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Sustainable Campus: Indoor Environmental Quality (IEQ) Performance Measurement for Malaysian Public Universities

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Abstract
Indoor Environmental Quality (IEQ) for academic buildings is one of the key characteristics of a sustainable campus. The low conditions of IEQ performance can contribute to the sick building syndrome and cause discomfort to the building users. Furthermore, good performance of IEQ can contribute to a comfort and conducive learning and working environment. The purpose of this paper is to discuss on the IEQ performance measurement of academic buildings for public universities in Malaysia. This research involved scientific measurement of academic buildings for public universities in Malaysia. The performance measurement focuses on the six key elements of IEQ; thermal comfort, humidity, noise comfort, air movement, lighting and thickness of CO2. The results were compared to the Malaysian Standard (MS 1525:2007) and UNESCO guideline. The findings showed that most universities are in the standard set, while some universities under the standards set and still in need of improvement. This study is useful for facilities managers in public universities in order to improve the IEQ on academic buildings in achieving sustainable campus.

*Keywords***:** Sustainable development, Sustainable environment, Sustainable campus, Indoor Environmental Quality, Malaysian public universities.

1. Introduction

Indoor Environmental Quality (IEQ) is one of the main criteria in a sustainable campus environment. IEQ becomes an important component in the assessment criteria of academic buildings at Higher learning institutions. The evaluation criteria for the measurement of eco-friendly building are Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning & Management, Materials & Resources, Water Efficiency and Innovation (Wan Yusoff & Wong Ru Wen (2014); GBI organization, 2010).

The concept of sustainability in the construction, development and management should be a priority to create a sustainable environment in creating harmonious atmosphere in the HEI campus. In addition, the sustainability of which is the construction and management of buildings that feature green building. The concept of green building was first articulated in the early 1940s in a conference setting up by the United Nations Environment Program aimed at reducing global warming which was then ignited by the Industrial Revolution in Europe.

In Malaysia, the concept of green building is still new and still growing at an early stage,

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especially in higher education institutions. However, with the establishment of a mechanism called the Green Building Index (GBI) that an organization be evaluators, consultants and advisors in creating environmentally friendly buildings in Malaysia, bringing the concept of sustainability has been the main focus of the government. In GBI components, Indoor Environmental Quality (IEQ) represents 21% for nonresidential building assessment such as academic buildings (GBI Organization, 2010). This means that the academic buildings need to be taken into account in the assessment of IEQ because apart from the building became the focus of the public, it also as an institution that educated generation and the succession to the leadership quality, it must begin from quality classrooms.

Awareness of creating a conducive environment is growing concurrently with researches that have been done. A good environment not only provides comfort, but also have a great impact on the quality of health, productivity, psychology and occupational performance in a building. In reality, IEQ rarely given priority in most development planning and management, However, research shows that, over 80% of human life, spent in the building, whether at work, school, recreational places and mostly in their homes.

In fact, according to a study by Yuan Hui (2005), there are certain number of people in the United States who spend time in the building for 23 hours and 15 minutes, or 97.7% of his life. However, only a small amount of knowledge and understanding about the importance of creating a healthy indoor environment for building were occupied

To ensure that the environment in the building is in good condition it is necessary that the occupants feel more comfortable and secure (Zainal, 2011). Unhealthy buildings, certainly affects the health of the residents. Building-Related Illness exists and can be identified through clinical studies (Ghodish, 1995). IEQ imbalance is to contribute to a Sick Building Syndrome, i.e., the building is cannot be able to function well in terms of ventilation, relative humidity, lighting, etc. (EPA, 1991)

This affects the quality of health of staff and students, the economic life of the building, and also the equipment for the purpose of teaching and learning as described by Al-Sagoff, (1985) which states that unfavorable IEQ threaten the quality of teaching and learning activities. Student's achievement and teacher performance are often linked to environmental conditions and infrastructure available in a particular institution.

2. Issues

Most existing studies focused on single aspects of the environment. For example, previous research focused on the study of single aspect such as lighting, acoustics, thermal comfort and air quality. According to Ardeshir (2005), many studies linking environmental factors in qualitative approach and quite general. While some studies are done so scientifically that raises questions about the appropriateness of the study.

