The following publication Hou H (2025), "Investigating the impact of spaces design on user satisfaction in university libraries: a case study". Facilities, Vol. 43 No. 7-8 pp. 571–593 is published by Emerald and is available at https://doi.org/10.1108/F-01-2024-0010.

Investigating the Impact of Spaces Design on User Satisfaction in University Libraries: A Case Study

Purpose

Modern university libraries are evolving to meet students' needs, offering varied study environments that cater to both private and group work. While existing research has recognised the important of library environment, there remains a research gap in understanding how individual attributes, such as age, gender, specific area locations, and feeling (different level of emotion states) influence student satisfaction with library interior design. This study aims to fill this gap by investigating the hypothesised relationships between these individual attributes and student satisfaction. It aims to offer practical design insights tailored to meet the varied needs of students.

Methodology

The study analyzed satisfaction among 404 library users across four library areas in one university library -- two designed for quiet study and two for collaborative discussion -- using questionnaires distributed by the research team. ANOVA and T-tests were used to assess how individual attributes and interior design elements, including size, seating plan, layout, seating ergonomics, and openness, affect library user satisfaction. A structural equation model was employed to analyze how attributes such as perceived interior design quality influence overall satisfaction in various library environments, with the goal of identifying specific improvements that could enhance the user experience.

Findings

The study revealed that users in traditional, non-co-working library spaces expressed greater satisfaction with the size, seating plan, and layout compared to those in co-working settings. Also, both groups of users found the ergonomics of seating and the openness of spaces to be equally satisfactory, suggesting that these factors are consistently well-received across different spatial designs. Furthermore, the research highlighted that both "age" and "location" (the specific areas of the library where users spent their time) significantly influenced users' satisfaction, with features that tailored well to their needs being particularly valued by both younger and older library users.

Original value

This study enhances the understanding of how interior design elements influence user satisfaction in university libraries. By incorporating variables such as location, gender, age, feelings into the analysis, it provides a nuanced framework to evaluate user responses to library indoor environments. The findings highlight the importance of tailored design strategies and suggest the need for improved tools to measure the complex interplay between user individual differences and the built environment.

Keywords: University library, interior design, individual attribute, user satisfaction, structural equation model, co-working space

1. Introduction

User-centered theory, as articulated by Vischer (2008a), focuses on the micro-perspective of the building user's experience, incorporating evidence-based design, neuro-scientific approaches, and post-occupancy evaluations. The user-centric approach for investigating user-building interaction centers on individual users' experiences and the functional uses of the built environment. The theory underscores the importance of considering human experience, preferences, and usability in designing and evaluating environments, aiming to align them with diverse user needs (Vischer, 2008b; Li et al., 2018). Guided by user-centered principles, modern library design has evolved to meet the diverse needs of current users, creating multifunctional and dynamic spaces that enhance accessibility and utility (Somerville and Brar, 2009).

Modern library design, guided by user-centered principles, responds to the evolving needs of users in the twenty-first century knowledge economy (Forrest and Halbert, 2020). The shift from traditional book-centric spaces to multifunctional, dynamic environments prioritizes skills such as creativity, interdisciplinary thinking, and collaboration. Recognizing diverse user needs, contemporary libraries include lounge areas, meeting rooms, and flexible seating, fostering collaboration and social interaction in acknowledgment of the dynamic and interactive nature of modern learning (Decker and Porter, 2018; McKillop, 2020).

While research has extensively explored factors influencing occupant satisfaction with indoor environments (Frontczak et al., 2011; Schiavon and Altomonte, 2014; Kamaruzzaman et al., 2017; Zhang, 2019; Hong et al., 2022), a gap exists in understanding how individual attributes specifically impact perceived satisfaction with interior design elements. Zhang (2019)'s study on the role of individual characteristics in user satisfaction in library indoor environments at Chinese universities utilised a questionnaire survey to evaluate factors such as gender, age, education, system experience, and computer skills as moderators affecting the connection between user satisfaction and work quality. The research underscores the significance of tailored design strategies to meet diverse needs and preferences of users. Setting the research context at a higher education campus, Hong et al., (2021) investigated the relationships between the built environments of learning commons and user productivity, including collaborative and individual work productivity, and overall environmental satisfaction.

Furthermore, previous studies have examined the impact of individual attributes like gender, age, and feelings on satisfaction (Bluyssen et al., 2015; Jiang et al., 2017; Haselsteiner, 2021; Hong et al., 2021), but have overlooked the role of "location" within the library's functional spaces. "Location", in this study, refers to functional study areas in different location designed to support different learning activities. The research explores the relationships between individual attributes, perceived interior design quality, and overall user satisfaction within a university

library setting. By examining the dynamics between individual attributes and user satisfaction across different library study areas (location), the study employs statistical methods to assess how factors like “age”, “gender”, and “location” within the library influence users’ perceptions. This study underscores the significance of adopting user-centric design principles, focusing particularly on tailored interior design elements to boost overall user satisfaction in library environments.

Space design within functional built environments is a pivotal aspect of facilities management, which entails ensuring that such spaces not only meet the diverse needs of users through adaptive and flexible design but also remain accessible, usable, and satisfactory (Greene and Myerson, 2011). Effective management of resources and services allows facilities management to actualize design principles, keeping spaces functional and comfortable for their intended uses. This study highlights the necessity for facilities management to align interior design with specific user attributes, such as gender, age, and individual preferences, advocating for a dynamic approach in the design and upkeep of spaces to meet evolving user needs, thereby boosting overall satisfaction and productivity.

2. Literature review

2.1 An overview of library studies on human-environment interactions

Several studies have investigated various aspects of the indoor environment of libraries, shedding light on factors such as microclimate, air quality, noise levels, and the impact of climate change. Investigations on the interaction between the outdoor environment and the indoor microclimate of historical libraries have highlighted the importance of understanding how external factors influence the indoor environment (Andretta et al., 2016). The assessment of indoor air quality in university libraries has been a subject of research, with a focus on gaseous and particulate pollutants, volatile organic compounds, and air quality index (Gunes et al., 2022). Similarly, the presence of airborne fungal spores in the indoor environment of libraries has been a concern, highlighting the susceptibility of indoor spaces to colonization by fungal species (Godson et al., 2021). In addition to air quality, the indoor environment of libraries has been studied in relation to noise levels, with a particular focus on the acoustic requirements of the space and the impact of noise pollution on user experience (Laze, 2017). Moreover, the indoor corrosivity in baroque library halls has been examined, emphasizing the need to understand and mitigate the impact of air pollution on cultural heritage objects (Kreislova et al., 2021).

The interior design of a library plays a crucial role in shaping the users’ perception and experience. An aesthetically pleasing and well-designed interior not only enhances the visual appeal but also contributes to the positive perception of library users (Anandasivam and Choy, 2008). The perception of users on modern interior design in libraries has been studied, and it has been found that the design significantly influences the users’ experience (Aisjah et al., 2021). Furthermore, the interior design must cater to the diverse roles served by modern librarians, such as teaching, advising, and archival management, and should support the evolving functions of libraries in the

digital age (Gerolimos and Konsta, 2008). Additionally, the practical aspects of interior design, such as signage systems and wayfinding, are crucial for ensuring that users can navigate the library space effectively (Su et al., 2021; Chiu and Ho, 2022).

2.2 Individual attributes and interior design

The influence of individual attributes on satisfaction with the indoor environment has been a subject of extensive research. Studies have explored the relationship between these individual attributes and various aspects of indoor environmental quality, occupant satisfaction, and well-being.

The relationship between gender and perceived indoor environment quality has been widely studied in previous literature. The impact of gender on thermal comfort and overall satisfaction with the indoor climate has been examined, with studies indicating that thermal comfort dominates overall satisfaction with the indoor climate and is rated as more important than visual and acoustic comfort or good air quality (Haselsteiner, 2021). Jiang et al., (2017) explores the influence of gender on satisfaction with the lighting environment in public spaces, indicating that gender elicited a difference in the evaluation of satisfaction with lighting, with men's ratings being higher than women's in certain areas. Hong et al., (2021) investigates the impact of age on student productivity in learning commons. The study reveals the importance of meeting standards in indoor environmental quality factors on individual productivity, indicating a potential relationship between age and perceived interior design quality. Chow and Fung (1995) assesses the indoor thermal environment in air-conditioned shopping malls. The study utilizes a subjective system of assessment to express the overall perception of the environment, indicating the significance of users' location within the indoor space. A study by Bluyssen et al., (2015) focuses on the association between the psychosocial work environment and occupants' complaints concerning indoor air, exploring self-reported health and comfort in office buildings. The study indicates the potential influence of occupants' feelings on perceived interior design quality. Chai et al. (2022) examines the relationship between building performance, including interior design, and the learning behavior of students, identifying that the interior environment quality as a critical factor affecting learning behavior. Hou et al. (2023a) and Feng et al., (2024) evaluated both building facilities and special design in building performance evaluation in the context of student dorms and university classrooms. They also investigate how students' personal attributes affect their perception of the building performance.

