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Identifying the Key Social Factors in Post Occupancy Evaluation of a Green Building

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ABSTRACT

Over the years, researchers have conducted various studies on the adverse effects from world development growth. The real-time evidence of changes in the climate favours the stakeholders to support the sustainable development concept by balancing the environment, economic, and social needs. The construction industry is one of the industries held responsible for the release of harmful emissions throughout its lifecycle. The awareness of the need of supporting the sustainable principle has led to many initiatives in reducing the energy consumption in buildings, which include the demand for green building construction. Although extensive research and evaluation tools of green buildings are carried out, less attention is made on social needs, which include the occupants' perception and satisfaction. Consequently, recent studies found discrepancies in occupant satisfaction claiming better comfort and health in green buildings. This study is therefore aiming to identify the key social factors that lead to occupants' satisfaction. Literature was carried out by systematically searching online literature databases, using keywords

searches, within ten (10) years of time frame from 2012 to 2021. Through the analysis, the following result on the social factors is obtained, namely comfort, health, safety, system's controllability, productivity at work, corporate satisfaction, water efficiency, and energy efficiency. By identifying these factors, this article is hoped to improve the development of the green strategy, supporting the eleventh and thirteenth trust in the Sustainable Development Goals (SDG).

Keywords: *Sustainable; Construction; Green building; Social factors; Post-occupancy evaluation*

INTRODUCTION

In recent years, the global population has grown rapidly, with an average of 80 million people a year. The United Nations has projected that the population will grow to 9.7 billion in 2050 and 10.9 billion in 2100 (Kaneda et al., 2020). From the overall population, more than 4 billion people or more than half of the world population live in urban areas, increasingly in highly dense cities (Klein et al., 2019). This rapid growth of population is calling for development to cater for the population and so sustainable construction in need to be investigated. The Energy Information Administration (EIA) of the United States categorizes four end-user sectors that consume energy, and three of them are linked to construction development which are the residential sector, commercial sector, and industrial sector. These include houses, apartments, offices, malls, schools, hotels, hospitals, warehouses, public assemblies, and places of worship (EIA, 2020). Thus, sustainability in the construction sector plays an important role across the whole life cycle, from planning to disposal. To combat the negative consequences for the environment caused by the construction industry, the demand for green buildings is increasing as a strategy to limit carbon dioxide emissions ((Scudu, Leonard, & Minter, 2019)

Green buildings are said to be beneficial to the environment, economic, and social. However, among these three principles of sustainability, social criteria achieved the least attention, which includes the user perception and satisfaction over the performance of the building (Alipour & Galal, 2021; Mansour & Radford, 2016). The energy

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consumed by buildings is mainly influenced by six factors, namely climate, building envelope, building services and energy systems, building operation and maintenance, occupants' activities and behaviour, and indoor environmental quality. Ahmad et al., (2021) added that the success criteria of building projects during its development and operation stage are crucial, enabling the witness the socioeconomic and environmental effects. While many past studies focused on the first three factors, human-related factors are still underexplored, and a study made by Yoshino et al. (2017), mentioned that human-related factors could provide as much influence on the performance of the building. Green building evaluation tools are developed to measure the performance of green buildings. Luangcharoenrat and Intrachooto (2018) stated that most of the building evaluation tools primarily give credits and emphasize more on the environmental and economic side, leaving social attention behind. Thus, this study aims to identify the key social factors of occupants in green buildings.

LITERATURE REVIEW

Introduction to Green Buildings

The construction industry accounts for a major share of environmental impact through its delivery on the development of infrastructure and facilities, calling on the need for sustainable development. The World Commission on Environment and Development (WCED) (1987) defines sustainable development as "…development which meets the needs of the present without compromising the ability of future generations to meet their own needs". Enshassi et al. (2016) emphasize that sustainable development in construction entails reducing resource use, resource reuse, using renewable and recyclable resources, protecting the natural environment, creating a safe and non-toxic environment, and pursuing quality in the built environment. Thus, green building is one of the efforts in supporting sustainable development policy.

Green building is considered as one of the measures for sustainable development in balancing the need to sustain the economy, environmental, and social health. The demand for its development has increased as its operation would eventually be beneficial for both

occupants and business owners in providing a better quality of the indoor environment and reducing the operation cost as compared to conventional building design (Aigbavboa & Thwala, 2019). It is currently regarded as one of the important alternatives to solve the energy crisis in both developing and developed countries. Green building is defined as a facility to provide the people with healthy, applicable, efficient space and natural harmonious architecture with the maximum savings on resources (energy, land, water, and materials), protection for the environment and reduced pollution throughout its whole lifecycle (Li et al., 2016; Zhao et al., 2015). Primarily, green building is designed to reduce or eliminate the impact of greenhouse gas (GHG) on humans, and the natural environment with efficient usage of environmentally friendly material and operational elements embodied throughout its lifecycle (Aigbavboa & Thwala, 2019). Ulubeyli and Kazanci (2018) summarized the factors in strategizing a maximum sustainable goals in green building industry. First, the economic factors are related to a company or industry that may be driven by inflation rate, interest rate, growth rate, unemployment trends, foreign exchange rates, foreign direct investment, labor costs and stuck market trends. Second, factors that are affecting the environmental performance includes the climate, weather, pollution, recycling, and ecology. Finally, the social factors are ones associated with cultural trends, demographic, population analytics, and buying trends.

