Assessment of Building Performance and Occupant Satisfaction in Student Housing: A Post-Occupancy Evaluation Study at KFUPM

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Abstract

Research on post-occupancy evaluation on student housing has been quite intensive in the past decade. However, some countries give little or no concern to the practice of improving design outcomes and building performance using post-occupancy evaluations. This study focuses on the use of post-occupancy evaluation (POE) of the design and the building performance of existing students` housing at the campus of King Fahd University of Petroleum and Minerals, Saudi Arabia. The evaluation methods used include on-site walkthroughs, questionnaire surveys and students' meetings. A comprehensive overview of the building performance provided, along with an evaluation of the satisfaction of the students. This study provides areas for improvement and provides guidelines and recommendations to serve as feedback and feed forward to university's Projects/Maintenance Department, to improve the design and maintenance in the design stage of future student housing buildings. Thus, the study has practical findings that contribute to enhancing future building design, utilization, and optimizing the designe process for similar projects, and improving the overall satisfaction of occupants of student housing facilities.

Keywords: Post-Occupancy evaluation; student housing; building performance; satisfaction of occupants; subjective evaluation; Saudi Arabia

1 INTRODUCTION

Post-occupancy evaluation (POE) is an essential tool that enables facility managers to continually enhance the quality and performance of the facilities under their operation and maintenance. This tool holds particular significance for organizations engaged in recurring construction programs or those managing a substantial portfolio of facilities requiring remodel in (Wolfgang F.E. Preiser et al., 2015)

POE is defined as a systematic process that compares the actual performance of a building, measured through performance indicators, with explicitly stated performance criteria. These criteria are typically documented in a facility program, which serves as a common prerequisite for the design phases in the building delivery cycle (2009 ASHRAE Handbook: Fundamentals , n.d.). While the concept of building performance evaluation has been extensively explored by researchers, the majority of attention has focused on commercial and residential buildings, such as sick office buildings and intelligent buildings, rather than student dormitories. Consequently, there is a need to investigate the performance of student dormitories comprehensively and holistically, considering various performance aspects.

This study aims to provide a detailed examination of the design and operation of existing Building 93 at King Fahd University of Petroleum and Minerals (KFUPM), including user satisfaction, standard requirements, and the influence of physical design on occupants. It is clear that Post-occupancy evaluation (POE) is absent in most university student housing facilities in Saudi Arabia. Consequently, the state of students' hostels in Saudi Arabia universities have been described as inadequate with low students' satisfaction (Mohammad A. Hassanain, 2007), (Muizz O et al., 2016).

The objectives of this study were as follows: (1) To gain a comprehensive understanding of the building performance in student housing at KFUPM, examining the degree of comfort provided by each element of building performance; (2) To assess the building performance for both the owners and occupants of the building; (3) To conduct an in-depth investigation, with a high level of accuracy, into methods for improving building utilization and the building delivery process for similar structures in the future, as well as exploring hypotheses regarding the influence of physical design on building occupants. Overall, the study will contribute to better understanding of post-occupancy evaluation and its application in the context of student dormitories located within the campus of King Fahd University of Petroleum and Minerals, and also useful for assisting building designs quality, and students performance.

2 LITERATURE REVIEW

In recent years, there has been an increasing amount of literature on post occupancy evaluation. Several studies have revealed that post occupancy evaluation is the process of evaluating building systematically and comprehensively after it has been occupied (Agyekum et al., 2016; Federal Facilities Council (FFC), 2001; Lee1 & Oh, n.d.). Post-occupancy evaluation also referred to post-occupancy review (POR) and define as the process for measuring a project's success and centers on the needs of the occupants (Aliyu et al., 2016). A number of studies have found that post-occupancy evaluation is the evaluation of the performance of buildings during usage for improvement and fitness for purpose(Muizz O. Sanni-Anibire et al., 2016; Nawawi & Khalil, 2008). In her major study, (Meir et al., 2009) labelled Post-Occupancy Evaluation into two methods, lateral studies - examining a limited number of parameters in a large number of case studies; and in-depth studies - providing a detailed analysis of all available parameters in a single case study.

It is necessary here to clarify exactly what is meant by Post-Occupancy Evaluation (POE) and over the past decade researchers worldwide have been dedicated to defining the concept of POE. According to Oladiran (2013), post occupancy evaluation is defined as any method directed towards determining and improving building performance in relation to users' satisfaction and the built environment (Federal Facilities Council (FFC), 2001; Oladiran, 2013). Walker, defined Post occupancy evaluation POE as "a systematic evaluation of a designed and occupied setting from the perspective of those who use it" (Walker, 2012). According to Khalil and Husin, the application of POE is prioritized as strategic level decision making and emphasized as continuous activity in environmental evaluation (Federal Facilities Council (FFC), 2001; Khalil & Husin, 2009). It is the evaluation of the performance of buildings during usage for improvement and fitness for purpose (Abdul Hadi Nawawi & Natasha Khalil, 2008; F. Stevenson, 2009). Post-Occupancy Evaluation (POE) is the process of evaluating space design systematically and comprehensively after user occupied (Hewitt et al., 2006; Lee1 & Oh, 2007).

In 2009, Meir et al. employed tools in POE include plan analysis, monitoring of building performance, indoor environment quality (IEQ), indoor air quality (IAQ) and thermal performance, and surveys including walkthroughs, observations, user satisfaction questionnaires-survey, and semi-structured and structured interviews (Meir et al., 2009) . The main purpose of these tools is to delineate the interrelation among the building, operation system and its occupants. POE serve as a way of providing subjective and objective feedbacks that can inform the decision-making and practice throughout the building's life-cycle from the initial design to occupation(Meir et al., 2009).

It is worth noting that the results of residential satisfaction cannot simply be generalized to university students' housing due to the differences arise from the users' characteristics as well as from the physical dimensions of housing (Amole, 2009). Some factors of residential buildings do not exist in the university dormitory context, such as homeownership and an opportunity to purchase their home (Teck-Hong, 2012; Zhonghua Huang et al., 2015), distance to work, location of schools (Djebarni & Al-Abed, 2000), building age and safety (Potter & Cantarero, 2006), satisfaction with community services (Grzeskowiak et al., 2003) and neighbors (Ibem & Aduwo, 2013; Jansen, 2014). In addition, difference also lies into the demographic background of the occupants (Najib et al., 2012) , such as number of family members (Jansen, 2014; Li Tao et al., 2014).

Our goal in this study is not an exhaustive review of all material published on Post-Occupancy Evaluation (POE), but, rather, to better understanding of POE and its application in the context of student dormitories located within the campus of King Fahd University of Petroleum and Minerals, and also useful for assisting building designs quality, and students performance. Building performance evaluation involves three major categories of elements: technical, functional, and behavioral performance (Horgen & Sheridan, 1996).

