to perform several functions within limited spaces is known as multifunctional furniture. This is often accomplished through innovative structural adjustments or concealed mechanisms (Pheasant & Haslegrave, 2006). Examples include ladder chairs, expandable tables, and foldable beds. These innovations respond to the increasing

demand for flexibility, portability, and space optimisation in offices, homes, libraries, and learning environments (O'Sullivan et al., 2012).

The ladder chair stands out as a remarkable example of adaptive design. It eliminates the necessity for multiple furniture items by allowing a seamless shift between sitting and climbing functions, thereby optimising space and minimising clutter (Göktaş et al., 2024; Al-Hinai et al., 2018). This approach aligns with the principles of functional minimalism, which advocates for clean, adaptable, and user-focused interior environments (Zemp et al., 2015).

Multifunctionality is likewise linked to enhanced user satisfaction and psychological well-being. Furniture that can be adjusted has a positive impact on users' perceptions of control over their surroundings, which enhances well-being and productivity (Musa, 2011). This adaptability also enhances workflow efficiency in institutional environments such as TVET workshops by minimizing the time spent on furniture reorganisation and optimizing space for multiple simultaneous activities.

2.3 Material Selection and the Role of Hybrid Composition

Any furniture piece's structural integrity, visual appeal, and environmental impact are all greatly influenced by the materials chosen and combined. Because of its availability, tactile comfort, and inherent warmth, wood has historically been the most common material used to construct ladder chairs. Strong and long-lasting woods like maple, oak, or teak are preferred, especially in situations where the chair must accommodate both sitting and climbing activities (Takyi Mensah, 2023). Using "maverick" woods that embrace natural imperfections, craftspeople like Matthew Burt have popularised a sustainability-conscious approach that emphasises both beauty and resourcefulness (Yang & Zhang, 2023).

Metal, particularly aluminium or stainless steel, is being used more and more in modern designs to improve both structural stability and aesthetic appeal. Particularly in tubular frames or thin-walled sections, metal provides excellent tensile strength, corrosion resistance, and design versatility (Boateng, 2012). The contrasting textures and aesthetic components create a remarkable blend of industrial and natural design when paired with wood.

Strong, lightweight, and aesthetically pleasing pieces can be made thanks to the hybrid composition of metal and wood. To guarantee strong joints and harmonious visual alignment, this method necessitates exact fabrication techniques. The fusion of these materials necessitates sophisticated joinery and welding skills, as well as close attention to material compatibility, surface finishes, and fastener selection to prevent structural weaknesses or mismatches in thermal expansion (Adu-Gyamfi et al., 2016).

The advantages of hybrid furniture designs for the environment are also highlighted by recent studies. The carbon footprint of production is greatly decreased by using recyclable metals and reclaimed wood (Viennet & Pont, 2017). Furthermore, these designs promote local value chains, particularly in developing nations where craftsmanship traditions and material availability can be efficiently leveraged for sustainable development.

2.4 Ergonomics and User Safety in Multi-Functional Furniture

The success of the ladder chair primarily rests on its capacity to support a variety of human users for a range of tasks. Ergonomics, the study of designing for human comfort and safety, becomes crucial in

this situation. When used in busy settings like studios, schools, and workshops, a badly designed ladder chair can be extremely dangerous (Fien, 2009).

Ladder chairs that are ergonomically sound must be customised to anthropometric measurements, taking into consideration factors like posture, balance, reach range, and stature. It is necessary to carefully calculate parameters like step spacing, seat width, backrest inclination, tread depth, and riser height. Furniture for workshops must specifically support dynamic postures, such as standing, climbing, reaching, and sitting, often in rapid succession (Takyi Mensah, 2023).

Non-slip treads, weight-bearing stability, and balanced center-of-gravity configurations that stop tipping are frequently features of safer designs. Prakash et al. (2022) state that ladder chairs and other dual-purpose furniture need to be subjected to stringent stability testing, especially at joints and conversion hinges, which are frequent failure points.

Additionally, rounding sharp edges, locking mechanisms, and clear markings can all improve user safety by lowering the chance of accidents. This is particularly important in high-traffic or educational settings where users might not be accustomed to weight limits or transformation mechanisms.

2.5 Fabrication Techniques: Integrating Craft with Innovation

The creation of a hybrid ladder chair requires expertise in both metalworking and woodworking, two disciplines with different customs, equipment, and material properties. Precision and a thorough comprehension of grain orientation, moisture content, and dimensional stability are essential for woodworking processes like cutting, planing, sanding, and joining (Taifa & Desai, 2017). Maple hardwood was used strategically in the researchers' ladder chair to balance weight, durability, and aesthetic appeal.

Cutting metal pipes, welding, grinding, and applying protective finishes are all part of the fabrication process on the metalworking side. To guarantee smooth, stable, and corrosion-resistant results, tools like welding machines, angle grinders, and powder-coating equipment are utilised (Bai et al., 2024).