The scientific research on IEQ in HEI has not been widely discussed in the country. And IEQ is rarely considered as a priority in most development planning and management (Sulaiman, MA et al., (2013a). Conducted studies of IEQ in HEIs in Malaysia are considered new and this is in line with the Strategic Plan for Development of Higher Education (PSPTN) towards the quality of teaching and learning activities at creating facilities in IEQ which provide comfort to the user and create conducive atmosphere. This is stated in the fifth PSPTN that improve the quality of teaching and learning by providing adequate and a well-functioning infrastructure. Although the responsibility to realize the importance of IEQ in academic buildings, especially on performance and quality in teaching and learning activities as a core activity of the institution.

Therefore, the study of the IEQ in academic building is crucial with the aim to know at what extent of IEQ in the campus university in Malaysia meeting the standards sets towards achieving sustainable campus.

3. Sustainable Development

The concept of sustainable development is a development model with an effort to proactively addressing the imbalances between developing and maintaining the nature. However, this concept is still not fully understood by the public, despite it was introduced since 20 years ago at the Earth Summit in Rio de Janeiro, Brazil. Various definitions have been given by various parties in differing perspectives and expertise (McManus, 1996). However, most definitions of sustainable development is to follow what is contained in the report of the World Commission on Environment and Development (WCED), which gives sustainable development as "a development activities implemented without harmed the need of future generations". The need is referring to the educational, economic, industrial and construction (Gedeon, 2005).

The definition of sustainable development encompasses three main ideas that mutually depend on each other, namely environmental, economic and social. Barbier (1987) has developed three ideas in the form of a circle to show the interdependence of each other. Figure 1 shows the main idea of sustainable development. It clearly shows that a sustainable development must be balanced according to the order of this idea.

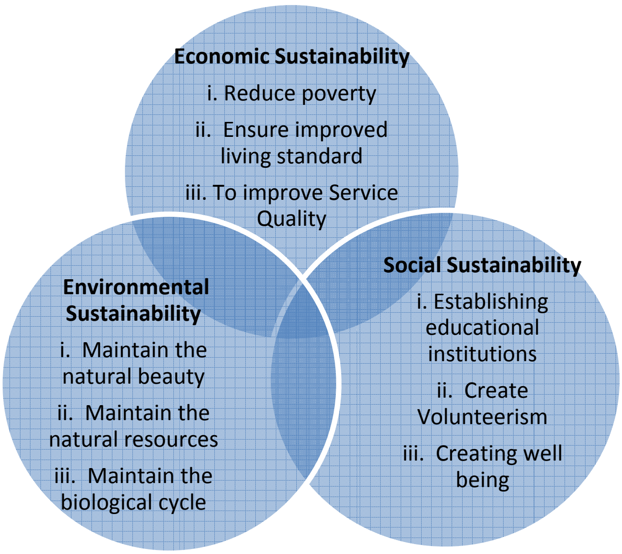

Figure 1: *Sustainable Development Concept (Barbier, 1987)*

Indoor Environmental Quality refers to the overall convenience of the building and facilities and the occupant's health. Many factors can contribute to poor indoor environment such as air pollution, thermal comfort, humidity, sound, light, odor, energy use, design, natural ventilation, indoor air quality (IAQ) and the presence of quantities of organic (VOC) in a building (EPA, 2009).

In recent years, public concern about IEQ rises. Therefore, building designs which bring the sustainable and environmental friendly features has increasingly been given attention to ensure the building's IEQ is guaranteed. The internal environment of a building is a key factor in the public health because of the enormous time they spent in the building.

National Occupational Health and Safety (NIOSH) has explained the IEQ as an issue that often occurs in buildings across the country. NIOSH also found that IEQ covers not only air pollution, but there are other factors such as comfort, noise, lighting, ergonomic stress and pressure of the workers involved. The study conducted has shown that the indoor environment pollution caused by the building itself or from outside the building.

