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ORIGINAL

EXPLORING THE INFLUENCE OF ECO-FRIENDLY SOFT FURNISHING DESIGN ON SPORTS FACILITY INTERIORS

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ABSTRACT

This study investigates the impact of eco-friendly soft furnishing design on the interior spaces of sports facilities, focusing on sustainability and environmental protection. By employing a quantitative approach through surveys and VGA picture analysis at the University of Mosul's architectural engineering departments, the research assesses how sustainable design features contribute to the functionality and livability of educational settings. A random sample of students who utilize these spaces provided insights into the connection between user needs, environmental considerations, and design elements. The findings highlight the importance of integrating sustainable design principles to enhance the usability and ecological footprint of interior architectural spaces in sports facilities.

KEYWORDS: Soft Furnishing, Interior Architectural, Environmental Protection, Low Carbon

1. INTRODUCTION

The intersection of interior design, environmental sustainability, and sports architecture offers a fascinating glimpse into how spaces can be optimized for both human performance and ecological responsibility. This study focuses on the role of soft furnishing design in enhancing the functionality and aesthetic appeal of sports facilities, while adhering to low-carbon and environmentally protective principles.

The importance of sustainable interior design is increasingly recognized in the context of sports facilities where the health and well-being of athletes are paramount(Liu, 2018). Interior design in sports facilities goes beyond mere

decoration. It encompasses the creation of environments that can significantly influence athlete performance, spectator experience, and overall energy consumption. Effective design solutions contribute to the psychological well-being of athletes, promoting relaxation, focus, and optimal performance. Moreover, for spectators, these spaces provide comfort and accessibility, enhancing their overall experience and satisfaction.

1.1 The Role of Soft Furnishings in Sports Environments

Soft furnishings in a sports context include items such as seating, mats, curtains, and carpets—elements that contribute to the acoustics, comfort, and thermal regulation of the space. The choice of materials and design of these furnishings can have substantial impacts on the environmental footprint of a facility. Sustainable soft furnishings are those selected and designed to minimize environmental impact through responsible sourcing, durability, and non-toxicity(Qin, Liang, & Zhou, 2018).

1.2 Low-Carbon and Environmental Protection in Design

Focusing on low-carbon and environmentally protective design principles involves using materials and methods that reduce carbon emissions and waste. This includes selecting furnishings made from recycled or rapidly renewable materials, utilizing low-emission manufacturing processes, and designing for longer life cycles to reduce turnover and waste. Additionally, these practices align with global sustainability goals and can significantly reduce the operational costs of sports facilities by minimizing energy consumption(Tomasi, Caparelli, Panepucci, & Foerster, 1999).

The methodological approach of this study involves a detailed analysis of the interior spaces of the architectural engineering departments at the University of Mosul, using surveys and VGA (Visual Graphics Array) picture analysis. By directly engaging with the students who utilize these spaces, the study aims to capture firsthand insights into how well current designs meet user needs and support sustainability goals. (Zhijun, 2019).

1.3 Research Objectives and Questions

This study is guided by the primary objective to identify and analyze sustainable characteristics that can make the interior spaces of educational settings, specifically those related to sports, more livable and conducive to users' needs. The central research question asks, "What are the sustainable characteristics that can make the interior space in educational settings livable?" Addressing this question involves exploring various dimensions of design and user interaction to offer recommendations for enhancing both environmental sustainability and user satisfaction in sports-related architectural spaces.

1.4 Continued Exploration

The subsequent sections of this paper will delve deeper into the specific sustainable practices employed in the design of soft furnishings for sports facilities, the impacts of these practices on user experience and environmental outcomes, and the broader implications for the field of sports architecture. By integrating theoretical perspectives with empirical findings, the study aims to contribute meaningful insights to the disciplines of interior design and sports management, advocating for a holistic approach to creating spaces that are both high-performing and environmentally responsible.

1.5 Theoretical foundations in furniture identification

According to Mono's theory, products have two parts of the aesthetics form function and content and symbolic function, which together make up the essence of that object's gestalt. These functions are distinct from technical performance functions. Due to its lack of interaction with the environment and the audience, an object lacking form beauty and conceptual content cannot ultimately be an effective object and lacks the appropriateness and equilibrium required to constitute a collection. (Wenbin & Xiaoyong, 2016)Furniture is influenced by elements other than those of a single dimension as a result of its diverse functioning and wide range of uses. This topic is useful for the process of designing furniture. The dominance of aesthetic goals in the product's shaping by the designer may enable the designer to employ more creative strategies. The balance of the social, form, technical, and economic elements, as illustrated in Table 1, determines the shape of the furniture and the degree of contact with the user and the space.