Careful engineering is needed at the wood-metal junctions to prevent material fatigue, corrosion, and loosening. To address these issues, methods like hybrid welding brackets, epoxy adhesives, bolting, and sleeve insertion have been developed (Ofield, 2025). Pre-drilled metal frames and reinforced hinge mechanisms supported bolted joints in the researchers' project, enabling safe transitions between ladder and chair modes.

Furthermore, surface treatment is crucial to guaranteeing durability. While anti-rust primers and enamel paints protect metal components from environmental deterioration, finishing wood with sanding sealer and varnish improves tactile comfort and provides moisture protection (Göktaş et al., 2024; Al-Hinai et al., 2018).

2.6 Educational and Institutional Relevance of Ladder Chair Design

Ladder chair design has ramifications for education and skill development in addition to product innovation. These kinds of projects are useful venues for contextual problem-solving, cross-disciplinary cooperation, and project-based learning in TVET institutions. Takyi Mensah (2023) and Uwaifo (2009) highlight how students can synthesise principles of design thinking, engineering, and sustainability to produce practical furniture solutions for institutional use.

In addition, experiential projects like ladder chairs cultivate craftsmanship accuracy, problem-solving abilities, and artistic autonomy, which are vital for learners entering fields such as carpentry, sculpture making, architecture, and furniture design. Hands-on interaction with actual materials and practical limitations transforms learning into an experiential process that enhances comprehension and long-term skill mastery (Adu-Gyamfi et al., 2016; Niedderer & Reilly, 2010).

Within resource-limited settings, adaptive furniture supports institutions in achieving spatial optimisation, economic efficiency, and ergonomic, user-focused layouts. Consequently, the ladder chair transcends its role as a mere design object to become an educational resource, an economic innovation, and a symbol of interdisciplinary collaboration.

3. Materials and Methods

3.1 Research Approach

This research employed a practice-driven, studio-centered methodology suitable for exploration within design and fabrication contexts. Practice-led research puts creative practice at the forefront of knowledge production, enabling iterative exploration through making (Adu-Gyamfi et al., 2016). The objective was to design, build, and test a ladder chair that combines sustainable material selection, ergonomic principles, and effective spatial utilisation, especially in workshop and vocational settings. This methodological approach followed a cyclical process involving conceptual design, prototyping, evaluation, and refinement. Each phase was documented and analysed to establish a link between theory and practice. The design stage involved ideation and sketch development based on anthropometric data and user requirements. The prototyping stage translated these ideas into tangible outcomes through material selection, joinery planning, and construction. The testing phase engaged users to assess ergonomics, stability, and functional efficiency, with feedback informing iterative improvements. This triangulation of design, fabrication, and evaluation ensures methodological transparency, reproducibility, and academic robustness consistent with design-based research traditions.

3.2 Materials Used

Hardwood and mild steel were carefully chosen for the ladder chair's construction based on their availability, workability, and mechanical qualities. Structural performance, aesthetic appeal, and conformity to sustainable design principles were taken into consideration when selecting materials. Table 1 below shows all the materials used for the fabrication of the ladder chair.

Table 1. Materials used for ladder chair fabrication

Material	Purpose/Use
Maple Hardwood	Seat, steps, and backrest
Mild Steel (25 mm square pipe)	Frame structure and support
Hinges (metal)	For the transformation mechanism
Bolts and Nuts	For wood-metal joining
Sanding Sealer	Wood surface finishing and sealing.
Varnish	Protection and enhancement of wood texture
Anti-Rust Primer	Prevent corrosion on metal surfaces.
Oil-Based Paint	Final finish on metal components

Because of its fine grain, ease of machining, and durability, maple hardwood was chosen. Because of its high tensile strength and suitability for powder coating and welding, mild steel was selected. To guarantee affordability and encourage regional craftsmanship, these materials were procured locally.

3.3 Design Process

Detailed working drawings, orthographic projection draughting, and hand sketching were all part of the design process. To guarantee ergonomic compliance, emphasis was put on using precise anthropometric measurements. To accommodate a variety of users, the seat height, tread dimensions, backrest angle, and step spacing were modified using information from Taifa & Desai (2017). To begin with the fabrication process, Figure 1 below shows the Conceptual Design Sketch and Orthographic Drawing aimed at guiding the researchers to create a great functional art piece.

