Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.1.00297

RESEARCH ARTICLE

Artificial Intelligence Innovation Method for Bamboo Furniture Based on User Perception

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ARTICLE INFO

Received: Apr 24, 2024

Accepted: Jun 24, 2024

Keywords

Artificial intelligence
Visual arts
Furniture design
Generating desing
Bamboo Furniture
Aesthetics

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ABSTRACT

Technologies in product creation of ideas, adaptation, and production are being driven by the introduction of Artificial Intelligence (AI) into Furniture Design (FD). The use of AI in Bamboo Furniture Design (BFD) is the primary focus of the present study, featuring the importance of how customer feedback motivates novel and sustainable products. In order to enable large-scale customization while reducing waste products, AI tools make it simple to develop creativity, test functionality digitally, and improve the production process. The crucial role of a user-centered strategy is highlighted by this investigation, User perception information collection was carried out using questionnaire research and user feedback. With the use of AI, we can see developments and trends in consumer preferences, which can direct us to an FD that is elegant as well as pragmatic. The study of aesthetics, long-term viability, simple utilization, intelligent controls, ergonomic modifications, ranging, and general comfort were all deemed to have significantly benefited from this research. The deployment of AI has been confirmed to significantly boost customer service and happiness, based on empirical research. The work underlines the innovative advantages of AI in the FD industry, providing the path for distinct, sustainable FDs that are adapted to each consumer's preferences.

INTRODUCTION

Artificial intelligence (AI) is an essential development in the rapidly evolving fields of production and design, challenging conventional methods to promote new kinds of imagination and creative thinking [1]. A fresh environment where robots may complement the imagination of humans while also eliminating routine duties is currently developing at the boundary of AI and the arts and crafts sector, which is a meaningful change away from conventional approaches [2]. The discipline of Furniture Design (FD) benefits substantially from this collaboration because it demands an advanced approach that reconciles design aesthetics, functionality, and environmentally conscious design [3].

The environmentally friendly and adaptable Bamboo Furniture (BF) offers a unique chance to participate in improvements based on AI. AI systems that can sort among vast amounts of data, understand customer demands, and produce aesthetically pleasing and practical designs are in substantial demand due to an increasing emphasis on customized and environmentally friendly designs [4-5]. The research being investigated explores the use of AI tools in BF design and production, focusing in particular on how to employ feedback from customers to make products that people truly value.

Based on ideation to produce goods, AI serves an integral role in all phases of FD [6]. By using complex algorithms, innovators are able to delve further into a more significant number of possibilities, free themselves from conventional drawbacks, and promote a more creative approach [7]. Tools driven by AI render massive customization possible, which enables highly accurate design adaptation for specific needs [8]. In addition to satisfying the growing need for distinctive, personalized products, the level of adaptation improves satisfaction among consumers.

A fundamental change towards an increased human-centric methodology has been accomplished with the introduction of customer feedback into the method of design [9]. Architects can discover several things about consumers' behaviors and preferences through the use of approaches from information technology, psychological theory, and the interaction between humans and computers. By using AI, these ideas, patterns, and trends emerge, which in turn help to the creation of FDs that are environmentally friendly, useful, and visually appealing [10-12]. Researchers point out the crucial role of feedback from customers in encouraging creativity in the present research that investigates the approaches and purposes of AI in Bamboo Furniture Design (BFD). The paper attempts to demonstrate the revolutionary promise of AI for creating BF that reaches beyond conventional consumer demands by thoroughly evaluating AI-driven design methods, customization features, and environmentally friendly factors. These findings indicate the import of data-driven design, where AI supports creativity and enables designers to challenge the scope of FD [13].

In the following sequence, the sections of the article are given as follows: Section 2 covers the background material of the study's conduct, Section 3 explains the methods used, Section 4 describes the analysis, and Section 5 concludes the results of the research study.