Interior design is a critical factor in shaping indoor spaces to evoke positive emotions and meet the specific needs of the environment. The design of indoor spaces aims to create a favourable atmosphere aligned with the intended purpose of the space (Torresin et al., 2019). Occupants' feelings or emotional states are crucial aspects for interior designers to understand in order to create satisfactory interior spaces. Feeling, as subjective experiences of emotions, are directly linked to an individual's well-being

and comfort (Rohde et al., 2020; Wang and Liu 2020; Zhang et al., 2024). They represent the personal way individuals interpret and process their emotions internally.

Feeling, as defined in psychological research, encompasses the conscious experience of emotional reactions, integrating a person's thoughts, beliefs, and desires with their emotions. In indoor environments, satisfaction derives not only from physical comfort but also from the emotional states influenced by the surroundings (Spence, 2020; Altomonte et al., 2020). Positive emotional experiences can boost satisfaction, productivity, and overall happiness, while negative emotions can lead to discomfort and decreased performance. To accurately assess these dynamics, indoor environment scientists have shifted towards using psychological frameworks that involve multidimensional scales. These scales evaluate factors such as perceived usability, aesthetic appeal, and emotional connectivity to the space, providing a comprehensive understanding of how occupants interact with their surroundings. This approach enables a nuanced examination of how the built environment impacts occupant satisfaction, guiding design practices towards enhancing both physical comfort and emotional well-being (Whittem et al., 2022; Lan et al., 2023a; Lan et al., 2023b).

The relationship between individual attributes and occupant satisfaction in various indoor environments has been previously investigated. The influence of situational leadership, work environment, competence, and motivation on employee job satisfaction at the National Library has been studied, emphasizing the importance of considering individual attributes in the workplace (Putra, 2021). Studies have traced the relationship between the quality of indoor environments and medical staff satisfaction levels, highlighting the importance of understanding the impact of individual attributes on occupant satisfaction in healthcare settings (Mahmood, 2021).

2.3 Interior design factors

Interior design is a multidimensional field that encompasses various elements crucial for creating functional and aesthetically pleasing indoor spaces (Juliá Nehme et al., 2020; Hou and Wu, 2021). When evaluating interior design, factors such as ergonomics, openness, seating, size, and layout play pivotal roles in determining the overall quality and effectiveness of the design (Kang et al., 2017).

Ergonomic, a key aspect of interior design, focuses on designing spaces and furniture that are tailored to human needs and behaviors, ensuring comfort and efficiency (Daniel, 2023). By considering anthropometry and human factors, designers can create interiors that promote well-being and productivity (Lin et al., 2024). Studies have shown that ergonomic considerations in interior design can significantly impact user experience and satisfaction (Safin et al., 2020).

The layout of a space is another critical component of interior design, influencing the flow, functionality, and visual appeal of environment (Ching and Binggeli, 2018). Proper space management and arrangement of elements such as furniture, seating, and circulation paths are essential for creating harmonious interiors.

Additionally, factors like seating design and placement can affect not only the comfort of users but also their performance and engagement (Ching and Binggeli, 2018).

Openness in interior design refers to the sense of spaciousness, light, and airiness within a space, which can contribute to a welcoming and comfortable environment (Wagner et al., 2018). Utilizing techniques such as visual customization, color preferences, and the strategic placement of elements can enhance the perceived openness of a space (Jo and Jeon, 2022). Moreover, the use of materials and design solutions that promote a sense of openness can positively impact the overall ambiance of the interior (Pastore and Andersen, 2022).

The size of a space is a fundamental consideration in interior design, influencing the functionality, comfort, and visual balance of the environment. Proper measurement and evaluation of space dimensions, furniture proportions, and circulation paths are essential for creating interiors that are both aesthetically pleasing and functional (Al-Zamil, 2017). Moreover, the size of elements such as seating and furniture should be carefully calibrated to ensure optimal comfort and usability.

3 Methodology

3.1 Field situation

This study adopts a case study approach, centering on a university library located at the campus of a university in Hong Kong. Established in 1972, the library underwent a substantial extension and revitalised project from July 2020 to the fourth quarter of 2023. The renovations encompassed modernising the restrooms, installing compact shelving on the ground floor, upgrading the air-conditioning system, replacing the goods elevator, and constructing new passenger lifts. Floors were reconfigured and repurposed up to the third level, with the sixth floor expanded to support both collaborative learning and quiet study areas. The 6th floor, as the top level, features high ceilings and large windows. The 6th and 1st floors house four main study areas, each featuring distinct designs. The revitalisation aimed at enhancing the library's functionality and aesthetic appeal, catering to a range of learning activities. This study was conducted after the renovation project was completed.

3.2 Research gaps and hypotheses

Modern university libraries have incorporated various functional design elements to cater to students' learning needs and study habits, such as quiet areas for individual study and co-working spaces designed for collaborative study. In light of these new design trends in university libraries, it is essential to explore student satisfaction with these changes and their preferences (Becker et al., 2016). One gap in current research is the lack of studies investigating the relationship between students' perception of these new design trends and student satisfaction. The impact of individual attributes on satisfaction levels with indoor environmental quality has been commonly explored in previous research. Attributes like "gender", "age", and "feeling", have been examined for their influence on human satisfaction in previous studies (Chow and Fung,

1995; Bluyssen et al., 2015; Jiang et al., 2017; Hong et al., 2021; Chai et al., 2022; Hou, 2025). However, "location" – where an individual is situated or which functional space they occupy (such as quiet area, co-working space) – has not been considered as a variable, and its relationship with human satisfaction has not been previously studied.

Furthermore, as per suggested by the literature review, the prevailing research on library environments has primarily concentrated on human comfort regarding the thermal condition, acoustic environment, indoor air quality, and lighting, leaving a considerable gap in understanding how library users perceive interior design elements, such as seating plan, layout, size, openness and ergonomics of seats, and their impacts on user satisfaction, highlighting the necessity for a more nuanced exploration in the context of university libraries (Becker et al., 2016). In this study, the satisfaction of "interior design" is measured by library users' satisfaction towards five interior design elements: size, seating plan, layout, ergonomics of seating, and openness.

Aside from evaluating how users perceive the interior design elements in the library context, individual differences are considered to play an influential role on how users perceive the indoor environment. The major individual attributes investigated in previous studies include gender, age, and emotional responses (Chow and Fung, 1995; Bluyssen et al., 2015; Jiang et al., 2017; Hong et al., 2021; Chai et la., 2022), and they are proved to shape users' preferences for indoor environment. While existing studies often address broader aspects of interior environments, limited research investigate the nuanced influence of individual attributes on subjective satisfaction with interior design elements. Understanding how individual attributes like gender, age, and feeling interact with design choices and contribute to overall satisfaction remains an underexplored area.

To examine the relationships between "gender", "age", "location" and "feeling", and library users' satisfaction of the overall library environment, H1-H4 are developed to analyse the inter-group results. ANOVA was used to conduct statistical analysis to provide comparison between sub-groups under the individual attributes.

- H1: There is a difference in level of satisfaction with the overall library environment between different study areas
- H2: There is a difference in level of satisfaction with the overall library environment among different library user age groups
- H3: There is a difference in level of satisfaction with the overall library environment between male and female library users
- H4: Feelings as an individual attribute affect library users' satisfaction with the overall library environment

In recent years, academic libraries have undergone a dramatic evolution, adapting to the shifting needs and behaviours of their users due to technological advancements, changes in study habits, and the diversification of learning modalities (Forrest and Halbert, 2020; McKillop, 2020). This metamorphosis has been characterised by an intentional design of distinct study areas within the library, each tailored to specific user needs (Forrest and Halbert, 2020). Quiet areas provide a sanctuary for individual study,

fostering concentration and reflection (Marshalsey, 2023). Discussion areas are designed to facilitate group study, encouraging collaboration and intellectual exchange (Marshalsey, 2023; Hou et al., 2023b). Rest areas offer a space for relaxation and mental recharge, while multi-media function areas are equipped to support digital learning and creative endeavors (Marshalsey, 2023). Each of these spaces is strategically located across various floors or areas within the library, reflecting a commitment to creating an environment that is as multifaceted as the academic community it serves.

