Evaluation of Indoor Environmental Quality – Case study of Lagos Offices

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Abstract
In order to mitigate the adverse effects of climate change, there has been a sustained focus on the provision of green or sustainable buildings and development over the years. To justify the added cost of green construction, the green indoor environment is often marketed as being responsible for increased worker comfort, satisfaction and productivity. This study uses both qualitative and quantitative means to evaluate this claim. The outcome is that the level of importance of the IEQ parameters varies across societies and cultures.

Keywords: IEQ, Comfort, Satisfaction, Productivity

1 Introduction
“Man is a funny creature. When it’s hot he wants it cold. When it’s cold he wants it hot. Always wanting what is not. Man is a funny creature” (Nagengast, 1999)

Studies in the some industrialized countries have shown that the populations spend about 90% of the time indoors (US EPA, 1989; Leech et al, 2002). As such, the quality of the indoor environment becomes important in how it impacts the health and wellbeing of the occupants. Based on an 8-hour workday, about 50% of an adult’s waking period is spent indoors within an office environment. This implies that the indoor environment should be conducive for work performance. This paper presents the findings of a pilot survey carried out to evaluate the indoor environmental quality (IEQ) factors in office buildings in Lagos, Nigeria.

In order to mitigate the adverse effects of climate change, there has been a sustained focus on the provision of green or sustainable buildings and development over the years. The major approach has been to minimize the impact of developments on the environment with major emphasis on energy use and material resources. However, the approach does not take full cognisance of the comfort perceptions of the occupants.

The indoor environment has had varied levels of importance through the ages. In ancient past, buildings were constructed for both security and comfort. Designs of the modern era placed emphasis on the building expressions and impressions. However the energy crisis of 1973 and the climate change revelation of the mid 1980s put focus on energy efficiency and conservation. In commercial buildings in the tropical climate, air conditioning has the highest percentage of energy use with lighting usually a distant second.
Unfortunately these two services, airconditioning and lighting, contribute to the physiological comfort within the indoor space and, therefore, are the main focus in a quest for energy conservation. Consequently, ventilation rates were lowered and the buildings became more airtight. Office lighting levels which were 300lux prior to the 1960s, and that had climbed to 700 lux with the affluence of the 1960s, was dropped to 400 – 500 lux following the oil crises in the early 70s (Levin, 2000). There is continuing advocacy that it can and should be lowered further.

However, there was an implication of the lower ventilation rates on the health of building occupants. The consequence was that buildings became damper and the indoor pollution increased as a result of the volatile organic compounds (VOC) which were prevalent in the modern furnishing and finishing (Hobday, 2011). The inadequate ventilation resulted in complaints of headaches, nausea, fatigue and asthma. The ailment or feeling became known as the sick building syndrome or tight building syndrome. The World Health Organisation (WHO) linked indoor air pollution to over 2.8 million deaths annually (Hoskins, 2003). Tuberculosis and legionella are frequently mentioned as ailments of bad indoor air quality (IAQ). It is therefore not surprising that focus had to go back to the indoor environment.

“During the 19th and into the 20th century... Energy efficiency was secondary to health. Improvements in ventilation, lighting and crowding are credited with helping to reduce the prevalence of tuberculosis. Today the position is reversed. The focus is now more on carbon emission savings and less on high standards of IEQ" (Hobday, 2011)

With the advent of the sustainable building certifications, due emphasis has been put on the quality of the indoor environment. For the LEED (Leadership in Energy and Environmental Design) certification, the quality of the indoor environmental ranks second behind energy and material considerations.

Much research is being carried out to evaluate the IEQ of residential and office developments. Unfortunately, a greater percentage of the research work is being carried
out in the Western Industrialized economies with Asia following but at a distance. Studies carried out in Africa are relatively very low. Sustainability is now a major consideration in the built environment and guidelines are based on research work carried out in the industrialized economies. Thus, there is a compelling need to evaluate the IEQ of office buildings in Lagos, Nigeria with the objectives of examining its relationship with comfort, satisfaction and productivity.

