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Daylight Performance and its Vital Effect on Building Occupants.

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Abstract

Throughout the predominance of artificial lighting, daylight design was not fully appreciated. An overall view of the advantages of daylight as a vital, sustainable way of thinking is put forward. This paper presents the importance of daylight performance in buildings as well as the users' response to it. In order to measure the users' level of comfort, productivity, preferences and issues such as glare and lighting control, a post-occupancy evaluation was carried out in The Learning Centre building at London Metropolitan University. While the degree of variability in the chosen illuminance level as well as the ratings of lighting quality and satisfaction of both: daylight and artificial were high, recommendations showed a lower average illuminance than present in the Learning Centre. Therefore, with such high light-conditions investigated, some parts of the artificial light could be switched off or controlled in favour of energy savings.

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Keywords: Daylighting, post-occupancy evaluation, user satisfaction, comfort

1 Introduction to daylight

Light can be perceived as the richest experience our sense has to offer. Light supplies people with the information and sensation of the world around us.

The Lighting Guides list seven distinct aspects of lighting design that need to be considered: legal requirements, visual function, visual amenity, architectural integration, energy efficiency and sustainability, installation maintenance and costs. A holistic approach to lighting design can give all possible benefits of energy and economy efficiency (CIBSE, 2009).

The main target in lighting design in buildings such as a library is to allow the users of a space to carry out their work quickly and accurately, without discomfort. When designing such a scenario it is necessary to identify all of the functions that the lighting is expected to fulfil.

According to Lighting Guide 5: Lighting for education (CIBSE, 2011) , in libraries the designer needs to allow for users to carry out a few main tasks such as finding the correct book, reading or studying, the use of computers and for displaying purposes.

Therefore recommendations and regulations are divided to a few different types of area, task and activity.

	Recommended maintained illumianance	Recommended maintained illumianance for special situations
Library/ information centres	300 lx (general)	200lx (vertically on bookcases) 500 lx (on reading desks and counters)

Figure 1 Places of public assembly (BSI 12464-1, 2011)

Daylight design is an essential part of lighting design and should be an inherent element of the educational environment, it is proved by IEA/OECD Light Labours Lost 2006 that electric lighting currently consumes 19% of the total global electricity which is 1.9 Gt of CO_2/year. Therefore lighting design should maximise the usage of daylight (CIBSE, 2011).

Because there is no substitute for electric lighting during darkness hours there is a need to save electricity during daylight hours because controlled daylight can replace up to 80% of lighting energy consumption during daytime hours.

In this case in order to integrate daylight and artificial light, zoning of electric lighting in regards to the distribution of daylight and choosing between switching and dimming control is needed. The satisfaction of occupants is a necessary condition for acceptance of technical solutions combining daylight and electric light.

The daylight and productivity issue expresses the idea that light-filled rooms are instinctively more welcoming and contribute to our sense of well-being and comfort, what is more, daylight provides a less stressful environment for students and staff, improves learning rates and saves energy (CIBSE, 2011).

Despite the fact that energy prices are increasing it is staff salaries that are the most expensive -up to 85% (Carter et al, 2010). Thus it can be assumed that even small increases in workers' productivity induce more money savings than savings on energy. From another perspective, daylight's effect on human's psychology and health influences occupier's attendance. The more happy and healthy occupiers are the better the attendance at work/school therefore the more productive and creative people are in are local environment, which is a very positive aspect of sustainability. Light and the feeling of health and well-being strongly link to each other because people perceive a working space with daylight more attractive and they feel they have a better mood, attitude and well-being to start work. Lastly, occupants can improve their task performance because of higher and clearer visibility. (Veitch et al, 2008)

2 Research and Post occupancy evaluation

This part of the research presents daylight and its use in buildings as well as the users' response to it and it contains the case study. The researched area is the The Learning Centre of London Metropolitan University. In order to achieve more accurate research in a post-occupancy evaluation 100 library's occupiers were surveyed.