The requirements of green building are delineated to several elements and criteria that enable its operation to reduce carbon emissions. The main features and measures of green building requirements are summarized in Table 1 below:

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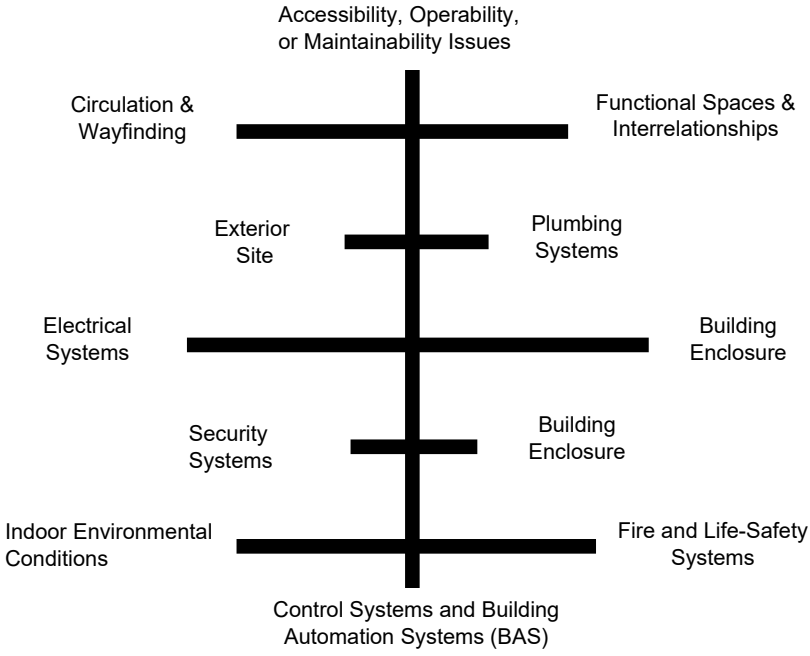
Table 1
Requirements of Green Buildings

Main features	Measures	Source
Energy Efficiency (EE)	• Insulation in the walls and roof • Low-e coatings, gas filling, & double-glazing windows • High-performance systems and appliances (air conditioning and mechanical ventilation (ACMV), high-efficiency chillers & pumps, LED lighting system) • Sensors (occupancy sensors, motion sensors, daylight harvesting sensors, photocell sensors, and wireless remote control) • Premium efficiency transformers	Hanania et al., 2015; Park, 2021
Indoor Environment Quality (IEQ)	• Indoor Air Quality (IAQ) • Temperature • Lighting (artificial & daylight) • Visual comfort • Acoustic comfort • Odour • Material – low or non-toxic material, minimal chemical emissions, moisture resistant, & healthfully maintained	Balali et al., 2020; Elnaklah et al., 2020
Sustainable Site Planning and Management	• Building automation systems (BAS)	Park, 2021
Environmentally friendly Material & Resources	• Recycled & renewable content • Resource-efficient in the production process • Locally available • Reusable or recyclable content and packaging • Durable	Balali et al., 2020
Water efficiency	• Rainwater harvesting • Greywater recycling • Pressure reduce valve • Non-potable water for cooling towers • Low flow plumbing fixtures	Wienerberger , 2018
Innovation	• Technology and able to generate electricity from renewable resources (photovoltaic systems)	Park, 2021

Post Occupancy Evaluation (Poe) as Building Performance's Tools

Preiser et al. (1988) defines POE as "the process of systematically comparing actual building performance i.e., performance measures with explicitly stated performance criteria. These are typically documented in a facility program, which is a common prerequisite for the design phases in the building delivery cycle. The comparison constitutes the evaluation in terms of both positive and negative performance aspects". In general, POE is a process of identifying the strength and weaknesses of the existing building's performance by providing feedback for future designs (Vásquez-Hernández et al., 2017). The benefits of using POE as evaluation tools include improving continuous improvement process by providing occupants' feedback, to gather and validate the needs of occupants and their buildings and reducing the building's operation cost (Zimmerman & Martin, 2001).