IEQ will affect the health of the residents, health, comfort and productivity (Sulaiman MA et al , 2013b; Peretti, 2010). IEQ levels can be assessed by measuring the physical parameters of the building and to conduct surveys to the residents of the building. IEQ is also an important element for the continuation of every building or office. The quality of the working environment is created in the building directly related to occupational health and quality of life. Fisk (2000) pointed out that a building IEQ unhealthy level will affect and reduce the performance and productivity of the occupants in the building.
This happens especially for people who spend most of their lives in the indoor environment. Balancing a healthy indoor environment and comfort in buildings actually requires the integration of various components. According to Edwin et al, (2008), the components are taken into consideration in order to create a healthy indoor environment are as follows:

i) Indoor air quality refers to the level of freshness, health, comfort, and the quantity of chemicals or the effects of toxic substances in the air.
ii) Ventilation either natural ventilation or mechanical aeration process.
iii) Thermal Comfort covers several aspects of the internal temperature, air speed and relative humidity.

Noise in connection with unwanted noise from either external or that could interfere with human or animal.

4. **Methodology**

The methodology used in this study is a scientific measurement. Scientific measurement was used to get a true picture of the level of academic buildings at public IEQ. A total of 20 universities (Table 1) involved in research with a sample size of 500 respondents, 25 samples for each university.

Table 1: Population of Consumers academic buildings, according to each university

No	University	Location	Number of Students & Academic Staff
1.	Universiti Malaya (UM)	Bangsar, Kuala Lumpur	Student: 26,341 Academic Staff: 2,106
2.	Universiti Pertahanan Nasional Malaysia (UPNM)	Sungai Besi, Kuala Lumpur	Student: 2,533 Academic Staff: 249
3.	Universiti Putra Malaysia (UPM)	Serdang, Selangor	Student: 31,180 Academic Staff: 1,594
4.	Universiti Kebangsaan Malaysia (UKM)	Bangi, Selangor	Student: 24,993 Academic Staff: 2,237
5.	Universiti Islam Antarabangsa Malaysia (UIAM)	Gombak, Selangor	Student: 29,802 Academic Staff: 1,908
6.	Universiti Teknologi Mara (UiTM)	Shah Alam, Selangor	Student: 185,022 Academic Staff: 8,516
7.	Universiti Pendidikan Sultan Idris (UPSI)	Tanjung Malim, Perak	Pelajar: 22,214 Academic Staff: 799
8.	Universiti Sains Malaysia (USM)	Gelugor, Pulau Pinang	Student: 28,277 Academic Staff: 1,895
9.	Universiti Utara Malaysia (UUM)	Sintok, Kedah	Pelajar: 31,617 Academic Staff: 1,337
10.	Universiti Malaysia Perlis (UniMAP)	Arau, Perlis	Student: 7,438 Academic Staff: 728
11.	Universiti Malaysia Kelantan (UMK)	Pengkalan Chepa, Kelantan	Student: 2,770 Academic Staff: 236
12.	Universiti Malaysia Terengganu (UMT)	Gong Badak, Terengganu	Pelajar: 7,263 Academic Staff: 574
13.	Universiti Sultan Zainal Abidin (UniSZA)	Gong Badak, Terengganu	Student: 6,311 Academic Staff: 388
14.	Universiti Malaysia Pahang (UMP)	Gambang, Pahang	Pelajar: 8,003 Academic Staff: 567
15.	Universiti Teknologi Malaysia (UTM)	Skudai, Johor	Pelajar: 34,618 Academic Staff: 2,100
16.	Universiti Tun Hussien Onn Malaysia (UTHM)	Batu Pahat, Johor	Student: 12,534 Academic Staff: 1,017
17.	Universiti Teknikal Malaysia Melaka (UTeM)	Air Keroh, Melaka	Pelajar: 9,006 Academic Staff: 763
18.	Universiti Sains Islam Malaysia (USIM)	Nilai, Negeri Sembilan	: Student 9,390 Academic Staff: 545
19.	Universiti Malaysia Sarawak (UNIMAS)	Kota Samarahan, Sarawak	Student: 10,927 Academic Staff: 763
20.	Universiti Malaysia Sabah (UMS)	Kota Kinabalu, Sabah	Student: 18,017 Academic Staff: 886

Source: Ministry of Higher Education, 2013

The total population in the academic building at the Malaysia University's is 538,508. Of that 508,256 students and 30,252 are lecturers (Ministry of Higher Education Malaysia, 2013).

The data obtained in this study were collected from July to December 2012.

