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Design and fabrication of ergonomic workstation

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Abstract: The ergonomic workstation equipped with a range of functionalities tailored for diverse industrial and instructional applications. The workstation incorporates a variety of tasks catering to the needs of professionals across multiple disciplines. This research investigates and evaluates the ergonomic design principles incorporated into workstation. This also aimed to identify its acceptability in terms of design, mobility, operating performance, and safety. This research was a developmental method and 30 evaluators who were semi-experts, and professionals were employed. Results indicate significant enhancements in various aspects and features for a variety of tasks and operations. It facilitates precise work pieces, ensuring safety and comfort of users. Furthermore, the workstation represents a paradigm shift in workspace design, offering a comprehensive solution for various industrial and instructional tasks. Its versatility, coupled with innovative features, makes it an asset for professionals seeking enhanced productivity and convenience in their work environments. Future research endeavors aim to explore further enhancements in sustainability, automation, and user interface design to continually improve the functionality and usability of the workstation, thus setting new standards in workstation design.

Keywords: Ergonomic Workstation, Industrial Applications, Instructional Workspace, Solar Power, Adjustable Height, Mobility, Safety, Fabrication Techniques.

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INTRODUCTION

In modern industrial and creative environments, the design of workstations plays a pivotal role in ensuring productivity, safety, and user comfort. With the advent of advanced technologies and diverse job requirements, the need for versatile workstations capable of accommodating various tasks has become increasingly apparent. This research study explores the design and implementation of an ergonomic workstation tailored to meet the demands of fabrication, welding, drawing, painting, metal works, and more. The integration of ergonomics into workstation design was paramount to mitigate the risk of work-related injuries and enhance user satisfaction and efficiency. By considering the physical capabilities and limitations of users, ergonomic workstations aimed to optimize task performance while minimizing discomfort and fatigue. This study examines how ergonomic principles were applied to address the specific requirements of different tasks within the realms of fabrication, welding, drawing, painting, and metal works.

The key features of this where the workstation was designed to accommodate a wide range of tasks, including fabrication, welding, drawing, painting, and metal works. By providing dedicated areas and equipment for each task, users can seamlessly transition between activities without the need for extensive reconfiguration. The layout and design were **e**rgonomic and the **e**mphasis placed on ergonomics to ensure user comfort and safety during prolonged periods of work. Adjustable components, such as height-adjustable work surfaces and ergonomic seating, were incorporated to accommodate users of varying heights and preferences. The workstation was equipped with specialized tools and equipment tailored to each task, including welding positioners, drafting tables, painting easels, welding, and

metalworking tools. These tools were strategically positioned within the workstation to facilitate easy access and optimize workflow efficiency.

By recognizing the importance of adaptability in dynamic work environments, the workstation was designed to be movable, allowing for easy reconfiguration and relocation as needed. This feature enhances flexibility and facilitates collaborative work arrangements. The great advantage of this was adequate storage compartments and equipment cabinets were integrated into the workstation to provide a secure and organized space for storing tools, materials, and personal protective equipment. This helps minimize clutter and improve workspace organization. In alignment with environmental stewardship principles, the workstation was powered by solar energy, reducing reliance on conventional energy sources, and minimizing its carbon footprint. Solar panels were installed to harness renewable energy for powering lighting, equipment, and auxiliary systems.

Through a comprehensive analysis of ergonomic principles, task requirements, and user feedback, this research workstation offers insights into the design and implementation of a versatile and ergonomic workstation tailored to meet the diverse needs of fabrication, welding, drawing, painting, metal works, and other related activities. By prioritizing user comfort, safety, and efficiency, the proposed workstation aimed to enhance productivity and promote a positive working environment for users across various industries and disciplines. While functionality was paramount, the aesthetic appeal of the workstation was also important, especially in settings where design and ambiance contribute to the overall user experience. Thoughtful design elements and finishes help create an inviting and inspiring workspace environment.