Using "location" as a variable within academic libraries is crucial because it enables an in-depth analysis of how different spatial environment impact user satisfaction and behaviour. Each library space, from quiet study areas and group discussion area to multimedia centers and rest areas, is purpose-built to fulfill specific functions and accommodate the varied requirements of its users. Investigating these distinct locations allows for a nuanced understanding of library users' preferences, closely linked to their individual study needs. This knowledge is invaluable for library management to optimize space design, ensure resources are used efficiently, and enhance the library's overall function as a dynamic learning environment. Modern libraries, having adopted purpose-built designs for various spaces, enable the exploration of library users' preferences for interior design in different areas within the library through the "location" variable.

In this study, library users located in various areas participated in the survey. Their perceptions of interior design quality and satisfaction with the overall environment are influenced by the distinct design styles associated with different "locations". Thus, it is necessary to investigate the impact of "location" – areas with different interior design elements within the same building, on occupants' satisfaction. Two relevant hypotheses (H5-H6) are shown as follows:

- H5: Library users in non-co-working spaces have significantly higher satisfaction with specific interior design elements (size, seating plan, layout) compared to those in co-working spaces.
- H6: Library users on the 6th floor exhibit higher satisfaction with various aspects of the library environment compared to those on the 1st floor.

Five hypotheses were proposed for measuring library users' satisfaction using a SEM-based theoretical model (Figure 1). The hypotheses (H7-H11) are illustrated as follows:

- H7: A positive correlation between library users' gender and their perception of the library's interior design quality.
- H8: A positive correlation between library users' age and their perception of the library's interior design quality.
- H9: A positive correlation between the location of users within the library and their

perception of the library's interior design quality.

- H10: A positive correlation between the feeling of library users and their perception of the library's interior design quality.
- H11: A positive correlation between the perceived quality of the library's interior design and the users' overall satisfaction with the library environment.

For H7-H11, they are developed to test the four individual attributes' relationship with their perceived interior quality. The perceived interior quality are measured by five questions in the questionnaire (Appendix 1). The five questions ask library users' satisfaction level regarding the five interior design factors – "gender, "age", "location" and "feeling". For "location", it means different study areas within the university library, including two co-working space and two non-co-working space areas. Detailed information of the four study areas is illustrated in Figure 2. For measuring "feeling", this study employs a three-point scale consisting of the following descriptors: good, not so good, bad (see Appendix 1). "Feeling" in this context refers to the conscious experience of emotional reactions, encompassing beliefs, and desires, significantly influenced by the environmental design and directly impacting satisfaction (Spence, 2020).

When measuring feeling, it is essential to employ validated scales and descriptors that effectively capture the emotional states of individuals. For example, the Objectified Body Consciousness Scale uses a 6-point scale to assess feeling related to body consciousness, highlighting the importance of selecting appropriate measurement tools (McKinley and Hyde, 1996). Similarly, the Behavior and Feelings Survey (BFS) was developed to monitor treatment progress during psychotherapy by evaluating internalizing and externalizing problems in youths (Weisz et al., 2019; Rognstad et al., 2022). In research contexts, a three-point scale with descriptors such as "positive", "neutral", and "negative" is often used to capture emotional states (Hanmontree et al., 2022). The choice of a three-point scale with descriptors like "good", "not so good", and "bad" for measuring feeling can be justified by its simplicity and the ease with which respondents can understand and select responses (See Appendix 1). The three-point scale for measuring "feeling" in this study is selected for its ability to provide clear, direct feedback from participants with minimal cognitive effort, aligning with streamlined data collection objectives and ensuring ease of response in a diverse university library setting. Structural equation modelling (SEM) test examine if there is statistically significant path from the observed variable "gender", "age", "location", and "feeling" to the latent construct "perceived interior design quality". For each hypothesis, a positive path coefficient would support that the individual attribute influences perceptions of design quality. Short forms of the variables are illustrated in Figure 1.

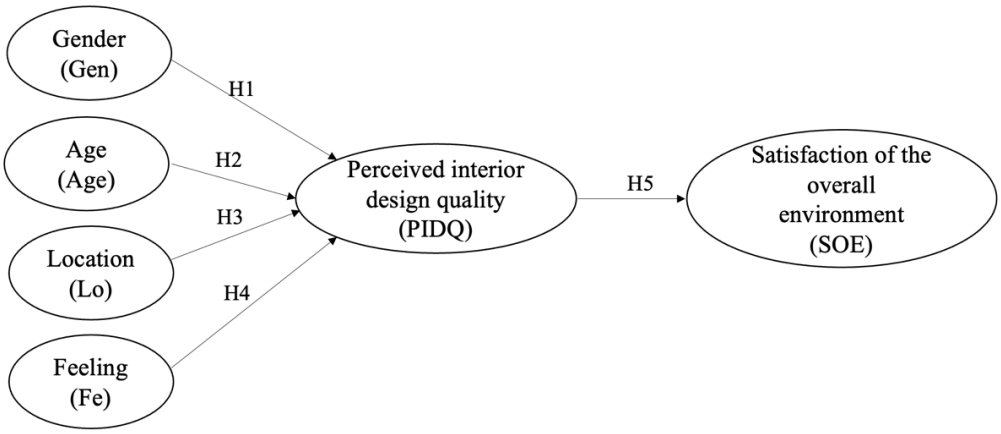


Figure 1. A theoretical model for library users' satisfaction (Source: Author's own work)

Note: Gen: Gender, Age: Age; Lo: Location; Fe: Feeling; PIDQ: Perceived interior design quality, SOE: satisfaction of the overall environment.

3.3 Research design

This study employs a quantitative method using a face-to-face questionnaire survey to investigate students' perceptions of interior design quality in the renovated university library. The independent variables in this study include various individual attributes (gender, age, location, and feeling), while the dependent variable is user satisfaction, specifically related to the interior design quality. This design is selected to directly evaluate the impact of the interior design quality on user satisfaction, allowing for a clear correlation between the library's physical changes and the users' experiences.

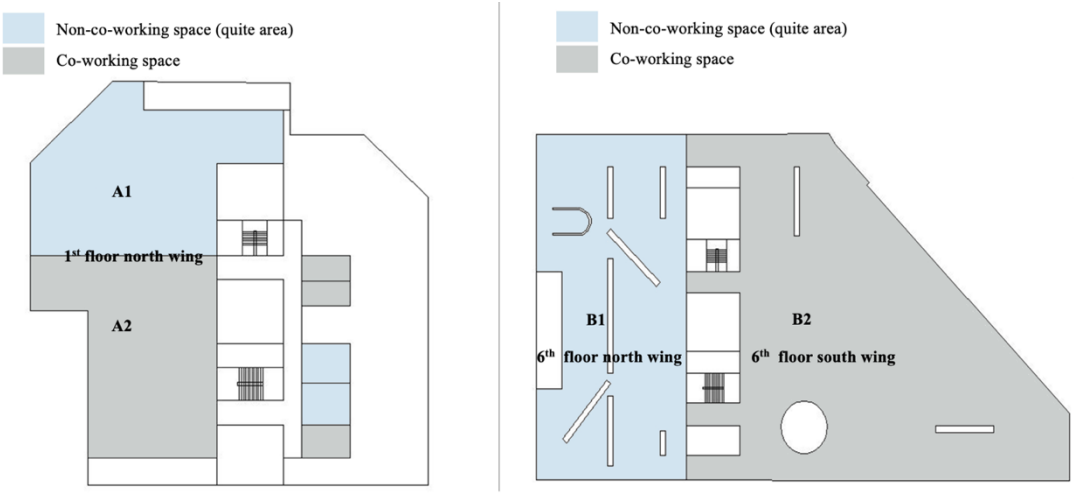
3.4 Research procedure

The survey was conducted over a period of seven days. The questionnaire, designed to measure user satisfaction with the library's interior design, was distributed in four strategically chosen study areas within the library. These areas, two on the first floor and two on the sixth floor, were selected to represent different usage contexts: collaborative spaces (A1, B1) and quiet study area (A2, B2) (Figure 2). Ethical approval was obtained from the author's institution (Ethical approval application number: HSEARS20240308008).