2 IEQ and Comfort

The functional value of a building, residential or commercial, cannot be truly assessed without considering the impact of the indoor environment on the occupants or users. The indoor environmental quality (IEQ) of a space has been given various definitions thus lending to the complex nature of the state or condition.

The Dictionary of Construction (2016) refers to IEQ as "an important criterion for green, or sustainable, building design (that) refers to (the) general overall building occupant comfort.” The dictionary includes humidity, ventilation/air circulation, acoustics and lighting as parameters of IEQ.

Coyle (2014), writing in Green Building 101 which is a USGBC publication, stresses the impact of IEQ on the health and wellbeing of the occupants. She did not mention comfort though this can be assumed to be inferred. Compared to the listing by the dictionary, she omitted acoustics but included ergonomics.

The NIOSH (National Institute for Occupational Safety and Health, 2015), in line with its core function, relates IEQ to the health and wellbeing of the occupants. The highlighted parameters were limited to lighting, air quality and dampness. The air quality has to do with air-borne contaminants and volatile organic compounds (VOC).

The Sustainable Facility Tool (2016), a resource of the U.S. General Services Administration (GSA), considers the following parameters: air quality, access to daylight and views, acoustics, occupant control over lighting and thermal comfort, work-space layout and sufficient area. They took the IEQ consideration beyond the physiological parameters to encompass the issue of personal control and workspace elements.

The Green Building Council of Australia affirms that IEQ is an important aspect of the overall sustainability of the building. The rating tool of the association identifies the core parameters as temperature, lighting and acoustics and these are believed to affect the occupants’ health, happiness and comfort.

The Whole Building Design Guide notes that the occupants’ wellbeing and productivity are affected by the common physiological factors as well as factors of aesthetics (light and colour, window views) and psychological (sense of enclosure, privacy and control, connection to nature). This view was supported by Ouwehande et al (2014) who listed six components of psychological comfort as self-acceptance, personal growth, purpose in life, positive relationship with others, environmental mastery and autonomy.

Bean (2012) added vibration to the five common physiological factors of indoor air, temperature, lighting, acoustics and odour.

Wargorcki et al. (2006) gave a comprehensive review of the physical factors as indicated in the figure below.
Fig 2 - The indoor Environment (Wargorcki et al., 2006)

The definitions above are not exhaustive but do confirm the complex and extensive nature of the indoor environment.

It is noted that the qualities of comfort, satisfaction and performance are influenced by both physiological and psychological parameters. The study by Frontczak et al (2011) showed that there are variations in the impact of the physiological parameters. As such, the conclusion has been that perceptions of comfort and satisfaction as impacted by IEQ may be dependent on the occupants’ awareness (or knowledge) and culture (Chappells et al, 2004). In an earlier study, Wilhite et al. (1996) had indicated that ‘Western’ standards were becoming predominant in perceptions of comfort. Can this be due to the fact that researches in other regions were not as advanced? Or is it the case of ‘globalization’?

It is important that practitioners in the built environment of Nigeria know or are aware of the perceptions of comfort of the Nigerian – especially whether it aligns with that of the ‘West’ or not. This will have significant impact on what is built and managed. How do workers in the Nigerian workplace perceive the concepts of comfort and satisfaction in relation to the quality of the indoor environment? How do their perceptions compare to the established measurements of their counterparts in the industrialized Western nations?

IEQ features prominently in all the sustainable building accreditation and assessment tools. LEED (Leadership in Energy and Environmental Design – by the U.S. Green Building Council) and BREEAM (Building Research Establishment Environmental Assessment Method – by the U.K. Building Research Establishment) are the two well-known tools in Nigeria. Certification is an assurance that the indoor environment will be comfortable and healthy.
Now both energy use and the IEQ of a space are inevitably linked to the sustainability of the space. A sustainable workplace is one that optimizes and conserves the use of natural resources and which also meets the needs of the people working there (Dwilson, 2014). The dread of climate change has pushed the topic of sustainability to the fore-front of political and professional discussions in the built environment. However, while sustainability has been legislated in most developed countries and by most international organizations, Nigeria still lags behind in this respect. This scenario may not hold for long.