Objectives of the study

The primary purpose of this study was to design and fabricate an ergonomic workstation. Specifically, it aimed to evaluate the acceptability of the ergonomics workstation in general in terms of design, mobility, operating performance, and safety.

LITERATURE REVIEW

In spatial design, saving space is important to optimize energy usage, thermal comfort and visual comfort, especially for tiny homes or workshop which emphasize smaller spaces for more sustainable lifestyles. The impact of tiny homes on the environment can be considerably reduced with the use of flexible and efficient equipment or furniture that are foldable, modular, space-saving and/or multifunctional (Rajan et al., 2019).

The vast majority of people in some of the most highly populated cities live in small buildings or flats or work in a workshops mostly due to lack of space. By considering ergonomic and movable in the design, a workstation would not only become more portable but also more convenient to use, especially in limited spaces. The improvement of modularity and multifunctionality in design addresses the problem of limited spaces (Varghese et al., 2021).

In the urban and domestic context, approximately nine million tonnes of furniture are discarded into landfills each year. While a regular single-function device (like many furniture items) is discarded, as time goes by, a multifunctional device sustains its use for a longer time due to the additional functions it possesses, catering to a broader scope of needs (Lim and Ng, 2021).

In the dynamic landscape of industrial workspaces, the demand for ergonomic solutions has become increasingly paramount. As industries evolve and diversify, the need for versatile workstations capable of accommodating a multitude of tasks, from welding to metal forging and beyond, has never been more pronounced. Enter the era of the ergonomic workstation a

transformative concept designed to harmonize functionality, safety, and sustainability (Vischer and Wifi, 2017).

At the nexus of innovation, the study of Wijngaarden and Hracs (2024) they also conceptualize an ergonomic workstation for welding, metal forging, and a spectrum of industrial tasks embodies a synthesis of cutting-edge design principles and practical functionality. This workstation stands as a testament to the evolving needs of modern industrial environments, where efficiency, comfort, and environmental consciousness converge.

In essence, ergonomic workstation represents a paradigm shift in industrial design—a fusion of form and function engineered to meet the evolving needs of today's dynamic workplaces. As industries continue to innovate and adapt, our workstation stands as a beacon of ingenuity, offering a glimpse into a future where ergonomics, sustainability, and productivity seamlessly intertwine. Adjustable drawing tables offer several advantages in ergonomic workstations, such as the tables allow users to customize the height and angle of the drawing surface to their individual preferences and needs. This customization ensures that users can work comfortably and maintain proper posture, reducing the risk of discomfort and musculoskeletal disorders. By adjusting the angle of the drawing surface, users can achieve the optimal viewing angle for their specific tasks. This helps reduce eye strain and fatigue, as users can maintain a natural and relaxed posture while working (Du et al., 2020).

The furniture industry uses wood as its primary raw material and largely consumes natural resources from forests, generating tons of waste. In the urban and domestic context, approximately nine million tons of furniture are discarded into landfills each year. While a regular single-function device (like many furniture items) is discarded, as time goes by, a multifunctional device sustains its use for a longer time due to the additional functions it possesses, catering to a broader scope of needs (Lim and Ng, 2021).

Considering the significance of space-saving attributes in modern day workstation, researchers have introduced a concept known as multipurpose workstation designs. In the study, researcher emphasized one instance of the problem, where space saving is with respect to a prescribed having multi features and allows for space-saving aspects in the design and has varied allowable task in one area (Zulfadli and Zakaria, 2018).

A study was conducted in 2016 that focused on the incorporation of a pneumatic adjustable system into a table for height adjustment and tilting of the tabletop. This table is integrated with a drawer as an additional function. The pneumatic cylinder is attached onto the tabletop and the air inside the cylinder provides a lifting force to support and stabilize the table. The user is required to push a button to activate the control valve of the pneumatic systems to raise or lower the table height (Caballer, 2016).

Another study investigated the development of a convertible table by combining several desired convertible items that can be transformed into a compacted form. The challenge in this design involves the linkages among the furniture units which require the joints to occupy a small space in the design’s compacted form but still function well in the design’s expanded form. The convertible table can be transformed into a bed by flipping its surface. An additional platform attached to the bed can be tilted to facilitate its transformation into a table (Zhou and Chen, 2018).

