

# Evaluation of Building Performance through Post Occupancy Study of Educational Building for Higher Studies

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**Abstract**—Growth of Educational building in India requires a new dimension in its building in use aspects to improve the learning environment to ensure the satisfaction of the user. To assess the performance of buildings with respect to building in use aspects post occupancy evaluation is the technique used by many practicing and academicians. The aim of the study is to evaluate the performance of the institutional building in National Institute of Technology, Tiruchirapalli, to improve the learning environment which is use by four main groups of users like teachers, students, non – teachers and researcher. The outcome of the study can be used in the design process of the future building to be designed in the educational campuses.

## 1. INTRODUCTION

Post occupancy evaluation is one the method used for assessing the performance of green buildings. Zimring [2] and POE defined as an examination of the effectiveness of occupied design environments for human users. While carrying out POE survey the life cycle assessment of the building should be taken into account to improve the effectiveness of the findings. Post – occupancy evaluation is a modern technique called as diagnostic tool allows the architects and facility managers to identify the critical issues related to building performances and helps to rectify the problems identified [1]. Abdul et.al, [5] explaining POE as multifaceted tool helps to solve problems related to buildings and building management, through which the performance of buildings and level of satisfaction of occupants can be evaluated.

### 1.2 Description of The Building

The building taken for the survey is department of Science and Humanities with Physics and chemistry department with Ground + two floors. Total built up area is 6425.29 sq.mt, Ground coverage: 8834.27 sq.mt, Area of Courtyard: 3870.05 sq.mt, Porch: 89.52 sq.mt, Total No. of Users: 650nos, Circulation Area: 1620sq.mt. The facilities of the building is

shared by research scholars of other department in the campus and also by the first year students of others engineering departments.

This building is situated in the western zone of the site of the whole campus and can be accessed through pedestrian walkways, bicycle, two wheelers, cars and heavy vehicles. The facilities in the buildings include laboratories, faculty room, meeting rooms, scholar's room and class room. The laboratories and other facilities are open for the 479 users of the building to work for about 24 X 7 Hours. While considering the design of the building an imaginary axis created by the large courtyard divides the building into two which is used by the two departments. The same courtyard acts as the focal element of the building and it is used as the gathering space satisfies the lighting and ventilation of the building. Each floor facilitated with administration office, 8 laboratories, 13 faculty rooms and common facilities with different interior layouts to suit their functional requirement.

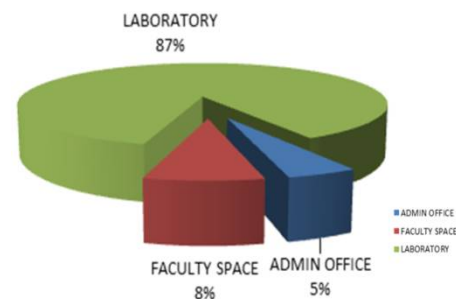


Figure 1: Space allocation % source: Author

Educational building taken for POE study has main entrance in the southern side used by pedestrians, users using cars and bicycle. Apart from main entrance there are other two entrances on east and west side each which is preferred by the users coming by cars. As because of the parking area side

entries are preferred by users using cars. At the centre very big courtyard with landscape plays a vital role in creating the pleasing environment and to some extent it enhances the productivity of the user.

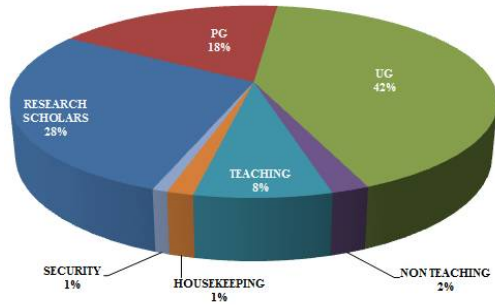


Figure 2 User's % source: Author

## 2. METHODOLOGY

POE is the study used to analyze the performance of buildings by taking into account the satisfaction and which drives solution to the problems evident through this study. Information required to conduct POE are Physical Plan of the building, Functional information of the spaces and Schedule of occupants and occupancy patterns. For conducting occupancy survey, the following information is required from occupant through questionnaire are Comfort - Thermal Comfort, Noise, Air & Light, Quality, Controls - Heating, Lighting and Ventilation and Building Design - Building layout, Functional characters, space utilization and user pattern. By conducting interview with Architect, Facility Manager, Visual survey design features can be documented. With the data collected the designer gets aware of the user's experience and thus users can also involve themselves in the design improves the performance of buildings [4].