Presently Nigeria does not really have a home-grown sustainability guideline. In Africa, only South Africa is believed to have such guidelines through the Green Building Council of South Africa that was established in 2007. Nigeria is still a potential member of the World GBC. The building industry in Nigeria has had to rely extensively on the international guideline which was principally developed by and for the developed western economies. Examples of such standards and guidelines include those of the American Society of Heating, Refrigeration and Airconditioning Engineers (ASHRAE), Chartered Institute for Building Services Engineers (CIBSE), Royal Institute of British Architects (RIBA), etc.

Green developments are in the forefront of environmental policies in the developed economies but there is still a problem with acceptability in the developing nations. Snushall et al (2005) reported that the “property industry will not sacrifice profit for the environment if it is not forced to do so by the planning bodies or its end users”. As concern increased, sustainability was legislated in the developed countries and it has also been branded. The ‘Green’ brand is now a marketing tool or asset. Companies have adopted green/sustainable policies because of improved reputations, publicity and increased investor concern.


“Comfort standards are social constructs which reflect the beliefs, value, expectations and aspirations of those who construct them.”

In other words, comfort and satisfaction can be impacted by awareness and culture. This may explain the global variance of the relative importance of the physiological factors of IEQ highlighted by Frontczak et al. How do Nigerians perceive comfort?

Most dictionaries define comfort as a state in which one is free of physical pain caused by pain, heat, cold, etc. Adebamowo (2007) defined it as a state of thermal rest devoid of heat or cold stress. It is also freedom from worry. Satisfaction is defined as the fulfillment of a desire, need or expectation. Comfort deals more with the physical but satisfaction is more perceptual in nature. This may explain why occupants’ feelings vary over time even though the physical environmental conditions were similar. In the survey conducted by Gossauer et al (2008) of 16 German offices, 54% of the respondents were satisfied in winter and 30% in summer despite the fact that the temperatures were at 23-24°C for both times. The researchers believed it had to do with a sense of control. Thus, perception and ultimately workplace satisfaction may vary across societies, generations and personalities.

3 IEQ and Satisfaction

The LEED buildings are marketed as being “competitive differentiators and make for happier employees and occupants”. It is in this respect that the linkage between the physiological parameters of indoor environmental qualities (IEQ) – thermal comfort, lighting, acoustic and indoor air quality (IAQ) – and the satisfaction, comfort, wellbeing and performance of the worker is getting more attention. There are many studies to support this school of thought
e.g. Seppanen et al. (1999), Heschong (1999), Milton et al. (2000) and Fisk (2002). But just as controversy has trailed the debate on the claims of the apocalyptic consequences of climate change, so is the linkage between IEQ, comfort, worker wellbeing and satisfaction generating its own controversy.

Kumar et al (2002) wrote on behalf of the IEQ linkage proponents:

“Research into the indoor environmental quality (IEQ) and its effects on health, comfort and performance of occupants is becoming increasingly essential. Facility managers are interested in IEQ’s close relationship to energy use. Employers hope to enhance employee comfort and productivity, reduce absenteeism and health-care costs, and reduce risk of litigation. The rising interest in the field has placed additional pressure on the research community for global guidelines on creating a safe, healthy and comfortable indoor environment”.

On the other side of the divide, there is no consensus on the relative importance of the IEQ parameters to occupants’ satisfaction. In their literature survey of different studies on IEQ, Frontczak et al (2011) highlighted the differences in the degree of influence of the physiological factors – see figure 3.