2.0 Background

2.1 AI in Creative Industries

A frame of reference change in generation after generation, manufacturing, and marketing of new ideas is being triggered by the introduction of AI into the fields of creativity. In areas including the arts of photography, literature, composition, and fashion, where AI is not only automating tasks but also boosting the creative process and enabling fresh kinds of expression that are artistic, this combination is particularly evident [14]. When employed in the art of design, AI algorithms may assist in developing new designs and frameworks that challenge the accepted standards of traditional aesthetics and usefulness. As a prime instance, AI has a chance to transform design by providing real-time simulations of numerous structural variations. This enables designers to probe more into more complicated and successful design models. The fashion sector is no exception; AI-powered tools research market dynamics and customer preferences and recommend novel designs, which improves the manufacturing process by predicting what designs will perform best.

In the field of artwork [15], AI has created a role through the application of tools such as neural cultural transmission and Generative Adversarial Networks (GANs), which produce works of art that are on scale with or possibly more sophisticated and attractive compared to works made by people. More individuals are able to participate part in creating art without professional instruction due to modern tools. However, they also make people consider what it takes to be innovative and original. The algorithms additionally create impacts in the music sector with compositions that include pop songs to complete symphonies. In order to generate fresh songs that are both visually appealing and unified, these AI systems search through enormous music libraries to find similarities and edifices. What emerged was a creative combination of human and computer inventiveness that has the ability to bring in a new era in the creation of music [16]. Also, recommendations that use AI to predict audience preferences in music, movies, and online games serve to adapt viewing experiences and increase engagement among users. Not only does this make users more fulfilled, but it also assists companies in these fields more effectively in relating their goods or services to customers' demands.

2.2 AI for FD Innovation

The imaginative application of AI in FD (Figures 1 (a) to (c)) indicates an enormous shift in the creation, design, and manufacturing process of home furnishings. Designers have the capacity to develop more creative, customized, and sustainable furniture products because of AI's impact through the entire design lifecycle, from concept to final production processes.

- **Concept Generation and Design Exploration:** By developing designers' ideas for different concepts, AI-powered tools are changing the creative thinking process. Generative AI can explore various possible design solutions. Designers can select the optimal design from the generated multiple solutions and further optimise and refine it. As an innovative design method, generative design significantly improves the efficiency and quality of furniture design, stimulates the creativity of designers, and reduces the design cycle by using computer algorithms to automatically generate multiple design solutions. With the development of artificial intelligence and big data technology, generative AI will play an increasingly important role in the field of furniture design, promoting the innovation and development of the industry.
- **Customization and Personalization:** When it comes to permitting considerable modifications, AI technologies really excel. AI systems may customize products that meet the demands of each customer through the analysis of data from user interactions and choices. Based on psychological data, BF might have to make changes to measurements, resources, or frame components to make them cozier and more functional. AI's rapidity and precision in merging and analyzing large amounts of data allow it to present recommendations that are customized to different opinions, which permits a certain level of customization.
- **Simulation and Prototyping:** AI supports a digital model of the design and function of an object of furniture before actual models are created. This is important in order to identify probable errors in design and test multiple substances under various conditions. AI may approximate the features of bamboo, such as its ability to support weight and resistance to wear, which can help designers refine their creations before starting manufacturing.
- **Optimization for Manufacturing and Assembly:** The optimization of the production process to minimize waste while boosting efficiency is an area of concern where AI plays an important role. With the support of AI, furniture makers and designers can predict the most efficient method to set up materials to minimize waste, which is especially significant when employing sustainable resources like bamboo. AI may additionally minimize costs and reduce time during production by suggesting the most optimal possible production processes.
- **Sustainability Analysis:** The most essential aspect of FD in today's socially aware business is environmental sustainability. AI studies resource life cycles and recommends alternatives that are environmentally friendly but lack in quality or visual appeal, permitting designers to minimize innovative designs' ecological impact. AI may analyze BF's products in order to assess production methods and adverse environmental effects, and it can even recommend methods to make the furniture endure more time and be good for the surroundings.