2.1 Technical Elements of Building Performance

Technical elements can be described as the foundational factors that create the environment necessary for conducting activities within a building. These elements encompass crucial aspects such as structure, sanitation, fire safety, and ventilation. They are directly related to health, safety, and welfare, often being incorporated into building codes. Measuring technical elements requires the use of instrumentation, and a robust infrastructure of organizations and information exists to support this process. The attributes of technical elements include:

Fire Safety: Fire safety in structures has been a subject of early and systematic evaluation, given its paramount significance in safeguarding lives and property. Key criteria evaluated include the fire resistance of major structural elements, measures for fire extinguishment and containment, assessment of flame spread, smoke generation, toxicity of burning materials, and ensuring ease of egress in case of a fire.

Structure: The element of structure has a significant research background and is well-established in building codes, showcasing a high level of reliability. Building codes provide details regarding structural properties, material strength, connections, and durability attributes. The evaluation of structures takes place both on-site and in laboratories, with a dedicated emphasis on continuous feedback and improvement processes.

Sanitation and Ventilation: Plumbing and ventilation systems are recognized for their high reliability and adherence to well-established performance criteria. However, the energy crisis and the trend towards tighter building designs have led to a decrease in ventilation criteria, underscoring the increased significance of conducting research on indoor air quality in post-occupancy evaluations.

Electrical: Electrical systems are recognized as highly reliable performance elements that are governed by building codes. However, they are susceptible to technical advancements and evolving functional requirements, especially in office buildings. These changes encompass the integration of new equipment, such as microcomputers and facsimile machines, as well as advancements in cabling technologies like fiber optics.

Exterior Walls: Exterior walls are commonly constructed using a combination of materials and joints, rendering them vulnerable to deterioration caused by environmental elements. Although a significant portion of exterior wall performance lacks regulation, product manufacturers' organizations have established performance criteria that address various factors including weathering, fading, moisture content, wind infiltration, buckling, cracking, cleanability, and corrosion.

Roofs: Roofs are highly susceptible to frequent building failures, as they are the most exposed elements along with exterior walls. Despite the presence of performance criteria and specifications, problems persist due to the complexity of assembling various roof components.

Interior Finishes: Performance criteria for interior finishes, encompassing floors, ceilings, and walls, prioritize aesthetic attributes such as fading, surface evenness, and cleanability. Additionally, durability, especially in the case of floor surfaces, emphasizes resistance to scratches, indentations, abrasions, spills, stains, cigarette burns, and other types of damage.

Acoustics: Although acoustical considerations are not commonly included in building codes, regulations are in place to govern sound in the workplace and ensure the protection of workers in noisy environments. Acoustics criteria encompass a wide range of factors, including ambient sound levels, sound transmission between areas and rooms, reverberation, and specific areas such as machine noise and auditorium acoustics. These regulations aim to address the impact of sound and promote a suitable acoustic environment in various settings.

Illumination: Standard illumination practices go beyond the minimum levels outlined in building codes, incorporating criteria that address both the quality and quantity of illumination. Factors taken into consideration in illumination criteria encompass human comfort, levels of visual perception, the physiological effects of light color, different types of bulbs, the growing use of video displays, the need for changes in focus, and increased user control of task lighting. Ongoing studies are dedicated to enhancing existing illumination criteria by delving into these aspects and exploring ways to improve lighting standards. By examining and evaluating these technical elements, a comprehensive understanding of the building's performance can be achieved, contributing to the overall effectiveness and efficiency of the facility.

2.2 Functional Elements of Building Performance

Functional elements play a crucial role in meeting the expectations of various organizations, such as business factories, schools, shops, and offices. These organizations rely on satisfactory functional performance from their buildings (Horgen & Sheridan, 1996). The functional elements encompass several aspects, including personnel and equipment access, security, parking facilities, and sufficient spatial capacity to accommodate the organization's activities. Additionally, utilities, telecommunications, adaptability to accommodate necessary equipment, responsiveness to changing needs over time, and efficient communication and circulation systems are important considerations. The functional elements directly support the activities within a building and must be tailored to meet the specific needs of the organization and occupants, both in quantitative and qualitative terms. The key aspects of the functional element include:

Human Factor: This aspect focuses on designing the environment, particularly the immediate surroundings, to match the physiological needs and physical dimensions of the building occupants (White, 1989).

Storage: Criteria for storage are limited, and the existing ones are often inadequate. Consequently, there have been relatively few post-occupancy evaluations conducted in this area.

Communication and Workflow: Post-occupancy evaluations and criteria for communication and workflow exist in the industrial sector and are now being applied to office environments.

Flexibility and Change: Studies conducted in the industrial and office sectors reveal that frequent changes are characteristic of these building types. Rapid advancements in technology further emphasize the significance of this functional element.

Specialization within Building Types: Specialization is becoming increasingly common in office buildings, as well as in the hotel and retail industries, necessitating tailored functional elements to meet specific requirements.

Overall, the functional elements of a building are crucial for enabling smooth operations and must be designed to address the unique needs of organizations and occupants, while considering factors such as human comfort, storage requirements, communication, adaptability to change, and specialization within different building types.

2.3 Behavioral Elements of Building Performance

The behavioral element of performance explores the connection between occupant activities and their satisfaction with the physical environment. It focuses on how the design of a building impacts the psychological and sociological well-being of its occupants (White, 1989). The key aspects of the behavioral element include:

Proxemics and Territoriality: Proxemics examines the interpersonal distance maintained among individuals for effective communication. Territoriality, on the other hand, pertains to the culturally defined spaces that individuals establish.

Privacy and Interaction: This aspect is concerned with controlling access to an individual's or group's territory, including physical, visual, and auditory access.

Environmental Perception: This aspect involves how individuals perceive and experience the building through their senses.

Image and Meaning: The subjective nature of this aspect focuses on the shape, materials, details, and decoration of the building, which contribute to its image and the meanings associated with it.

By examining these behavioral elements, researchers can gain insights into how the design of a building influences occupant behaviors, interactions, and overall satisfaction.

2.4 Student Housing Design Guidelines

Design handbooks offer guidelines on the standards and criteria for planning dormitories, encompassing various aspects of performance. These guidelines cover spatial performance requirements, thermal performance requirements, acoustic performance requirements, indoor air quality requirements, and visual performance requirements. By adhering to these guidelines, designers can ensure that dormitories meet the necessary standards for providing adequate space, thermal comfort, sound insulation, air quality, and visual conditions. These criteria play a crucial role in creating dormitory environments that are conducive to the well-being and satisfaction of their occupants.