Table 1: Effective factor in the formation of interior furniture

ECONOMIC FACTORS	TECHNICAL FACTORS	FORM FACTORS	SOCIAL FACTORS
PURCHASING POWER	desirable performance	Symbols Content of work	Culture
RIVALS	Ergonomic	Aesthetic Proportions	Tradition
FASHION	Manufacturing ability	Ergonomic proportions	Social Class
ADVERTISEMENT	Multipurpose	Style of furniture	Psychological needs of the audience

The collection's aesthetics are determined by the matching arrangement of the components in the furniture form, which is derived from the proportions of the components in relation to one another, just like in internal architecture. The introduction of the final form is essential. A piece of furniture is impacted by a variety of elements from many areas that include content and define identity (B. W. Guo & Y. X. Guo, 2016). The form structure pattern of the various furniture types demonstrates how form and social index function as a connected

loop of form and content in interactions with people. Due to the fact that culture and social feedback serve to produce symbols, beliefs, and visual messages, some of which include decorations. Culture has specific social patterns that reveal a portion of the values, thoughts, and beliefs that are manifested in things, services, and activities.

Objects, various styles, food, clothing, products, and spaces are all linked to objectivity in culture. The level of taste and the quantity and kind of audience demand, on the other hand, are determined by socioeconomic circumstances and are important in determining the style. The type of furniture in the two styles shown in Figures 1 to 3 represents contrasting attitudes toward form, macro and micro aspects, consumer culture, target community psychology, market demand, and audience purchasing power.

Figure 1: Art Nouveau Chair2

Figure 2: Interior view of the Hotel Tassel 3

Figure 3: Chairs and pots Work of Alvar Aalt

Figures 1 and 2 depict furniture and a room with Art Nouveau-inspired details that combine macro and micro elements. These two designs have a unique harmony thanks to the usage of stretches and dips in the space, as well as the colours, textures, and vegetative element symbols. one of the styles that was influenced by the philosophy of the East and the Far East is the Art Nouveau style. This philosophy has an attitude that is infinite and productive, which is reflected in the beginning and end of the main lines in the body of design and space. Therefore, the chair in picture 1 and the space in the Tassel Hotel in figure 2 are clearly related. Figure 3, created by Aldo Alvar, on the other hand, illustrates the many form-styling techniques as well as the application of free lines and curves. He used the margins to influence his conception of and approach to modern design (Chang, Huang, & Lai, 2015). In his works, he included forms found in the ocean, mountains, and land ecosystems and demonstrated how, for instance, wavy and circular edges may be used in pots. One of the most well-known furniture designs in the world, his chairs feature soft and pleasant forms and were created utilising processed natural materials like wood layers. Alto was able to bend multi-layer boards into chairs that were designed with comfort in mind while deciding where to position the legs and seats. Despite having various perspectives on contemporary design, this style adopts a biomorphic appearance.

2. Review of Literature

The integration of sustainable design in sports facilities, particularly through the use of environmentally friendly soft furnishings, has emerged as a crucial aspect of modern architectural practice. This literature review delves into the current research surrounding the application of low-carbon and environmentally protective design principles in sports environments, focusing on the selection and implementation of soft furnishings that enhance both athlete performance and environmental sustainability.

2.1 Sustainability in Sports Facilities

The concept of sustainability in sports facilities has evolved significantly over the past few decades. Initially focused on the energy efficiency of large stadiums and arenas, the scope has broadened to include the materials used within these spaces, particularly soft furnishings. Studies such as those emphasize the need for sports facilities to reduce their carbon footprint by adopting sustainable materials and technologies in construction and interior design. The research highlights how sustainable practices can not only reduce environmental impact but also lower operational costs in the long term.

2.2 Soft Furnishings and Athlete Performance

The relationship between soft furnishings and athlete performance is well-documented, with research indicating that the physical environment can significantly affect an athlete's psychological well-being and performance. For instance, (Kim, Yang, Abdel-Malek, & Nebel, 2005) explore how the tactile and aesthetic qualities of interior materials can influence athletes' stress levels and mental preparedness. These findings suggest that carefully chosen soft furnishings that adhere to both ergonomic and ecological standards can play a pivotal role in enhancing athletic performance(Yang, 2008).