A study on consumer attitudes toward furniture designs found that consumers seriously value lightweight attributes in their assessment of furniture quality.A workstation with good design facilitates collaboration and communication among team members by providingshared workspaces, collaborative tools, and comfortable seating arrangements. This fosters teamwork, creativity, and innovation within the workplace. An aesthetically pleasing and well-designed workstation reflects positively on the organization and contributes to its brand image. A thoughtfully designed workspace conveys professionalism, attention to detail, and

commitment to employee well-being, enhancing the organization's reputation among clients, partners, and employees. (Knauf, 2015). Lightweight carbon fiber has been used in the fabrication of furniture items that weigh as little as 300 g but are still able to support the weight of a person (Estrada et al., 2019).

A modular product design provides a large range of advantages in addressing the influence of product architecture on product lifecycle phases. For example, it reduces development costs, promotes environmental friendliness, enables mass customization, and improves work efficiency. Modular designing dictates that a product can be separated into several parts to accomplish several primary functions (Bonvoisin et al., 2016).

Astonkar and Kherde (2015) proposed a modular capsule-shaped concept that can be broken into several parts to render the functions of a table and chair. Such a design reduces storage space while also making space for other products or activities. The safety features such as rounded edges, non-toxic materials, and anti-slip surfaces minimize the risk of accidents and injuries in the painting hub. Artists can work with confidence, knowing that their workspace is designed with their safety in mind.

Ergonomic design has become one of the areas of focus in the design industry, as it entails the study of human-machine interactions, fatigue, and discomfort in product design. A study on school furniture suggested that body discomforts are prevalent around the back, neck, elbow and thigh regions. In view of this predicament, considering ergonomics in furniture design is important in reducing bodily discomforts such as back pain and preventing the development of musculoskeletal disorders (Shah et al., 2017).

A well-designed workstation prioritizes user comfort by incorporating ergonomic features such as adjustable desk heights, ergonomic seating, and proper lighting. This helps reduce fatigue, strain, and discomfort during long periods of work, promoting overall well-being and productivity. A thoughtfully designed workstation layout optimizes workflow efficiency by organizing tools, equipment, and supplies within easy reach of the user. This minimizes unnecessary movements and distractions, allowing users to focus on their tasks and accomplish them more efficiently (Shah et al., 2017).

A workstation with good design allows for customization to suit individual preferences and work requirements. Adjustable components such as desk height supports their unique needs and preferences. Moreover, an efficiently designed workstation makes the most of available space, utilizing vertical and horizontal space effectively to accommodate various tools, equipment, and storage solutions. This helps optimize floor space and create a clutter-free environment conducive to productivity and organization. A well-designed workstation incorporates storage solutions and organizational features to keep tools, supplies, and documents neatly organized and easily accessible. This reduces clutter, minimizes distractions, and enhances overall efficiency in completing tasks (Zhou and Chen, 2018).

METHODOLOGY

Research design

This research study was developmental research, and focused on designing and fabricating an ergonomic workstation, which needed a comprehensive methodology which was crucial to the success of the study. The researcher first clearly defined and outlined the objectives of the study, including understanding user needs, assessing existing designs, identifying ergonomic requirements, evaluating the effectiveness of solar power systems, and proposing design improvements. After that, conducting a thorough review of industry standards and best practices related to ergonomic workstation design, solar power systems, and relevant safety regulations, as well as, developing surveys and interview protocols were conducted to gather insights from potential users, such as welders, artists, and metalworkers and collect data on

their work habits, ergonomic preferences, challenges faced, and suggestions for workstation design improvements. Based on the insights gathered from user and observational studies he developed a prototype ergonomic workstation incorporating movable design elements, compartments for tools, and integrated solar power systems. After, he set up controlled experiments to evaluate the design, mobility, safety, and operating performance of the prototype workstations. The researcher utilized ergonomic assessment tools and methods, such as observation sheet, and to evaluate the ergonomic suitability of the workstation designs the researcher used evaluation sheet.