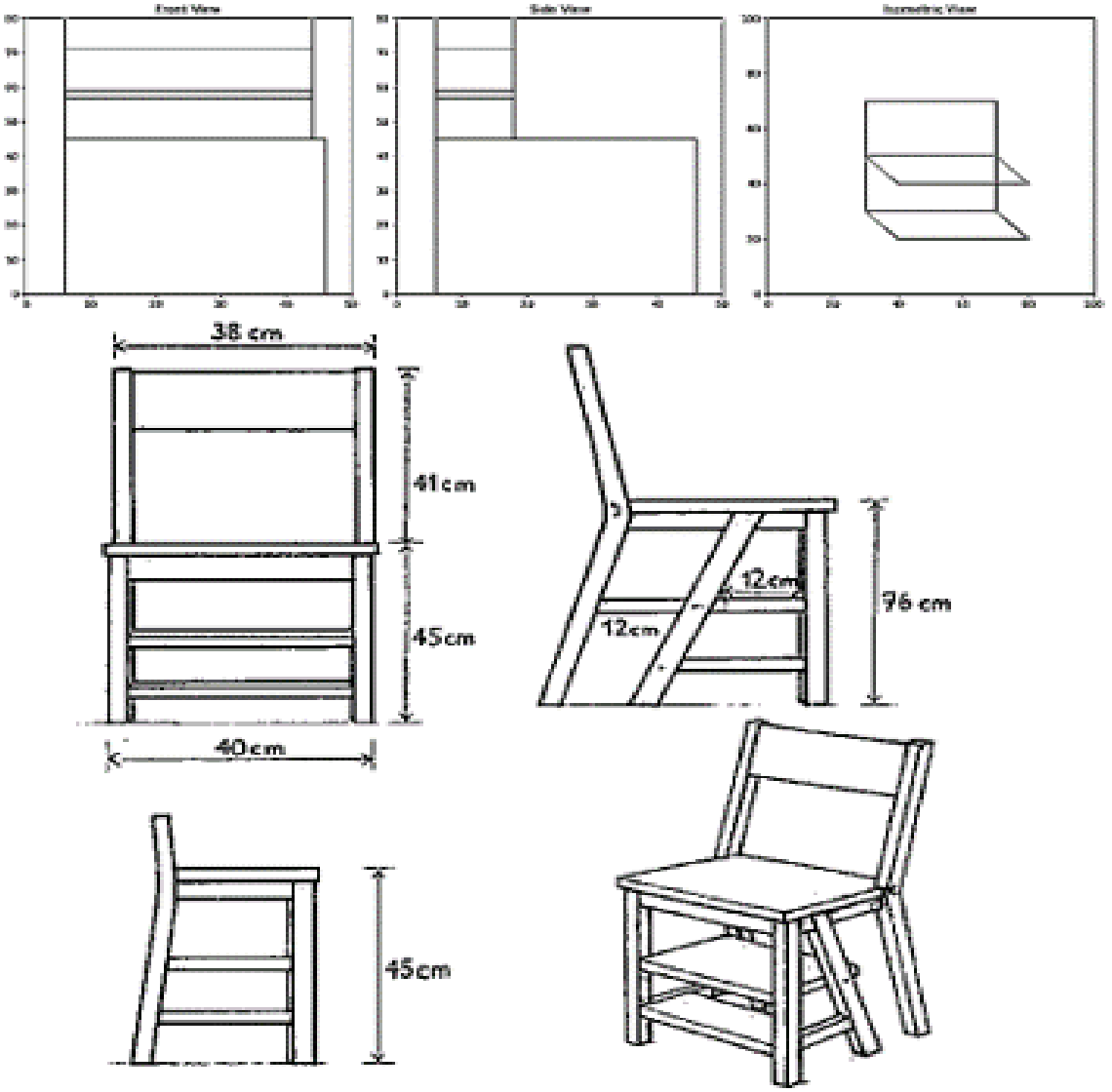

Fig 1. Conceptual Design Sketch and Orthographic Drawing (Authors' construct, 2025)

3.4 Fabrication Procedure

The fabrication process was broken down into four main stages: design conceptualisation, which included creating orthographic drawings and sketching them; material selection, which involved sourcing and evaluating wood, metal, and fasteners; fabrication and finishing, which included machining steel and wood, welding, drilling, sanding, coating, and joining components; and evaluation and refinement, which included structural verification, functional testing, and user observation. The fabrication process is displayed in Table 2 below.

Table 2. Fabrication Phases and Activities

Phase	Description
Design Conceptualization	Sketching and generating orthographic drawings
Material Selection	Sourcing wood, metal, and fasteners; assessing material quality
Fabrication and Finishing	Machining wood and steel, welding, drilling, sanding, coating, and joining
Evaluation and Refinement	Functional testing, user observation, and structural verification

3.4.1 Woodworking Operations

Among the woodworking tasks were:
1. Using a table and mitre saws to cut maple boards
2. Using belt and orbital sanders for shaping and smoothing
3. Drilling bolt junction holes precisely
4. Applying sanding sealer and varnish for sealing and finishing

3.4.2 Metalworking Operations

Involved in the fabrication of metal:
1. Using abrasive saws to cut mild steel square pipes
2. Using MIG welding to assemble the frame
3. Smoothing weld joints by grinding and polishing
4. Using anti-rust primer for priming and oil-based paint for finishing

Following the fabrication phases and activities as outlined in Table 2 above, Figure 2 below shows all the operational activities on the woodworking and metalworking phases, like machining, welding, drilling, sanding, coating, and joining, and ends with the evaluation and refinement.