2.3 Eco-Friendly Materials in Interior Design

A critical component of sustainable interior design in sports facilities is the use of eco-friendly materials for soft furnishings. According to a study material such as recycled fabrics, organic cotton, and natural rubber have lesser environmental impacts and are increasingly being utilized in sports settings. These materials are not only sustainable but also contribute to the health and safety of the space, a factor particularly important in sports environments where physical contact with surfaces is frequent.

2.4 The Role of Technology in Sustainable Design

Technology also plays a significant role in the sustainable design of sports facilities. Innovations such as digital modeling and material lifecycle assessments allow designers to predict the environmental impact of their choices before implementation. As noted by (Jin, Shi, & Huan-Huan, 2013), advanced technologies like BIM (Building Information Modeling) and digital twins are crucial for optimizing the design and operation of sports facilities in a sustainable manner.

2.5 Challenges and Opportunities

Despite the apparent benefits, the transition to sustainable soft furnishings in sports facilities faces several challenges. Cost implications,

durability concerns, and limited availability of suitable materials are frequent obstacles cited by facility managers. However, as discussed by(Renyi & Bingbing, 2017) these challenges also present opportunities for innovation and development within the industry, pushing manufacturers and designers to explore new materials and methods(Lou, 2019). The literature on sustainable design in sports facilities underscores the importance of integrating environmental considerations into every aspect of architectural design, from the macro scale of the building down to the micro scale of interior furnishings. As this field continues to evolve, further research is needed to address the existing gaps, particularly in the long-term sustainability of eco-friendly materials in the physically demanding environment of sports facilities. This will not only contribute to the global sustainability agenda but also ensure that sports facilities continue to serve as spaces of safety, comfort, and performance enhancement.

3. Interior design and space planning with several intelligences at play.

3.1 Basics of Indoor Space Layout

The indoor environment, which mirrors the external environment, is where most people live and work. Indoor settings need to fulfil peoples' basic needs for production and survival as well as their spiritual aspirations. Thus, the profession of interior design was established. The secret to successful interior design is to apply architectural design principles to give the interior space specific purposes that are appropriate to its nature, surroundings, and standards. Indoor sceneries are typically displayed using a specific layout (B. Guo & Y. Guo, 2016). The arrangement is also what makes indoor scenes unique, and it is the aspect that most accurately captures their features. As a result, indoor space planning has also emerged as a crucial component of interior design. As 3D technology continues to advance quickly, 3D models of indoor settings are being used in an increasing number of contexts, including CG animation films, 3D game settings, and virtual reality scenarios. These games frequently have dynamic indoor scenes that users can explore. Research on indoor space layout has directly resulted from the pressing requirement for indoor scene modelling. Even though academics have conducted a lot of research on indoor space planning, just a few well-developed research applications have been made.

3.2 The Indoor Environment Data Model's Core Data Module

The interior climate space matching framework, space format data entry, space design metadata administration framework, and space format streamlining the board framework are all essential for the indoor climate space format's major information module. (Jiao & Chen, 2019)The previously mentioned subsystems are utilized to separate the essential data for the indoor

climate space design. Figure 4 portrays the spatial game plan matching framework.