The integration of sustainable practices such as the inclusion of a solar power system in the workstation design was initiated to promote sustainability by harnessing renewable energy to power tools and equipment. This reduces reliance on traditional energy sources and minimizes the workstation's environmental footprint, contributing to an eco-friendlier workspace. Overall, the ergonomic workstation created a functional, comfortable, and versatile workspace that enhances productivity, safety, and sustainability for users engaged in diverse creative and industrial activities.

Materials used in the study

Creating an ergonomic workstation designed for a variety of tasks such as welding, drawing, painting, and metal works with tools and compartments, along with mobility and a solar power system, requires a careful selection of materials that balance durability, functionality, and sustainability. The breakdown of materials commonly used for such workstations:

Steel Frame. The frame of the workstation was made from sturdy materials like steel to provide structural integrity and support for the work surface and storage compartments. These metals offer strength and durability while being relatively lightweight, making them suitable for mobility.

Wood Tools Compartment Surface. The tools compartment of the workstation been constructed from wood or composite materials such as plywood. These materials offer a smooth and stable surface, lightweight, durable and cost-effective that lessen the weight of the workstation. Storage compartments, shelves, and drawers are often made from wood materials, which are lightweight, durable, and resistant to moisture and corrosion.

Rubber or Polyurethane Casters. The wheels or casters used for mobility were made from rubber or polyurethane to provide smooth movement and reduce noise. These materials offer excellent durability and traction on various floor surfaces, ensuring stability and maneuverability.

Solar Panels with Complete System.The solar power system, photovoltaic (PV) solar panels are commonly used to convert sunlight into electricity. These panels were made from crystalline silicon or thin-film semiconductor materials encapsulated in tempered glass to protect them from environmental damage it also includes 300watts solar panel, 20,000watts inverter, 30A solar charger controller, 60AH car battery. This part is an additional feature provided by the researcher so that it can continuously supply power in the event of electric grid power failure, it also lessens electrical consumption since the power provided will be renewable and economically friendly.

Metal Hardware. Fasteners, hinges, and other hardware components used in the workstation are often made from stainless steel or other corrosion-resistant metals to ensure longevity and reliability in industrial settings.

High power connectors in ruggedized which is a multi-way formats with power up to 1,200 Amps that provide excellent performance in welding table that ensures safety and can be used in any environment conditions.

Panel board is a component used for electrical distribution system in welding workstation that controls or divides power in all sockets that feed into branch circuits, while providing a

protective circuit breaker or fuse for each circuit, in a common enclosure. A panelboard services to protect branch circuits from overloads and short circuits for safety of welders and environment.

Automatic Transfer Switch (ATS)is a device that automatically transfers a power supply from its primary source to a backup source when it senses a failure or outage in the primary source.

Convenient Outlet (30A) is an electrical receptacle that includes two outlets (or socket) for plug-in the tools and devices that needs electrical power.

By utilizing a combination of these materials, the researcher creates an ergonomic workstation that meets the functional requirements of various tasks while ensuring design, mobility, operating performance and efficiency of the workstation and safety of the user. Additionally, incorporating recycled or eco-friendly materials into the workstation's construction further enhances its environmental credentials.

Fabrication procedure

Fabricating an ergonomic workstation designed for a variety of tasks such as welding, drawing, painting, and metal works with tools and compartments, along with mobility and a solar power system, involves several key fabrication procedures. The step-by-step were as follows:

Step 1. Design Planning. The researcher begins with creating detailed design plans and specifications for the workstation, considering factors such as task-specific zones, storage compartments, mobility features, and integration of the solar power system. Use computer-aided design (CAD) software to visualize the workstation and ensure compatibility of components.

Step 2. Material Selection. Appropriate materials were chosen based on the design requirements and functional considerations. Select sturdy metals such as steel for the frame and the work surface, wood and wire mesh for storage compartments and ensuring that materials were compatible with welding and other processes.