### 2.1 Details of the Study

The questionnaire formulated with 60 questions targeting four groups of users (Teachers, non- Teachers, supporting staff and students) of the building. Questionnaire classified as Building in use and visual survey. The questionnaire includes the main aspects of Building use such as circulation, space and furniture for individual work, space for work and teaching, internal environmental comfort, building "expression" especially its look and feel, the building's management and user's view of how the academic block satisfies their need and perceptions. Among 579 users 123 responses are collected. Age and working hours are also analyzed. 75% of users are between 15 – 40 years and 25% of the users are between 40-60 years. Research scholars use 144 hrs/week, UG students use 6hrs/week and PG students use 8hrs/week and rest of the users like faculty, supporting staffs use 40hrs/week.

### 2.2 Analysis of Data Collection

Responses collected classified as building in use aspects and visual aspects satisfaction index is fixed based on the rate of satisfaction. Satisfaction index is designated to each and aspects of the buildings to evaluate the performance.

Table 1: Showing the satisfaction index to evaluate the performance of Building

S. No	Rate of Satisfaction	Satisfaction Index
1	>85%	Strongly Satisfied - SS
2	70.1% - 85%	Satisfied - S
3	55.1% - 70%	Dissatisfied - DS
4	<55%	Strongly Dissatisfied - SD

The satisfaction indices were calculated as follows [3]

$$\text{Satisfaction Index}(I) = \frac{\sum_{i=1}^5 (a_i)(x_i)}{5 \sum_{i=1}^5 x_i} \times 100\%$$

Where a is the constant representing the weight assigned to i and X<sub>i</sub> is the variable representing the frequency assigned to i. The response for i is 1,2,3,4,5 and is illustrated as follows

X<sub>0</sub> = frequency of "Very Good" response corresponding to a<sub>0</sub> =5.

X<sub>1</sub> = frequency of "Good" response corresponding to a<sub>1</sub>=4.

X<sub>2</sub> = frequency of "Poor" response corresponding to a<sub>2</sub>=3.

X<sub>3</sub> = frequency of "Very Poor" response corresponding to a<sub>3</sub> =2.

X<sub>4</sub> = frequency of "No Opinion" response corresponding to a<sub>4</sub> =1.

In order to achieve higher levels of user satisfaction with all the quality of the building with respect to built environment, any performance element whose rate of satisfaction is less than 70% is considered to be the defective element in performance. The following scale is established the level of satisfaction for every element of performance.

If the satisfaction index value is above 85% then the respondents are "Strongly Satisfied".

If the satisfaction index value is between 70.1% and 85% then the respondents are "Satisfied".

If the satisfaction index value is between 55.1% and 70% then the respondents are "Dissatisfied".

If the satisfaction index value is below 55% then the respondents are "Satisfied".

### 3. RESULTS AND DISCUSSION

#### 3.1 Analysis of Responses of students about Building in use Aspects and Visual Aspects of the Building

The students are asked about the visual and building in use aspects of the building. In total 100 students are asked to answer the question, in that 30 of them are research scholars and rest of them are UG and PG Students of Physics and Chemistry department.

The questions about the building in use aspects are asked to students and they are about

- Air movement in building, Natural day lighting, Interior finishes and Frequency of maintenance activities. The satisfaction index values for above factors shows that all the 100 respondents were “Strongly Satisfied” with an average satisfaction index % is >85%
- Temperature comfort – summer, Temperature comfort – winter, Temperature variations in spaces and Ventilation at work space. The satisfaction index values for above factors shows that all the 100 respondents were “satisfied” with an average satisfaction index % ranges between 70.1% to 85%
- Noise distraction and Glare at work space. The satisfaction index values for above factors shows that all the 100 respondents were “Dissatisfied” with an average satisfaction index % ranges between 55.1% to 70%
- Using artificial day lighting, Freedom to control temperature, Lighting & ventilation, power backup and Travel distance from parking. The satisfaction index values for above factors shows that all the 100 respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

With respect to Visual Aspects some of the questions are asked to the students. The questions are about

- Internal landscape maintenance, Amount of internal greenery and Level of cleanliness. The satisfaction index values for above factors shows that all the 100 respondents were “Strongly Satisfied” with an average satisfaction index % is >85%
- Aesthetics of the building, Views from inside the building and Amount of external greenery. The satisfaction index values for above factors shows that all the 100 respondents were “Dissatisfied” with an average satisfaction index % ranges between 55.1% to 70%
- Safety instructions, Signage for emergency exits, External landscape maintenance and signage inside the building. The satisfaction index values for above factors shows that all the 100 respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

#### 3.2 Analysis of Responses of Teachers about Building in use Aspects and Visual Aspects of the Building

The teachers are asked about the building in use aspects and Visual Aspects of the building. In the teachers user group there are about 10 faculty of Chemistry, 11 Faculty of Physics and 13 Faculty of Architecture Department in that the responses are collected from 8 faculty from all the group of faculty.