2.4.1 Spatial Performance Requirement:

The spatial performance requirement for student rooms is of paramount importance as these spaces serve as the primary environment where students engage in activities such as studying, sleeping, dressing, and socializing. Single rooms are designed to offer controlled privacy for their occupants in relation to other students. They may have direct access to the corridor while ensuring complete privacy when entering or exiting the room. It is recommended that single rooms have a minimum area of 120 square feet. On the other hand, double rooms are the current standard in student housing, with their sizes ranging from 145 to 250 square feet. To ensure efficient use of space, specific dimensions for room furniture are recommended:

- *Bed:* 40.5" W x 84" L x 30" H
- *Desk:* 24" D x 36.5" W x 30.25" H
- *Desktop Organizer:* 12" D x 34.75" W x 30" H
- *Dresser:* 24" D x 36.5" W x 30.25" H
- *Bookcase:* 12" D x 34.75" W x 30" H

2.4.2 Thermal Performance Requirements

Thermal comfort is a subjective experience that reflects an individual's satisfaction with the thermal environment. It is influenced by various factors, including air temperature, radiant temperature, relative humidity, air speed, clothing, and activity level. In the case of this building, it is centrally air-conditioned, and specific thermal performance requirements are set to ensure occupant comfort. The acceptable limits for these parameters are as follows:

- *Temperature:* The recommended range is between 24°C and 27°C.

- *Relative humidity:* The acceptable range is between 30% and 60%.
- *Average air movement:* The desired air movement should be less than 0.20 m/s (40 fpm).

By maintaining these thermal performance requirements within the designated ranges, the building can provide a comfortable and pleasant thermal environment for its occupants. This promotes productivity, well-being, and overall satisfaction among the building users.

2.4.3 Acoustical Performance Requirement

Effective acoustic design aims to optimize desired sounds while minimizing unwanted noise. In the context of student accommodation, it is important to create an environment that balances tranquility with the ability to facilitate communication and interaction. Students should be able to communicate easily, both with their peers and through telephone conversations, without the need to raise their voices or feel concerned about their conversations being overheard. The acoustical performance requirements address three key aspects:

- *Interior Noise Reflection:* The design should minimize the effects of exterior noise from neighboring rooms within the building. It is recommended to achieve a noise level of 55 dB. Excessive noise levels can significantly hinder students' ability to concentrate and negatively impact their learning experience.
- *Exterior Noise Reduction:* The room should be designed to effectively reduce external noise from entering the space, ensuring a peaceful study environment.
- *Interior Noise Reduction:* Similarly, the room should have measures in place to reduce noise transmission within the interior, allowing for a quiet and comfortable living environment.

By incorporating these acoustical performance requirements, the design of the student accommodation can create an environment conducive to concentration, communication, and overall well-being.

2.4.4 Indoor Air Quality Performance Requirements

Indoor air quality (IAQ) is of paramount importance in student housing environments due to its direct impact on the learning process and occupants' well-being (Bayer Sidney A Crow John Fischer, 1998)(Ministry of the Environment Singapore, 1996). The following factors contribute to the significance of prioritizing IAQ:

- *Learning Environment:* The primary goal of universities is to facilitate an optimal learning experience, which is directly influenced by the quality of the indoor environment. By ensuring good IAQ, a conducive atmosphere for learning can be created (Ministry of the Environment Singapore, 1996).

- *Ventilation Rate:* ASHRAE 62-73 recommends a minimum air ventilation rate of 5 cubic feet per minute (cfm) per person to achieve an odor-free and comfortable environment. Adequate ventilation helps maintain air freshness and reduces the buildup of pollutants.
- *Carbon Dioxide (CO2) Levels:* Carbon dioxide is used as an indicator of ventilation efficiency. The acceptable concentration of CO2 indoors, according to ASHRAE standard 55-1996, is 1000 parts per million (ppm). However, research indicates that CO2 concentrations exceeding 600 ppm can have adverse physiological effects, including fatigue, drowsiness, lack of concentration, and breathing difficulties.
- *Suspended Particles:* The maximum recommended concentration for suspended particles in the indoor air is 150 milligrams per cubic meter (mg/m3). Controlling the level of airborne particles helps ensure a healthier and cleaner indoor environment.

2.4.5 Visual Performance Requirement

Optimal lighting plays a crucial role in providing a comfortable and healthy visual environment that supports students' activities. To achieve this, the following visual performance requirements should be considered:

- *Illuminance Level:* The recommended illuminance level for the tabletop is 500 lux. However, it is important to avoid extremely high light levels near windows, as they can cause discomfort or glare for students. Balancing lighting levels throughout the space is essential (Preiser, 1995).
- *Daylight Integration:* Whenever feasible, utilize natural daylight as a source of ambient lighting. Incorporating windows and skylights can enhance the visual environment while reducing the reliance on artificial lighting during daylight hours.
- *High-Performance Lighting Systems:* Supplement natural light with integrated, high-performance ballasts, lamps, fixtures, and controls (Preiser, 1995). This helps ensure efficient and effective lighting distribution throughout the space.
- *Flicker Reduction:* Substitute magnetic fluorescent lamps with high-frequency electronic ballasts to minimize flickering. Flickering can cause visual discomfort and fatigue, so using electronic ballasts helps provide a more consistent and pleasant lighting experience.

- *Glare Control:* Mitigate direct glare from both natural and artificial light sources within the field of view, especially in areas with highly reflective surfaces. Glare can impair visual comfort and performance, so proper positioning of lighting fixtures and the use of glare-reducing materials are important considerations.
- *Task and Ambient Lighting:* Employ task/ambient lighting systems that offer reduced levels of diffuse, general illumination while incorporating task lighting where needed (Joseph De Chiara & John Hancock Callender, 1983). This allows for flexibility and customization to support specific tasks or activities.
- *Light Color and Window Placement:* Utilize appropriate light-colored wall finishes to enhance light reflection and distribution within the space. Additionally, strategic window placement can optimize daylight penetration and reduce the need for excessive artificial lighting.

3 RESEARCH METHODS

3.1 Research Design and Building Description

A university of King Fahd University of Petroleum and Minerals located in the east Saudi Arabia was selected based on its typical characteristics. The data were collected only from students who stayed on campus in King Fahd University of Petroleum and Minerals. The university consists of eighteen blocks of student housing (three-story to four-story). This university was selected for two reasons: it has a fairly excellent ranking in Saudi Arabia, indicating that it is a satisfactory representative of the university sample; and it shares similarities to other world universities in terms of university size, areas and number of students.

The building under study was constructed in 1988 and comprises four stories. Each story is divided into four flats or apartments, with each flat containing six rooms. Two students are accommodated in each room, resulting in a total of 192 students residing in the building. The building is situated 50 meters away from the main road leading to ARAMCO in the northern direction. The library and faculty lecture buildings sit in the middle of the campus and 400 meters away from the student's dormitories.

