

Post Occupancy Evaluation of Daylight in School of Environmental Science Prototype Buildings, Modibbo Adama University of Technology Yola, Nigeria

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Abstract

Post occupancy evaluations are employed to access user satisfaction with occupied buildings. Feedback from users of newly constructed buildings is pertinent as it provides indications of success and failures in the buildings. The purpose of this article is to present the findings of a Post Occupancy Evaluation (POE) conducted on the School of Environmental Sciences (SES) prototype Building in Modibbo Adama University of technology, Yola. The main objective of the survey was to gauge the opinion of Occupants on the day lighting conditions of their offices. A questionnaire survey was administered; measurements of the physical interior conditions as well as inspection of all offices were included to support the survey. Results showed 57% of the occupants' of the building were satisfied with the day lighting of their office space.

Keywords: - Daylight, Post Occupancy Evaluation, Prototype Buildings, Yola

INTRODUCTION

The School of Environmental Sciences (SES) prototype building is one of 14 Units of repetitive Departmental complexes built by Modibbo Adama University of Technology, Yola. For these new buildings to be considered successful, it is important to validate them through a Post Occupancy Evaluation. A Post Occupancy Evaluation (POE) is imperative to enable a feedback mechanism to the designers and owners. It entails a systematic assessment of the performance of a facility once it has been occupied and used to determine if the facility meets the level of expectation that was envisaged in the conceptual stages of the design in terms of both human occupants and the building services that it encloses (Hygge and Lofberg, 1999).

Hewitt *et al* (2005) describes POE as a term for a broad range of activities aimed at understanding how buildings perform once they are built, and the level of satisfaction of building users within the environment created. The aim of an occupancy evaluation study is to carry out a systematic assessment of the performance of a facility once it has been occupied and used. It is to determine if the facility meets the level of expectation that was envisaged in the conceptual stages of the design, in terms of both human occupants and the building services that it encloses (Doulos, *et al* 2007).

Building Occupants or employees wish to work in an environment that is conducive to their health and wellbeing. When these conditions are absent in a work environment, the morale, productivity and performance of employees can deteriorate. In order to address these issues, the idea of POE came into being (Emuze *et al*, 2013). Sanders and Collins (1995) attempted to provide some understanding of how the built environments influences the attitudes and beliefs that occupants hold about the environment in which they work and how the environment may affect their job performance. The evaluation could address any single facet of a built environment such as acoustics, thermal comfort or lighting, or it could address all of them at the same time. POE is an evaluation tool that is perceived as a sub process of building

performance evaluation and can be defined as the act of evaluating buildings in a systematic manner after they have been built and occupied for some time (Preiser and Vischer, 2005).

Few POEs have focused specifically on the lighting conditions of a building. Buildings are rarely studied in use to determine if the daylight design strategies implemented achieve the intent of creating a sufficiently day lit and visually comfortable work environment from the perspective of building occupants, or how occupant behavior affects the level of daylight availability and electrical lighting energy reduction anticipated during design (Konis 2013). This aim of this POE is to address the day lighting of the SES prototype building. It is geared towards understanding the needs and preferences of occupants regarding window size, shape and position, the view angle, daylight and lighting conditions.

POE provide an indication of major successes and failures in building performance. They can be used to improve and explain the performance of a building and are useful not only to the occupants and owners but also to the designers, who learn from both their mistakes and successes and can apply these findings to future projects.

The POE techniques provide a means for evaluating occupant responses to changes in an environment and linking this response to physical measures of that environment. Typically, post occupancy evaluations use a battery of test to assess environmental conditions in the facility, including questionnaire surveys of the occupants, physical observations and individual interviews. This technique is thus designed to provide information about the occupants' reaction to their work spaces and document the physical conditions to which they are responding (Sanders and Collins 1995).

The process of POE involves three different aspects of building performance; Technical, Behavioral and Functional aspects. Technical elements of POE include- fire, safety, structural integrity, sanitation, durability, acoustic and lighting. Behavioral aspects include issues such as privacy, security, symbolism of buildings, social interactions, perceptions of density and territoriality (Preiser, 1995).