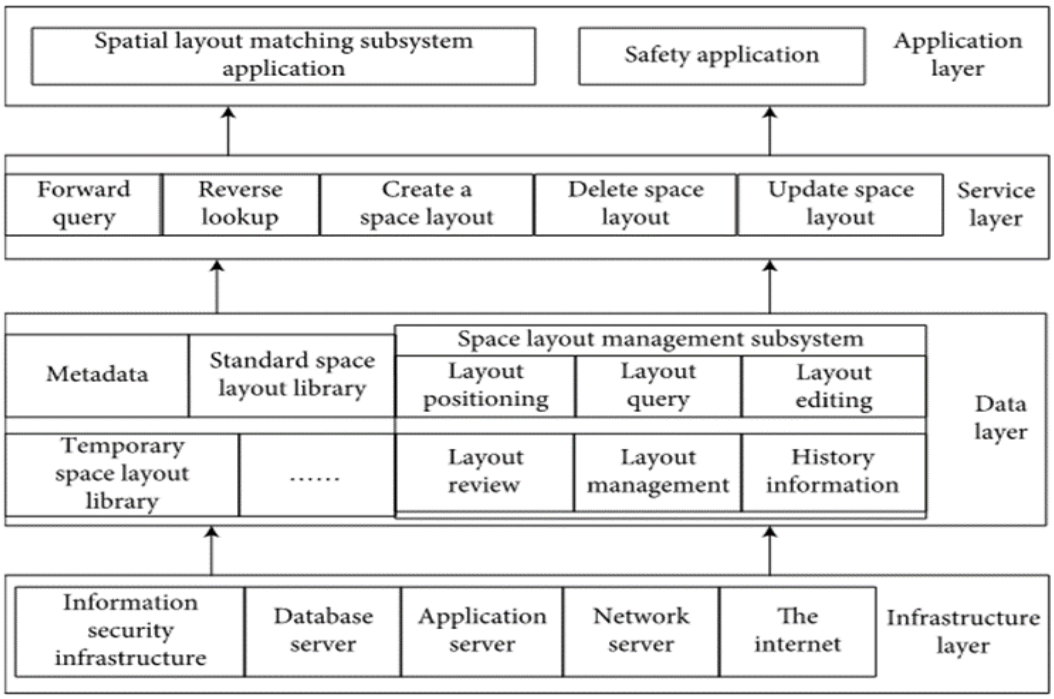

Figure 4: Method for organising and matching physical spaces.

3.3 Relevance of Spatial Organization to Study

There is critical exploration esteem in the independent plan and streamlining of indoor space course of action. The customary format configuration is work escalated and wasteful, regardless of the way that interior space design has a critical application history in many fields. The ongoing techniques for design configuration are fundamental and juvenile, with frustrating outcomes and various fabricated issues like complex cooperation. The format of interior spaces can be consequently planned and enhanced, which can essentially diminish the responsibility of creators and even advantage buyers straightforwardly. (Wenru, 2020)Reenactment carries out programmed plan during the space configuration process, which significantly limits the responsibility of the creator and improves the efficiency and responsibility of format plan. The essential disadvantage of manual format is that it is obliged by the ability and mastery of the planner, and that utilizing PC help regularly creates improved results than manual plan.

4. STUDIES ON THE OPTIMIZATION OF INTERIOR SPACES

4.1 Create a Model of the Spatial Organization of the Indoor Environment

The indoor width and indoor length are first used to decide the

standardized section entryway direction of the indoor climate space, which is then acquired by normalizing the entry position of the indoor climate space.

$$E_x = \frac{E_{xo}}{W} \qquad (1)$$

$$E_y = \frac{E_{yo}}{L} \qquad (2)$$

The two-layered covariance grid of the indoor climate

$$C_{2\times 2} = \begin{bmatrix} cov(x,x) & cov(x,y) \\ cov(y,x) & cov(y,y) \end{bmatrix} \qquad (3)$$

$$Cov(x,y) = Cov(y,x) \qquad (4)$$

The geometric feature of the indoor environment space is

$$F = \left(E_X, E_{Y,} S, R, C\right) \qquad (5)$$

Among them, is the region of the indoor climate space, the proportion of the length to the width of the indoor climate space is, and the augmentation of the indoor climate space is.

The area directions of the indoor climate space are

$$x_p = \frac{x}{w} \qquad (6)$$

$$y_p = \frac{y}{L} \qquad (7)$$

Among them, addresses the direction worth of the position point of the indoor useful region on the - hub of the indoor climate space design coordinate framework, and addresses the direction worth of the indoor practical region area point on the - hub of the indoor climate space format coordinate framework.

4.2 Upgrading the Staggered Design of Spatial Highlights

The staggered reproduction model of spatial qualities is utilized as the populace, the populace is instated, and the wellness of various people in the whole populace is determined

$$f(i) = \frac{k}{f(U_i)} \qquad (8)$$

The likelihood of an individual being chosen in the populace wellness

$$V_i = f(i) \sum_{i=1} f(i) \qquad (9)$$

Aggregate likelihood of people in populace wellness:

$$R_i = \sum_{j=1} V_i \qquad (10)$$

Crossover probability:

$$V_c = \frac{n}{2n} + \frac{f_i f}{2(fmaxf)} \qquad (11)$$

5. Simulation Experiments

5.1 Virtual Simulation

Two arrangements of unmistakable autonomous styles are gotten and models are created, marked as endlessly set, subsequent to summing up and breaking down the interior plans of the three shopping centres. Each set contains numerous signs of a similar kind. Set is fundamentally splendid in variety, with a scope of improving tones and shapes; logo set is essentially dim in variety, with a couple of beautiful varieties, and the shape is overwhelmed by a solitary square shape. The things recorded are basically mathematical or exceptionally framed. The virtual space portrayed in Figure 5 was made in the analysis by putting two sign sets in a similar conveyance and plan in the indoor part of the business road. At last, the meandering in SA and SB with a similar course and speed according to the client's point of view is finished utilizing multi-knowledge dynamic innovation, and video information of the wandering field of vision in particular recognizable proof sets for additional examination was delivered.