Figure 1
Criteria and Typical Scope of POE in Physical Evaluation



Building's performance in the post-occupancy stage is what determines the overall sustainability level of the green buildings which signals that it is crucial to continuously evaluate its performance throughout the life cycle. Despite the concern on sustainable project's performance, Li et al. (2018) mentioned that the current practice of monitoring the project's performance is solely focusing on the design stage. Therefore, POE can be regarded as an essential element in determining and delivering overall project success. Figure 1 illustrates the criteria and typical scope of POE in the physical evaluation of the facility (Kennett, 2021).

Social Attributes in Green Building for Performance Efficiency

A recent study carried by Ahmad et al., (2021) pertaining to key criteria of successful green building project shows that meeting the needs of building occupants ranks the highest, followed project aspirations, realizing sustainable operations, and achieving green building certifications rank the lowest. This shows that knowing what occupants' objectives are crucial, and this requirement must be prioritized. Mansour and Radford (2016) suggested that the design attributes in evaluating the building performance were based on two criteria, which first the potential of occupants gaining benefits through the building designs, and second by incorporating the experience characteristics that shall be evaluated by the end-users. In addition, Yoshino et al., (2017) mentioned that one of the significant barriers in achieving efficient use of energy in green buildings is the lack of knowledge in understanding the role of human behaviour as occupants of the building.

METHODOLOGY

The review was carried out by systematically searching the online literature database, using keywords and bibliographical searches, within ten years of time frame, from January 2012 to April 2021. Searches were conducted using the online database Web of Science (WOS), Scopus, EBSCO using the initial keywords "green building" and "post-occupancy evaluation". In total, seventy-seven (77) articles were reviewed mainly post-occupancy evaluation in green buildings. The abstract of related articles was screened at this stage, and the searches are limited to only

articles highlighting occupants' feedback and experience to collate the social attributes. Twenty-two (22) articles were further reviewed at this stage, while the remaining articles were excluded as the assessment are much focusing on the environmental and economic attributes.

The finding of the articles was later themed to identify the key building performance attributes during the occupancy stage. Using these themes, other keywords are identified, namely "social factor, "behavior / attitudes", "perception / satisfaction", and "assessment / evaluation". Further searches were conducted using these keywords, with the aim of collating the social factor of green building occupants.

Finally, twelve (12) were found to match the final criteria. Throughout the reviewing process, thematic analysis method was utilized, and patterns were set to identify few important criteria, including the geographical of the case study, type of building, standard and assessment tools used, and its methodological approach. Finally, out of twelve (22) articles, nine (12) were chosen to include in this review, while the remaining number of articles were found to not highlighting the social criteria during its assessment process.

FINDINGS AND DISCUSSIONS - TO IDENTIFY THE KEY SOCIAL FACTORS OF THE OCCUPANT'S SATISFACTION

Table 2 lists the main attributes and its description associated to key social factors of green building occupants' satisfaction. Based on the review, there are about nine attributes have been identified. The attributes are comfort, health, safety, system's controllability, productivity at work, corporate satisfaction, water efficiency, and energy efficiency. The main attributes of social factors are mainly associated with human health and well-being as green designs provides better indoor environmental quality and hence better comfort to the occupants.

Table 2:
Collation of Key Social Factors from Past Research

Building Type	Geogra-phical	Main attributes	Details on the main attributes	Author
Office building	Shanghai, China	• Comfort	• IAQ • Thermal • Relative Humidity • Acoustic • Illuminance (Interior lighting)	(Wang & Zheng, 2020)
Office building	Abu Dhabi	• Comfort	• Illuminance (Interior lighting)	Andargie et al., 2020
Housing-apartment	Ukraine	• Comfort	• Thermal • Relative Humidity	Valeriy et al., 2020
Office building	Canada	• Comfort • Health	• Acoustic • Illuminance (Interior lighting) • IAQ • Thermal	Bajraktari et al., 2019
Office building	United States of America	• Comfort • Controllability	• IAQ • Thermal • Illuminance (Interior lighting & daylighting) • Outdoor visual • Spatial • Acoustics • User-friendly system	Altomonte et al., 2019
Office building	South Africa	• Comfort • Productivity • Controllability • Health	• IAQ • Thermal • Illuminance (artificial lighting) • Daylighting • Ventilation effectiveness • Outdoor views • Acoustic • Furniture (ergonomics) • Spectrum of paint use • Spatial (place to meet, and public place) • Amenities	Aigbavboa & Thwala, 2019
University building	Australia	• Comfort • Safety	• IAQ • Thermal • Spatial	Moore & Iyer-Raniga,