In their analysis of the survey database of the CBE (Centre for the Built Environment) of the University of California, Berkeley, Kim et al (2012) concluded that IEQ factors have both positive and negative impacts on the occupant overall workspace space satisfaction (Fig 4).
Leaman et al (2007) concluded that that there are numerous confounding factors that can impact and distort the relationship between IEQ and satisfaction. Bhyssen et al (2011) confirmed Humphrey’s (2005) finding that overall satisfaction does not depend on individual IEQ physiological factors but on a collective whole. The question of which is the predominant factor is yet to be answered.

4 IEQ and Productivity

“It should be noted that good IEQ is a necessary, but not sufficient pre-requisite for enhanced productivity, since other factors, specific to individual contexts, and not directly related to IEQ, can also have a significant impact.” (Paevere, 2008)

Linn et al (2011) noted that for the measurement of the worker’s productivity to be comprehensive, the following factors needed to be considered:

1. Personal factors (e.g. motivation, satisfaction)
2. Organizational factors (e.g. quality of management, payment/salary and reward system).
3. Social factors (e.g. relationship with others)
4. Indoor physical environmental factors (e.g. accessories, work environment).

They confirmed that the study of the performance of the office worker or office productivity is a complex topic and that to measure productivity in a quantitative way was difficult. Thus subjective productivity measures was generally acceptable

In essence, the qualities of comfort, satisfaction and performance go beyond the physiological factors. Linn et al (2013) further noted:

Businesses are becoming aware of the financial implications of occupying poor performing buildings in regards to energy, water and waste but their understanding of improvement process is still developing. ... Optimizing employee productivity is a complex science. It needs to be considered more broadly taking into account the organizational and management context, an individual employee’s job satisfaction and the social work environment. .... There is no doubt that future research will need to expand its analysis from purely physical
parameters to a more holistic assessment. This more comprehensive analysis should also address technology enablers, such as IT, communication equipment, connectivity and cloud computing.

5 Methodology
The study consists of a survey of 10 offices on the Island and Mainland of Lagos. The offices were selected randomly. As expected, some offices declined permission on grounds of security and distraction of workers. No public building is included in the survey because of the bureaucratic delay in securing government approval.

There were 3 parts to the survey:

1. Physical measurement of the indoor environment parameters of temperature (dry bulb), relative humidity (RH), lighting lux level and the sound level for the work spaces. All measurements were taken by meters from PCE Instruments UK Ltd

2. A quantitative survey using questionnaires sent online to the workers in the 10 offices. The target was to get at least 5 completed questionnaires from each office. There were better returns in a number of offices. One did not respond at all. One limitation is that the questionnaires were not returned on the same day as when the physical measurements were taken.

3. A quantitative survey in which at least 3 employees would be questioned about their workspace and the issues of IEQ. The survey also included presenting 9 different office layouts and asking for the preferences of the workers. Pictures were used so as to standardize the survey.

The CBE IEQ instrument has the highest usage internationally (Peretti et al, 2011) and it was adopted for the quantitative study. This decision was also to justify the validity and reliability of the study. The instrument covers the IEQ parameters of office layout and furnishing, thermal comfort, air quality, lighting, acoustic, cleanliness and maintenance. It uses a 7-point Likert scale that measures the satisfaction of the workers for the aspects of the parameters as well as the overall satisfaction for the space. There were also questions of how the parameters enhance or interfere with getting the job done.

Another set of questions was added to measure the relative importance of the factors that impact productivity. This was based on the studies by Onyeizu et al (2013) who had identified the five factors as:-

1. Personal factors (e.g. motivation, satisfaction).
2. Organizational factors (e.g. quality of management, payment/salary and reward system).
3. Social factors (e.g. relationship with others).
4. Indoor physical environmental factors (e.g. accessories, work environment).
5. Convenience.

The results were then compared. Onyeizu et al covered offices in green buildings in Auckland, New Zealand. How will workers in Lagos, Nigeria compare?