Each student housing has a laundry room, study room and car park. Out of the three student housing options available, this building was selected for the purpose of this study. It is worth noting that all the students residing in this building are graduate students pursuing either a PHD or an MS degree. The rooms in the building adhere to standard sizes, with each room spanning an area of 16-20 square meters. The total area of the entire building amounts to 4128 square meters. Each room is equipped with ceiling fan, air condition system window type. To provide further clarity, typical layout of student housing room is shown in Figure1.

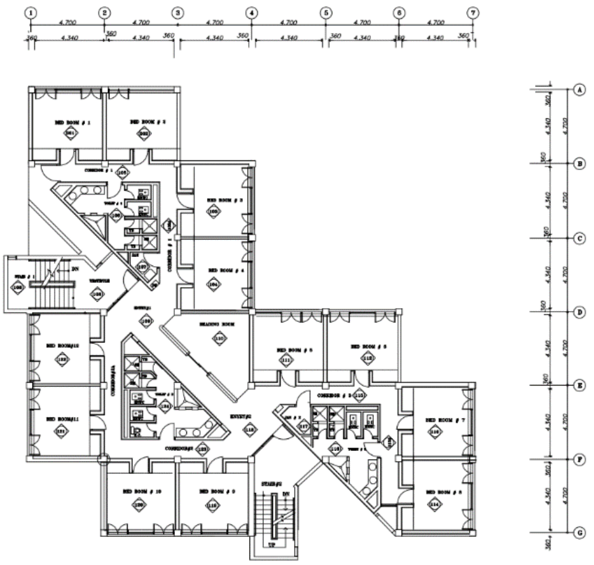

Figure 1 The layout of typical room in the Student Housing

3.2 The questionnaire survey instrument

The questionnaire embraces six sections. The first section asks about *Thermal Comfort* of the student room (5 items). The second section cover the satisfaction of *Acoustical Comfort* inside the room and hall (6 items). The indicators were assessed on a 4-point scale without neutral choice (1 for strongly dissatisfied to 4 for strongly satisfied) to measure the level of student's satisfaction with the subjective and objective variables of the student housing. The third section asks about *Indoor Air Quality* (11 items). The fourth section about *Visual Comfort* (5 items). The fifth section asks about *Overall Building Services* (4 items) and the last section asks about *Functional Element Performance* (8 items) such as car parking, building entrances, room space, furniture, cloth closet and space for computer.

After questionnaire survey was completed. The questionnaire surveys administered to the students who are living in the sixteen flats of the building#93 in the university dormitories. A total of 100 graduate and PhD students were included in the survey sample. The number of participants from every floor level was determined appropriately with proportional-to-size. The survey forms were designed to capture the students' perspectives on various aspects of the building's performance. Table 1 provides a breakdown of the number of respondents. In total, 41 students participated in the survey, representing 41% of the total student population in Building#93. The survey responses provided valuable subjective insights into the students' experiences and perceptions of the building.

Table 1 Breakdown of the respondents

Floor No	Flat #1	Flat #2	Flat #3	Flat #4	Number of Student
1st floor	3	2	2	2	9
2nd floor	4	2	2	2	10
3rd floor	2	4	6	1	13
4th floor	3	3	1	2	9
Grand Total					**41**

3.3 Variables used in the study

This study conceptualized student's satisfaction as influenced by objective and subjective measurements of student housing variables as shown in Fig. 2

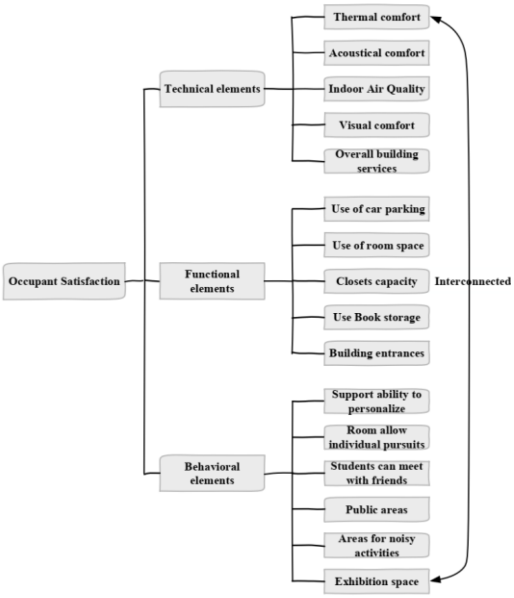

Figure 2. Technical, Functional and Behavioral elements framework for Post-Occupancy Evaluation (POE) of university students Housing

3.3.1 Objective measurements variables

These include a comprehensive physical walkthrough survey of the building and embraces four sections, *site of the building, safety and security, interior finishes, exterior walls*. These variables were measured by the researchers to identify any visible indicators of performance stress and user modifications. During this walkthrough, careful observations were made regarding various performance elements within the building. This approach allowed for a qualitative assessment of the building's condition and potential areas of concern.

3.3.2 Subjective measurements variables

These include variables about *thermal comfort, Acoustical Comfort, Indoor Air Quality(IAQ)* in dormitories, *Visual Comfort, Overall Building Services,* and *Functional Element Performance* such as car parking, building entrances, room space, room furniture, cloth closet and space for computer type of mattresses. These variables were measured on a four-point scale (1 for strongly dissatisfied to 4 for strongly satisfied) without neutral choice. The survey responses provided valuable subjective insights into the students' experiences and perceptions of the building.

3.4 Data analysis

Six types of data analysis for technical elements of building performance were performed. The technical elements in building performance (TBP) serve as the foundational environment for carrying out various activities (Alex Zimmerman & Mark Martin, 2010). These elements can be objectively measured using appropriate instrumentation, and there exists a robust infrastructure of organizations and information to support this assessment process. In evaluating the TBP, six key attributes are considered, and respondents are asked to rate each attribute on a four-point scale. This scale ranges from 1 to 4, with 1 representing "Strongly Dissatisfied" and 4 representing "Strongly Satisfied" in terms of quality. To determine the acceptability of each parameter, the value of 3 on the rating scale is selected. This choice aligns with ASHRAE's ventilation and comfort standards, which emphasize the importance of acceptability. Additionally, using a value of 3 facilitates ease of analysis. If 75% or more of the occupants rate a specific parameter as 3 or higher on the scale, it is deemed acceptable in their perception. This approach allows for a standardized evaluation of the technical elements in building performance, enabling a comprehensive understanding of occupant satisfaction and overall quality. By assessing acceptability based on the majority opinion, it provides a practical measure to gauge the level of satisfaction within the built environment.

4 RESULTS AND DISCUSSION

4.1 Walkthrough Analysis

Based on the observations presented in Table 2, several defects and areas of concern were identified within the building across different elements. Starting with the site, it was noted that there is a lack of sufficient green areas surrounding the building (Fig. 3A), which not only impacts the aesthetic appeal but also limits the availability of outdoor spaces for recreational purposes. Additionally, the absence of an adequate number of shaded trees contributes to increased heat gain and discomfort in outdoor areas. In terms of safety and security, one major issue is the absence of a sprinkler system, which poses a potential risk in the event of a fire. The lack of this crucial safety feature could compromise the building's ability to protect its occupants and contain the spread of fire.