Participant recruitment was conducted on-site, with research assistants inviting library users in each of the four areas to participate. This approach ensured a diverse sample reflective of the library's user base. To maintain consistency in data collection, the same four research assistants administered the surveys simultaneously in each location, equipped with standardised instructions to avoid variability in the data collection process. The research assistants were stationed in the library from 9am to 6pm, aiming to survey a representative sample of library users across various times of the day. The instruments used in the questionnaire are detailed in Appendix 1, ensuring transparency and replicability. This structured approach allows for the accurate

replication of the study in similar environments. “Perceived interior design quality” is measured by library users’ satisfaction with the size, layout, seating plan, ergonomics of the seat, and openness. The reliability of the “perceived interior design quality” scale was assessed using Cronbach’s alpha (α), calculated with SPSS 22.0 software. The obtained Cronbach’s alpha value of 0.897 significantly exceeds the commonly accepted threshold of 0.7, indicating robust internal consistency for this measure.

Figure 3 shows photographs of the four study areas under investigation. The questionnaire survey was conducted over a period of 7 days, with the distribution being simultaneously administered by four students. A number of 404 valid responses were received. Table 1 reports the individual attribute information of the survey participants.



Note: A1: Non-co-working space (quite area) situated in the north wing of the 1st floor

A2: Co-working space situated in the north wing of the 1st floor

B1: Non-co-working space (quite area) situated in the north wing of the 6th floor

B2: Co-working space situated in the south wing of the 6th floor

Figure 2. Floor plans of the four study areas (Source: Author’s own work)

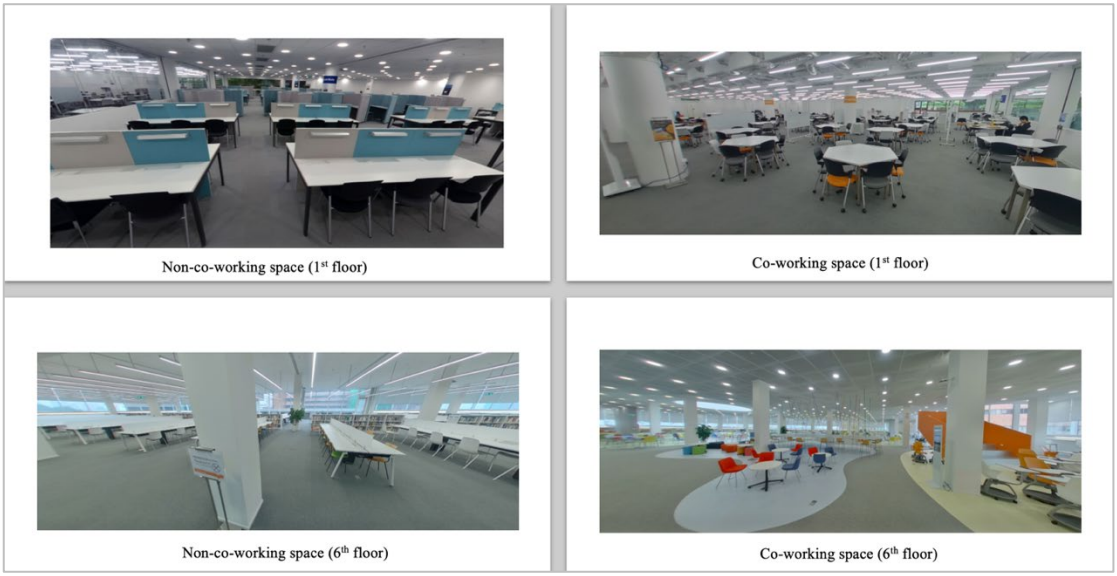


Figure 3. Photographs of the four study areas under investigation (Source: Author's own work)

Table 1. Individual attributes of the survey participants (Source: Author's own work)

Individual attributes	Attribute level	Number (%)
Age (Age)	16-20	188(46.53%)
	21-25	178(44.06%)
	26-30	31(7.67%)
	31-35	6(1.49%)
	36-40	1(0.25%)
	Above 40	0 (0%)
Gender (Gen)	Female	216(53.47%)
	Male	184(45.54%)
	Prefer not to tell	4(0.99%)
Location (Lo)	1/F North Wing (Quite area)	64(18.54%)
	1/F North Wing (Co-working design space)	57(14.11%)
	6/F North Wing (Quite area)	108(26.73%)
	6/F South Wing (Co-working design space)	175(43.32%)
Feeling (Fe)	Bad	8(1.98%)
	Good	297(73.51%)
	Not so good	99(24.50%)

5. Analysis and findings

5.1 Library users' satisfaction of the overall environment by location, age, gender, age and feeling

An ANOVA single factor test was performed to investigate The relationships between individual characteristics and the satisfaction of the overall environment. The results of the ANOVA single factor test are used to explain the H1-H4.

Table 2. ANOVA single factor test (Source: Author's own work)

	Groups	Count	Sum score	Average	Variance	Statistics
Location	1/F North Wing (Quite area)	55	284	5.163	0.954	F-value: 8.0032 P-value: 3.58E-05
	1/F South Wing	51	245	4.803	0.840	
	6/F North Wing (Quite area)	93	511	5.494	1.035	
	6/F South Wing	152	839	5.519	0.992	
	Total	351	1879	5.3532	1.034	
Age	16-20	164	871	5.310	1.099	F-value: 0.991114 P-value: 0.397067
	21-25	155	828	5.376	0.994	
	26-30	26	137	5.269	0.844	
	>30	6	36	6.000	0.800	
	Total	351	1879	5.353	1.034	
Gender	Female	193	1037	5.429	1.077	F-value:2.011946 P-value: 0.156965
	Male	158	828	5.273	0.982	
	Total	351	1879	5.353	1.034	

Feeling	Bad	5	27	5.400	2.300	F-value: 2.796178 P-value: 0.062415
	Good	264	1432	5.424	0.921	
	Not so good	82	420	5.121	1.293	
	Total	351	1879	5.353	1.034	

The ANOVA single factor test results analyzing the satisfaction of library users with the overall environment revealed the following: "location" significantly affects satisfaction, as evidenced by a p-value well below 0.05, confirming hypothesis H1 that different study areas within the library influence user satisfaction levels. However, neither "age" nor "gender" showed significant effects on satisfaction, with p-values greater than 0.05, leading to the retention of the null hypotheses for H2 and H3; this indicates no appreciable differences in satisfaction across different age groups or between genders. Lastly, the influence of "feeling" on satisfaction nearly reached statistical significance (p-value of 0.062415), suggesting a possible effect, but not enough to conclusively reject the null hypothesis for H4 at the conventional 0.05 level. This points to a trend where feeling might impact satisfaction, but further evidence is required to establish a definitive conclusion.

The ANOVA single factor test results from Table 2 provide critical insights into how different factors influence library user satisfaction, highlighting several implications for library design and user experience enhancement. The significant impact of "location" on satisfaction highlights the importance of spatial design, revealing that user satisfaction varies across different library areas. This suggests that specific environmental or architectural features unique to each location may enhance user satisfaction. Conversely, the absence of statistically significant differences in satisfaction based on "age" and "gender" suggests that these demographic factors might not be pivotal in the general design considerations for library environments.

However, the nearly significant influence of users' feeling on their satisfaction indicates the importance of the library's atmosphere in shaping emotional responses. This finding points to the potential benefits of creating a comfortable environment that could universally improve satisfaction levels, regardless of users' age or gender. These insights should guide future enhancements in library design, focusing particularly on optimizing the elements that make certain areas more favorable, thus better catering to the diverse needs and preferences of all library users.

5.2 Library users' satisfaction towards specific design element by different functional areas

T-test and ANOVA test were performed to investigate the satisfaction rating by library users stayed in different functional areas. T-test was used to investigate the satisfaction scores difference between library users who stayed in the non-co-working space (1/F north wing and 6/F north wing) and co-working space (1/F south wing and 6/F south wing). Table 3 shows the results of the t-test.