There are also three levels of POE, *Indicative*- a quick walk through evaluation, *Investigative*-interviews, survey questionnaires and *Diagnostic levels*- focused, longitudinal and cross sectional evaluations. POE techniques include questionnaires and physical measurements. Sanders and Collins (1995) state that these two techniques; allow identification of relationship between subjective measurements of the environment provided by the occupants, and objective physical measurements of same spaces.

Post Occupancy Evaluation of the building indicates how successful the building is, where the problems are and to some extent, how the performance can be improved. The result of the POE can give an environmental quality stamp on a building as a whole, but also give indications to certain good or certain poor environmental conditions (Hygge and Lofberg, 1999).

Post Occupancy Evaluation and Daylighting

Daylight is the main natural light source and has a dynamic character. It varies in level, direction and spectral composition with time, which is very beneficial for people. Daylight affects both visually and non-visually the wellbeing of building occupants. Visually, the daylight distribution inside a space does not only influence the visibility of the task but also has an enormous influence on the visual appearance of the space. By optimizing the use of daylight as the main light source for visual tasks, it has the potential to reduce energy use by artificial lighting (Hellinga, 2013). Poor quality of lighting in the work place causes eye strain which leads to dizziness and stress. Light sends visual messages to the occupants of the

building which could decrease or increase the good mood and motivation levels of the individuals in the building (Samani, 2011).

According to Menzies and Wherrett, (2005), proponents of sustainable design have argued that environmentally friendly technologies and design strategies enhance environmental quality by such features as increased use of the day lighting and increased contact with the natural environment. The desire for natural light rather than electric light is one of the reasons why windows are so important to building occupants.

Windows are important for a comfortable and healthy indoor environment. The two most important functions of windows are provision of daylight access and a view to the outside (Boyce *et al*, 2003). Windows provide a connection between inside spaces and the outside world. By means of a window rooms are lit with daylight, naturally ventilated and Occupants can view the outside environment (Hellinga, 2013).

Although mainly beneficial, daylight can cause visual discomfort through glare and distractions, such as reflections or shadows, and many office workers do find glare and a lack of solar shading to be a problem. (Menzies and Wherrett, 2005). As a whole, daylight levels, lighting and glare are found to be very important in determining comfort and productivity in the workplace. It is also important to minimize negative aspects of windows such as glare and unwanted passive solar gain through appropriate building and window design.

People prefer to have daylight in their work environment, mainly because daylight is believed to be healthier than electric lighting. The short term variations in natural light provide variety and interest in a way that continuous electric lighting cannot (Hellinga, 2013).

Windows have physical and psychological benefits which affect health, mental wellbeing, motivation and productivity. In working spaces, there is ample evidence emphasizing that access to windows affects mood, motivation and productivity (Menzies and Wherrett, 2005). Several surveys have documented that people believe that daylight is superior to electric light in its effects on people. The preference for day lighting was attributed to the belief that working by daylight results in less stress and discomfort than working by electric light (Galasiu and Veitch, 2006).

Heerwagen and Heerwagen (1986) surveyed occupants of an office building in Seattle, USA. More than half of the occupants reported that they believed that daylight is better for psychological comfort, for office appearance and pleasantness, for general health, for visual health, and for colour appearance of people and furnishings.

A post occupancy evaluation conducted by christoffersen *et al* (1999) in 20 Danish buildings with perimeter offices and workstations positioned at a maximum distance of 7m from the windows also showed a strong preference for work places located near windows. The office workers expressed their opinions about windows, daylight and electric light in their working environment. Over 70% of the respondents said that they were never bothered by sunlight and were “highly satisfied” or “satisfied” with the day lighting conditions in their offices, and 80% were never bothered by glare (Galasiu and Veitch, 2006).

Aries (2005) performed a questionnaire research in 10 office buildings in the Netherlands, almost all respondents (94%) answered that they find it important to have a window in their office space. Daylight availability turned out to be the most important reason that the participants would like to have access to a window.