Fig 2. Workshop activities (Measuring → Cutting → Welding → Grinding → Assembling→ Finishing→ Testing (Source: Saah, 2025)

3.4.3 Assembly and Integration

After the metal and wood parts were finished, they were assembled using:
1. Bolted joints that were pre-drilled to join the metal to the wood
2. The hinges that allow you to switch between chair and ladder positions
3. Gussets and brackets to strengthen load-bearing joints

3.5 Safety and Quality Testing

After it was finished, the ladder chair was put through a battery of performance, usability, and safety tests. Given the product's dual functionality and potential for use in studio and educational settings, this was crucial. As shown in Table 3, the ladder chair underwent safety and usability evaluation, which included tests for load capacity, stability, ergonomic comfort, and transformation ease; all criteria were successfully met, with the chair supporting 120 kg, resisting tipping, offering comfortable posture, and converting within 10 seconds.

Table 3. Safety and Usability Evaluation Criteria

Criterion	Test Method	Outcome
Load Capacity	Static weight application (120 kg)	Passed
Stability	Tipping resistance simulation	Passed
Ergonomic Comfort	Postural analysis in the seated position	Passed
Transformation Ease	Conversion time and steps counted	Passed (10 seconds)

These tests validated the ladder chair's dependability, security, and performance in both normal and extreme circumstances.

4. Post-Studio Stage, Findings, and Aesthetic Appreciation

4.1 Post-Studio Reflections

The ladder chair project's post-studio phase signalled a significant shift from fabrication to functional and aesthetic assessment. During this phase, the entire production process, from sourcing materials and technical execution to design alignment and end-user experience, was reflectively assessed. The researchers aimed to ascertain whether the final product achieved its intended design goals to provide

a piece of furniture that is safe, ergonomic, and space-efficient and can be used as both a seat and a stepladder through careful observation and iterative feedback.

During this phase, reflections verified that the design was successful in turning the idea of a multipurpose chair into a real, functional item. The combination of contemporary metalworking techniques and traditional carpentry showed that, with careful execution and material selection, interdisciplinary fabrication techniques could produce cohesive outcomes. Additionally, the ladder chair presented a promising model for educational projects in Technical and Vocational Education and Training (TVET) institutions and had a high potential for replication in workshop-based settings.

Important information about usability, tactile experience, and structural performance was also discovered during this phase. For example, information on ergonomic flow and motion continuity was obtained from the way users engaged with the transformation mechanism. Understanding how intended users, such as students, teachers, and artisans, engaged with the product both functionally and spatially was made possible thanks in large part to the input obtained through structured observation.

4.2 Findings

4.2.1 Structural Integrity and Stability

The ladder chair's excellent structural performance under a range of use circumstances was one of the study's main conclusions. For adult users, the hardwood climbing and seating surfaces and mild steel frame provided adequate load-bearing capacity. With no indications of structural deflection or instability, static load testing verified that the chair could sustain weights of up to 120 kg in both chair and ladder configurations. The square steel pipe framing reduced the chance of tipping by providing a low centre of gravity and distributing the weight evenly across the base. The structural joints, particularly the bolted metal–wood interfaces, held up well under repeated transitions, indicating that the hinge mechanisms and fasteners selected were suitable for building hybrid furniture. These results support the claim made by Prakash et al. (2022) that, with careful reinforcement and alignment of connection points, mixed-material furniture can provide superior mechanical performance.

4.2.2 Functionality and Transformability

The ladder chair’s ability to switch between its two modes with ease and efficiency was another noteworthy result. The conversion mechanism only needed one pivot motion, which was held up by metallic hinges that were firmly attached to the steel frame and the wooden treads. Depending on user experience, the transformation time averaged 10–12 seconds. Other than lifting and repositioning the hinged backrest, no extra tools or physical effort were needed.

This transformation's ease of use and intuitiveness highlight the importance of user-centred design principles in multipurpose furniture. Yang et al. (2023) point out that space-saving furniture’s usability is improved by its intuitive convertibility, particularly in institutional settings where users may need to quickly modify their workspaces.

4.2.3 Ergonomic Alignment

The backrest angle, tread depth, step risers, and seat height were all designed with anthropometric analysis in mind. These dimensions fell within adult users’ comfortable ranges, according to post-studio observations. With a height of about 450 mm, the seat was in good alignment with accepted ergonomic seating guidelines. Safe climbing and standing during task performance were

made possible by the ladder's treads and risers, which were evenly spaced to support natural foot placement.

The ergonomic design is adequate, as users reported no undue strain when using the ladder or sitting for extended periods of time. These results corroborate those of Prakash et al. (2022), who stressed that in order to prevent discomfort or injury, multipurpose furniture needs to take into consideration a broad range of body dimensions and postural requirements.

4.2.4 Space Efficiency and Environmental Suitability

The ladder chair produced significant space-saving results. It freed up valuable floor space by integrating the functions of a chair and a ladder into a single footprint, eliminating the need for two distinct pieces of furniture. This benefit is especially pertinent in small design studios, workshops, and classrooms where workflow is improved by spatial flexibility.

Additionally, the ladder chair's small size in chair mode made it simple to integrate with workbenches or storage units. The product was perfect for spaces that use vertical storage because it was tall enough to reach overhead shelves in its ladder configuration. These results back up what Göktaş et al. (2024) and Al-Hinai et al. (2018) say that spatial adaptability is a basic necessity in contemporary learning and creative settings, particularly when resource limitations necessitate effectiveness and mobility.