With respect to Visual Aspects some of the questions are asked to the students. The questions are about

- Views from inside the building, internal landscape maintenance, amount of internal greenery and level of cleanliness. The satisfaction index values for above factors shows that all the respondents were “Strongly Satisfied” with an average satisfaction index % is >85%
- aesthetics of the building. The satisfaction index values for above factors shows that all the respondents were “Dissatisfied” with an average satisfaction index % ranges between 70.1% to 85%
- Safety instructions, signage for emergency exits, external landscape maintenance, amount of external greenery and signage inside the building. . The satisfaction index values for above factors shows that all the respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

The questions about the building in use aspects are asked to students and they are about

- Temperature comfort – summer, temperature comfort – winter, temperature variations - in spaces, ventilation at work space, air movement in building, noise distraction and natural day lighting. The satisfaction index values for above factors shows that all the respondents were “Strongly Satisfied” with an average satisfaction index % is >85%.
- Using artificial lighting and Interior finishes. The satisfaction index values for above factors shows that all the respondents were “satisfied” with an average satisfaction index % ranges between 70.1% to 85%.
- Glare at work space, power backup, frequency of maintenance activities and travel distance from parking. The satisfaction index values for above factors shows that all the respondents were “Dissatisfied” with an average satisfaction index % ranges between 55.1% to 70% Freedom to control temperature and lighting & ventilation. . The satisfaction index values for above factors shows that all the respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

### 3.3 Analysis of Responses of Non-Teachers about Building in use Aspects and Visual Aspects of the Building

The Non- Teachers are asked about the physical, psychological, visual and building in use aspects of the building. In total 10 Non – Teachers are asked to answer the question.

With respect to Visual Aspects some of the questions are asked to the Non- Teachers. The questions are about

- Aesthetics of the building, views from inside the building, internal landscape maintenance, amount of internal greenery and level of cleanliness. The satisfaction index values for above factors shows that all the 10 respondents were “Strongly Satisfied” with an average satisfaction index % is >85%
- External landscape maintenance and amount of external greenery. The satisfaction index values for above factors shows that all the 10 respondents were “Dissatisfied” with an average satisfaction index % ranges between 70.1% to 85%
- Safety instructions. The satisfaction index values for above factors shows that all the 10 respondents were “Dissatisfied” with an average satisfaction index % ranges between 55.1% to 70%
- Signage for emergency exits and signage inside the building. The satisfaction index values for above factors shows that all the 10 respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

The questions about the building in use aspects are asked to Non – teachers and they are about

- Temperature comfort – summer, temperature comfort – winter, temperature variations - in spaces, ventilation at work space, Air movement in building, noise distraction, natural day lighting, interior finishes and frequency of maintenance activities. The satisfaction index values for above factors shows that all the 10 respondents were “Strongly Satisfied” with an average satisfaction index % is >85%
- Using artificial day lighting and glare at work space. The satisfaction index values for above factors shows that all the 10 respondents were “satisfied” with an average satisfaction index % ranges between 70.1% to 85%
- Freedom to control temperature, lighting & ventilation, power backup and travel distance from parking. The satisfaction index values for above factors shows that all the 10 respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55%

### 3.4 Analysis of Responses of Supporting staff about Building in use Aspects and Visual Aspects of the Building

The supporting staff are asked about the visual and building in use aspects of the building. In total 11 supporting staff are

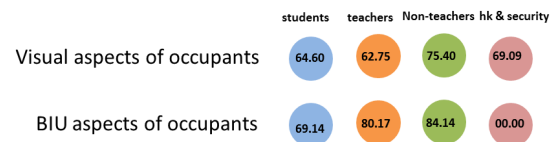
asked to answer the question, in that 4 of them are security and rest of them are staff related to housekeeping.

With respect to Visual Aspects some of the questions are asked to the supporting staff. The questions are about

- Use of materials for maintenance and internal greenery. The satisfaction index values for above factors shows that all the 11 respondents were “Strongly Satisfied” with an average satisfaction index % is >85% (Table:4)
- Safety instructions. The satisfaction index values for above factors shows that all the 100 respondents were “Strongly Dissatisfied” with an average satisfaction index % is <55% (Table:4)

## 4. CONCLUSIONS

In order to assess the performance of whole building overall satisfaction of occupants are compared and also satisfaction index is also compared



In specific the rate of satisfaction is compared with the 14 building in use factors (Temperature comfort – summer, Temperature comfort – winter, Temperature variations - in different spaces, Ventilation at work space, Air movement in building, Noise distraction, Natural day lighting, Using artificial daylighting, Glare at work space, Freedom to control temperature lighting & Ventilation, Interior finishes, Power backup, Frequency of maintenance activities and Travel distance from parking) to get more insight into the performance of the building. Non teachers and teachers are satisfied – this indicates that the building in use aspects are highly performing