Still, In a study of the Heschong Mahone Group (2003) office workers who reported that they did not have enough daylight were more likely to report that they suffered from fatigue, headache and /or eye strain. Hellinga (2013) explains that the results of many studies (Edwards and Torcellini, 2002; Van den Beld and Van Bommel, 2002; figueiro *et al.*, 2006) show that daylight is not only perceived as being beneficial for health, but it also really improves the health and productivity of employees and students.

METHODOLOGY

Questionnaire Survey

This research was geared towards gauging the opinions of users of one unit of the SES prototype building. Findings from the survey will be used as input for a more extensive questionnaire research on the repetitive Departmental buildings in the University. The research design formulated was a questionnaire survey and the principle of voluntary participation was upheld. The questions employed in the questionnaire were sourced from the IEA task 21: Annex 29 (Hygge and Lofberg, 1999) and Hellinga, (2013).

The main objective of the POE questionnaire was to evaluate the occupants' response to the building. It will give an indication of what users think of the building as a whole, of its interior work environment including noise, thermal conditions and especially how the lit environment is experienced and how well users think that the lighting and day lighting control system work.

The study population consisted of Lecturers from the Department of Building and the Department of Surveying and Geoinformatics. A small number of respondents were employed for a "within persons" comparison. 20 questionnaires were distributed and only 14 were returned. This resulted in a 70% response rate. The 7 page questionnaire was divided into 4 sections; **Section A** elicited responses relative to occupants' personal information in terms of age, gender, and sensitivity of the eyes of the respondents, **Section B** dealt with general questions about the building, **Section C** included questions about individual Office space and **Section D** treated questions about the indoor environment.

Examined Building

The building examined for the pilot study is the second Block of the SES Prototype building, housing the Departments of Building and the Department of Surveying and Geoinformatics. The building was designed by Physical Planning Unit of the University and has been occupied by the Departments since 2015, and the questionnaire research took place in June 2016.



Figure 1: The School Environmental Sciences prototype building.



Figure 2: The SES prototype building (South Elevation)



Figure 3: Top two brown are the prototype buildings indicate their location and orientation.

The SES prototype building is a one-storey rectangular complex comprising of Offices, Lecture rooms Studios, Laboratories, Break rooms and Conveniences. The building is compartmentalized in to 2, with the Student areas being located on the ground floor and the Staff areas on the first floor. This paper focuses on the first floor of the building to assess day lighting in the office spaces.

The building covers an area of 2285sqm and is 11.3m high. It has two courtyards separated by a lobby joining the two blocks of the building. The sizes of the courtyards are 65sqm each. The longer side of the building rests on East-West axis and the shorter size on the North-South axis. The building is surrounded by trees on the Eastern and Southern sides but on Northern and Western sides, there are no obstructions and the surrounding land is flat. The offices are mainly private rooms located along the perimeter of the building. The office types include; 2 Head of Departments office (56sqm each), 2 HOD's Secretary (31sqm each), 10 professor's office (28sqm each), 2 Single office A (17.5sqm each), and 12 single office B (12sqm each).



Figure 4: First Floor Plan (dimension in mm)

