

Indoor health and comfort for the green workplace at university

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ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received June 22, 2020 Received in revised form July 05 2020 Accepted July 27, 2020 Available online December 01, 2020</p> <p><i>Keywords:</i> Greenship Green workplace Indoor health and comfort Interior space</p> <p><i>*Corresponding author:</i> Susan Interior Architecture Universitas Ciputra Suabaya, Indonesia Email: susan@ciputra.ac.id ORCID: 0000-0001-7066-1961</p>	<p><i>Greenship interior space is a rating tool used in ensuring more sustainable and healthy indoor space with the focus on the health and comfort of the users thermally, visually, and acoustically. It is important to study this concept further to ensure a healthier workspace where most workers spend 80-90% of their time. This is necessary because a well-designed indoor health and comfort has the ability to prevent the emergence of sick building syndrome and increase employee productivity. This research was conducted using the Ciputra University workplace as a case study. Moreover, a descriptive quantitative approach was implemented with data collected through observation, interviews, and field measurements. The results showed the possibility of optimizing the visual comfort and outside view in the workplace to obtain the appropriate level of illumination and to improve workers' productivity. This, therefore, means, a workplace needs to address the environmentally and socially conscious behavior and also support employee performance in order to improve productivity in line with the strategies of a green workplace.</i></p>

Introduction

Buildings have been observed to be a major factor mitigating climate change and this has led to increased attention to its design, performance, and evaluation (Yuliani, Hardiman, and Setyowati 2020). This also caused the need for green buildings which are characterized by energy and resource efficiency as well as the need for a comfortable, healthy, and productive environment (Subroto 2019; Pradono 2019). According to the Green Building Index (2014), buildings are very influential to the health of space users while the ability to sustain this space is determined by human existence and their activities (GBI 2014). The concept of sustainability for Interior Space based on the Green Building Council Indonesia (2016) primarily aims to (1) protect human health and comfort (2) reduce pollution and environmental damage, and (3) reduce energy and resources

(Green Building Council Indonesia 2017). Moreover, the assessment parameters for Greenship Interior Space consist of 6 criteria which are the Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material and Resources Cycle (MRC), Building and Environment Management (BEM), and Indoor Health and Comfort (IHC) which is the criterion with the highest rating points (Figure 1).

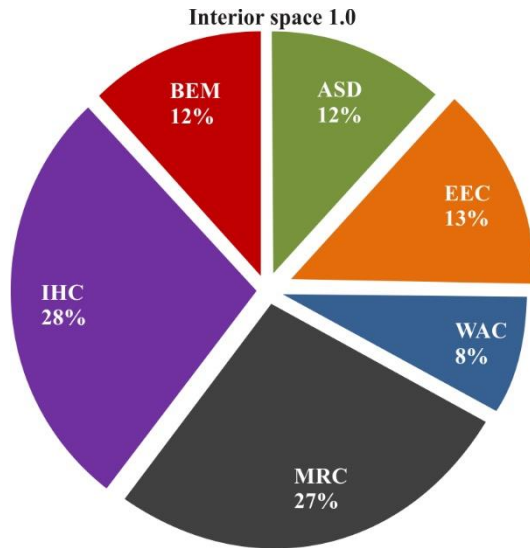


Figure 1. Greenship interior space assessment criteria
 Source: (Green Building Council Indonesia 2017)

These criteria have become a very important reference for sustainable design due to their ability to ensure energy and resource savings, reduction in building operating costs, improvement in the health and comfort of users, and increment in workers' productivity. "The Business Case for Green Building" reported buildings with a green concept to have the ability of enhancing health and productivity of the occupants (World Green Building Council 2013). It has also been reported that users are also more satisfied with their environmental quality, especially the interior as a whole. This is majorly due to the fact that green buildings provide better quality lighting, ventilation as well as CO₂ and VOC concentrations in space (Lim et al. 2012)

Most of human activities reported to be taking 70-90 % of their time are conducted indoor (Darus, Ahmed, and Latif 2011). This makes indoor health and comfort very important to the users and a matter of concern to the Green Building Council Indonesia, especially with the focus on assessing the Greenship of interior space. The organization reported the possibility of having pollutants from both inside and outside sources with those associated with air in the warm humid climate country assumed to be mainly from the mechanical ventilation system designed to minimize air infiltration and reduce cooling load energy. Indoor Air Quality and Comfort assessment tools are designed to prevent air quality problems and protect the occupants' health using the following 12 criteria (Table 1).