Table 3. T-tests between space design and satisfaction of the interior design elements (Source: Author's own work)

Satisfaction of	Space design (mean ± S.D.)		t	p
	Non-co-working space (n=172)	Co-working space (n=232)		
Size	5.26±1.40	4.92±1.66	2.183	0.030*
Seating plan	5.07±1.37	4.59±1.42	3.399	0.001**
Layout	5.24±1.16	4.88±1.30	2.841	0.005**
Ergonomics of seating	4.76±1.16	4.57±1.22	1.515	0.131
Openness	5.22±1.14	5.19±1.18	0.304	0.131
The overall environment	5.38±1.00	5.37±1.00	0.072	0.943

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Statistically significant differences in satisfaction were observed between library users in non-co-working spaces and those in co-working spaces regarding three interior design elements: size, seating plan, and layout. Specifically, users in non-co-working spaces reported higher satisfaction levels with the "size" (mean 5.26 ± 1.40 vs. 4.92 ± 1.66, p = 0.030), "seating plan" (mean 5.07 ± 1.37 vs. 4.59 ± 1.42, p = 0.001), and "layout" (mean 5.24 ± 1.16 vs. 4.88 ± 1.30, p = 0.005) compared to those in co-working spaces. These findings indicate that the spatial arrangements and dimensions in non-co-working areas are more favourably perceived by the users.

In contrast, no significant differences were found in satisfaction with the "ergonomics of seating" (mean 4.76 ± 1.16 for non-co-working vs. 4.57 ± 1.22 for co-working, p = 0.131) and "openness" (mean 5.22 ± 1.14 for non-co-working vs. 5.19 ± 1.18 for co-working, p = 0.131). This suggests that aspects related to the physical comfort of seating and the sense of space openness were similarly satisfactory to users in both types of spaces.

Moreover, the overall environment satisfaction scores were nearly identical between the two groups (mean 5.38 ± 1.00 for non-co-working vs. 5.37 ± 1.00 for co-working, p = 0.943), indicating that the general perception of the library's atmosphere is uniformly positive across different spatial designs. This uniformity in satisfaction with the overall environment, despite differences in specific design elements, highlights the complexity of factors contributing to users' overall satisfaction.

Table 4 presents the results of an ANOVA comparing satisfaction scores among users located in different study areas of the library for various aspects of the library environment. Statistically significant differences in satisfaction were found with the "size", "seating plan", "layout", "openness" and "the overall environment" among the four selected areas in the library.

Table 4. ANOVA analysis between the four study areas and satisfaction of the interior design elements (Source: Author's own work)

Satisfaction of	Location (mean ± S.D.)	F	p

	1/F Non-co-working space (n=64)	1/F Co-working space (n=57)	6/F Non-co-working space (n=108)	6/F Co-working space (n=175)		
Size	4.56±1.36	4.21±1.58	5.67±1.27	5.15±1.62	14.787	0.000**
Seating plan	4.80±1.30	4.14±1.23	5.23±1.40	4.74±1.45	7.932	0.000**
Layout	4.92±1.04	4.37±1.23	5.43±1.19	5.05±1.28	9.669	0.000**
Ergonomics of seating	4.75±1.13	4.49±0.97	4.76±1.19	4.60±1.30	0.880	0.451
Openness	4.83±1.09	4.68±1.14	5.45±1.11	5.35±1.14	9.143	0.000**
The overall environment	5.11±0.99	4.89±0.99	5.54±0.97	5.53±0.96	8.630	0.000**

Note: *p < 0.05; **p < 0.01; ***p < 0.001

The ANOVA analysis results suggests that library users located in the 6th floor of the library provide a higher level satisfaction rating compared to those stayed in the 1st floor. The results also revealed that among all the interior design elements, "ergonomics of seating" received the lowest satisfaction ranking by library users located in the 6th floor. It implies that they considered "ergonomics of seating" as an important components reflecting interior design quality, but are less satisfied with this element comparing with other four elements.

The findings from the statistical analyses, as delineated in Tables 3 and 4, offer significant insights into user satisfaction concerning different interior design elements in university library spaces. Specifically, the mean values in Table 3 indicate that library users in non-co-working spaces report higher satisfaction levels with "size", "seating plan", and "layout" compared to those in co-working spaces. This suggests that in the study space intended for individual study and concentration, such as quiet areas for individual study, users may place a higher value on space size, the arrangement of seating, and overall layout. The findings may reflect the fact that in in environments designed for individual study and concentration, such as quiet study areas, the size of the space, the arrangement of seating, and the overall layout tend to attract users' cognitive attention comparing to other design elements. This underscores a critical consideration for library designers: the importance of customizing design elements to match the specific functions of each area to boost user satisfaction.

Further insights are provided by the ANOVA results, which reveal more dynamic differences in satisfaction across different library locations. Users on the 6th floor, particularly in the non-co-working space, expressed higher satisfaction with most design elements compared to those on the 1st floor. This indicates that users in areas designated for quiet study might have higher expectations or greater appreciation for well-designed spaces that support their specific needs for focus and minimal distractions. The ergonomics of seating, despite its low satisfaction scores, did not vary significantly between different areas, indicating a potential area for improvement across

the board. These findings suggest that while some aspects of library design can be standardized, others need to be carefully customized to the unique characteristics of each space, especially in environments like libraries where different areas are designated for diverse activities and user needs.

5.3 Structural equation modelling results

This study used SmartPLS.4 software to construct the PLS-SEM model and the statistical analyses were deployed (Farooq et al., 2018). To assess the discriminant validity, the heterotrait-monotrait (HTMT) ratio criterion was employed, where the value of HTMT less than 0.85 indicates a good discriminant validity (Hair Jr et al., 2021). To assess the measurement model, convergent validity and discriminant validity were tested. Hair et al. (2021) suggested that convergent validity is confirmed if the loadings, the average variance explained (AVE), and the composite reliability (CR) are greater than 0.7, 0.5, and 0.7, respectively. In addition, the validity of the structural inner model must be assessed to ensure model goodness of fit. The coefficient of determination R^2 and adjusting R^2 were used to assess the model fit. It should be noted that R^2 values below 0.1 may be considered weak, values between 0.1 and 0.25 may be considered weak explanatory power, and values greater than 0.5 and less than 0.75 may be considered moderate explanatory power.

5.3.1 Heterotrait-monotrait (HTMT) test

The heterotrait-monotrait ratio of correlations (HTMT) is a valuable statistical tool utilized in structural equation modeling (SEM) and confirmatory factor analysis (CFA) to assess discriminant validity between latent variables or constructs. Discriminant validity is crucial in ensuring that distinct constructs are more dissimilar than similar to each other. The HTMT ratio quantifies this concept by comparing the average correlation between indicators of different constructs (heterotrait correlations) to the average correlation between indicators of the same construct (monotrait correlations). In the provided correlation matrix for variables “age”, “feeling”, “gender”, “perceived satisfaction of interior design”, and “location”, the HTMT ratio is computed by taking the square root of the average heterotrait correlations divided by the square root of the average monotrait correlations. The formula is shown as follows:

$$\text{HTM} = \frac{\sqrt{(\text{average heterotrait correlations})}}{\sqrt{(\text{average monotrait correlations})}} \qquad \textit{Equation (1)}$$

An ideal scenario is indicated by an HTMT ratio less than 0.85, suggesting good discriminant validity. Conversely, an HTMT ratio close to or greater than 1.0 implies potential overlap or similarity between constructs. In the matrix of Table 5, the HTMT ratios range from 0.035 to 0.791, revealing that discriminant validity is generally maintained among the constructs, with the “perceived interior design quality” (PIDQ)

and "location" constructs demonstrating a higher correlation, possibly indicating some degree of conceptual similarity.

Table 5. Heterotrait-monotrait ratio of correlations (HTMT) (Source: Author's own work)

	Age	Feeling	Gender	PIDQ	Location
Age					
Feeling	0.061				
Gender	0.044	0.008			
PIDQ	0.176	0.089	0.149		
Location	0.107	0.057	0.062	0.156	
Overall	0.035	0.075	0.056	0.791	0.198

Note: PIDQ – perceived interior design quality

For "perceived interior design quality", which has four instruments, the Cronbach's alpha is 0.833, suggesting good internal consistency. For "perceived interior design quality", the AVE is 0.604, slightly above the commonly recommended threshold and being indicative of reasonable convergent validity.