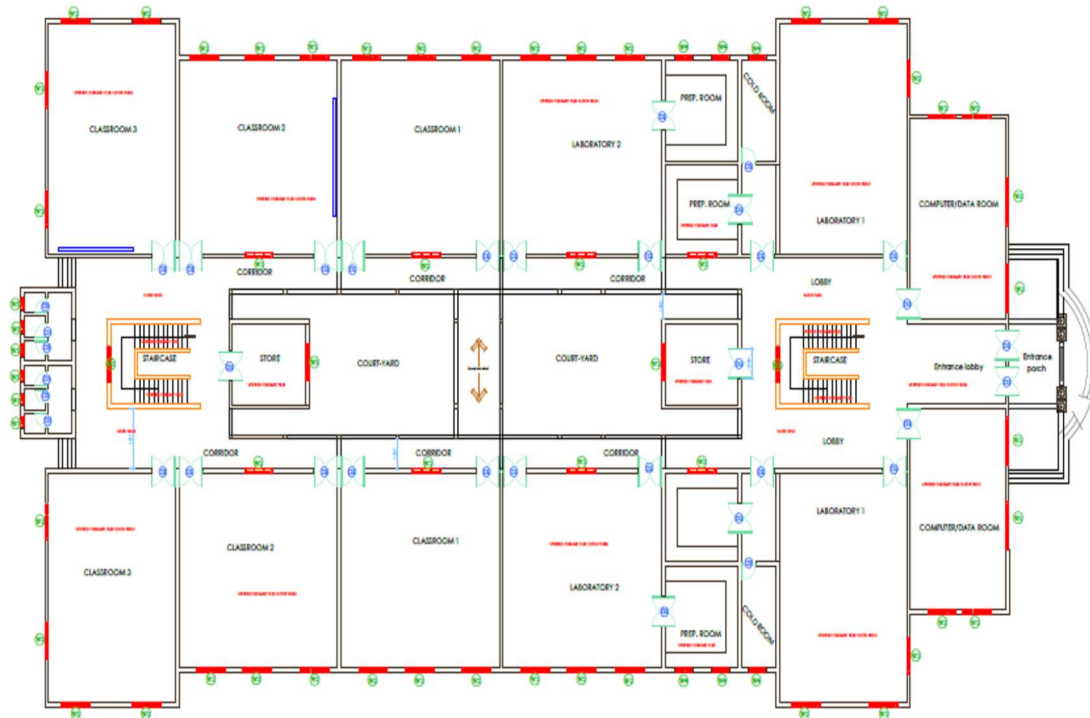


Figure 5: Ground Floor Plan (dimension in mm)



Figure 6: Approach Elevation

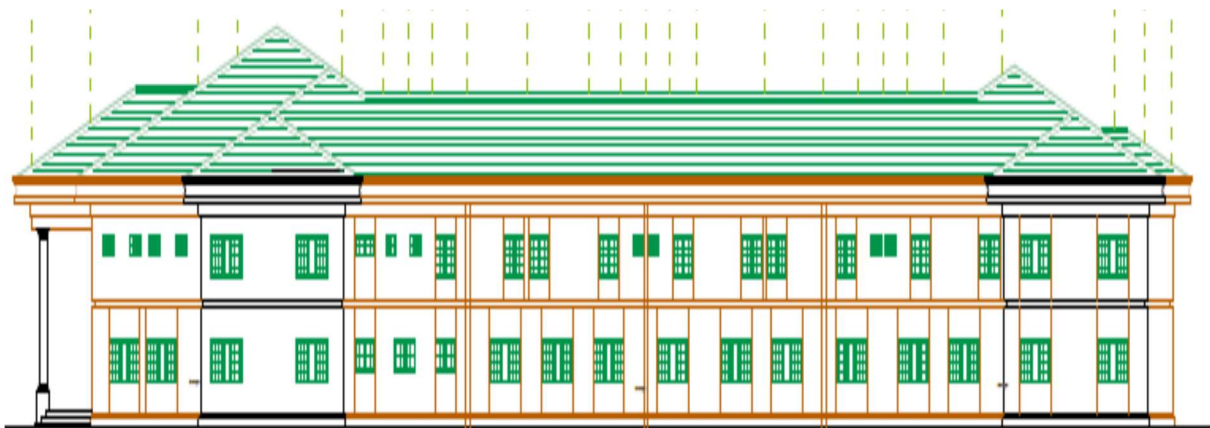


Figure 7: South Elevation

Windows are located on the external walls of the building and along the corridors. There are 138 windows on the first floor of the building. 66 open directly to the outside surrounding, 38 open to the courtyard and 34 open to the corridors and lobbies. There is no provision for shading devices in the building. Curtains are however used to reduce intense sunlight. The windows (office windows) are located at 0.9m above floor level. The windows include 1.2m by 1.2m and 1.8m by 1.2m Aluminium sliding windows and casement windows. Daylight enters the building through the windows on the external walls and borrowed light from windows along the corridors.