Table 1. Indoor health and comfort criteria

Code	Criteria	Credits
IHC P	No Smoking Campaign	P
IHC 1	Outdoor Air Introduction	1
IHC 2	CO ₂ Monitoring	2
IHC 3	Chemical Pollutant	9
IHC 4	Indoor Pollutant Source Control	2
IHC 5	Biological Pollutant	1
IHC 6	Visual Comfort	3
IHC 7	Outside View and Daylight	2
IHC 8	Thermal Comfort	2 (+2B)
IHC 9	Acoustic Level	1
IHC 10	Interior Plants	2
IHC 11	Pest Management	1

Source: (Green Building Council Indonesia 2017)

An environmentally-friendly office is expected to improve comfortability and ensure a productive environment with more control of operating costs and also improve employees' participation in saving energy, water, and implementing appropriate waste management strategies.



Figure 2. Research object, workspace of Universitas Ciputra lecturers

A workplace needs to consider energy efficiency, new technology, and the occupant's health and comfort in its design. The efforts towards energy-saving are also expected to provide a healthy and comfortable space solution and not to reduce the quality of the indoor environment (Figure 2).

The research was, therefore, conducted to determine the existing condition of the workspace by assessing the Indoor Health and Comfort (IHC) from Greenship Interior Space and suggest design recommendations to achieve a green workplace. This is necessary due to the ability of a well-designed workplace to support employees' performance by improving their productivity and health. This is in agreement with the findings which showed the performance of an occupant is

determined by several factors supported by a good work environment (Stringer 2010).

Health, Wellbeing and Productivity in Offices: The Next Chapter for Green Building (World Green Building Council 2014) summarizes the health and comfort factors affecting productivity as follows:

- 1) Indoor Air Quality;
- 2) Thermal comfort;
- 3) Daylighting and lighting;
- 4) Biophilia;
- 5) Noise;
- 6) Interior layout;
- 7) Look and feel;
- 8) Active design and exercise;
- 9) Amenities and location.

The Greenship Interior Space criterion is especially beneficial for sustainability and to create healthy and better indoor quality for the occupants. This study was conducted because this was observed to be lacking in several workspaces. Some studies have, however, discussed the Greenship Existing Building at universities (Nurcahyo et al. 2018), users' perception of green buildings with office functions (Mediastika and Lie 2015), research in LEED-certified buildings (Lee and Guerin 2010), factors influencing the comfort level of users in a University (Yahya et al. 2014), indoor health and comfort effects on tenant's productivity (Sakellaris et al. 2016), assessment of IHC in an adaptively reused building (Wardhani and Susan 2019), and strategy to optimize IHC (Susan and Wardhani 2019).

Method

This research was conducted using the descriptive quantitative method with data collected through observation, interviews, and field measurements. The observations were used to analyze the existing conditions as well as the geometric and lighting assessments. Moreover, the building system was used to determine the (1) no-smoking campaigns (2) introduction of outside air (3) CO2 monitoring (4) chemical pollutants (5) control of indoor pollutant sources (5) biological pollutants (6) visual comfort (7) display outdoor and daylight (8) thermal comfort (9) acoustic level (10) interior plants (11) pest management, and (12) room occupant survey. The case study for this research was Ciputra University, Indonesia.

Several instruments were used to collect data and this involved the application of lighting assessments to measure visual comfort and daylight through lux values at grid points in range 1.00 to 1.20 meter using lux meter. The thermal comfort was evaluated using a digital room thermometer to determine the temperature and relative humidity inside the room while the acoustic level was measured through the use of a decibel meter.

The results from the observation and measurements were compared with the Greenship Interior Space standards and the discrepancies were used in improving and modifying building systems.

Result and discussion

Indoor health and comfort assement

The observation and measurements from the existing Indoor Health and Comfort in the workspace at Ciputra University are explained as follows:

- 1) No smoking campaigns

This prerequisite criterion for Indoor Health and Comfort has been fulfilled by the commitment of management to set all rooms in the university smoke-free. No-smoking campaigns are also being conducted in the form of stickers placed in several areas in the university.

- 2) Outdoor air introduction

The workplace has access to outside air from the window but they are rarely opened to avoid the public glare. This, therefore, means this criterion has not been fulfilled.