Figure 1: a) to c) AI-generated BFD

2.3 User Perception-Based Design Process

Designing products with the user's desires, demands, and views in mind from the beginning is the ultimate objective of the user perception-based design approach, which is an enormous change from past methods. In the framework of BFD, where both aesthetics and functionality are essential to customer satisfaction, this method provides the basis for customer-driven design methods because it integrates various techniques from fields like information technology, psychological theory, and interface design.

It all commences with collecting an enormous quantity of data on what customers think. As part of this method, experts will use interviews, questionnaires, user testing, and personal inquiries to collect qualitative and quantitative data. As a component of BF, designers may study user behavior to determine the shape, material structure, durability, and color scheme choices concerning furniture elements. In addition to more conventional data collection techniques, such as interviews and questionnaires, advanced methods, such as eye-tracking and emotion recognition algorithms, can be implemented to collect data on consumers' subtle, unaware responses.

Processing and evaluating the collected data to identify trends is where AI really excels. By evaluating plenty of consumer feedback, ML models—especially those based on NLP and predictive analytics—can discover encoded preferences and trends. Consider feedback from clients and reviews as a case study. By using sentiment analysis, businesses can assess customer satisfaction and pinpoint locations that could use some enhancement.

Implementing the results to guide the creative approach is the subsequent level. Approaches from Generative Design (GD) are of particular use in this context. Using consumer preferences found via the analysis of data, advanced AI systems produce multiple design choices that depend on factors like sizes, products in order, and predicted load-bearing capacity. By fusing their artistic skills with AI-generated designs, designers might refine their decisions till they create BFD that not only exceeds but outperforms consumer demands.

In the end, design and repeated testing are highly significant. After designs have been reduced down through generations, models are created and then evaluated with actual people to collect their opinions. This data is then used to enhance the designs over time. This process continues until a design has been developed that meets both its practical needs and the demands of the users. A more robust connection between the product and its users develops through the user perception-based design method, boosting the product's appeal and functionality. Businesses can increase customer happiness, trust, and profitability by integrating consumer feedback into the manufacturing process while developing products that fit their demands and preferences.

(a) (b) (c)

Figure 2: a) aesthetic influence, b) Comfort and Ergonomics influence, c) Cultural and Innovative influence

User perception in the context of BFD can vary widely depending on several factors like demographics, cultural influences, and individual preferences (Fig. 2 (a) to 2 (c)). Here are a few key aspects of user perception that are particularly important:

- **Aesthetic Appeal**: How visually appealing users find the BF, including style, color, finish, and overall design.
- **Comfort and Ergonomics**: The level of comfort provided by the furniture, which includes ergonomics like the shape, dimensions, and how well the furniture supports the body during use.
- **Durability and Quality**: Perceptions about the sturdiness, durability, and overall quality of the bamboo materials and construction methods used.
- **Functionality**: The quality of usability flexibility to multiple empty spaces and functional features all impact how effectively furniture performs the purpose it was designed for.
- **Environmental Impact**: Considering bamboo is a renewable material, the level to which the furniture is deemed as being environmentally friendly is significant. Factors like the legal procurement of bamboo and the low impact of manufacturing on the natural environment form a component of the approach.
- **Value for Money**: Value and cost experiences, considering the cost when compared to the furniture's assessed durability and high quality.
- **Cultural Fit**: The level of significance to which the furniture reflects the consumer's historical and culturally particular aesthetic choices as they relate to the area in consideration.
- **Innovativeness**: The measure of creativity and originality that people associate with the objects of furniture, primarily when AI, along with other cutting-edge innovations, were employed throughout its design.
- **Maintenance and Care**: The accessibility with which the home furnishings can be cleaned, repaired, and generally maintained.
- **Health and Safety**: Complaints or comments regarding the furniture's safe coverings and stability and additional safety and health-promoting concerns.