Students are equally spread across various rates of satisfaction – due to their numbers, expectations, restricted autonomy and fatigue (mental pressure and physical distance)

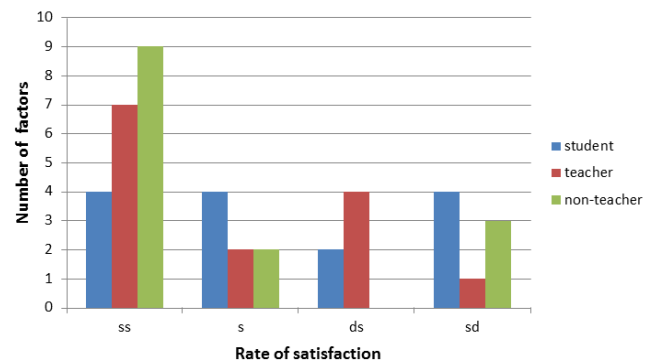


Figure 3 Comparison of Rate of Satisfaction of Building in use Aspects with its factors source: Author

As like building in use aspects the rate of satisfaction of Visual aspects compared with its 10 factors. Non teachers and teachers are distributed on two extremes – because of their nature of work, exposure to better built environments and maintenance

Students are strongly dissatisfied with visual aspects such as signage, safety instructions and external landscape maintenance (due to high temperatures and the need for shade).

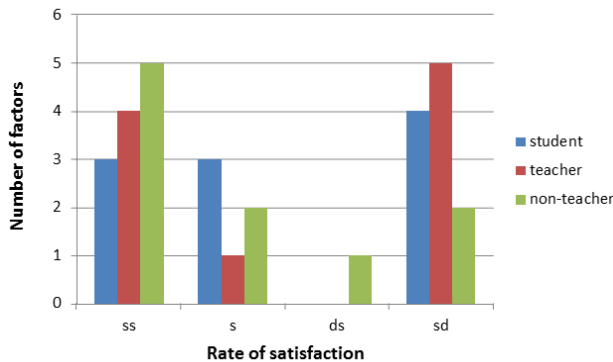


Figure 4: Comparison of Rate of Satisfaction of Visual Aspects with its factors source: Author

By comparing the overall satisfaction of occupants the factors which got more appreciation and which needs further attention and improvement are visible. Factors that need attention

1. Satisfied and strongly satisfied aspects Building In Use.
2. Visual aspect is a common dissatisfied aspect among users except non-teachers

Aspects of the building lies in “Strongly satisfied” Index

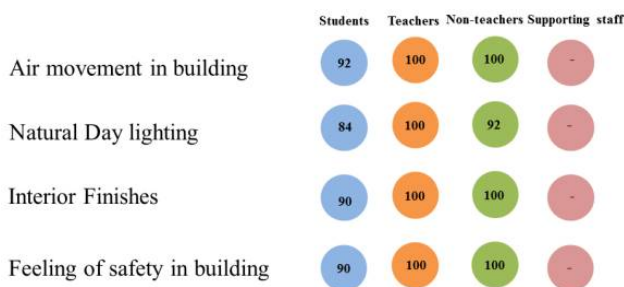


Figure 5: Comparison of responses of user groups with strongly satisfied Building in Use Aspects source: Author

Aspects of the building lies in “Strongly Dissatisfied” Index

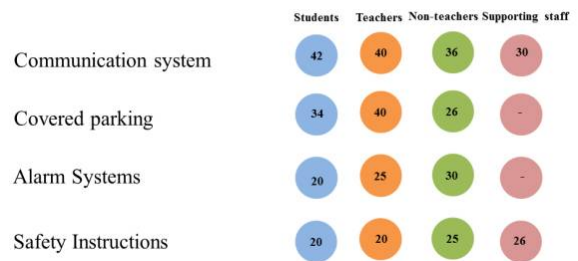


Figure 6 Comparison of responses of user groups with strongly dissatisfied Building in Use Aspects source: Author

5. FINDINGS AND RECOMMENDATIONS

After conducting the post occupancy study in the educational building some of the findings and recommendations are listed about the building in use and visual Aspects of the building. In this study the physical and Psychological Aspects are studied superficial to focus on building in use and Visual aspects. Some of the recommendations are

1. The capturing of sky at various visual points of the building enriches the productivity of the entire user.
2. The important feedback of expert member is the design and provisions related to services, which includes rainwater pipe, Air conditioners outlet and other service lines from the Laboratories are completely exposed which affects the aesthetics of the building.

In future the findings and recommendations of this study may help designers and architects to improve the performance of buildings with respect to building in Use aspects and visual aspects.

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