- 3) CO2 monitoring

This criterion has not been satisfied due to the consideration of the workspace not to have high-density and this means there is no need for CO2 sensors to prevent shortages of fresh air and maintain the health of the occupants. It has been discovered that good indoor air quality, low levels of CO2, and high levels of ventilation have the ability to improve productivity by 8-11%. Meanwhile, CO2 levels are used in measuring air quality and have been found to be causing fatigue when the value is high. This has also been reported in several studies to have negative effects

on memory and concentration (Bakó-Biró et al. 2012).

4) Chemical pollutant

The wall is made of 10 cm light brick and a 12 cm plastering finish for the outer wall while the inner wall is painted using paints free from heavy metals and mercury and this means they are safe for the health of the occupants. Moreover, the exposed ceilings were finished with paint having very low VOC content while the floor is decorated with Homogenous Tile 60x60 cm in natural white color. There is no asbestos in the interior parts of the building and all the materials selected and used were observed to have fulfilled the chemical pollutant criteria and were awarded 7 points. Meanwhile, the furniture has some adhesive contents with high contents of VOC and formaldehyde.

5) Indoor pollutant source control

The workspace does not meet this criterion due to the lack of access to an exterior because it is located on the 5th floor.

6) Biological pollutant

There is a need to reduce biological contamination in space in order to maintain the health of the occupants. It is, however, impossible to achieve this criterion due to the lack of appropriate documentation on the cleaning of air conditioning ducts by the building management.

7) Visual comfort

This criterion aims to ensure appropriate lighting is in the workplace to aid the productivity and comfort of the occupants. The window in the workroom was observed to be facing east and this limits the optimal use of daylight during working hours (8 AM-4 PM) due to the closure of the window to avoid glare. Artificial lighting is usually used instead to provide illumination and this was measured with a lux meter.

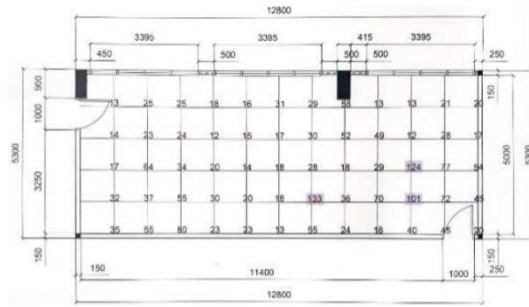


Figure 3. Artificial light illuminance grid

The results showed the artificial lighting is unable to meet the level of illumination suitable for the workspace as observed from the 350-lux recorded. This value makes the light produced to be dim, thereby, causing the eyes to get tired quickly.

There is also no individual lighting system and curtain management integrated with the natural lighting system in the room. The results of field observations and measurements showed this criterion does not satisfy the required benchmarks.

8) Outside view and daylight

A window is placed along the walls of the workplace which is directly oriented to the outside view but the arrangement of the workstation and furniture limits the access. The results showed the outside view covered 55.9% of the total area. There is, therefore, the need to carefully design the height of the partitions in the workplace to improve employee performance and environmental satisfaction (Lee and Guerin 2010).

The natural light intensity in the workplace is not up to 300 lux and this is associated with the window along the walls facing east and the outside wall covered with secondary skin to reduce the solar radiation but which further limits the sunlight entering the building.