Figure 8: Shared office showing day light access (left), private room showing daylight access (right)

RESULTS AND ANALYSIS

Offices and Occupants

The examined building is comprised of individual offices along the perimeter of the building. Almost all the Respondents (93%) have private rooms while only 7% have shared rooms with 2 to 3 people per room. Where 1= strongly agree, 2= agree, 3= neutral, 4=disagree and 5 = strongly disagree.

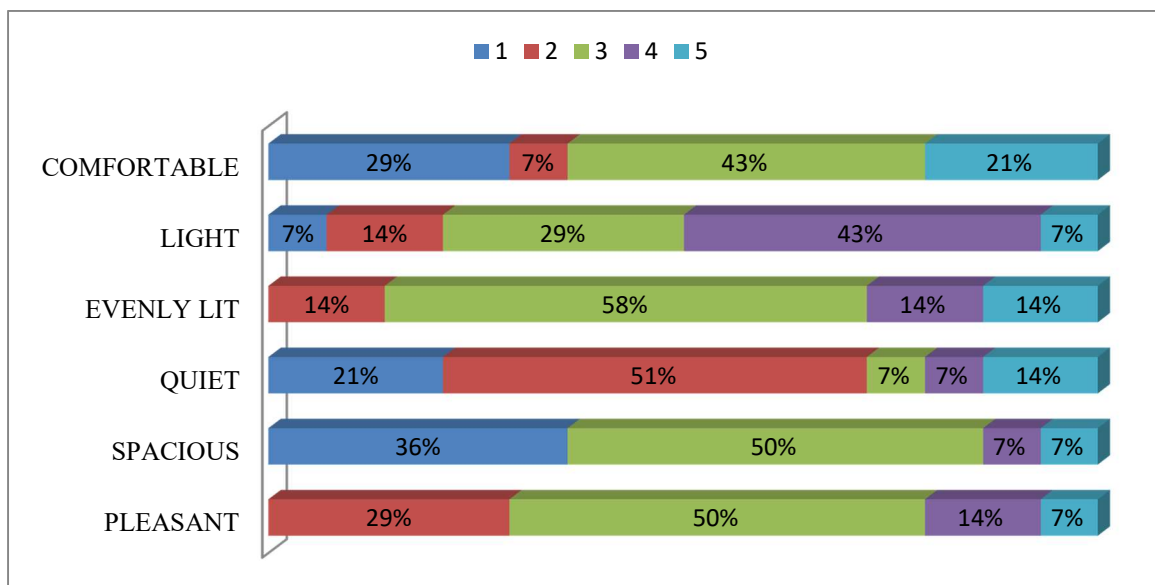


Figure 9: General impression of respondents' office space

Respondents were asked to describe their office space with the following words; comfortable, light, evenly lit, quiet, spacious and pleasant. 43% were neutral about their office being comfortable, 43% strongly disagreed with the office being light, 58% were neutral about the office being evenly lit, 51% agreed with the office being quiet and 50% were neutral about the office being spacious and pleasant.

The survey population was all males (100%) with age distribution ranging from ages 30-39(36%), ages 40-49 (43%), and ages 50- 59 (21%). Only 21% of the respondents wear glasses during working hours while 14% “regularly” wear glasses outdoors and 29% “sometimes” wear glasses outdoor. The remaining do not wear glasses in both instances. In terms of satisfaction with their work place, 14% of respondents were satisfied, 57% were somewhat satisfied and 29% were dissatisfied. This illustrated in table 1 below.