4.3 Aesthetic Appreciation

From a design standpoint, the ladder chair offers a striking illustration of how practicality and aesthetic appeal can coexist peacefully. A contemporary yet cosy aesthetic appropriate for both residential and educational settings was provided by the contrast between natural maple wood and matte black mild steel. In addition to being useful, the materials chosen greatly enhanced the product's tactile and aesthetic appeal.

4.3.1 Material Aesthetics and Craftsmanship

The natural grain of the maple was highlighted by the application of sanding sealer and varnish to the wooden components, creating a smooth and welcoming surface finish. These finishes improved the product's tactile and visual appeal, making it wear-resistant and pleasant to the touch. On the other hand, the oil-based black paint and anti-rust primer-coated mild steel frame offered a visually solid foundation that represented robustness and longevity.

The high degree of craftsmanship involved was demonstrated by the precise hole placements, smooth corner curvature, and joint alignment. Sanding was used to soften all edges, especially the treads and the backrest, to guarantee comfort and safety when in contact. The focus on surface treatment supports Ofield's (2025) claim that fine craftsmanship in furniture design enhances aesthetic quality in addition to ensuring durability.

4.3.2 Design Language and Visual Balance

The product conveys intention and balance visually. With equal visual weight on both its vertical and horizontal axes, the ladder chair has a symmetrical silhouette. The simple joinery and subtle detailing reinforce the sense of visual stability created by this proportionality. The backrest's vertical slats reinforce the object's dual nature by subtly echoing the ladder function.

A minimalistic design language is supported by the restrained use of colour and material variation. Because of its restraint, the ladder chair can be used in a wide range of spatial settings without being overly noticeable or stylised.

4.3.3 Perception and User Response

Based on unofficial observational feedback, the first user reactions were overwhelmingly positive. The product's aesthetic clarity, transformation mechanism, and compactness were all praised by users. Curiosity was piqued by the dual-use design's functional novelty, and instant interaction was encouraged by its simplicity of use.
These answers support Yang et al.'s (2023) findings that users value furniture designs that provide surprise, adaptability, and meaningful engagement. In this sense, the ladder chair adds to a more dynamic and interesting built environment in addition to fulfilling a functional need.

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

4.4 Thematic Analysis of Observational Feedback

To combine insights from both formal and informal observations made during the post-studio evaluation of the ladder chair prototype, a qualitative thematic analysis was carried out. Students, teachers, and workshop employees were among the users who were encouraged to use the product in both chair and ladder modes. Emergent themes on perceived value, comfort, safety, functionality, and aesthetics were used to classify the feedback.

Theme 1: Functional Intuitiveness and Ease of Transformation
The transformation mechanism was praised by many users as "simple," "intuitive," and "surprisingly smooth." Without verbal guidance, participants were able to transform the chair into a ladder, according to observers, typically in 10–12 seconds. The product's "useful dual-purpose" and "clever design" were also praised by users.

"I like that you don't need to press or unlock anything; it just folds and works."
(Participant 3, Instructor)

This indicates a high level of functional transparency, in which the product makes clear its intended uses and does not require any prior technical knowledge. One of the study's main design tenets, user-friendly transformation devoid of complicated mechanisms or tools, is validated by this (Prakash et al., 2022).

Theme 2: Perceived Ergonomic Comfort and Safety
Strong user satisfaction with regard to perceived safety and physical comfort was also noted in the feedback. While the ladder mode was characterised as "secure" and "trustworthy," even when climbing with tools in hand, the chair mode provided a stable and balanced seating experience.

"The seat is firm but comfortable. I could sit and work for a while without feeling stiff."
(Participant 6, Student)

"It doesn't shake when you climb it. The steps feel solid and well-spaced."
(Participant 1, Technician)

This theme confirms previous findings that well-proportioned dimensions and anthropometric compliance enhance comfort and physical confidence during use (Sathishranganathan et al., 2019). Furthermore, perceptions of structural stability were improved by visual cues like metal framing and thick treads.

Theme 3: Aesthetic Appeal and Material Quality
The contrast between the matte black metal frame and the natural wood was frequently praised by participants. The chair was characterised by observers as “clean,” “modern,” and “minimalistic”. The wood’s finish was praised for being smooth and showing the grain, which conveyed a feeling of fine craftsmanship.

“This would look great in a design studio or even a minimalist home. The wood is beautiful.”
(Participant 4, Artisan-in-training)

An often-underappreciated result of functional furniture design is user trust and emotional connection, which were bolstered by the handcrafted quality and obvious attention to surface detailing (Pain et al., 1996).

Theme 4: Space Efficiency and Contextual Relevance
The product's alignment with space-saving goals was also validated by feedback. The chair’s small footprint and ability to "disappear" into the layout when not in ladder mode were particularly valued by users in institutional and workshop settings.