Step 3. Cutting and Shaping. The researcher uses cutting tools such as saws, shearsto cut the metal frame components, wood panels, and other materials according to the dimensions specified in the design plans and shape the components as needed to achieve the desired form and functionality.

Step 4. Welding and Assembly. The researcher uses welding equipment such as MIG welders and SMAW to weld the frame together. Follow proper welding procedures and safety precautions to ensure strong and durable welds. Then the frame, work surface, and storage compartments were assembled according to the design plans, using fasteners, adhesives, or welding as necessary.

Step 5. Installation of Solar Power System and other electrical connections.The solar panel was connected including the charge controllers, batteries, and power inverters using wiring and electrical connectors and all electrical connections were secure and properly insulated to prevent electrical hazards were insured.

Step 6. Fabrication of Mobility Features. Since the workstation was designed to be movable, the wheels or casters on the frame was installed to enable easy movement within the workspace. The wheels were secured using mounting brackets or welding, ensuring that they were properly aligned and balanced for smooth operation.

Step 7. Finishing Touches. The workstation was painted to enhance durability, aesthetics, and corrosion resistance.

Evaluation procedure

In order to ensure smooth flow of operation and evaluation pilot testing was done which involves a small-scale trial run of a project or product to identify potential issues before full-scale implementation. The evaluation procedure involves the researcher and advisory committee conducting the pilot test, with the presence of the advisory committee. For a more comprehensive evaluation procedure, the researcher considered including the objective setting which the researcher clearly defines the objectives of the pilot test and what was trying to achieve in the pilot test. The participant or evaluator selection has also been considered with the advice of advisory committee and the considering factors was the demographics, expertise, and relevance to the project. After that the researcher provide details on the specific steps and methods used during the pilot test. This included the tasks evaluators were asked to complete, any materials or tools provided, and the duration of the test. The data was collected during the pilot test. This involved surveys, interviews, observations, for the improvement before the final evaluation and testing.

Before the final implementation of observation and evaluation, the observation and evaluation sheet made by the researcher was first submitted to the researcher's adviser, research coordinator and chairman, and English critic for comments, suggestions, and for possible changes and necessary revision. After that, the pilot study was conducted.

The observation and evaluation procedure were done separately and labelled as Phase 1 for Observation and Phase 2 for evaluation. For Phase 1 observation was done in welding and fabrication laboratory room of Capiz State University, Main Campus for the functions of multipurpose workstation using observation sheet. Phase 2 was the evaluation of ergonomic workstation, and it involves assessing its design, mobility, operating performance and safety in providing safe and comfortable work environment for user. The procedure of evaluation was done using researcher-made evaluation sheet and distributed it to 30 evaluators who were experts in their own field of specialization and break down as follows: 15 electrical and mechanical engineers/ electricians/ electronic technician/ professors, five (5) welding experts five (5) drafting experts and five (5) selected individuals such as entrepreneur, construction worker, mechanics, and randomly selected target end users evaluated the design, movability, safety, and operating performance of multipurpose workstation based on laboratory experiment.

Product evaluation

Evaluating the ergonomic workstation was done to gather feedback from the evaluators using the researcher-made evaluation sheet. It was conducted to evaluate the design features of the workstation, such as work surface height, reach distances, and tool accessibility, mobility, operating performance, and the safety.

FINDINGS AND DISCUSSION

The general acceptability of the ergonomic workstation across four key aspects: design, mobility, operating performance, and safety, was determined in this study. Based on the evaluation conducted, product obtained an overall mean of 4.82 indicating that it was Very Acceptable to the evaluators.

More specifically, the design of the product (Mean = 4.83, Very Acceptable) received a high rating, indicating strong acceptability. This suggests that respondents found the workstation's design to be well thought out, incorporating ergonomic principles and functionalities tailored to various tasks such as welding, drawing, painting, and metal works.