5.3.2 Model fit

Table 6 compares the fit indices of two models: the saturated model (a perfectly fitting model) and the estimated model (the actual model under consideration). Generally, the estimated model closely approximates the saturated model, as indicated by similar values across these indices. The non-significant chi-square values for both models suggest a good fit, although this test is sensitive to sample size. While the NFI for the estimated model falls above the threshold of 0.8, other fit indices remain within acceptable ranges. The R^2 values indicate moderate explanatory power, with both models explaining around 52% of the variance in the endogenous variables. Overall, the estimated model demonstrates a reasonable fit to the data, aligning with the specified fit criteria.

Table 6. Model fit (Source: Author's own work)

	Saturated model	Estimated model
SRMR	0.057	0.06
d_ULS	0.177	0.196
d_G	0.055	0.063
Chi-square	125.602	141.797
NFI	0.893	0.879
R^2	0.522	
R^2-adjusted	0.521	

Note: SRMR<0.08; d_ULS<0.95; d_G<0.95; NFI>0.8; R2 and R2-adjusted>0.5 (moderate explanatory power)

5.3.3 Path analysis

Table 7 presents key information on the relationships within the proposed model, focusing on the path coefficients, standard deviations, t-values, p-values, and decision outcomes. The explanation of the short forms of the variables can be found in Figure 4. Notably, the positive path coefficient between "age (age)" and "perceived interior design quality (PIDQ)" (0.166, p = 0.001) suggests that as individual's age increases, their perception of interior design quality tends to improve. Similarly, the negative relationship between "Gen" and "PIDQ" (-0.12, p = 0.013) indicates that, on average, "PIDQ" tends to decrease for certain "Gen" categories. The positive association between "Lo" and "PIDQ" (0.139, p = 0.003) suggests that varying locations may influence a positive change in "PIDQ". However, the relationship between "Fe" and "PIDQ" is not statistically significant (p = 0.226), suggesting that "Fe", in this context, may not significantly impact occupants' "PIDQ". Importantly, the robust and highly significant positive path coefficient (0.722, p < 0.001) between "PIDQ" and "SOE" underscores the substantial influence of "PIDQ" on the "SOE" construct, emphasizing its pivotal role in the broader context of the model. These findings contribute valuable insights into the nuanced relationships among the variables under investigation. Figure 4 illustrates the results of the SEM.

Table 7. Path coefficients (Source: Author's own work)

Relationships	Path Coefficients	STD	T	P	Decisions
Age -> PIDQ	0.166	0.051	3.262	0.001**	**Yes**
Fe -> PIDQ	-0.061	0.051	1.211	0.226	No
Gen -> PIDQ	-0.12	0.048	2.488	0.013*	**Yes**
PIDQ -> SOE	0.722	0.026	28.318	0.000***	**Yes**
Lo -> PIDQ	0.139	0.046	3.011	0.003**	**Yes**

Note: *p < 0.05; **p < 0.01; ***p < 0.001

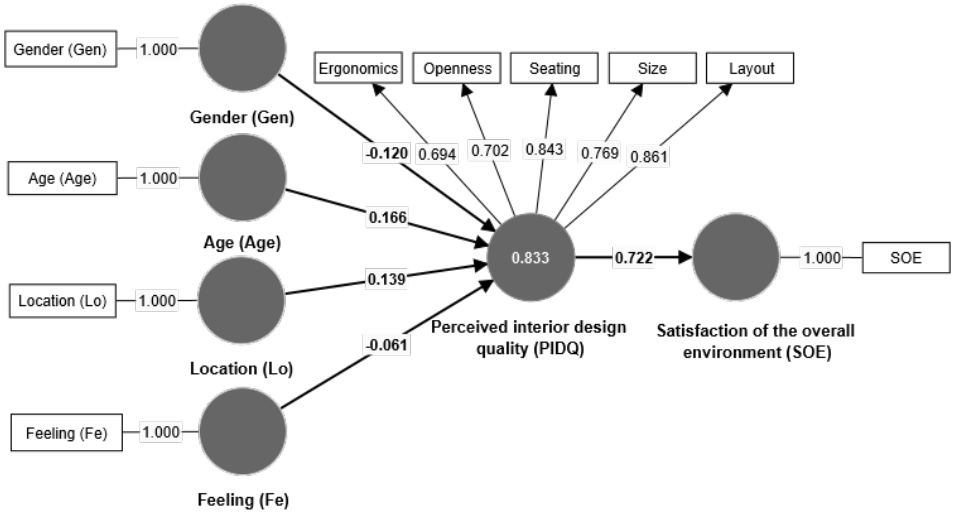


Figure 4. Results of the SEM (Source: Author's own work)

6. Discussion

The findings from this study highlight the critical role of "perceived interior design quality" in influencing overall satisfaction with library environment, demonstrating that effective design is pivotal in enhancing user experience. The strong correlation between interior design perception and user satisfaction underscores the importance of thoughtful and user-centric design elements in university libraries. This is particularly evident in the preferences expressed by older students, such as those in their senior year, who show a more favourable view of the library's interior design. This group's positive response might be attributed to their extensive exposure to various educational settings, enhancing their appreciation for supportive and aesthetically pleasing study environments. Additionally, the study identifies significant gender-based differences in design perception, suggesting that male and female students may prioritize different elements in library design. These insights resonate with the findings by Greene and Myerson (2011), underscoring the need for a refined approach to indoor interior design that effectively accommodates the diverse preferences and requirements of various space users.

Moreover, the study's findings regarding the influence of location on perceived interior design quality reveal that different areas within the library distinctly affect user perceptions. For instance, the study areas on the 6th floor, characterized by high ceilings and large windows, are particularly appreciated for their use of natural lighting, aligning with previous research that highlights the importance of natural light in creating inviting study spaces (Peng et al., 2022). Users in the north wing's quiet area of the 6th floor report higher satisfaction, indicating that specific design features such as spaciousness and light quality significantly contribute to user satisfaction. These results not only align with but also extend the findings of prior research like that of Cha and Kim (2018), which emphasizes the role of spatial attributes in library user satisfaction. The implications of these findings are clear: library design should prioritize specific, well-considered spatial elements to enhance the learning experience and satisfaction of its users, supporting a more tailored and user-focused approach in library space planning.

While previous research has extensively examined the connections between indoor environments and human cognitive and emotional responses (Horr et al., 2016; Coburn et al., 2017), this study specifically aimed to explore how the individual attribute "feeling" influences library users' satisfaction with the interior design. However, the findings indicate that "feeling" do not significantly impact users' perceptions of the interior design in this particular study context. The relationship between individual cognition and the built environment is complex and often non-linear, potentially involving various mediating factors that could influence how these variables interact. For instance, personal expectations, prior experiences, and specific situational contexts might play significant roles in shaping how individuals perceive and react to the design of their surroundings. This complexity suggests that future research should consider a broader range of variables and possibly employ a mixed-methods approach to capture the full spectrum of cognitive and emotional responses to interior design.

Understanding these dynamics more deeply could lead to more effective design strategies that are responsive to the nuanced psychological needs of library users.

While the co-working design concept is increasingly utilized in office spaces and is being integrated into various other functional areas, it does not emerge as the predominant factor influencing occupants' satisfaction. This is consistent with previous research, such as studies by Robelski et al. (2019) and Tan and Lau (2020), which also found that while co-working areas are a modern and popular design approach, they do not necessarily rank as the most critical element in determining user satisfaction.

In the context of this study, it is evident that library users consider a range of interior design elements when evaluating their satisfaction. The findings suggest that the design of co-working spaces within the library had a minimal impact on the users' satisfaction levels. This observation indicates that while co-working spaces may add value to the functionality and aesthetic appeal of the library, other aspects of the library's interior design play more significant roles in shaping overall user satisfaction. Consequently, this study highlights the importance of a holistic approach to library interior design, where multiple factors are considered to meet the diverse needs and preferences of library users.

The research findings also suggest a multifaceted approach to optimizing university library spaces based on user preferences and demographics. Key strategies include designing spaces with adjustable features to cater to student groups with specific needs (e.g. quiet areas and co-working space), enhancing natural lighting throughout the library to improve mood and productivity, and incorporating flexible design elements and adjustable lighting to support various forms of study and collaboration. The study also emphasizes the importance of continuous user feedback and the use of advanced tools to measure psychological impacts, ensuring that the library's interior design evolves in line with the diverse and changing needs of its users. By focusing on these strategies, university libraries can significantly enhance user satisfaction and create more engaging, functional environments.