“This replaces two items with one. And I can slide it near the bench when I don’t need it.”
(Participant 5, Workshop Assistant)

This theme highlights that space efficiency encompasses more than just physical dimensions; it also involves how well furniture fits into a changing environment. Practical benefits of the chair included its small size, ability to stack, and unobtrusive appearance.

Theme 5: Educational Value and Design Inspiration
Lastly, the ladder chair’s potential as a design learning tool was discussed by a number of participants, particularly instructors and advanced students. They indicated interest in teaching workshop skills, material integration, and human-centered design through comparable fabrication projects.

“This would be a great project for Level 200 sculpture, interior design, and furniture students. It covers metal, wood, joinery, and ergonomics in one.”
(Participant 2, Instructor)

As a result, the product's value goes beyond its usability to include a pedagogical platform, technical training, and a catalyst for creativity in vocational design education (Ofield, 2025; Takyi Mensah, 2023; Viennet et al., 2017).

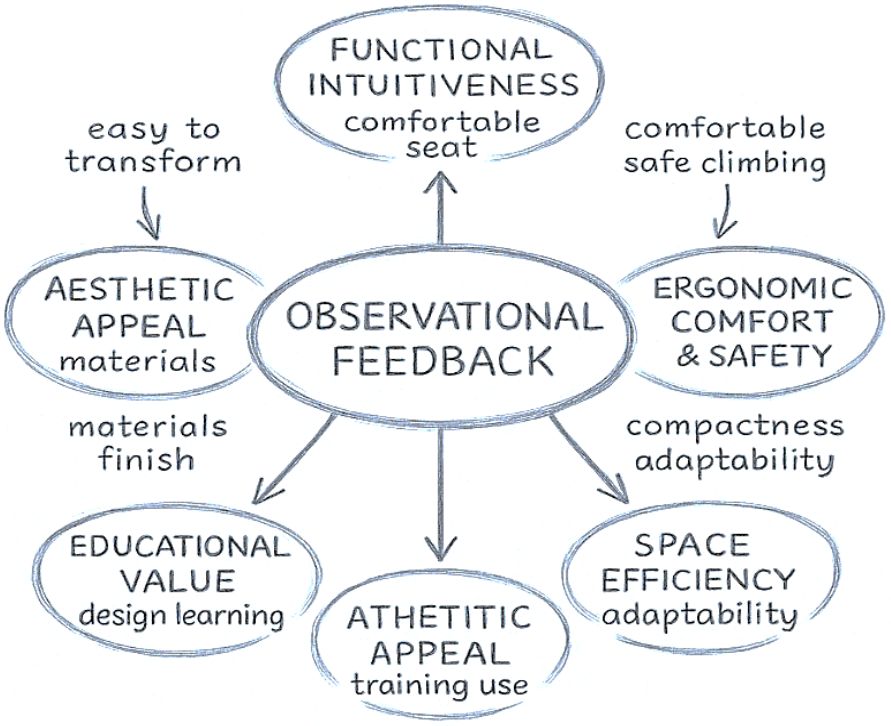

Fig 3. Graphical thematic map (Authors' construct, 2025)

Figure 3 above illustrates how the thematic analysis not only supports the ladder chair design's user-centred goals but also offers insightful information about its wider applicability as a tool for ergonomic, educational, and spatial innovation.

5. Summary, Conclusions, Recommendations, and Implications of the Findings

5.1 Summary of the Study

This study concentrated on designing, creating, and testing a multipurpose ladder chair that can be used for vertical access and seating in small spaces. Guided by a practice-led, studio-centered approach, the research combined eco-friendly materials, mixed fabrication techniques, and anthropometric data to produce a prototype adaptable to design studios, educational settings, and other compact institutional spaces. Employing traditional woodworking alongside metalworking techniques, the chair was fabricated from maple hardwood and mild steel square tubing. Its dimensions and folding mechanism were guided by human-centered design principles, with orthographic projections informing the physical construction.

After fabrication, the chair was evaluated for structural robustness, ergonomic performance, transformation efficiency, and visual appeal, with user feedback analysed thematically. The findings confirmed the chair's robust construction, appealing aesthetics, and user-friendly functionality. The outcomes showed how such a design could improve design education by providing real-world, multidisciplinary learning experiences in addition to solving practical space problems.

5.2 Conclusions

Regarding the applicability and possibilities of dual-purpose furniture design, the ladder chair project provided a number of insightful findings. Firstly, the study demonstrated that combining climbing and seating functions within one piece effectively minimises furniture duplication, enhancing space efficiency. The chair accommodated both sitting tasks and safe access to elevated storage, proving highly beneficial in compact environments.

Secondly, insights from user interaction and observational data confirmed adherence to ergonomic principles. Participants reported no discomfort while using the seat, steps, or backrest, all of which were found to be dimensionally safe and comfortable. This underscores the importance of grounding design decisions in anthropometric data to ensure user well-being.

Thirdly, the hybrid use of metal and wood ensured a balance between sustainable material use, structural performance, and aesthetic refinement. The visual harmony created by the matte-black metal and varnished maple reflected deliberate care in material selection and finishing.