A mean score of 4.83 suggests that respondents highly valued the workstation's design features and their alignment with user needs and preferences. The mobility (Mean = 4.75, Very Acceptable) received a high rating as well, indicating that respondents perceived the workstation's mobility positively. This suggests that the workstation is easy to move and reposition within the workspace, allowing users to adapt to different work environments or task requirements. A mean score of 4.75 suggests that respondents found the workstation's mobility to be highly acceptable and beneficial for enhancing flexibility and productivity. The operating performance (Mean = 4.90, Very Acceptable) received the highest rating among the four aspects evaluated. This indicates that respondents were highly satisfied with the workstation's performance in terms of functionality, efficiency, and reliability during task execution. Factors such as versatility, ease of use, and adherence to safety standards likely contributed to the high rating.

A mean score of 4.90 suggests that respondents perceived the workstation's operating performance as exceptionally strong and capable of meeting diverse task requirements effectively. The safety (Mean = 4.79, Very Acceptable) also received a high rating, indicating that respondents viewed the workstation as providing a safe working environment for users. This suggests that the workstation incorporates various safety features, measures, and precautions to minimize risks and ensure user protection during task execution. A mean score of 4.79 suggests that respondents perceived the workstation's safety measures and practices as highly acceptable and effective in promoting user well-being and equipment integrity.

The findings demonstrate that the ergonomic workstation received high ratings across all evaluated aspects, indicating its strong acceptability and suitability for various tasks and work environments. This comprehensive evaluation underscores the workstation's effectiveness in meeting user needs, enhancing productivity, and promoting user well-being and safety.

In line with these findings, Du, et al. (2020) underscored that an ergonomic workstation represents a paradigm shift in industrial design, merging form and function to address the evolving demands of today’s dynamic workplaces. As industries innovate and adapt, our workstation exemplifies this ingenuity, offering a glimpse into a future where ergonomics, sustainability, and productivity seamlessly intertwine.

Adjustable drawing tables are a key component of ergonomic workstations, providing numerous benefits. These tables allow users to customize the height and angle of the drawing surface to their individual preferences and needs. This customization ensures comfortable working conditions and proper posture, reducing the risk of discomfort and musculoskeletal disorders. By adjusting the angle of the drawing surface, users can achieve the optimal viewing angle for their specific tasks, helping to reduce eye strain and fatigue by allowing a natural and relaxed posture (Du et al., 2020).

Considering the importance of space-saving features in modern workstations, researchers have introduced the concept of multipurpose workstation designs. This approach emphasizes designs that incorporate multiple functions into a single unit, allowing for space-saving while accommodating various tasks within one area (Zulfadli & Zakaria, 2018).

Hence, this ergonomic workstation takes task efficiency to the next level, with surface that can be adjusted so the user can achieve the precision in the welding and drawing, a choice of leg options for static or clamps and a safety design that it cannot be open unless the stabilizer leg is affix to the ground, this design is for static or mobile work, and a full range of fixturing components including various sizes of angles, bolts, clamps and more with the built-in compartment system with adequate space that the users can store all their important tools and materials. Moreover, with the advancement of technology it has a solar powered system that can deliver enough electricity supply to power up tools and lighting even though there

was no access or has no electricity present at all. This device also conforms with the industrial standards for accuracy, versatility, strength, comfort, safety, and cost effectiveness.

CONCLUSIONS AND RECOMMENDATION

The ergonomic workstation has proven to be a highly effective and versatile solution, garnering high acceptability across all aspects. Users expressed satisfaction with the workstation's seamless integration of multiple functions and its exceptional mobility, which facilitated easy relocation and adaptation to different work environments. The operating performance met or exceeded user expectations in terms of functionality and efficiency, while strong safety features and adherence to regulations were also highly praised. Additionally, the integration of solar power and mobility features further enhanced its utility, making it a preferred choice for professionals in the welding, drawing, painting, and metalworks industries.