			• Acoustic • General amenities	2019
Office-bank	Brazil	• Comfort • Building design features • Corporate satisfaction	• IEQ-Thermal, Illuminance, acoustics, ergonomics, cleaning & air quality • Building features – sustainability &neighbourhood • Corporate satisfaction – work satisfaction level, interactive behavior, communication, welfare, and morale at work, & sense of community	Sant'Anna et al., 2018
Office building	United States	• Comfort • Social territories • Water efficiency • Energy efficiency	• Spatial- social & privacy space • Visual- interior design (colour and tactile finishes) • Odours • Acoustic • IAQ • Thermal • Relative Humidity • Ventilation effectiveness • Illuminance	Mansour & Radford, 2016

Table 3 described the definition of each main attribute. Based on the review, it is proposed that green buildings have a better indoor environment, comfort, water, and energy efficiency quality than conventional buildings. However, these statements have been viewed differently by users of a green building that is influenced by various factors. For instance, a study in Australia has revealed no evidence that green buildings are more comfortable than conventional due to the system's malfunction (Paul & Taylor, 2008). Similarly, Karji et al. (2021) stated that the findings from the existing literature are inconsistent with relations between social benefits in green building and job satisfaction. However, occupants with better work productivity and well-being can potentially provide benefits to the organization's financial benefits. In addition, research made in China revealed that higher satisfaction on health and productivity could be attained based on the finding from a study

that comparing the conventional and green building during the POE stage (Gou et al., 2012).

Table 3:
Main Attributes' Definition and Criteria in the Built Environment

Main attributes	Explanation of the terms	Source
Comfort (c)	A condition of mind expressing occupant's satisfaction with the thermal environment which include air temperature, radiant surface temperature, air velocity, and relative humidity	(Yudelson, 2008)
Health (h)	A healthy building shall provide the occupants with sufficient space, window design that allow natural ventilation and daylight, seclude from noise and air pollution source, well-maintained water supply and waste system, and clean and hygienic environmental conditions	Dovjak, et al., 2019
Safety (s)	Building's safety performance includes stability of physical condition of the building and security in providing a quality environment	Nizam et al., 2018
System's controllability (sc)	Ability to have control over their environment and system installed in the building which includes room temperature, ventilation, amount of daylighting and artificial lighting, and noise level	Aigbavboa & Thwala, 2019
Productivity at work (p)	A positive work environment and good indoor environment quality could enhance occupants' work productivity and reduce absenteeism and staff turnover	Al Horr et al., 2017; BasuMallick, 2020
Corporate satisfaction (cs)	A positive emotional response and feeling experienced by the occupants at a workplace and executing tasks given	BasuMallick, 2020
Water efficiency (we)	Amount on the use of water supply from building design features, which include a system that consumes less potable water and reuse water for other services (landscaping & washroom)	Mansour & Radford, 2016
Energy efficiency (ee)	Amount of energy that could be saved during its operation to eliminate energy waste	Mansour & Radford, 2016

Some researchers argued that thermal comfort is ranked by building occupants to be of greater importance compared with visual and acoustic comfort and good air quality (Frontczak & Wargocki, 2011). The overall satisfaction with the indoor air and temperature might also be influenced by the climate, such as Gou et al,(2012), the comfort rated higher in summer but worse in winter. Khoshbakht et al.,(2018) also

highlighted that the non-environmental factors on occupant satisfaction, such as gender, age, hours spent in the building and in the workstation, might influence the qualitative attributed of the green building during the POE stage.

CONCLUSION

The concept of green building which utilizes sustainable technologies and design approaches certainly will give positive impacts to the environment with optimum resource efficiency and better comfort living for the occupants. However, much attention is given to study on the environmental and economic impacts of green buildings, as the numbers can be seen as the output of the research eventually. The influence of green buildings on the social aspect has rarely been conducted, as it's complex to measure the feelings and satisfaction of the occupants who have the diversity of needs according to their age, race, gender, attitude, and many other factors. Meanwhile, this should not be used to defend the lack of study on the social needs of occupants in green buildings, as they are supposed to occupy a healthy social environment. Many evidence has shown that green buildings do not ultimately satisfy the occupants, and worse many negative feedbacks were received of how the occupants are feeling dissatisfied with the green building designs. The goal of the development of green buildings will not be fulfilled without the consideration of satisfying the needs of occupants. Hence, it's first therefore essential to study the social factors that contribute satisfaction in comforts to the occupants to bridge the gap of performance and user satisfaction.

CONTRIBUTIONS OF AUTHORS

Siti Nurul Ainun Mohd Mustafa: Writing-Original draft preparation, Conceptualization, Methodology
Natasha Khalil: Writing-Original draft preparation, Writing-Reviewing & Editing
Asmah Alia Mohamad Bohari: Writing-Original draft preparation, Writing-Reviewing & Editing
Hong-Trang Nguyen: Writing-Reviewing & Editing

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