Implementing the insights from this study into facilities management practices can significantly enhance the design and functionality of university libraries. Facilities management teams can integrate user feedback mechanisms into regular maintenance and redesign cycles, making continuous adjustments that reflect evolving user needs and preferences. By prioritizing elements that influence user satisfaction -- such as lighting quality, seating ergonomics, and layout of collaborative spaces -- facilities managers can create environments that support studying and collaboration while also catering to the demographic and psychological profiles of library users. This proactive and data-driven approach not only fosters increased user engagement and academic performance but also ensures that library environments remain dynamic, functional, and responsive to the diverse needs of their users.

The limitation of this study lies in several key areas that affect the applicability of the findings. Firstly, the sample size may not adequately represent the wide variability in user satisfaction, potentially limiting the robustness and generalizability

of the findings. Additionally, its cross-sectional study design captures only a single point in time, which restricts the ability to track changes or long-term trends in user satisfaction. Furthermore, the focus on just one university library may not reflect conditions in other educational settings, thus limiting the broader applicability of the results. Lastly, the study might not fully account for potential biases influenced by contextual factors. User satisfaction with library design could be shaped by cultural expectations, specific functions of the library spaces, or the unique needs and preferences of the user population. These elements can significantly skew perceptions of interior design quality and overall satisfaction, indicating a need for future research to adopt a more inclusive approach that considers a variety of user perspectives and environmental contexts. The implications of this study are significant for both theoretical frameworks and practical applications in university library design. It emphasizes the importance of a holistic design approach that incorporates aesthetic and functional elements to enhance user satisfaction. By revealing how perceived interior design quality significantly influences satisfaction, the study suggests that library administrators and designers should prioritise both aesthetic and utilitarian aspects. Also, the findings highlight the need for flexible design strategies that can cater to the diverse needs and preferences of various user demographics, such as age and gender. This tailored approach can increase library engagement and resource utilization. Furthermore, the study points to the necessity for more sophisticated tools to measure the emotional impacts of design, encouraging a deeper exploration of how physical environments influence user feelings. This dual focus on aesthetics and emotional response in library design could lead to more effective and welcoming library spaces.

7. Conclusion

Conclusively, study significantly advances the understanding of the intricate dynamics between interior design elements and user satisfaction in the context of a university library. While existing research has predominantly focused on utilitarian aspects, such as lighting and air quality, the exploration of aesthetic and experiential dimensions brings attention to the often-neglected elements of seating, layout, size, openness and ergonomics of seating. By integrating individual differences such as gender, age, and feeling into the theoretical model, we provide a comprehensive framework for evaluating library users' satisfaction. SEM analysis highlights the central role of perceived interior design quality, demonstrating its substantial impact on overall satisfaction with the library environment. The discernible influence of age, gender, and library location further underscores the need for tailored design approaches that consider specific user demographics and diverse spatial contexts.

Additionally, the empirical analysis extends our insights into practical implications. The examination of user satisfaction based on specific design elements in different library locations unveils nuanced preferences and areas of distinctive satisfaction. Co-working spaces, while widely adopted in modern designs, do not emerge as the most critical factor affecting user satisfaction, challenging common

assumptions. However, the study also identifies a critical gap in understanding the role of individual feelings, emphasizing the need for more nuanced measurement tools to capture the complex interplay between emotions and the built environment. Ultimately, this research provides valuable guidance for future library design practices, urging a holistic approach that balances functional necessities with the nuanced experiential aspects of interior design in university libraries. This study's findings enrich facilities management practices by providing a user-centric investigation approach that emphasizes the importance of aligning space design with user-specific demographic and emotional feeling, ensuring environments are not only functionally efficient but also finely attuned to enhance user satisfaction.

Acknowledgement

An AI tool/language model was utilized for proofreading this paper.

References

Aisjah, H.N. and Shintawati, Y., (2021), September. The Perception of Users on the Modern Interior Design of the Library. In 3rd Annual International Conference on Public and Business Administration (AICoBPA 2020) (pp. 399-404). Atlantis Press.

Altomonte, S., Allen, J., Bluyssen, P.M., Brager, G., Heschong, L., Loder, A., Schiavon, S., Veitch, J.A., Wang, L. and Wargocki, P., (2020). Ten questions concerning well-being in the built environment. *Building and Environment*, *180*, p.106949.

Al-Zamil, F.A., (2017). The Impact of Design Elements on the perception of spaciousness in Interior Design. *International Design Journal*, 7(2), pp.177-187.

Andretta, M., Coppola, F., & Seccia, L. (2016). Investigation on the interaction between the outdoor environment and the indoor microclimate of a historical library. *Journal of Cultural Heritage*, 17, 75-86.

Anandasivam, K. and Fatt Cheong, C., (2008). Designing a creative learning environment: NTU's new Art, Design and Media Library. *The Electronic Library*, 26(5), pp.650-661.

Berkers, R., Van der Voordt, T. and Dewulf, G., (2016). Learning space preferences of higher education students. *Building and Environment*, 104, pp.243-252.

Bluyssen, P., Roda, C., Mandin, C., Fossati, S., Carrer, P., Kluizenaar, Y., … & Bartzis, J. (2015). Self-reported health and comfort in 'modern' office buildings: first results from the european officair study. *Indoor Air*, 26(2), 298-317.

Cha, S.H. and Kim, T.W., (2020). The role of space attributes in space-choice behaviour and satisfaction in an academic library. *Journal of Librarianship and Information Science*, 52(2), pp.399-409.

Chai, Q., Li, H., Tian, W., Zhang, Y., & Wang, L. (2022). A framework for assessing the performance of adaptively reused buildings from users' perspective: a case study of school building. *Advances in Civil Engineering*, 1-15.

Ching, F.D. and Binggeli, C., (2018). Interior design illustrated. John Wiley & Sons.

Chiu, D. and Ho, K. (2022). *Editorial. Library Hi Tech*, 40(1), 196-197.

Chow, W. and Fung, W. (1995). Indoor thermal environment survey in air-conditioned shopping malls in Hong Kong. *Indoor Environment*, 4(2), 102-112.
Coburn, A., Vartanian, O., & Chatterjee, A. (2017). Buildings, beauty, and the brain: a neuroscience of architectural experience. *Journal of Cognitive Neuroscience*, 29(9), 1521-1531.
Daniel, R. M. (2023). Measure and mis-measure: rethinking anthropometry in interior design. *Journal of Interior Design*, 49(1), 17-34. Decker, E.N. and Porter, S.M., (2018). *Engaging design: Creating libraries for modern users*. Bloomsbury Publishing USA.
Farooq, M.S., Salam, M., Fayolle, A., Jaafar, N., Ayupp, K., (2018). Impact of service quality on customer satisfaction in Malaysia airlines: A PLS-SEM approach. *Journal of Air Transport Management*. 67, 169-180.
Feng, Z., Hou, H.C. and Lan, H., (2024). Understanding university students' perceptions of classroom environment: A synergistic approach integrating grounded theory (GT) and analytic hierarchy process (AHP). *Journal of Building Engineering*, p.108446.
Forrest, C. and Halbert, M. eds., (2020). *Beyond the Information Commons: A Field Guide to Evolving Library Services, Technologies, and Spaces*. Rowman & Littlefield.
Frontczak, M. J., Schiavon, S., Goins, J., Arens, E., Zhang, H., & Wargocki, P. (2011). Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. *Indoor Air*, 22(2), 119-131.
Gerolimos, M. and Konsta, R. (2008). Librarians' skills and qualifications in a modern informational environment. *Library Management*, 29(8/9), 691-699.
Godson, C., Maureen, O., Barbara, O., & Adannia, N. (2021). Assessment of airborne fungal spores in indoor environment of libraries in nnamdi azikiwe university. *International Journal of Advanced Research*, 9(11), 506-520.
Greene, C. and Myerson, J., 2011. Space for thought: designing for knowledge workers. *Facilities*, *29*(1/2), pp.19-30.
Gunes, G., Yalçin, N., & Çolaklar, H. (2022). Investigation of indoor air quality in university libraries in terms of gaseous and particulate pollutants in bartin, turkey. *Environmental Monitoring and Assessment*, 194(3).
Hair Jr, J., Hair Jr, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., (2021). A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications.
Hanmontree, P., Prinyawiwatkul, W., & Sae-Eaw, A. (2022). Emotion and wellness profiles of herbal drinks measured using different questionnaire designs. *Foods*, 11(3), 348.
Haselsteiner, E., 2021. Gender matters! Thermal comfort and individual perception of indoor environmental quality: A literature review. *Rethinking sustainability towards a regenerative economy*, pp.169-200.
Hong, S., Kim, Y., & Yang, E. (2021). Indoor environment and student productivity for individual and collaborative work in learning commons: a case study. *Library Management*, 43(1/2), 15-34.