Table 1 - Satisfaction with Workstation/Place

Satisfied	14%
Somewhat satisfied	57%
Dissatisfied	29%

Windows

All offices in the examined building have at least 3 windows (1.2 by 1.2m) on 2 parallel walls, 2 on the external wall and 1 on the internal wall along the corridor. Since window size is the parameter, which influences the daylight availability most in an office, it is of interest to know how the occupants’ judged the actual size of their windows (Christoffersen *et al*, 1999). The subjects were asked to rate their windows as far too big, slightly too big, exactly good, slightly too small, and far too small. All respondents’ (100%) agreed that their window size was exactly good. Respondents’ were also asked to report the position of their desk in the room in relation to the windows.

Table 2- Orientation of respondent’s workstation

Window to the right	43%
Window to the left	50%
Other	7%

Table 2 shows half of the respondents (50%) have windows to the left of their workstation, 43% have windows to the right, none of the respondents have windows at back or facing their workstations.

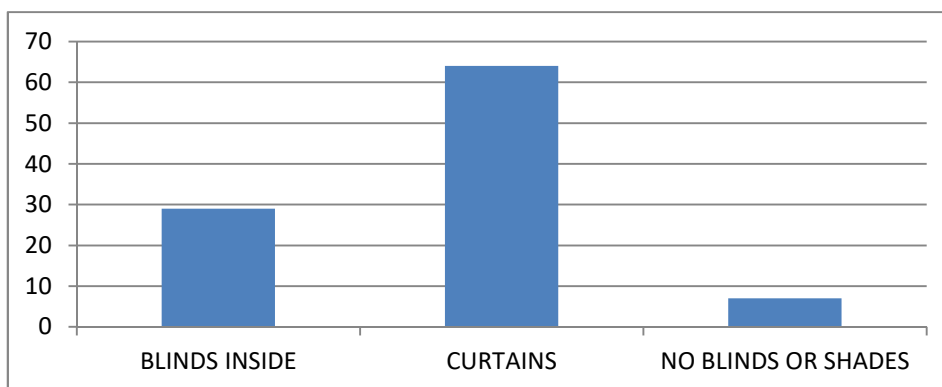


Figure 10: Types of Window Shades or Blinds Present in percentage.

Daylight

Daylight design of the examined building consists of windows along the perimeter walls. The respondents of the survey were asked to rate daylight levels of their offices. The respondents’ of the survey were “somewhat satisfied” (57%) with the daylight conditions at their desk, 14% were “satisfied” and 29% were “dissatisfied”. This could be because of their proximity to the windows. Direct sunlight coming through the windows sometimes cause glare, as a result

occupants use curtains (65%) and blinds (29%) for shading. Others (7%) use neither. This illustrated in the figure 11 below;

When asked if they would be able to carry out their work with only daylight, 86% of respondents replied they could” sometimes” carry out their work with only daylight and 14% of the respondents replied they could” regularly” carry out their work with only daylight. On nuisances resulting from daylight, 14% of respondents replied that they had daylight reflected in their eyes while 86% replied that they had no complaints.