The quantitative survey had a set of questions to gauge satisfaction with the work environment and to compare the measured parameters with acceptable building standards. Since satisfaction with the aesthetics was a measure of psychological satisfaction, the workers were to pick from the nine pictures what their ideal workplace would look like. The pictures are pasted below.
Fig 5 - Workspace Sample A

Fig 6 - Workspace Sample B

Fig 7 - Workspace Sample C
http://www.genlight.com.sg/products_main_clip_image002_0001.jpg
Fig 8 - Workspace Sample D

Fig 9 - Workspace Sample E

Fig 10 - Workspace Sample F
http://www.heston-wto.com/imageRepository/175c1716-a66b-4a00-a0c7-8b45c673aadb.jpg
6 Results and discussion
A brief description of the 10 offices is presented in the table below

<table>
<thead>
<tr>
<th>Office reference</th>
<th>Type of business</th>
<th>Description</th>
<th>Questionnaires returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Architecture</td>
<td>Converted residential apartment. The large former living room serves as the main studio. Airconditioning is by mini-split units.</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Architecture</td>
<td>Floor of purpose built office with central airconditioning</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Pension Fund Management</td>
<td>Purpose built office with DX cassette units</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Architecture</td>
<td>Converted residential building but remodeled as office. The attic is also used as studio. Airconditioning is by mini-split units.</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Fund Management</td>
<td>Purpose built office with mini-split airconditioners</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Financial Market</td>
<td>Floor of purpose built office with central airconditioning</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Architecture</td>
<td>Floor of purpose built office with mini-split units</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Architecture</td>
<td>Floor of purpose built office with central airconditioning</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>Engineering - MEP</td>
<td>Floors of purpose built office with central airconditioning</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>Engineering - Structures</td>
<td>Converted residential building. Airconditioning is by mini-split units.</td>
<td>6</td>
</tr>
</tbody>
</table>

Of the 75 questionnaires returned, 3 were invalidated and removed from the data analysis.
The survey was restricted to the main open office or the smaller rooms as in the cases of the converted residential buildings – offices 1 and 9.

<table>
<thead>
<tr>
<th>IEQ FACTORS</th>
<th>OFFICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Codes</td>
<td>1</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>24 ± 2</td>
</tr>
<tr>
<td>RH (%)</td>
<td>50-60</td>
</tr>
<tr>
<td>Sound Pressure (dBA)</td>
<td>35-45</td>
</tr>
<tr>
<td>Light level (Lux)</td>
<td>300-500</td>
</tr>
<tr>
<td>Occupancy rate</td>
<td>10</td>
</tr>
</tbody>
</table>
From the table, only 30% of the spaces meet the temperature comfort range. The workers in the spaces with central airconditioning cannot adjust the temperatures and usually put on their jackets when they feel cold.

30% of the spaces are outside the humidity range.

No space meets the acoustic requirement. The reason for this may be that most of the offices are located on busy roads. The windows are all single glazing except for office 6. The internally generated noise is also appreciable.

For the light levels, the higher figures are for spaces near the windows. There is no daylight saving switches to take advantage of the high illuminations near windows but very few of the workers switch off the lights. Also most of the offices have the window blinds closed either because of glare or to avoid distraction from the street scenes. The views were generally not interesting except for offices 2, 6, 7 and 8. There was no consequence with the low lux levels as most of the workers were using computers and they could adjust the monitors as desired. The non-uniformity of the lighting was not noticed by the workers. It is assumed that they had adapted.

The occupancy rates fall short of the optimal of 10m²/person and only two offices meet the minimum 8m²/person.

Very few of the offices made any attempt at energy conservation. Those who occupied offices in large buildings confirmed that they paid fixed charges for infrastructure. Whether they use the energy or not they pay. Therefore there is no incentive to conserve energy.

The workers that were interviewed were asked to assess the indoor environment as it impacted performance. The response is given in the table below.