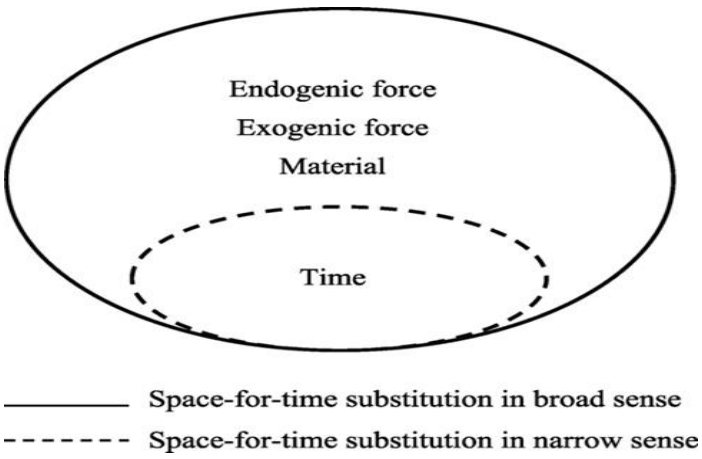

Figure 5: Map depicting the identification of local space.

The certainty score, which communicates the certainty level of the discovery model for the as of now perceived logo and connects with whether the client "sees obviously" the logo, is basically used as the assessment standard regarding the importance of the logo. The certainty score is normally lower when the marker is farther away from the client, and the backwards is valid when the distance is nearer. In this manner, the certainty score can convey a logo's particular quality, for example, whether it is easy to perceive, simple to find, and so on. As far as pertinence, the two arrangements of plans take a normal of 0.68 s and 0.46 s, individually, for all-class acknowledgment of set An and set B, individually. To fix the erroneous recognizable proof of each and every classification in set B, it requires 0.11 seconds. Figure 4 shows the typical degree of certainty for each arrangement of ID sets' different recognizable proof classes. Table 2 shows mean confidence of the two sets of set identifiers.

Table 2: Mean confidence of the two sets of set identifiers.

IDENTITY SET A	IDENTITY SET B
3.6	2.9
4.2	3.6
4.8	4.2
5.2	5.8
5.6	6.3
7.2	6.9
7.9	7.2

5.2 Critical Evaluation of Experiment Data

The object is positioned anywhere in the interior calibration experiment, the matrix's components are computed, and the average value is determined. Table 3 displays the starting position information. We can infer from the experimental data that the matrix elements are quite stable.

Table 3: The matrix of experimental information.

SPATIAL LOCATION	α_{00}	α_{01}	α_{10}	α_{11}
P1	0.3652	0.4025	0.6852	0.3856
P2	0.3895	0.4236	0.6712	0.3889
P3	0.4125	0.4836	0.6352	0.3895
P4	0.444	0.4966	0.6991	0.3985
P	0.4586	0.5825	0.6953	0.3999

The trial picked three computerized camera photos with a white closer view and a dark foundation for the little space, and it made stamped focuses on those focuses. Physically choosing the showed spots nearby since the mouse's picking exactness is lacking, the visual profundity esteem arrangement is wrong, and this technique presents a significant plan shortcoming. In Table 4 the projection mistakes of the featured locales are shown.

Table 4: The outcomes of experimental spatial positioning.

SPATIAL LOCATION	MOVE 1	MOVE 2	MOVE 3
P1	2.362	3.589	3.652
P2	2.869	3.865	3.978
P3	3.256	3.999	4.222
P4	3.856	4.256	4.896
P5	3.963	4.896	5.896
P6	3.988	5.263	6.235

As per the exploratory discoveries and the projection blunder of the calculation utilized in the article, which is portrayed in Table 5 the indoor space configuration is more judicious in light of the fact that the projection technique utilized in this paper has a fundamentally lower mistake than the ordinary strategy. The most extreme mistake is just 0.272.

Table 5: Extracting projection errors automatically from spatial models.