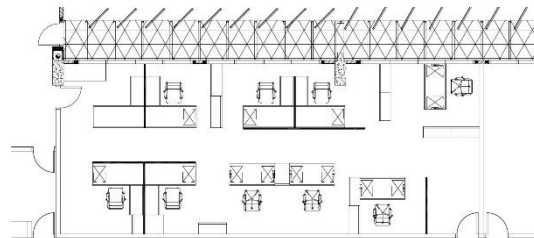


Figure 4. Workplace layout

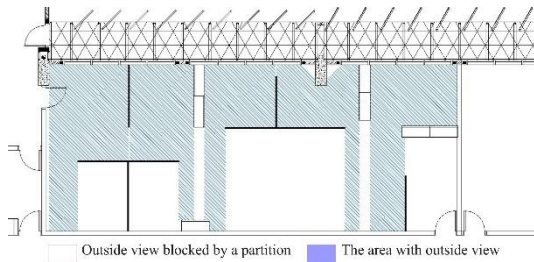


Figure 5. The area with outside view

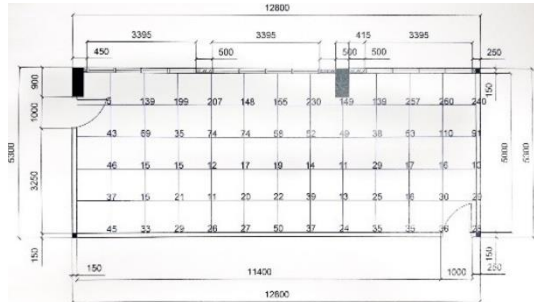


Figure 6. Daylight illuminance grid

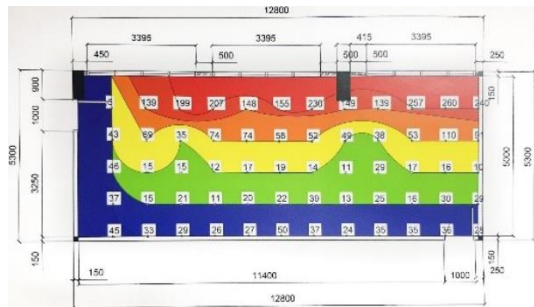


Figure 7. Isocontour graph

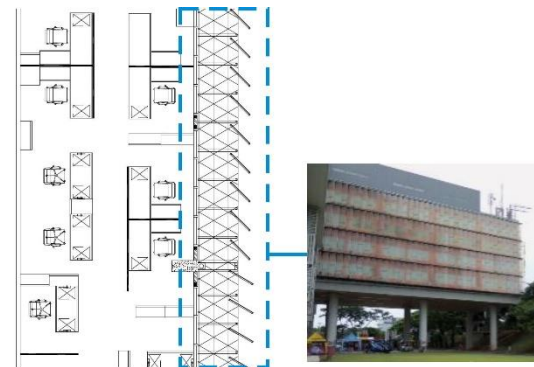


Figure 8. Secondary skin outside the building

The two benchmarks for this criterion are not fulfilled. Meanwhile, several studies have shown an increase in productivity due to the proximity to windows with the most significant factor being the outside views, especially those that connect with nature (World Green Building Council

2014). Therefore, there is a need to optimize daylighting in the workplace due to the ability of natural lights as one of the potential passive strategies to save energy and improve the visual comfort of the occupants without having to spend more on installation and operations (Lim et al. 2012).

9) Thermal comfort

This criterion aims to ensure a stable condition in the room temperature to improve user productivity. The observations showed the workplace temperature and humidity were not set in line with greenship benchmark which is $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and $60\% \pm 10\%$ respectively. Moreover, the artificial ventilation system includes 2 split air conditioners placed at the end of the room and are observed not to be an effective cooling spot for individuals. This means both benchmarks required for this criterion are not fulfilled. It is, however, possible to achieve thermal comfort using energy-saving efforts by optimizing the air conditioner to have a good distribution pattern. There are three types of distribution which are perfect mixing, displacement, and radiant cooling. The displacement type has been discovered to be the most rapid to achieve thermal comfort due to its ability to directly drain cold air 30-40 cm above the floor and has a direct effect on the user's work area by moving heat to the top where no one resides (Seputra 2018). Previous research showed thermal comfort has an effect on employee satisfaction and its control has the ability to improve productivity.

10) Acoustic level

The noise level in 90% of the area is 40 dBA and this does not meet the design criteria recommended by SNI 03-6386-2000 which is 30-35 dBA. This, therefore, makes it difficult to be productive in the office area due to the discomfort caused by the noise. Meanwhile, even though the value does not meet the required SNI level, a background sound at 45dBA is recommended for an open-plan and 40dBA for private or cellular office (World Green Building Council 2014).

11) Interior plants

There are no indoor plants to enhance the environmental quality of the interiors and the decreased stress level was reported to be as a result of the access to green open space (Lottrup, Grahn, and Stigsdotter 2013). The occupants of the workplace with indoor plants have better

mood levels and feel comfortable in space than rooms without plants (Larsen et al. 1998).

12) Pest management

The building management has implemented periodic pest control with the principle of accuracy in materials, tools, time, and applicators.

13) Room occupant survey

Building management has not conducted a survey to measure occupant's comfort in order to determine the effect of the design on building operating systems. It is, however, recommended to integrate building assessment, inspection, questionnaire, and environmental measurements to ensure better indoor quality (Carrer and Wolkoff 2018).

The analysis showed the workspace only meets the standard for IHC 3, chemical pollutants, IHC 11, and pest management. Therefore, only 8 points were achieved from the maximum point of 29 achievable.