Product designers and manufacturers are able to tailor their products to the demands and requirements of the consumers they are targeting by knowing these facets of consumer opinion.

2.4 Machine Learning (ML) Approaches in Furniture Design

Designers' approaches to creating and developing furniture have been drastically changed by the addition of ML techniques. With the support of MLs based on data computations, the design process can be more intelligent, successful, and innovative, enabling it to adapt to increasing customer preferences and practical demands.

- **Predictive Analytics**: The deployment of analytics to predict is a core of ML in FD. ML algorithms may predict new furniture designs by studying previous sales data, feedback from consumers, and market dynamics. It allows designers to predict their most common designs, products, and features in order, allowing businesses to come up with ideas ahead of time instead of in response to market requirements.
- **Generative Design**: With the use of variables such as sizes, materials, and limitations on funds, GD algorithms use ML to create several design choices. In addition to promoting rapid ideation, this technique tests the boundaries of traditional design by providing patterns and styles that human designers might not instantly identify. To demonstrate the concept, ML

may improve the design of furniture items to guarantee optimal weight distribution, durability, and material efficiency. The outcome is an item of furniture with novel shapes that effortlessly integrate functionality with aesthetics.

- **Customization at Scale**: With ML, large-scale customization can be achieved because designs can be freely changed to meet specific preferences without significantly increasing the price of manufacturing. The application of algorithms allows for the real-time customization of designs according to an awareness of and prediction of personal preferences obtained from data about customers. In today's market, where personalization is a point of differentiation, this method is advantageous.
- **Material Optimization**: Using the support of ML algorithms, designers are able to select the best materials for their creations. ML may choose the most cost-effective and environmentally friendly components for an object of furniture by considering its design preferences, environmental sustainability login information, material durability, and other pertinent factors.
- **Quality Control**: ML is added during manufacture to ensure adherence to design criteria and high standards. To make sure their products are up to par, manufacturers can use ML-trained computer vision systems to identify and correct mistakes in design or deviations automatically while they're creating the final product.
- **Sustainability and Lifecycle Analysis**: ML supports FD as more environmentally friendly by predicting the ecological effects of different design adoptions by ecosystem analyses. ML provides designers with the information required to make sustainable decisions, like choosing more durable or recyclable components, by replicating a product's complete history.

3.0 METHODOLOGY

3.1 Data Collection: A Case Study on Congregation User Perception Data

The succeeding section presents an in-depth examination detailing how we collected user feedback for a office leisure chair with a furniture manufacturer. Employing several polls and feedback forms, the approach attempts to understand a specific demographic's views of the chairs' aesthetics, functionality, and safety.

i. **Sample Population**: The participants in this research will be workers in offices (those who sit at a workstation for the majority of their day of work, usually between the ages of 25 and 50). The sample of participants comprised an extensive selection of genders, jobs, and logistic demands; it originated from five businesses situated in Guangxi, Guangdong and Zhejiang, China. The 100people who participated were selected at random from among, but we ensured that they comprised an equal number of staff members from every organization.

ii. **Survey Design**: The online questionnaire included 20 questions that had been developed specifically to assess different facets of the work environment chairs' customer service. For easier use of quantitative analysis, questions have been separated into multiple-choice and Likert scale responses. Three questions were left open-ended to collect qualitative findings.

The survey covered topics such as:

- Overall satisfaction with the chair.
- Comfort level during and after use.
- Adjustability and its effectiveness in providing personalized comfort.
- Aesthetic appeal and suitability for the office environment.
- Perceived durability based on usage.

iii. **Feedback Forms**: Users were prompted to fill out a feedback form after a few weeks of using the chairs. The form specifically inquired about their durability and whether their views had shifted due to frequent use. In order to maintain the request for feedback in simple terms, we used a five-point Likelihood Scale (ranging from "very unsatisfied" to "very satisfied") to ask five important inquiries and allowed ample space for comprehensive comments, particularly specifics regarding any discomfort or features that were unavailable.