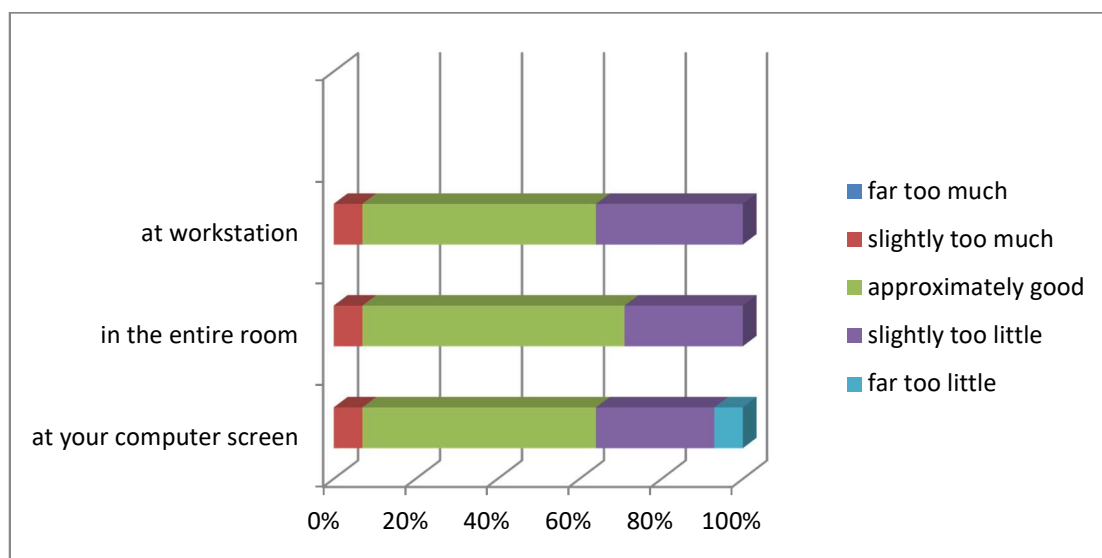


Figure 11: Level of Light (Daylight and Artificial Light Combined)

Artificial Light

The guidelines for artificial lighting in rooms with desired work surface illuminance (lux) are normally based on national codes or recommendation. Respondent were asked how often the artificial light was on while they were working. 64% of them answered that they ”sometimes” had artificial light on while working, 29% responded that artificial light was ” regularly” on while they worked and 7% said the artificial light was never on while they worked. On lighting nuisances, only 7% of respondents complained of artificial lights in their eyes, only 7% of respondents also complained of artificial light regularly being reflected in their computer screen. Nine-three per cent (93%) of respondents however have no complaints. On the level of light (daylight and artificial light combined), 57% of the respondents agree that the light level at their workstation and at their computer screen was “approximately good” and 64% of the respondents agree that the light in the entire room was also approximately good. This is illustrated in figure 12 below.

Respondents were also asked if they were satisfied with the possibilities to control lighting in their office 43% answered that they were dissatisfied while 57% answered that they were somewhat satisfied.

Satisfaction with Indoor Environment

To judge performance of the day lighting in relation to other aspects of the indoor environment, questions about thermal comfort, ventilation, noise and privacy were also asked. The figure below illustrates their responses.