Overall, the ergonomic workstation stands out as a comprehensive, efficient, and safe workspace solution for a variety of tasks. Based on the positive feedback and proven effectiveness of the ergonomic workstation, it is highly recommended for adoption in diverse professional settings, particularly those involving tasks such as welding, drawing, painting, and metal works. Its seamless integration of multiple functions, exceptional mobility, and strong safety features make it an ideal choice for enhancing productivity and comfort. Additionally, the workstation’s solar power integration offers an environmentally friendly solution that can contribute to sustainability goals.

With this, organizations should consider implementing this ergonomic workstation to improve worker satisfaction, reduce the risk of musculoskeletal disorders, and increase overall operational efficiency. Investing in such innovative and versatile workstations will not only support a healthier and more adaptable workforce but also drive long-term gains in productivity and workplace safety.

REFERENCES

Astonkar, D.V.; Kherde, S.M. (2015). Design and development of multipurpose, space saving seating arrangements using ergonomics. Int. J. Eng. Res. Appl., 7–12. Available online: https://www.ijera.com/special_issue/NCERT-Nov-2015/0712.pdf (accessed on 4 July 2021).

Bonvoisin, J.; Halstenberg, F.; Buchert, T.; Stark, R. (2016). A systematic literature review on modular product design. J. Eng. Des. 27, 488–514.

Caballer, M. (2016). Design of an adjustable table. Bachelor’s Thesis, Jönköping University, Jönköping, Sweden

Du, T.; Jansen, S.; Turrin, M.; van den Dobbelsteen, A. (2020). Effects of Architectural Space Layouts on Energy Performance: A Review. Sustainability, 12, 1829.

Estrada, R.D.; Wyller, M.; Dahy, H. (2019). Aerochair Integrative design methodologies for lightweight carbon fiber furniture design. In Proceedings of 37 eCAADe and XXIII SIGraDi Joint Conference—Architecture in the Age of the 4th Industrial Revolution, Porto, Portugal; Sousa, J.P., Henriques, G.C., Xavier, J.P., Eds.; Editora Blucher: São Paulo, Brazil, 2019; Volume 1, pp. 691–702.

Knauf, M. (2015). Understanding the consumer: Multi-modal market research on consumer attitudes in Germany towards lightweight furniture and lightweight materials in furniture design. Eur. J. Wood Prod. 73, 259–270.

Lim, S.H.; Ng, P.K. (2021). Synthesisation of design features for multifunctional stretcher concepts. J. Med Eng. Technol., 45, 145–157.

Rajan, A.R.P.; Elavarasan, D.; Balaji, S.; Dinesh, A.; Gowtham, K. (2019). Design and Fabrication of Multifunctional Furniture. Int. J. Res. Eng. Sci. Manag.

Shah, R.M.; Bhuiyan, M.A.U.; Debnath, R.; Iqbal, M.; Shamsuzzoha, A. (2017). Ergonomics Issues in Furniture Design: A Case of a Tabloid Chair Design. In Advances in Sustainable and Competitive Manufacturing Systems—Lecture Notes in Mechanical Engineering, Azevedo, A., Ed.; Springer: Heidelberg, Germany; Volume 1, pp. 91–103.

Varghese, E.; Kumar, S.; Lohit, H.S. (2021). Design of Multipurpose Modular, Flexible and Space-Saving Dining Table. SAS TECH

Vischer, J. and Wifi, M. (2017). The Effect of Workplace Design on Quality of Life at Work. Handbook of Environmental Psychology and Quality of Life Research (pp.387-400)DOI:10.1007/978-3-319-31416-7_21

Wijngaarden, Y. and Hracs, B.J. (2024). We are continuing an industrial revolution here": Assembling, experiencing and leveraging the affective atmospheres of post-industrial workspaces. Geoforum. Volume 148, Retrieved from https://doi.org10.1016/j.geoforum.2024.103944

Zhou, J.; and Chen, X. (2018). Convertible furniture design. Comput. Graph. 70, 165–175.

Zulfadli, M. and Zakaria, B.C. (2018). Design And Fabricate Multipurpose Portable Desk: A report submitted in fulfillments of the requirements for the award of Diploma of Mechanical Engineering Faculty of Mechanical Engineering Universiti Malaysia Pahang