3.2 Analyzing User Data to Extract Insights for Design Innovation

Modern office leisure chair designs depend significantly on the analysis of user data collected from polls and feedback forms. In order to gather information about user opinions, happiness, and issues, this comprehensive examination uses data analysis and concept creation. In order to enhance the product in an in-depth manner, this method integrates both short-term survey results and long-term input from customers.

Quantitative Analysis of Survey Data: Comfort, flexibility, visual appeal, and stability were some of the features that consumers had the most excellent satisfaction with based on the preliminary survey findings. On a ranking system ranging from 1 to 5, every questionnaire item was assessed, and a degree of satisfaction was determined based on ratings above 3. To show the response of the chair, consider the 'Comfort During Use' feature, which obtained an impressive average rating of 4.5 from 90% of users. 'Physical Discomfort Reported', on the other hand, could use a few improvements; it only received 2.5 out of 5 stars, and 60% of the people surveyed were happy with it. In order to find the design's shortcomings and strengths, statistical methods were utilized, including mean research and satisfaction proportion computation.

Thematic Analysis of Feedback Forms: A broader overview of the customer's behaviour as time passed has been shown by the input provided on forms that were filled out following a few weeks of use. For this study, we employed the chair's distinctive features to divide opinions into general trends. Even though the average rating for "Long-term Comfort" was 4.4, 12% of those surveyed said they had issues with the assistance of the cushions, suggesting a demand for materials that keep individuals happy for extended. Comparably, the design team was instructed to consider ergonomic changes in the points of armrest height and back support due to the 'Physical Discomfort Reported' category's 40% fault rate, which clearly pointed to flaws with these components.

3.3 Integration of Insights for Design Innovation

Improvements to the design were ordered by priority based on the pooled findings from the two datasets. Attempts were taken to maintain the advantages of earlier designs in areas where there was a significant connection between favorable reviews and happiness, such as perceived stability and visual appeal. In addition, modifications and physical discomfort were the features that were the primary objective of design modifications due to poor satisfaction and particular feedback indicating discomfort. In response to customer comments about the flexibility feature, for example, we standardized the controls and made the instructions more explicit so that they would be simple for people to comprehend and use. The outcomes of the polls and feedback forms on the chairs for the office are outlined in Table 1, and the analysis of the results throughout several weeks of use is displayed in Table 2:

Table 1: Findings from survey and feedback forms

Survey Item	Average Rating (Out of 5)	Percentage Satisfied (>3 Rating)
Overall Satisfaction	4.2	85%
Comfort During Use	4.5	90%
Adjustability Effectiveness	3.8	75%

Aesthetic Appeal	4.0	80%
Perceived Durability	4.3	87%
Long-term Comfort	4.4	88%
Physical Discomfort Reported	2.5	60%

Table 2: Analysis of the feedback forms

Feedback Item	Average Rating (out of 5)	Percentage Reporting Issue	Key Insights
Long-term Comfort	4.4	12%	Sustained comfort for most; need better cushion support for extended use.
Physical Discomfort Reported	2.5	40%	Issues with armrest height and lumbar support, suggesting redesign.
Adjustability Effectiveness	3.8	25%	Adjustability features are well-received; they need more superficial, more intuitive mechanisms.

3.4 AI Integration: Enhancing Design through GD of AI

Redefining the design procedure for comfortable workplace furnishings, the GD of AI in analyzing user data gives designers an advanced toolset for creating innovative, human-centered designs. To develop GD models that can adapt rapidly to new customer demands, this novel AI collects enormous amounts of input from customers.

GD Models: By using ML algorithms, the GD of AI develops numerous design solutions based on defined criteria like visual appeal, comfort, and user-reported happiness ratings. In order to find the most effective designs that respond to user interests and fulfill practical demands, these AI models analyze trends in user data. For instance, GD of AI recommended multiple changes to design differing in size, shape, and material to determine the best practical fit when feedback from customers highlighted problems with back support.