<table>
<thead>
<tr>
<th>OFFICES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does your daily work performance in the workspace environment feel like?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very dissatisfaction</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Satisfying</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Satisfying</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Generally the feeling was satisfactory except for office 3 where the workers complained of the congestion and lack of privacy. Office 6 had a very satisfying assessment. When the workers were questioned, they mentioned the relational factor amongst the workers as being the major contributory factor. There was no consensus for office 8.

The workers were asked to choose an office layout that conformed to their dream or expectations. Workspace design sample D had the highest score followed by workspace sample E. Workers in office 6 did not see any that was better than what they have.
Table 4—Workers preferred workspace design.

<table>
<thead>
<tr>
<th>OFFICES</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please tell us about your dream working environment and your desires in terms of space, furniture, ambience, layout and lighting (Respondents’ preferred workspace sample)</td>
<td>D</td>
<td>E, A, G</td>
<td>D, E</td>
<td>B, E, F</td>
<td>D, E</td>
<td>none</td>
<td>D, E</td>
<td>D, E</td>
<td>F</td>
<td>D, E</td>
</tr>
</tbody>
</table>

For the quantitative study, 74% of the 72 respondents that had their questionnaires analysed were professionals – Engineers, Architects, Accountants, Lawyers, etc. 48% of them were under 30 years of age. Of the lot, 43% worked in offices with closed window blinds with 24% actually confirming that the outside view was not interesting.

Respondents were asked to score the 35 parameters of the five factors that influenced productivity (Onyeizu et al, 2013). The parameters are:

1. **IEQ factors**: Daylight, Glare, Too hot/too cold, Artificial lighting, Too noisy/too quiet, View, Air quality

2. **Social factors**: Relationship at work, Relationship outside work, Distraction/disturbance

3. **Personal factors**: Injury, Loss of sleep, Life experiences, Other financial stress, Medication effects, Health/wellbeing, Transport to Work, Relationship outside work, Relationship at work, Distraction/disturbance.

4. **Organizational factors**: Job security, Access to health care, Workload, Refreshments at work and Poor management.

5. **Convenience factors**: Overcrowding, Inadequate equipment, Uncomfortable furniture, Position relative to equipment, Cleanliness, Office décor, Personal storage, Privacy, Positive relative to colleagues, Poor Equipment and Furniture arrangement.

The respondents were asked to measure the impact using a scale of ‘indifferent’, ‘slightly important’ and ‘very important’. The responses were weighted from 0 to 2. Fig 4 above shows that the parameter of health/wellbeing was the most important. Air quality was the highest IEQ factor and ranked 7th. Outside view, another IEQ factor, was ranked the lowest. The result was compared to that of Onyeizu et al.
Fig 14 – Importance of factors that impact the perceived productivity of the Lagos office worker

The comparison gives valuable insight. What is important in Auckland is not necessarily so in Lagos. Health/wellbeing is critical for the Lagos worker but it came in at 33rd in the Auckland ranking. Poor equipment was the highest in Auckland but came in 32nd in Lagos. Effect of medication was lowest for Auckland but the lowest for Lagos was outside view.
Some of the differences can be explained by knowledge of the local environment. Injury was 33rd for Lagos but only 10th for Auckland. In Nigeria, the public healthcare system is not commendable and the private ones are expensive. Also there is no disability allowance for the workers. Thus the risk of injury is taken seriously.

The IEQ parameter of temperature (too hot/too cold) was ranked 29th for Auckland and 13th for Lagos. Airconditioning is a common feature of most offices in Lagos. The external environment is dusty, warm and humid and the use of airconditioners is mandatory for comfort in most offices. It is assumed that it will be present and no longer features as a variable.

The parameters were grouped into their respective factors and the weighted averages were compared.

A comparison of the means shows that the IEQ factors were the least important while organizational factors were the most important factors of productivity for the Lagos worker. However the Anova test of the means did not return a significant difference at 95% level of confidence. The P-value was 0.601 and $F_{\text{critical}}$ was greater than $F$.