Table 2 Signs defects in the building

Elements	Site	Safety and Security	Interior Finishes	Exterior Walls
Signs of Defects	No sufficient green areas around the building.	No sprinkler system.	Durability of walls materials	Moisture content **Fig 3. A**
	No sufficient numbers of shaded trees around the building.	No warning signals provide visual as well as audible cues.	Floor finishes	Corrosion **Fig 3. B**
			Type of window glass **Fig 3. E**	Wind infiltration through the walls
				Cracks in walls **Fig 3. F**
				The esthetic quality of exterior walls.

Moving on to the interior finishes, concerns were raised about the durability of the walls' materials, indicating a potential weakness that may result in premature deterioration or damage. Furthermore, the condition of the floor finishes was noted to be compromised, requiring attention and maintenance to address wear, stains, or other forms of damage. Regarding the exterior walls, various issues were observed. Corrosion on the walls suggests a potential problem with the materials or protective coatings, which can lead to structural degradation and impact the overall appearance of the building (Fig. 3B). The type of window glass used may not provide adequate thermal or sound insulation, affecting energy efficiency and occupant comfort (Fig. 3E). There were also indications of wind infiltration through the walls, indicating potential insulation deficiencies or gaps that can result in discomfort and energy loss. Cracks in the walls were identified, suggesting possible structural issues requiring further investigation and repairs (Fig. 3F). Lastly, the esthetic quality of the exterior walls was deemed compromised, highlighting the need to address any visual shortcomings.

These findings emphasize the importance of addressing these defects and concerns to ensure the building's functionality, safety, and overall appeal. Remedial actions, maintenance measures, and potentially design improvements should be considered to rectify these issues and enhance the building's performance and user experience.

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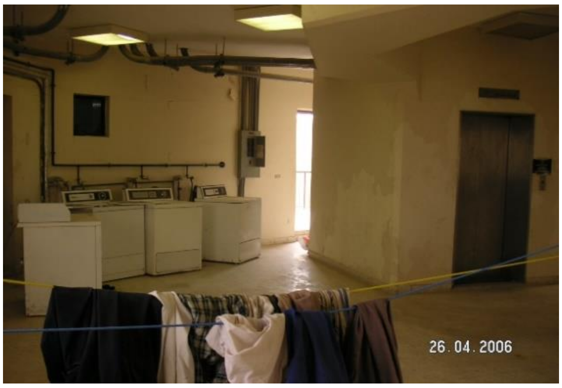
A. Moisture content in exterior walls

B. Corrosion

C. TV and Internet Connection



D. Laundry

E. Plastic shading on windows

F. Cracks

Figure 3 Photos show observed defects in the building.

4.2 Technical Analysis by Occupant Survey

4.2.1 Students' Satisfaction with Thermal Comfort

To assess the actual conditions of thermal comfort, field measurements are essential. In this particular case, the student rooms are equipped with a central air conditioning system, and there is no individual control over the thermostat. Consequently, students are unable to adjust their thermal environment according to their preferences. Upon examination, it was observed that the glazing used in the building is clear and lacks any shading treatment or devices. As a result, students have resorted to covering the windows with aluminum foil to mitigate solar heat gain. Furthermore, the curtains provided in the rooms are inadequate in isolating solar heat, The profiles of the respondents are presented in a Figure 3.E. Figure 4 depicts the students' satisfaction with various aspects of the current air conditioning system, the building's ability to allow fresh air, and the use of shading curtains. However, the lack of temperature control in their rooms has been a common complaint among the students. Despite this concern, it is noteworthy that approximately 75% of the students expressed satisfaction with the overall thermal comfort in their rooms within the building. This analysis highlights the importance of considering thermal comfort in building design and the need to address issues such as temperature control and solar heat gain to enhance occupant satisfaction and well-being.

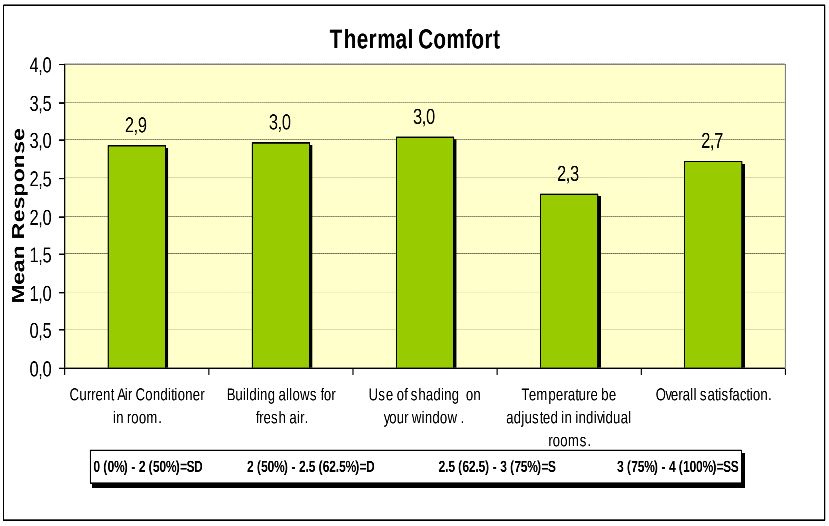


Figure 4 Subjective Assessment about Thermal Comfort in Student's Room in Building # **93**

4.2.2 Students' Satisfaction with Acoustical Comfort

Ensuring a good acoustic performance in student rooms is crucial, as these spaces serve dual functions of studying and sleeping, both of which require a quiet environment. Consequently, the acoustic comfort parameter was assessed to determine the level of satisfaction among the students. Figure 5 provides insights into the students' perceptions of acoustic comfort. It reveals that over 70% of the sample population expressed satisfaction with the acoustic comfort in the corridor and the noise levels in their rooms. However, it is worth noting that over 70% of the responses also indicated satisfaction with the isolation of their room's windows from the outside environment and the noise levels within their rooms. On the other hand, more than 60% of the students reported experiencing noise from adjacent rooms and the corridor, suggesting potential areas for improvement in terms of noise isolation. Addressing these issues would contribute to creating a more conducive and quieter environment for studying and sleeping. These findings underscore the importance of paying attention to acoustical comfort in student housing design, ensuring effective noise control measures to enhance the overall satisfaction and well-being of the students.