Simulation and Testing: After the GPU of AI proposes viable design solutions, it employs simulation techniques to predict how those designs will perform in real-life scenarios. Virtual settings are used for stress tests, physiological reviews, and durability testing. Essential as it is for minimizing production time and resource costs, this step decreases the designs by selecting the most financially viable ones before proceeding to manufacturing.

Rapid Prototyping: The process of designing prototypes is also expedited by GD of AI. Rapid prototype creation using 3-D printing and numerically controlled machining enables real consumers to inspect and review AI-generated designs. In this repeated method of rapid testing, users can provide immediate input that is then used to improve the designs by feeding it back into the ML models.

Iterative Design Process: The iterative loop, powered by the GD of AI, continuously enhances the design based on ongoing user feedback. This process enables a dynamic approach to product development where design adaptations are made in real time, ensuring that the final product remains cutting-edge and highly tailored to user needs.

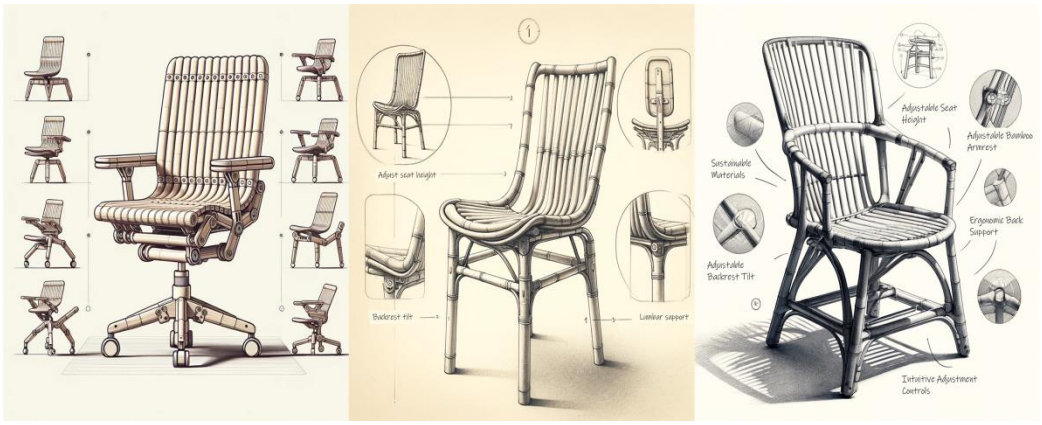
3.5 Design Innovations: Inspired by AI Analysis of User Perceptions

The insights derived from AI analysis of user data directly influenced several innovative changes and introductions of new features in office Leisure chair designs.

Ergonomic Adjustments: Based on user feedback indicating discomfort with armrest and lumbar support, AI-driven GD algorithms were used to create multiple variations of armrest shapes and lumbar support mechanisms (Fig. 3 (a)). These designs were then tested virtually for ergonomic efficiency and comfort, using AI to simulate different body types and seating positions.

Sustainable Material Use: Predictive analytics highlighted a growing user preference for sustainability (Fig. 3 (c)). In response, AI was used to analyze the environmental impact of various materials, helping designers select those that balanced durability, comfort, and sustainability. Additionally, AI simulations tested the long-term environmental impact of these materials, ensuring that the chairs were both user-friendly and eco-friendly.

Aesthetic Customization: AI also facilitated greater customization in aesthetics without compromising ergonomic integrity (Fig. 3 (c)). Using data from user preference trends, AI-GD offered a range of colour and material finishes that could be personalized for individual tastes while maintaining overall design consistency.