PROJECTION ERROR	FIRST PICTURE	SECOND PICTURE	THE THIRD
MAXIMUM ERROR	0.256	0.365	0.385
AVERAGE ERROR	0.352	0.452	0.436
STANDARD DEVIATION	0.423	0.496	0.635

5.3 Test Analysis

The analysis presents the energy utilization coefficient of indoor environmental spatial design advancement to test the adequacy of multi-knowledge dynamic in streamlining indoor conditions. The improvement of indoor environmental spatial design utilizes more energy the higher the worth of the energy utilization coefficient. The indoor climate format enhancement arrangement of the paper, the streamlining of the surface concealing space design, and the advancement of the binocular sound system vision space format are completely tried utilizing the energy utilization coefficient. Table 6 shows the experimental outcomes.

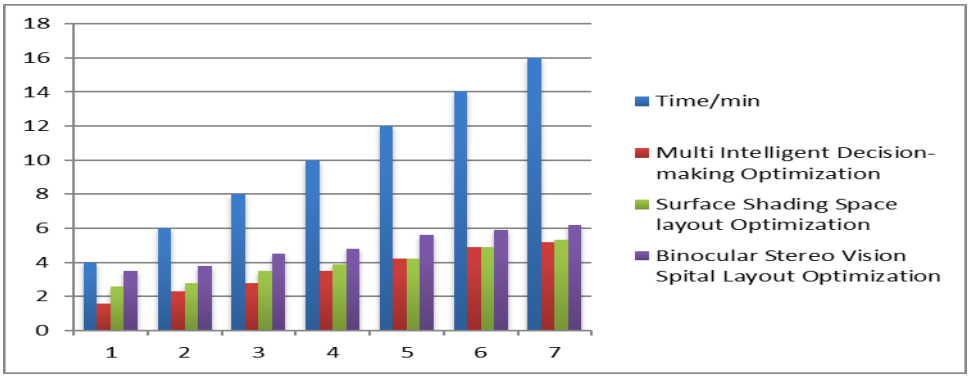

Table 6: A study's findings on the efficiency of energy consumption.

Three frameworks are utilized to test the energy utilization coefficient of indoor climate space design improvement: the bended concealing space format advancement framework, the binocular sound system vision space format streamlining framework, and the indoor climate space format enhancement framework in view of multi-knowledge direction. the design of the inside space with the best accuracy. In Table 7, the trial discoveries are shown.

Table 7: Verification of the optimal spatial layout for an indoor environment.

TESTING FREQUENCY	MULTI INTELLIGENT DECISION-MAKING OPTIMIZATION	SURFACE SHADING SPACE LAYOUT OPTIMIZATION	BINOCULAR STEREO VISION SPITAL LAYOUT OPTIMIZATION
3	1.9	2.6	3.2
5	2.3	2.9	3.5
7	2.8	3.8	4.2
9	3.2	4.5	4.8
12	3.9	5.8	5.6
14	4.2	5.9	5.9
16	4.8	6.8	6.2

It very well may be displayed from the test brings about Table 7 that the normal enhancement exactness is 98.32% when the indoor climate space design improvement framework in light of multi-knowledge navigation is utilized to advance the indoor climate space format. The plan of environmental space can be advanced with a typical precision of 42.2%, while the format of binocular sound system vision space can be enhanced with a typical exactness of 70.87%. The indoor climate space design streamlining framework in view of multi-knowledge direction has the most noteworthy advancement exactness when the improvement precision of the three indoor climate space format enhancement frameworks is analyzed. The design improvement process has been streamlined, which emphatically affects the indoor climate space format's exactness.

6. CONCLUSION

This study's investigation into the impact of soft furnishing design on interior spaces in sports facilities underpins a significant shift towards sustainability and environmental protection within the sports industry. The adoption of low-carbon, eco-friendly soft furnishings not only supports global sustainability goals but also enhances the functionality and aesthetic appeal of sports environments, which are critical for both athletes and spectators. The integration of materials that are both sustainable and conducive to optimal sports performance represents a holistic approach to sports facility management. It balances ecological concerns with the physical and

psychological needs of athletes, highlighting the interconnectedness of environmental health and human performance. Moreover, the use of innovative materials and technologies discussed throughout this study illustrates a promising pathway toward more sustainable sports practices. Future research should focus on the long-term impacts of these sustainable practices, exploring not only their environmental benefits but also how they influence athlete performance over time. Additionally, broader industry engagement with these practices will be crucial in mainstreaming sustainability in sports facilities globally. The conclusions drawn from this study underscore the necessity for continued innovation and advocacy for sustainability in sports, ensuring that the sports industry remains a leader in environmental stewardship and athlete-centric design. This research not only contributes to academic discussions but also serves as a practical guide for industry practitioners aiming to implement sustainable practices in their operations.

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