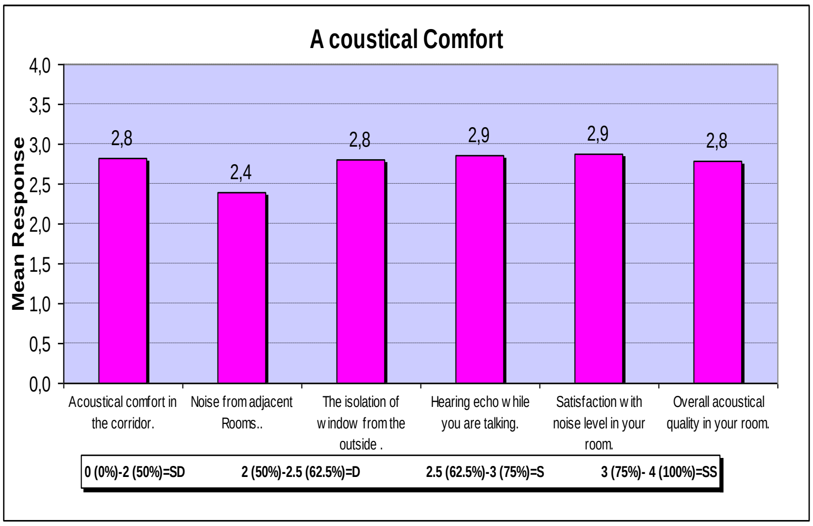


Figure 5 Subjective Assessment about Acoustic Comfort in Student's Room in Building # **93**

4.2.3 Students' Satisfaction with Indoor Air Quality

Ensuring good indoor air quality (IAQ) in dormitories is of paramount importance for several reasons. Figure 6A presents the analysis of IAQ in the student rooms, revealing some noteworthy findings. Firstly, it is worth noting that 62.5% of the students expressed dissatisfaction with the indoor air quality, reporting symptoms such as fatigue, skin irritation, and feelings of tiredness or sleepiness. These findings indicate potential IAQ issues that need to be addressed to create a healthier living environment for the students. However, in contrast, 77% of the sample population indicated satisfaction with the indoor air quality in their rooms. This observation may be attributed to the fact that students often rely on artificial lighting and keep their windows closed, leading to a lack of daylight and fresh air circulation. This practice can result in a darkened room with increased levels of IAQ pollutants, potentially contributing to feelings of tiredness and a desire to sleep.

These findings emphasize the significance of promoting proper ventilation, access to natural light, and fresh air exchange in student rooms to enhance IAQ. Implementing strategies that allow for adequate daylighting, encouraging the opening of windows when feasible, and addressing potential sources of indoor air pollutants can contribute to improving the overall IAQ and addressing the concerns expressed by the students. By prioritizing IAQ and implementing measures to enhance it, the living environment in the dormitories can be improved, supporting the well-being and comfort of the students.

Regarding indoor air quality pollutants, Figure 7 provides insights into the satisfaction levels of students regarding the concentration of dust, cleaning products, and tobacco smoke in their room environments. Remarkably, 75% of the students expressed satisfaction with the concentration of these pollutants in their rooms. However, it is important to note that 62.5% of the sample population reported dissatisfaction with indoor air quality pollutants. This discrepancy in perception could be attributed to the prevalence of dust in Dhahran, which is known to be 2-10 times higher compared to other cities. The dusty environment poses challenges as the dust particles find their way into the rooms through cracks, windows, doors, and various other pathways.

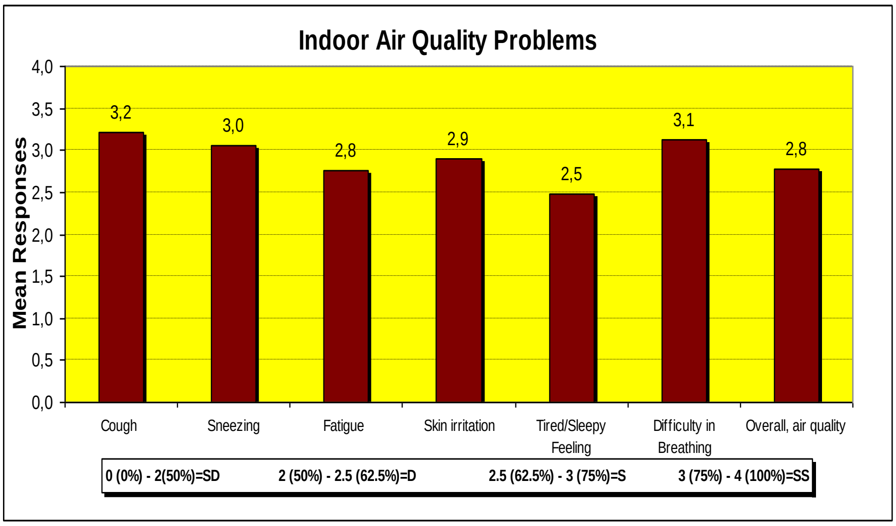


Figure 6 Subjective Assessment about IAQ Problems in Student's Room in Building # **93**

The high concentration of dust can adversely affect indoor air quality, leading to issues such as sneezing problems among the students. To mitigate this problem, it is crucial to make the rooms more airtight to prevent dust from infiltrating through small openings in windows and doors. By improving the sealing of these openings, the entry of dust particles can be minimized, thereby enhancing the indoor air quality and reducing associated respiratory discomfort. Addressing the issue of dust infiltration and adopting measures to improve air tightness in the rooms can contribute to creating a cleaner and healthier environment for the students, promoting their well-being and overall satisfaction with the indoor air quality.

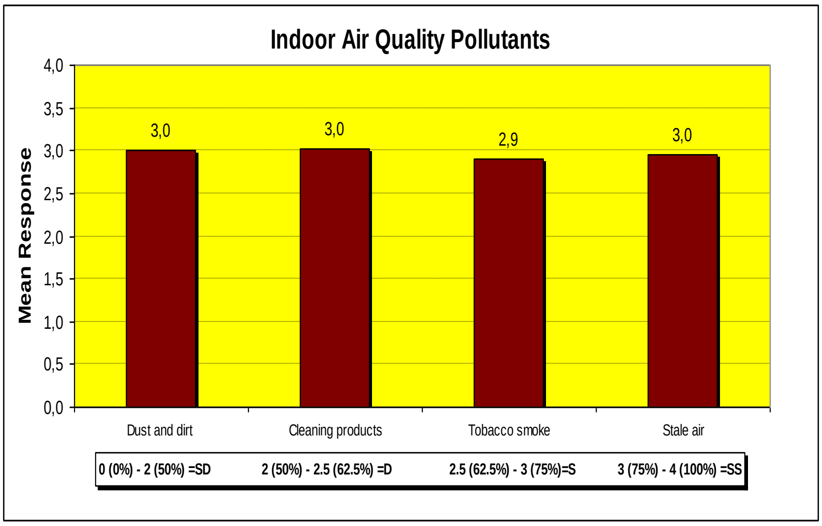


Figure 7 Subjective Assessment about IAQ Pollutants in Student's Room in Building # **93**