(a) (b) (c)

Figure 3: a) Ergonomic design, b)Intuitive adjustment controls, c) Sustainable and Aesthetic materials（It is proposed to change figure（a） into a bamboo office lounge chair with armrests and backrest.）

4.0 Statistical Analysis

4.1 Quantitative Data Supporting the Improvements in Design and User Experience

The statistical analysis (Table 3) of user feedback data before and after implementing the design improvements highlights significant enhancements in various aspects of the BF. Here's a detailed look at the quantitative data supporting these improvements:

Comfort Level: The comfort level experienced a notable increase from an average rating of 3.8 before the improvements to 4.7 after, reflecting a 23.68% improvement. This significant enhancement indicates the success of the ergonomic features incorporated into the new designs.

Intuitive Controls: The intuitive controls feature demonstrated the highest percentage of improvement, with the rating rising from 3.2 to 4.3, marking a 34.38% increase. This significant enhancement highlights the effectiveness of making the controls more user-friendly and accessible.

Aesthetic Appeal: The aesthetic appeal of the furniture improved from an average rating of 4.0 to 4.8, showing a 20.00% increase. The design's visual components and adaptability were appreciated, and this demonstrates that.

Sustainable Materials: The amount of usage of environmentally friendly products used to be considered good at 4.2, but after the changes, it increased to 4.6, representing a 9.52% boost. It indicates that the furniture's sustainable development and the business's commitment to the environment are highly valued by people who use it.

Customization Options: A rise of 18.92% was introduced to the choice of customization, which increased from 3.7 to 4.4. All that suggests is that users are far more satisfied now that they are able to render their home furnishings unique.

Value for Money: A 7.69% boost was found in the opinion of value for money, which improved from 3.9 to 4.2. While this might only count for a small portion of the total, it indicates that users' opinions on the furniture's value have evolved for the greater good.

Durability Perception: Opinions of life increased by 9.76%, from 4.1 to 4.5. Customers trust the furniture's long-term reliability and dependability because of this.

Maintenance Ease: A score boost from 3.8 to 4.4 implies a 15.79% increase in maintenance simplicity. This indicates that consumers had an improved experience overall since the latest designs were less of an inconvenience to clean and maintain.

Statistical analysis demonstrates that BF's customer service has been significantly enhanced throughout all platforms as a result of the design modifications. This statistical information indicates how well AI and consumer input combine to produce creative designs that are up to standard with the expectations consumers expect.

Table 3: Design and customer experience optimization data analysis

Design Aspect	Before Improvement (Avg Rating)	After Improvement (Avg Rating)	Improvement Percentage
Comfort Level	3.8	4.7	23.68%
Intuitive Controls	3.2	4.3	34.38%
Aesthetic Appeal	4.0	4.8	20.00%
Sustainable Materials	4.2	4.6	9.52%
Customization Options	3.7	4.4	18.92%
Value for Money	3.9	4.2	7.69%
Durability Perception	4.1	4.5	9.76%
Maintenance Ease	3.8	4.4	15.79%

5.0 CONCLUSION

An enormous movement advance in the industry's innovative design and manufacturing processes has been made with the introduction of Artificial Intelligence (AI) into Bamboo Furniture Design (BFD). By a thorough examination of customer opinions and choices, this research investigation has demonstrated how AI could transform Furniture Design (FD), customization, and environmental sustainability. Whether improving production procedures or developing GD ideas, AI-driven tools have proven extremely useful across the creative process. Designers are able to expand their scope, and test accepted assumptions about design and functionality by employing algorithms that analyze customer data and approximate performance in the real world. AI's power to allow extensive customization—the accurate tuning of designs to customer preferences—not only increases user happiness but also meets today's market demand for personalized goods. Data demonstrates that user satisfaction improves significantly when user perception is considered throughout the design process. Substantial collection and analysis of data have provided significant knowledge into customer choices; these results will inform the creation of visually pleasing and functionally practical furniture. Findings demonstrate substantial improvements in important areas of design, including ergonomics, user-friendliness, sustainability, visual appeal, and control clarity. The statistical proof of these advances demonstrates that applying AI and customer input into creative design ideas provides better results than envisioned.

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