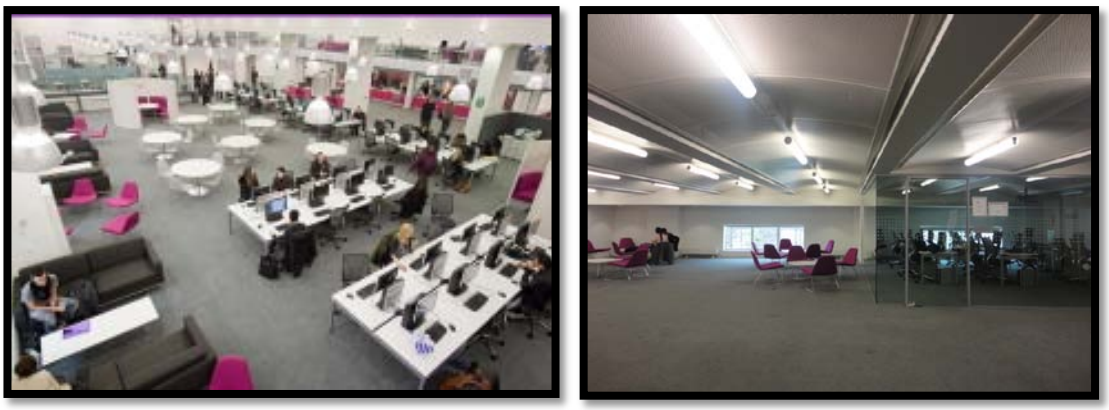
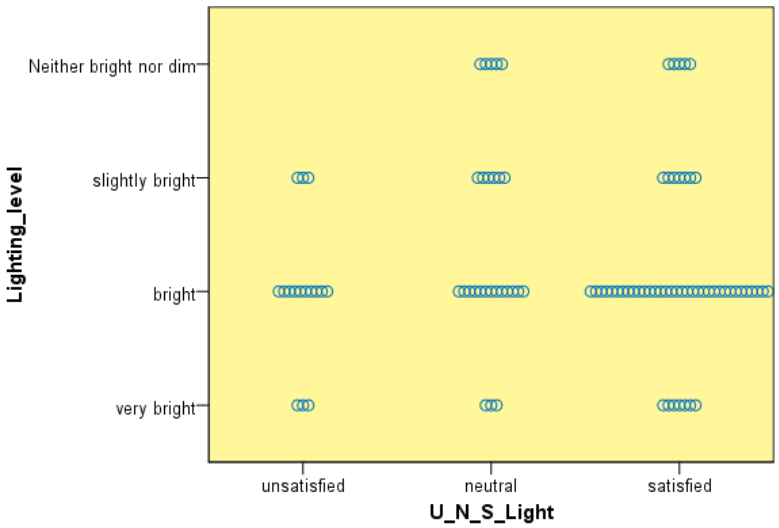


Figure 2 Pictures of library's interior (londonmet.ac.uk, Photographer: Pniewska)

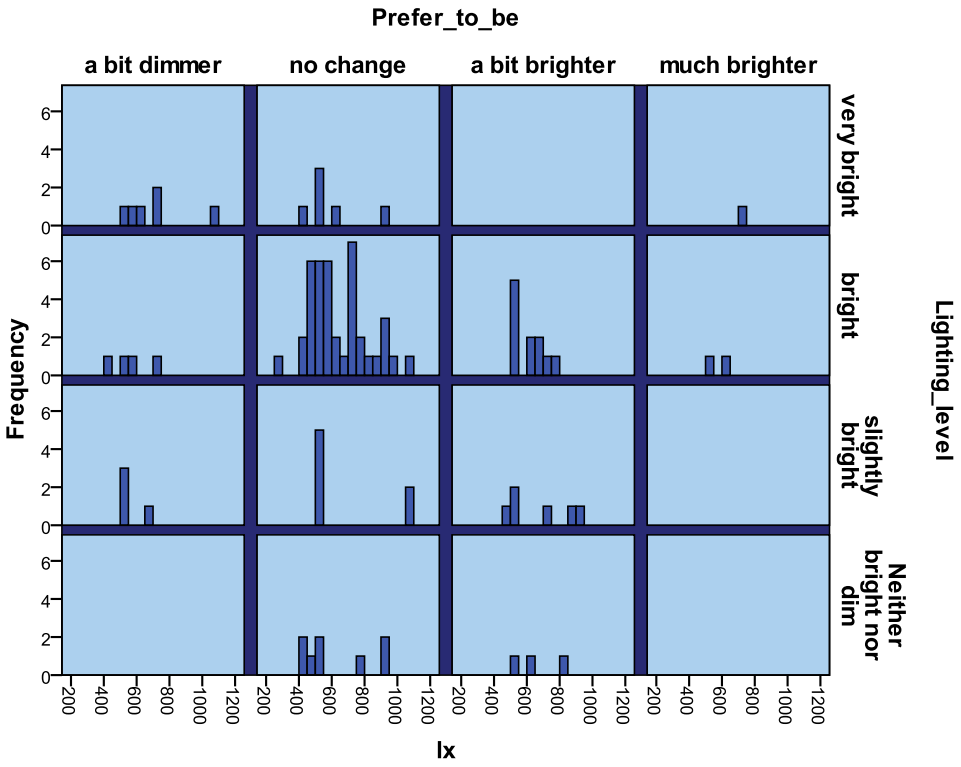
Firstly, information about participants was provided (sex, age and vision defects). There were no significant differences in the analysis of age, sex or sight defects. The average of hours per day in the library and average, maximum and minimum illuminance were calculated. Study reported also preferences between daylight, artificial light and daylight in relation to productivity, in comparison to other factors such as: temperature, ventilation, crowding and noise. Subsequently lighting level preferences were displayed. The two last sections discussed issues such as glare and control.