4.2.4 Students' Satisfaction with Visual Comfort

In terms of lighting conditions in the students' rooms, the majority of the students reported receiving adequate lighting levels (above 500 lux) for studying purposes. To evaluate the quality, quantity, arrangement, and level of artificial lighting in their rooms, the students were asked subjective questions in this section. Figure 8 provides valuable insights into the students' satisfaction levels regarding the arrangement and lighting level in their rooms. Notably, 75% of the students expressed satisfaction with the arrangement and lighting level in their rooms. However, it is worth mentioning that some of the sample population reported dissatisfaction with the adequacy and level of artificial light in the room environment. Addressing the concerns of those students who expressed dissatisfaction with the lighting conditions can contribute to enhancing their overall comfort and productivity. It is important to consider individual preferences and variations in lighting requirements when designing the lighting system for student rooms. Adequate and adjustable lighting fixtures, as well as the use of natural daylight whenever possible, can help create a more comfortable and conducive study environment. By striving to improve the adequacy and level of artificial lighting in the rooms, the university can ensure that students have a well-lit space that supports their academic activities and promotes a positive learning experience.

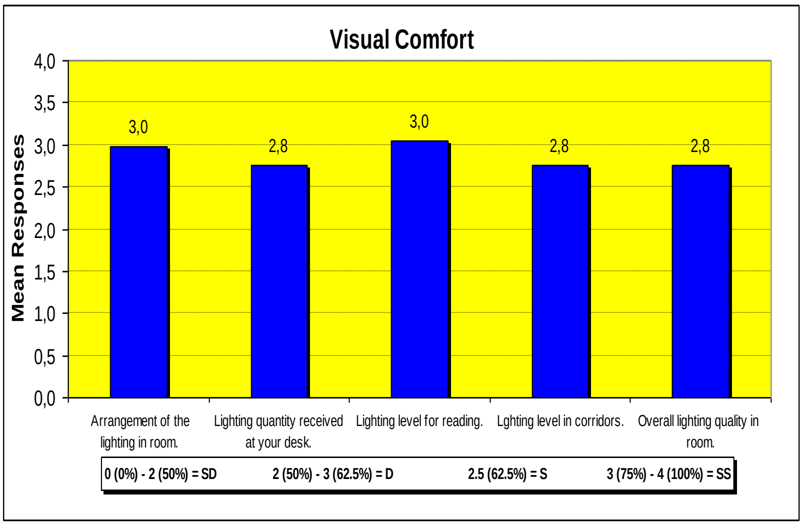


Figure 8 Subjective Assessment about Visual Comfort in Student's Room in Building **# 93**

4.2.5 Students' Satisfaction with Overall Hostels Services

This section focuses on analyzing the satisfaction of users regarding the quality of materials, level of cleanliness, building maintenance, and overall services provided in the rooms. The objective is to assess the students' perceptions and opinions in these areas. Figure 9 presents the findings related to user satisfaction with these parameters. It is evident that the two factors receiving the highest satisfaction ratings are the quality of materials and the level of room cleanliness. This implies that when the materials used in the rooms are of high quality and the cleanliness is well-maintained, the overall satisfaction of the students tends to be higher. Furthermore, the results indicate that there is a correlation between these two factors and the satisfaction levels with maintenance and overall services in the building. When students perceive the quality of materials and room cleanliness to be satisfactory, they are more likely to express higher satisfaction with maintenance and the overall services provided. These findings highlight the importance of prioritizing the use of high-quality materials and maintaining a high standard of cleanliness in the student housing facility. By ensuring that these factors are consistently met, the university can contribute to the overall satisfaction and well-being of the students. It is crucial to maintain a proactive approach to maintenance and deliver comprehensive services that meet the expectations and needs of the students, thereby fostering a positive living environment and enhancing their overall experience.

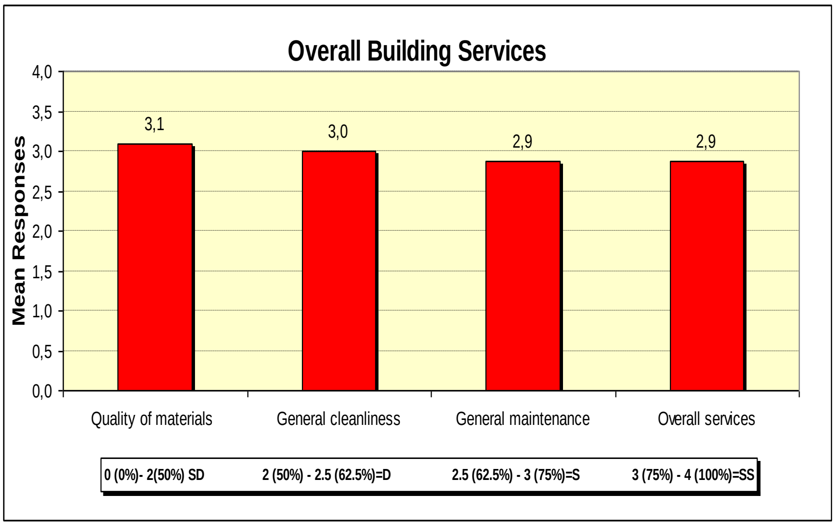


Figure 9 Subjective Assessment about Building Services in Student's Room in Building # **93**

4.3 Functional Analysis by Occupant Survey

The functional analysis of the building is aimed at understanding how well the building's design and features support the activities and needs of its occupants. In this section, the students were asked specific questions to gauge their satisfaction with various functional elements of the student housing facility. The survey focused on aspects such as car parking space, number of entrances/exits, room space, closet capacity, type of mattresses, book storage, and space for computer and other academic work. The responses provided valuable insights into the students' subjective experiences and perceptions. Figure 10 summarizes the findings related to the students' satisfaction levels with these functional elements. It is notable that 75% of the students expressed satisfaction with the car parking space, number of entrances/exits, room space, and the capacity of their closets. These factors seem to meet their expectations and adequately fulfill their needs. However, the survey also revealed areas where students reported dissatisfaction. Approximately 60% of the students expressed discontentment with the adequacy of book storage, type of mattresses, and the available space for computer and other academic work in their rooms. These findings indicate the need for improvement in these specific functional aspects to better cater to the students' requirements and enhance their overall experience. The results emphasize the importance of considering the students' feedback and preferences when designing and providing functional amenities in the student housing facility. Addressing the areas of dissatisfaction, such as improving book storage options, ensuring comfortable mattresses, and optimizing space for academic work, can contribute to creating a more conducive and functional environment for the students.