Fourth, there were no tools or instructions needed for the smooth and simple transition between chair and ladder modes. The product's usefulness and appropriateness for dynamic learning environments were enhanced by its ease of conversion.

Lastly, the study verified that these design projects have significant educational value in addition to being pertinent for resolving actual spatial problems. The ladder chair integrated design thinking, craftsmanship, and problem-solving into a single, purposeful project, making it an example of project-based learning in Technical and Vocational Education and Training (TVET).

5.3 Recommendations

A number of suggestions are made in light of the study's findings to direct future research, practice, and innovation. First, in order to accommodate a variety of user groups, such as younger students, senior citizens, and people with physical limitations, it is advised that future prototypes include a greater range of anthropometric data. This would increase the product's applicability and inclusivity.

Second, future iterations could experiment with lighter and more affordable materials, even though the use of mild steel and maple provided durability and aesthetic appeal. Aluminium or laminated bamboo are two substitutes that could lighten the load and make transportation easier, particularly in situations where mobility is crucial.

Third, in subsequent iterations, designers ought to take modularity into account. It would be simpler to disassemble, maintain, and customize if knock-down joints or modular connections were used. Additionally, this would promote circular design principles, increasing the product's sustainability over time.

Fourth, it is advised that design instructors incorporate projects like ladder chairs into the curricula of polytechnic and TVET programs. Students can work together across disciplines, tackle real-world problems, and gain useful fabrication and design skills through these projects.

Lastly, the ladder chair should be investigated for commercialisation due to its strong functional and aesthetic appeal. The design could be modified by furniture manufacturers and interior designers for institutional settings, urban residences, and small offices where there is a strong need for space-saving solutions.

5.4 Implications of the Findings

The study's findings have a number of ramifications for sustainable furniture development, design education, and spatial planning. The ladder chair project emphasises the importance of practical,

multidisciplinary assignments that bridge theory and practice for educational institutions. Students working on these projects gain knowledge of design tools and fabrication methods as well as critical thinking, creativity, and teamwork abilities.

The study shows how multipurpose furniture can meet practical needs without sacrificing comfort, security, or aesthetic appeal from the perspective of design practice. The effective fusion of human-centered dimensions, mechanisms, and materials emphasises how crucial holistic thinking is to modern furniture design. From a sustainability standpoint, using hardwood that is sourced locally and making efficient use of materials are in line with international objectives for conscientious production and consumption. By reducing material waste and increasing functional output, the ladder chair helps achieve Sustainable Development Goal 12 (Responsible Consumption and Production).

Lastly, the study recommends that institutional planners spend money on flexible and effective adaptive furniture systems, especially in the educational and vocational sectors. The ladder chair serves as an example of how furniture can improve working, learning, and teaching environments in addition to helping with spatial problem-solving.

Acknowledgement

In order to facilitate this study on the design and fabrication of a ladder chair for vertical access and space optimization, the authors would like to express their gratitude to Mabel Saah for her research assistance and the Department of Sculpture Technology of the Takoradi Technical University. We would especially like to thank the technical staff and workshop instructors, whose advice during the production phase significantly improved the final prototype's quality. Additionally, we value the insightful comments made by students, teachers, and craftspeople during the post-studio evaluation, which greatly aided in the design's improvement and evaluation. Their involvement increased the research's impact and practical relevance.

References

Adu-Gyamfi, S., Donkoh, W. J. & Addo, A. A. (2016). Educational reforms in Ghana: Past and present. Journal of Education and Human Development, 5(3), 158–172. https://doi.org/10.15640/jehd.v5n3a17

Al-Hinai, N., Al-Kindi, M. & Shamsuzzoha, A. (2018). An Ergonomic Student Chair Design and Engineering for Classroom Environment. International Journal of Mechanical Engineering and Robotics Research, 7 (5), 534-543. https://doi.org/10.18178/ijmerr.7.5.534-543

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). A systematic review of research on sitting and working furniture ergonomic from 2012 to 2022: Analysis of assessment approaches. Heliyon, 10(7), e28384. https://doi.org/10.1016/j.heliyon.2024.e28384

Boateng, C. (2012). Restructuring vocational and technical education in Ghana: The role of leadership development. International Journal of Humanities and Social Science, 2(4), 108-114.

Dittakavi Tarun, V., Mohan Srikanth, R., Jithendra Kumar, I., Mehar Anudeep, S., & Srikanth. (2017). Stress analysis on a chair-less chair. International Journal of Theoretical and Applied Mechanics, 12(4), 699-708.

Famiwole, R. O., Oke, J. O., & Amadii, N. S. (2012). Potentials of vocational and technical education: Empowering youths and vulnerable adults for poverty reduction in Nigeria. Journal of Science and Management, 1(2), 157-162.

Fien, J., Maclean, R. & Park, M. (Eds) (2009). Work, learning and sustainable development: Opportunities and challenges. Springer Dordrecht.