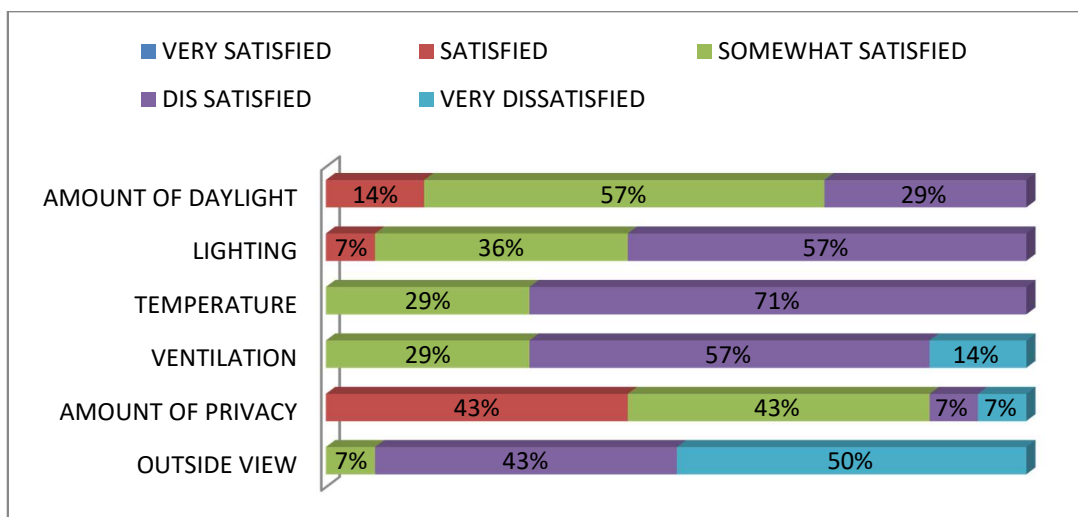


Figure 12: Respondents’ Satisfaction with Work Place

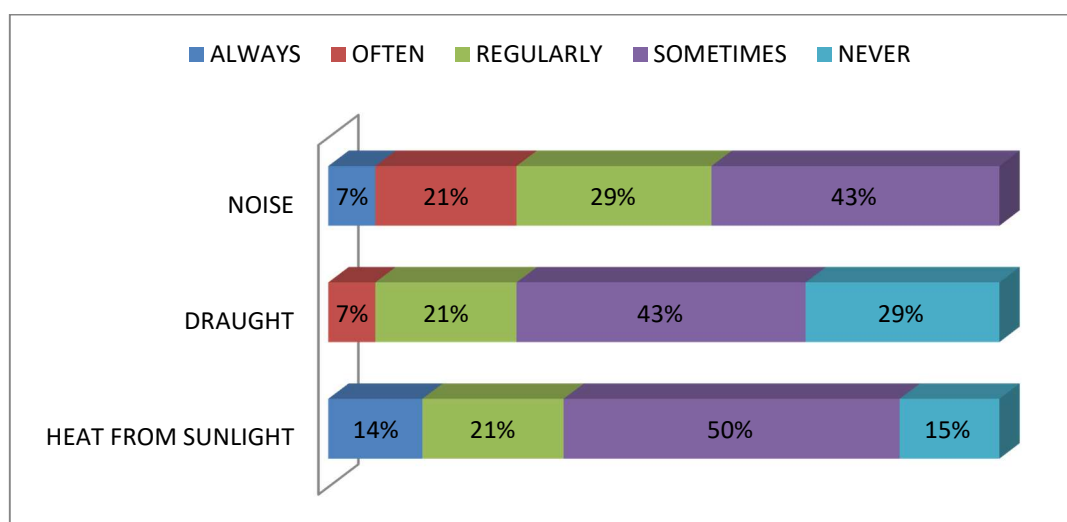


Figure 13: Disturbance at Work Place

Figure 12 above shows the respondents were generally dissatisfied with their indoor environment, 57% were “dissatisfied” with the lighting, 71% were “dissatisfied” with the temperature, 57% were “dissatisfied” with the ventilation and 50% were “very dissatisfied” with the outside view. Conversely, 57% of respondent were “somewhat satisfied” with the amount of daylight and 43% were “satisfied” with the amount of privacy.

Respondents were also asked about some nuisance experienced at the workplace. Figure 13 shows 43% responded that their work place was “sometimes” noisy and draughty and 50% responded that their workplace “sometimes” got heated from sunlight.

CONCLUSION

The aim of a post occupancy evaluation (POE) is to carry out a systematic assessment of the performance of a building once it has been occupied and used. This survey was embarked upon to gauge respondents’ satisfaction with their office spaces. The survey sought the opinion of occupants of the building regarding numbers, sizes, shapes and position of windows, daylight and lighting. Respondents’ were generally satisfied with the lighting level of their workplace.

Results indicate that most occupants' were satisfied with the number, size and position of the windows. They were also satisfied with the amount of daylight admitted into their offices.

Occupants of the SES building rely on both daylight and artificial light in their workplace. Findings show a majority of occupants were comfortable working with daylight only. Only few users complained of glare from sunlight. Other facets of the indoor environment were however not satisfactory. Respondents reported dissatisfaction with ventilation, temperature and outside view.

Corrective measures such as proper landscaping of the building can be attempted to mitigate User dissatisfaction with the outside view. Landscaping can also be employed to reduce thermal discomfort. Trees can be planted to provide shading while soft landscape elements like grass could be used to absorb direct sunlight and reduce the attendant heat gain.

Design solutions of the prototype building regarding separation of functions, access to daylight, privacy and noise control were successful as users were appropriately satisfied in this regard. New developments of the prototype can continue to utilize these solutions. Design inadequacies like absence of shading devices, lack of proper landscaping and considerations for thermal comfort were also highlighted in the course of the survey. Slight modifications on the building layout and orientation are recommended for subsequent developments of the prototype. A more exhaustive study of the repetitive prototype building in the school will be implemented to build on the findings of this survey.

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