Hong, S., Kim, Y. and Yang, E., (2022). Indoor environment and student productivity for individual and collaborative work in learning commons: a case study. *Library Management*, *43*(1/2), pp.15-34.
Horr, Y. A., Arif, M., Kaushik, A., Mazroei, A., Katafygiotou, M., & Elsarrag, E. (2016). Occupant productivity and office indoor environment quality: a review of the literature. *Building and Environment*, 105, 369-389.
Hou, H. and Wu, H., (2021). Tourists' perceptions of green building design and their intention of staying in green hotel. *Tourism and Hospitality Research*, 21(1), pp.115-128.
Hou, H.C., Wang, Y. and Lan, H., (2023a). Student residential apartment performance evaluation using integrated AHP-FCE method. *Journal of Building Engineering*, 67, p.106000.
Hou, H.C., Wang, Y. and Lan, H., (2023b). Student residential apartment performance evaluation using integrated AHP-FCE method. *Journal of Building Engineering*, 67, p.106000.
Hou C. (2025) Enhancing Engineering Education: Efficacy of a Virtual Classroom on Learning Basic Indoor Thermal Environment Engineering Concept ISSN: 2759-7563 – The Korean Conference on Education 2024: Official Conference Proceedings (pp. 585-596) https://doi.org/10.22492/issn.2759-7563.2024.46
Jiang, H., Li, X., Kang, J., & Kong, Z. (2017). An evaluation of the lighting environment in the public space of shopping centres. *Building and Environment*, 115, 228-235.
Jo, H.I. and Jeon, J.Y., (2022). Influence of indoor soundscape perception based on audiovisual contents on work-related quality with preference and perceived productivity in open-plan offices. *Building and Environment*, *208*, p.108598.
Juliá Nehme, B., Rodríguez, E. and Yoon, S.Y., (2020). Spatial user experience: A multidisciplinary approach to assessing physical settings. *Journal of Interior Design*, 45(3), pp.7-25.
Kamaruzzaman, S. N., Egbu, C., Mahyuddin, N., Zawawi, E. M. A., Chua, S. J. L., & Azmi, N. F. (2017). The impact of ieq on occupants' satisfaction in malaysian buildings. *Indoor and Built Environment*, 27(5), 715-725.
Kang, S., Ou, D. and Mak, C.M., (2017). The impact of indoor environmental quality on work productivity in university open-plan research offices. *Building and Environment*, 124, pp.78-89.
Kreislova, K., Fialová, P., & Boháčková, T. (2021). Indoor corrosivity in klementinum baroque library hall, prague.
Lan, H., Hou, H.C., Gou, Z., Wong, M.S. and Wang, Z., (2023a). Computer vision-based smart HVAC control system for university classroom in a subtropical climate. *Building and Environment*, 242, p.110592.
Lan, H., Hou, H.C. and Gou, Z., (2023b). A machine learning led investigation to understand individual difference and the human-environment interactive effect on classroom thermal comfort. *Building and Environment*, *236*, p.110259.

Laze, K. (2017). Findings from measurements of noise levels in indoor and outdoor environments in an expanding urban area: a case of tirana. *Noise Mapping*, 4(1), 45-56.
Li, P., Froese, T.M. and Brager, G., (2018). Post-occupancy evaluation: State-of-the-art analysis and state-of-the-practice review. *Building and Environment*, 133, pp.187-202.
Lin, M., Lu, W., Li, N. and Geng, W., (2024). Exploring the relationship between library reading space height and user perception: A physiological and subjective analysis. *Building and Environment*, p.111307.
Marshalsey, L., (2023). *Sensory Affect, Learning Spaces, and Design Education: Strategies for Reflective Teaching and Student Engagement in Higher Education*. Routledge.
McKillop, C.A., (2020). Designing Effective Library Learning Spaces–Student2Scholar: A Case Study. In *Designing Effective Library Learning Spaces in Higher Education* (pp. 45-59). Emerald Publishing Limited.
McKinley, N. M. and Hyde, J. S. (1996). The objectified body consciousness scale. *Psychology of Women Quarterly*, 20(2), 181-215
Pastore, L. and Andersen, M., (2022). The influence of façade and space design on building occupants' indoor experience. *Journal of Building Engineering*, *46*, p.103663.
Peng, L., Wei, W., Gong, Y., & Jia, R. (2022). University library space renovation based on the user learning experience in two wuhan universities. *International Journal of Environmental Research and Public Health*, 19(16), 10395.
Putra, P. (2021). The influence of situational leadership, work environment, competence, and motivation on employee job satisfaction at the national library of indonesia. *International Journal of Current Science Research and Review*, 04(07).
Robelski, S., Keller, H. R., Harth, V., & Mache, S. (2019). Coworking spaces: the better home office? a psychosocial and health-related perspective on an emerging work environment. *International Journal of Environmental Research and Public Health*, 16(13), 2379.
Rohde, L., Larsen, T.S., Jensen, R.L. and Larsen, O.K., (2020). Framing holistic indoor environment: Definitions of comfort, health and well-being. *Indoor and Built Environment*, 29(8), pp.1118-1136.
Safin, S., Pintus, P. and Elsen, C., (2020). Ergonomics in design and design in ergonomics: Issues and experience in education. *Work*, *66*(4), pp.917-931.
Spence, C., (2020). Senses of place: architectural design for the multisensory mind. *Cognitive research: principles and implications*, *5*(1), p.46.
Somerville, M.M. and Brar, N., 2009. A user-centered and evidence-based approach for digital library projects. *The Electronic Library*, *27*(3), pp.409-425.
Su, W., Lu, Z., & Sun, Y. (2021). Let eyes tell: experimental research on university library signage system and users' wayfinding behavior. *Library Hi Tech*, 40(1), 198-221.

Tan, T. H. and Lau, K. F. (2020). Understanding users' and hosts' motives to co-working space: case of kuala lumpur, malaysia. *Open House International*, 46(1), 81-95.

Torresin, S., Albatici, R., Aletta, F., Babich, F., & Kang, J. (2019). Assessment methods and factors determining positive indoor soundscapes in residential buildings: a systematic review. *Sustainability*, 11(19), 5290.

Vischer, J.C., (2008a). Towards a user-centred theory of the built environment. *Building research & information*, 36(3), pp.231-240.

Vischer, J.C., (2008b). Towards an environmental psychology of workspace: How people are affected by environments for work. *Architectural science review*, 51(2), pp.97-108.

Wagner, A., Kilincsoy, Ü., & Vink, P. (2018). Visual customization: diversity in color preferences in the automotive interior and implications for interior design. *Color Research & Application*, 43(4), 471-488.

Wang, H. and Liu, L., (2020). Experimental investigation about effect of emotion state on people's thermal comfort. *Energy and Buildings*, 211, p.109789.

Weisz, J. R., Vaughn-Coaxum, R. A., Evans, S. C., Thomassin, K., Hersh, J., Ng, M. Y., … Mair, P. (2019). Efficient monitoring of treatment response during youth psychotherapy: the behavior and feelings survey. *Journal of Clinical Child & Adolescent Psychology*, 49(6), 737-751.

Whittem, V., Roetzel, A., Sadick, A.M. and Kidd, A.N., (2022). How comprehensive is post-occupancy feedback on school buildings for architects? A conceptual review based upon Integral Sustainable Design principles. *Building and Environment*, *218*, p.109109.

Zhang, Z., (2019). The effect of library indoor environments on occupant satisfaction and performance in Chinese universities using SEMs. *Building and Environment*, *150*, pp.322-329.

Zhang, D., Hou, H., Tsang, T.W., Mui, K.W. and Wong, L.T., (2024). Predicting students' thermal sensation votes in university libraries taking into account their mood states. *Indoor and Built Environment*, *33*(5), pp.859-875

Appendix 1. Questionnaire instrument