Göktaş, O., Ergin, E., Çetin, G., Hicret Özkoç, H., Fırat, A., & Gülsunar Gazel, G. (2024). Investigation of user-product interaction by determining the focal points of visual interest in different types of kitchen furniture: An eye-tracking study. Displays, 83, 102745. https://doi.org/10.1016/j.displa.2024.102745

Musa, A. I. (2011). Anthropometric evaluations and assessment of school furniture design in Nigeria:A case study of secondary schools in rural areas of Odeda, Nigeria. International Journal of Industrial Engineering Computations, 2(3), 499–508. https://doi.org/10.5267/j.ijiec.2011.03.006

Niedderer, K., & Reilly, L. (2010). Research practice in art and design: Experiential knowledge and

organised inquiry [Editorial]. Journal of Research Practice, 6(2), 1-11. Article E2. http://jrp.icaap.org/index.php/jrp/article/view/247

O'Sullivan, K., O'Keeffe, M., O'Sullivan, L., O'Sullivan, P., & Dankaerts, W. (2012). The effect of dynamic sitting on the prevention and management of low back pain and low back discomfort: a systematic review. Ergonomics, 55(8), 898–908. https://doi.org/10.1080/00140139.2012.676674

Ofield, J. (2025, April 27). Can Your Office Chair Impact Your Health? Houston Experts Say Yes! Rosi Inc. https://www.rosiinc.com/blog/your-office-chair-impacts-your-health/ Pain, H., Pascoe, J., Gore, S., & McLellan, D. L. (1996). Multi-adjustable chairs for children withdisabilities. Journal of medical engineering & technology, 20(4-5), 151–156. https://doi.org/10.3109/03091909609008395

Pheasant, S., & Haslegrave, C.M. (2006). Bodyspace: Anthropometry, Ergonomics and the Design of Work, Third Edition (3rd ed.). CRC Press. https://doi.org/10.1201/9781315375212

Pongo, N. A., Effah, B., Osei-Wusu, B., Obinnim, B., & Sam, F. K. (2014). The impact of TVET on Ghana's socio-economic development: A case study of ICCES TVET skills training in two regions of Ghana. American International Journal of Contemporary Research, 4(1), 185-192.

Prakash, S., Babu, S., & Shukla, S. (2022). Design and fabrication of chair cum ladder. International Research Journal of Modernization in Engineering Technology and Science, 4(3), 732-734.

Saah, M. (2025). Fabrication of ladder chair for sculpture workshop (Bachelor's thesis). Faculty of Applied Arts & Technology, Department of Sculpture Technology, Takoradi Technical University.

Sathishranganathan, C., Santhosh Kumar, G., Prakash, P. S., & Prabhakaram, J. G. (2019). Design and fabrication of chair-less chairs. International Journal of Innovative Technology and Exploring Engineering, 9(2), 103-107. https://doi.org/10.35940/ijitee.A4968.129219

Taifa, I. W., & Desai, D. A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. Engineering Science and Technology, 20(1), 232–239. https://doi.org/10.1016/j.jestch.2016.08.004

Takyi Mensah, E. (2023). Changes in Ghana's Technical and Vocational Education and Training since its Independence: From the Perspective of Educational Policy, International Journal of Vocational and Technical Education Research, 9 (2), 40-49. https://doi.org/10.37745/ijvter.15/vol9n24049

Thariq, M. M., Munasinghe, H., & Abeysekara, J. (2010). Designing chairs with mounted desktop for university students: Ergonomics and comfort. International Journal of Industrial Ergonomics, 40(1), 8–18. https://doi.org/10.1016/j.ergon.2009.10.003

Ulrich, K., Eppinger, S. & Yang, M. C. (2020). Product design and development (Seventh Edition). Irwin McGraw-Hill.

Usman, A. N., & Tyabo, A. (2013). Revitalizing technical and vocational education (TVET) for youth empowerment and sustainable development. Journal of Educational and Social Research, 3(4), 149–154. http://dx.doi.org/10.5901/jesr.2013.v3n4p149

Uwaifo, V. O. (2009). Training technology and vocational education teachers for the new 9-3-4 education system in Nigeria: Its problems and prospects. International NGO Journal, 4(4), 160–166.

Viennet, R. & B. Pont (2017). Education policy implementation: A literature review and proposed framework. OECD Education Working Papers, No. 162, OECD Publishing, Paris, https://doi.org/10.1787/fc467a64-en.

Yang, X., & Zhang, Z. (2023). Development of a Rehabilitation Chair Design Based on a Functional Technology Matrix and Multilevel Evaluation Methods. Applied Sciences, 13(20), 11404. https://doi.org/10.3390/app132011404

Zemp, R., Taylor, W. R., & Lorenzetti, S. (2015). Are pressure measurements effective in the assessment of office chair comfort/discomfort? A review. Applied Ergonomics, 48, 273–282. https://doi.org/10.1016/j.apergo.2014.12.010

Figure References : Figure 1, 2, 3: Authors' archives (2025)

Disclaimer: All authors submitting graphics to JAARD affirm that they possess the necessary rights to utilise and publish the graphics provided, thereby indemnifying JAARD against any claims of copyright infringement or other intellectual property disputes