Strategies towards ensuring green workplace

Green workplaces can be highly productive and directly contribute to the bottom line. This is associated with the fact that environments with the ability to promote human productivity have a competitive advantage. Several factors have been identified in developing spaces to help workers to be productive and successful in their job. The transformation to a high-performance green workplace is one of these factors due to its ability to improve employee productivity as well as to reduce office operational cost and business carbon footprint (Heck et al. 2012).

Several points are suggested to improve the lecturer green workplace in Ciputra University based on the results from the Indoor Health and Comfort assessment. This involves physical attributes such as connection to nature, exercise ability, sensory change and variability ability, personal environmental control, and good indoor air quality (Stringer 2010).

1. Connection to nature.

Human beings have a deep connection to nature which is specifically associated with natural light, access to outside view, landscape features such as vegetation and water as well as the use of natural materials in the interior aspect. Moreover, the environment and its contents are interconnected as one entity and this means there is a need for its preservation (Widodo 2019).

Indoors plants in the form of plants in pots or green walls are proposed to be added to the existing workspace to bring nature closer to the occupants.

2. Ability to exercise.

The building design has the ability to promote exercise through open interior stairs, tempting natural walking paths, and in-house fitness facilities. The exposure to fitness not only encourages innovation and concentration but also decreases sick days and long-term corporate healthcare costs. It is proposed that posters or morals be pasted on the existing workspace to encourage the use of stairs as vertical transportation to keep the occupants active and healthy.

3. Sensory change and variability

A lack of visual stimuli benumbs the senses during the day and this hinders the ability of a worker to remain alert. Moreover, an inconducive work environment makes workers lose concentration and creative capacity. A workplace with an atmosphere without sensory stimulation usually leads to passivity. The optimization of daylight exposure through windows along the wall and an integrated curtain system to prevent glare is proposed in the new workplace.

4. Personal control

There is a need for the personal control of the occupants over noise, lighting, desk height as well as a desk and chair adjustability. It is, therefore, proposed that old furniture be replaced with adjustable tables and chairs and additional task lighting should be provided on each workstation to ensure personal control over lighting.

5. Indoor air quality

Sick building syndrome is the common name given to the negative effects of poor air quality in the workplace. It is, however, possible to prevent it mainly by the strict use of green cleaning methods, maintenance of ventilation and air conditioning (HVAC), selection of green materials and furniture systems, enhanced outside air circulation, proper scheduling of construction, and proper design of the building envelope. The existing workspace is proposed to have an additional exhaust fan to supply fresh air while green materials are to be selected for furniture finishing.

Some other productivity inhibitors observed include noise, visual distractions, and interruptions (Stringer 2010).

1. Acoustic and visual distractions

Open-office environments which are working spaces with few enclosed offices and full-height walls are increasingly becoming popular. They are usually considered "greener" due to their less need for artificial light, resources, and ventilation. It makes it easy for employees to see and hear each other more frequently and this usually leads to better communication. This is considered positive for organizational efficiency but has the ability to reduce productivity, particularly when workers attempt to perform tasks requiring a high degree of concentration. A private space with visual and acoustic divider and accessible for occupants to conduct work and meeting requiring high concentration is proposed to be added to the existing workspace.

2. Glare

The side effect of maximizing windows and daylight is the glare it produces on computer monitors. This means natural light sometimes has negative effects on productivity. It is, however, possible to avoid this situation through appropriate building orientation, window treatments, and other construction techniques. An automatic integrated curtain system is, therefore, proposed to be added to the existing workplace to avoid glare from daylight exposure.

3. Interruptions

Interruptions during basic and regular tasks are stimulus required to continue moving forward. It also has the ability to reduce the motivation to resume work due to the longer time to reorient. The workers are, therefore, proposed to be provided with access to a variety of spaces to work remotely, avoid distractions, and improve their effectiveness.

Conclusion

The Universitas Ciputra workplace for lecturers has several potentials, especially in the use of natural lighting by replacing the shading device with task lighting to achieve illuminance required by standards. It is also possible to maximize the outside view by changing the partition layout used

as a barrier between the workstations. The results also showed a workplace should not focus only on the environmentally and socially conscious behavior but also support employee performance to improve productivity. Moreover, green workplaces also need to ensure effective and wise resources by staying lean and appropriately sized to support greater environmental responsibility. It is also expected to be a way to create better environmental quality for the employees without abandoning their health and productivity.

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