Onyiezu et al (2013) had concluded that:

“The concern of this paper is whether or not the method by which worker productivity in ‘green’ certified buildings is measured is sufficient to prove that green accreditation increases productivity. These claims are based on results that appear to be extremely precise and can measure the percentage increase in productivity to two decimal places. This paper has shown that when compared with other factors, IEQ is of less significance to productivity”.

The Lagos study has the same conclusion.
The analysis of the CBE instrument indicates that 81% of the respondents reported that they are satisfied with the indoor environment. A lower number of 72% believes that the quality of the indoor environment positively influences their productivity. Thus even though the IEQ factors were not the most important, they still contributed to the productivity of the worker.

Table 5 – Workers satisfaction with the indoor environment.

<table>
<thead>
<tr>
<th>All things considered, how satisfied are you with your workspace as relates to the environmental parameters (- thermal, lighting, acoustics, air quality)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very much interferes</td>
<td>0.00</td>
</tr>
<tr>
<td>Moderately interferes</td>
<td>0.00</td>
</tr>
<tr>
<td>Slightly interferes</td>
<td>5.79</td>
</tr>
<tr>
<td>Neutral</td>
<td>3.86</td>
</tr>
<tr>
<td>Slightly enhances</td>
<td>17.36</td>
</tr>
<tr>
<td>Moderately enhances</td>
<td>25.08</td>
</tr>
<tr>
<td>Very much enhances</td>
<td>55.94</td>
</tr>
</tbody>
</table>

Table 6 – Impact of IEQ parameters on productivity.

<table>
<thead>
<tr>
<th>Overall, how is your productivity enhanced of interfered by the environmental parameters (- thermal, lighting, acoustics, air quality)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very much interferes</td>
<td>1.39</td>
</tr>
<tr>
<td>Moderately interferes</td>
<td>4.17</td>
</tr>
<tr>
<td>Slightly interferes</td>
<td>5.56</td>
</tr>
<tr>
<td>Neutral</td>
<td>16.67</td>
</tr>
<tr>
<td>Slightly enhances</td>
<td>15.28</td>
</tr>
<tr>
<td>Moderately enhances</td>
<td>33.33</td>
</tr>
<tr>
<td>Very much enhances</td>
<td>23.61</td>
</tr>
</tbody>
</table>

The respondents were asked to measure how the different factors affected their ability to get there job done. A comparison of the weighted means is given in fig 17.

The Anova test was carried out on the difference between the means. The P-value was 0.006 and F_{critical} was less (though close) than F. This indicates that there was a significant difference between the means. Some parameters were more influential than the others. Lighting affected productivity more than any other factor followed by office layout. Quite a number of the participants in the qualitative survey indicated their desire for spacious workspaces. Overcrowding was ranked 17\textsuperscript{th} in the importance of parameters.

The data was tested to confirm if there was a regression in the parameters. The R-square was 0.534. However, the P-values for 4 of the 7 factors were too high (>0.05). A regression could not be established.
Conclusions

More than 60% of the offices that were surveyed did not meet the international standards for the indoor environmental parameters of temperature, humidity, acoustics and lighting. Yet, the subjects indicated satisfaction of their workspaces. This implies that comfort studies would need to be conducted for Lagos and that the international standards should only be a guide.

The study also showed that there is a variation in the relative importance of the IEQ parameters that impact productivity. This supports the view of Chappells et al (2005) that comfort and satisfaction have social and cultural connotations. One cap does not fit all.

For the Lagos worker, there is no significant difference in the impact of the five factors – IEQ, social, personal, organizational and convenience – even though IEQ was shown to be the least important. This finding corroborates that of Onyiezu et al (2013) in their study of green offices in Auckland, New Zealand.

We all still have a collective ecological responsibility and the goal of the architects and engineers in the built environment is achieving optimal comfort for the occupants while not forgetting their health and wellbeing.

References


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