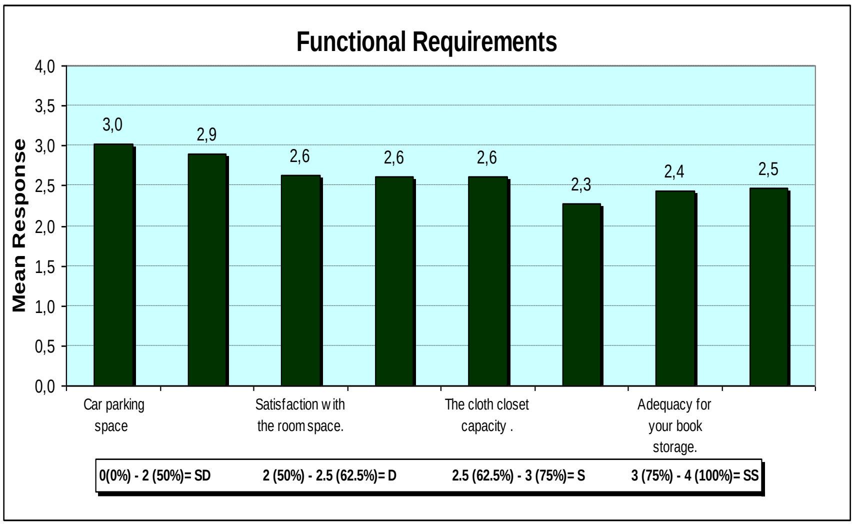


Figure 10 Functional Requirements of Student's Room in Building **# 93**

4.4 Behavioral Analysis by Occupant Survey

The behavioral elements of building performance examine the impact of building design on the psychological and sociological well-being of its occupants. This section focuses on assessing the students' subjective experiences and satisfaction regarding the behavioral aspects of the student housing facility. The survey included general questions related to the building's ability to support personalization of the workspace, provide space for individual pursuits, facilitate informal meetings with friends, foster a sense of community through public areas, offer spaces for noisy activities, and include an exhibition space for displaying students' work. Figure 11 presents the findings regarding the students' satisfaction levels with these behavioral elements. The results indicate that 62.2% of the students expressed satisfaction with the building's support for personalizing their workspace and the availability of spaces for informal meetings with friends. This suggests that the building design has been effective in providing an environment that accommodates individual preferences and encourages social interactions.

However, approximately 60% of the students reported dissatisfaction with certain aspects. They expressed discontentment with the room's ability to support individual pursuits, the absence of designated areas for noisy activities or physical engagement, and the lack of an exhibition space where students can showcase their work. These findings suggest that there is room for improvement in these areas to better meet the students' behavioral needs and enhance their overall experience. Creating spaces that allow for individual pursuits, providing areas where students can engage in noisy activities, and establishing an exhibition space can contribute to a more well-rounded and fulfilling environment for the students. These additions can promote personal growth, community engagement, and creative expression within the student housing facility.

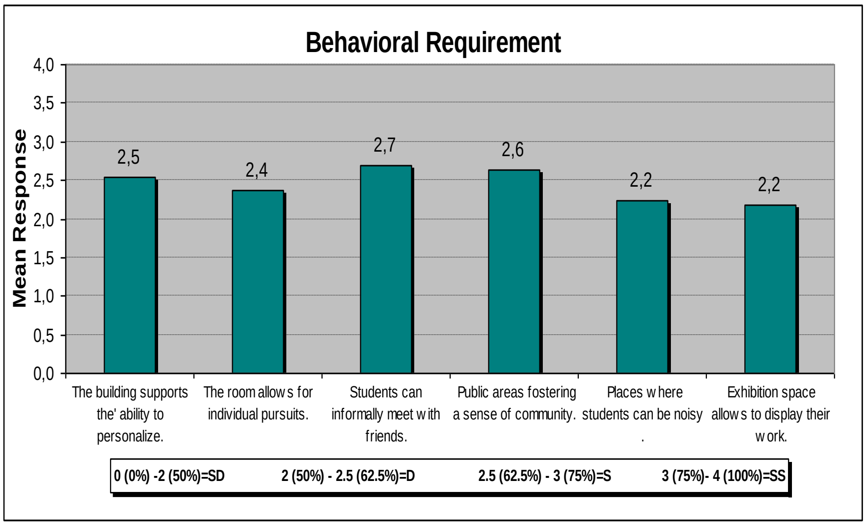


Figure 11 Behavioral Requirements of Student's Room in Building **# 93**

5 CONCLUSION AND RECOMMENDATIONS

This study has given an account of and the reasons for the widespread use of Post-Occupancy Evaluation (POE) to assess the performance of student housing at King Fahd University of Petroleum and Minerals. In this investigation, the aim was to explore the potential of Post-Occupancy Evaluation (POE) in identifying issues through user satisfaction. One of the more significant findings to emerge from this study is that several areas of poor performance in student housing require improvements and would seriously affect the quality of education and the psychology of the student. It was shown that the thermal comfort level of the rooms was unsuccessfully designed and requires to install a sensor for temperature control in individual rooms. It was also shown that acoustical comfort in the rooms was ineffectively studied and noise from adjacent rooms occurred, usage of acoustic walls to reduce sound level in the rooms is essential. The second major finding regarding to indoor air quality was that dust infiltrate the rooms and occupants also feel tiered and sleepy, the use of seals to tight gaps around windows and doors and providing a good source of natural ventilation to maintain the air circulation and movement in the room when the windows has been closed due to heat or dust is significant. The arrangement of the artificial lighting units in the halls were badly distributed and cause of visual discomfort require to redistribution of artificial lighting units with sufficient number. Some of available services in student housing under investigation include internet facilities, cafeteria, fire extinguishers, parking lots, mini-market, cleaning services, CCTV and ATM. One of the key finding is that the overall satisfaction of most of the students with the student housing building and services is “good”; but their satisfaction with the facilities is highest with the cleaning services. The findings of this study suggest that the accommodation and services in the university student dormitory require improvement.

The present study, however, makes several noteworthy contributions to the knowledge of Post-Occupancy Evaluation (POE) and its applications feature. The implications of this study are multiple. Valuable feedback for university student housing manager for improving their services, this research recognized drawbacks for existing university student housing operation. This will provide facility manager with strong understanding of the difficulties in the student housing operation. It is also provides, feed-forward, for architects designers with significant guidance for university student housing design. The current study was limited to single case study research. Although a typical case of university student housings investigated in-depth would generate rich data and evidence (Brager & Baker, 2009; Yuan & Zuo, 2013), the generalization of the studies to other context should take with care.

These findings provide the following recommendations for actions and have been categorized into two groups: *Short-term problems*, these are issues that can be addressed by the University Projects/Maintenance Department. Prioritization of these problems can be done based on urgency and financial considerations. By allocating resources and addressing these issues promptly, the overall performance of the student housing facility can be improved in the short term. *Long-term problems*, these problems demand the involvement of contractors, consultants, and significant financial investments. The recommendations for long-term problems can serve as design guidelines for all types of buildings, not just student housing. By addressing these issues at a fundamental level, the university can enhance the performance and quality of its buildings in the long run.

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