Results from the research draw the following main conclusions:

- **People can adapt to the lighting level environment they work in very fast and wide range of luminous conditions** (in this case 277-1056 lx) **are acceptable and satisfy most people** (in broad spectrum of light over 60% said 'no change' for lighting preferences and over 65% were satisfied with lighting conditions overall);

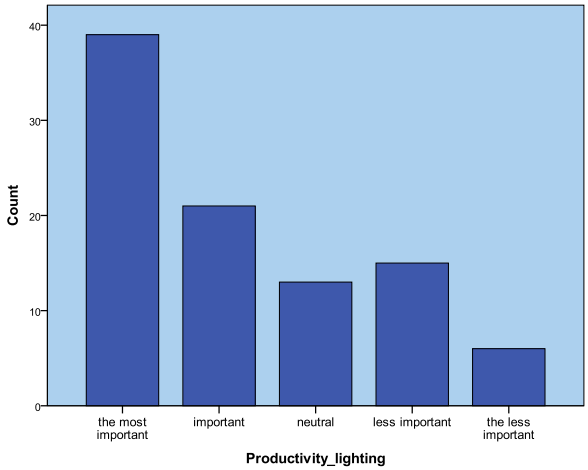


- **Preferred illuminance level in the library is very variable from one individual to another** (Graphs showed no correlation between illuminance and preferences. Lighting level was found as bright for most of the people and preferences were different what is more, people perceived it variously: from unsatisfied through neutral to satisfy);



- **There is preference for daylight**, associated with opinion that daylight supports psychical comfort, general health, healthy vision, colour appearance of people and furnishing and building appearance and pleasantness. In case of work performance daylighting and electric lighting were chosen equally. For jobs requiring fine observation electric lighting was preferred;

- The most numerous part of group placed **lighting as the most important (40% of responders) and important (20% of responders) aspect according to the productivity** as well as most significant and good influence on productivity. This coincides with Leaman and Bordass (1999) results which show that noise and then heating and cooling produces the strongest association with productivity. Nevertheless thesis research that the less important variable according to the productivity for responders is crowding;



- Problems with glare from sun and sky and artificial light was not assumed very problematic, although it various widely from one person to another because 15% of people were very unsatisfied with discomfort glare from artificial lights;
- **None of the occupiers used the dim part of the scale**. When designing the questionnaire, an answer 'neither bright nor dim' was put as an optimum value of the scale. It seems that responders assumed the 'bright' version as a comfortable and optimum lighting level;

- The importance of providing the building or users with the control of lighting was suggested so that the building can promote the sustainable idea that **good lighting controls can lead to occupant's comfort and energy-efficiency**. The plan of Learning Centre could be divided into zones of control relative to the amount of daylight present. Also light in some parts of the library such as techno booths or individual-groups tables could have occupancy control or be turned off if not in use. But it should be consider according to the general appearance as well.

Although the research seemed very concise, and the right amount of occupiers have been surveyed there are a few ways that the research could have been improved, if further investigation was made possible.

One way would be to take measurements and survey the library without artificial lights. Secondly, measurements could have been made when it is dark and no daylight is ensured. Thirdly, electricity bills could have been collected and simulation could have been carried out to calculate what the electricity impact is on the present lighting environment.

Fourthly, would be to compare the luminous conditions chosen by the occupier's to the conditions that they report that they want. Discrepancies might indicate areas to target in training people to use controls.

At fifth place, would be to analyse the use of various control interfaces and interface locations such as wall-mounted; remote controls; computer screens and get to know occupiers reaction, preference as well as personal experiences with either of the mentioned.

At sixth place, the most effectively done in a laboratory setting would be to analyse the energy use that results from the choices made by individuals using manual controls, in contrast to automated or no controls. Both laboratory and field data may be used for this purpose.

Despite the fact that research results show that lighting is a very important element of building design, other studies about lighting quality do not seem an extreme importance in comparison to other factors such as: noise, temperature, ventilation, noting that some people are oblivious to the lighting conditions around them provided they are above some minimum lighting level (Boyce, 1998).

This might be true, particularly at the level of justifying more costly lighting choices. However, a high percentage of disagreement with the statement that "The lighting in

an office is not important to me" suggests that lighting does matter to the ordinary occupant, at least at the most simplest level.

The problem remains that we are only slowly identifying the lighting conditions that would satisfy most people, a problem that is further complicated by the fact that preferred conditions vary widely from one individual to another.(Veitch et al, 2000)

Since, at the moment it is difficult to accurately predict daylight contribution using current metrics, architects should cooperate with experts in daylight design and consider the latest design tools and metrics to include and predict excellent daylight contribution throughout all learning spaces. Unfortunately, delaying and therefore including this in later design and construction stages of a project will result in daylight exploitation being very difficult in future. Consequently it has become vital for architects and building designers to include daylight design from the initial building concept stages right through to completion and post occupancy evaluation stages.

When daylight is included in a holistic design together with the building form, function, program and orientation, then there is a place for the integration of electric lighting therefore completing the lighting design process and lighting control strategy to provide satisfaction, pleasure, productivity, health and beauty in learning spaces for both the user and the environment.

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