Scientific Measurement Method

Three (3) processes are used to obtain the quality data which eventually will be used as the evidence in order to strengthening the arguments and insights pertaining to the study initial investigation, the reference image and the scientific tests.

Preliminary Investigation

Early inspection is done to get an overall idea of building complex designs in each university academic. In this case, the whole building indoor environment can be identified and beneficial when making a detailed examination later. It is important to ensure that no factors of unforeseen circumstances in the measurement process, such as a building imperfection. In the event, it cannot be used as a sample for the measurement performed.

Picture Reference

Pictorial references refer to the relevant plans such as electrical and mechanical systems plan, and the structure of the building. This is to provide an understanding of the technical procedures such as ventilation, lighting or anything else element will be studied Advanced. Such preliminary information is important to provide a better understanding of the building layout.

Scientific testing

This test is performed using specialized equipment to test the IEQ elements. The equipment used is in the form of mobile. According to Health Canada (1995), brief measurement can be done by someone who is not an expert for the purpose of viewing the situation. All data collected will be recorded and analyzed. Figure 2 to Figure 6 shows the equipment used in the process of scientific tests.

EQUPMENT	FUNCTION
Figure 2 : CO_2 meter 	This tool (Figure 2) is used to measure the presence of CO_2 in the atmosphere in units of ppm. The level of sensitivity is 1. The gadget is very light and easy to carry around anywhere and this simplifies the process of measuring CO_2 in the air. This tool is quite easy to handle due to its size and weight are portable in nature. In the measurement process, the tool is placed at the midpoint in each of the classes for 2 minutes to get a reading.
Figure: 3 Flow meter 	Figure 3 shows the measurement of air movement device, Flow meters. This tool is used to measure the velocity of the air flow cycle in m/s. The level of sensitivity of the device used is 0.1. This tool is on static display at the optimum surface at 0.8 meter from the floor of the classroom.

 Figure 4: Lux light meter	Figure 4 shows the light intensity measurement device Lux Light Meter. Use of this equipment is to measure the intensity of light and is measured in Lux. The level of sensitivity of this device is 1. A pocket sized portable to go anywhere but somewhat sensitive. This tool takes less than 5 seconds to get a reading level of lighting. Readings taken the optimum surface of the table or the size of 0.8 meter from the floor.
 Figure 5: Digital Thermo-Hygrometer / Hydrometer	Figure 5 shows the tool Digital Thermo-hygrometer. Use tools is to measure the temperature in units ° C and humidity in the unit %. The level of sensitivity to temperature is 1 and for moisture sensitivity level is 1. The gadget is small in size and easy to carry around everywhere. To get the temperature and relative humidity readings, these tools let the lecture hall during the process of learning takes place and the weather is sunny and good until the red indicator light turns yellow.
 Figure 6: Acoustic noise meter	Figure 6: shows the sound intensity measurement tools Acoustic noise meter. Its purpose is to measure the sound intensity level in dB. The level of sensitivity of this device is 0.1. This tool is small and easy to carry and use for process measurements. The level of sensitivity of this device is proportional to the rate of the noise level in a room. For this study, the device was set to record the average sound intensity readings within 30 seconds for each time a reading is taken.

Measurement **P**rocess

For the measurement of IEQ in an academic building, the scientific measurement data collection was used. The scientific measurements performed in the study by measuring parameters such as temperature (° C), relative humidity (percent), air velocity (m/s), the level of CO2 concentration (ppm), the level of illumination (Lux) and the rate of sound intensity (dB). Five classrooms selected for each university and the measurement is done in two days. Readings are taken three times in each classroom to get the average daily reading. The first reading is taken between 8:00 am to 10:00 am, the second reading between the 12:00 pm to 1:00 pm and the third reading between the 3:00 pm to 5:00 pm. Measurements taken at the optimal time when students are in the academic buildings and by reference and adoption of ASHRAE.

5. The Quality Of The Internal Environment (Ieq) In Academic Buildings In Malaysia

Findings

The measurement of Indoor Environmental Quality (IEQ) was performed in 20 universities across Malaysia. For each university, five samples of classrooms were

selected randomly. The measurements were made during the learning and teaching process in progress was aimed at getting accurate reading and better result. Five classrooms were selected for each university and the measurement is done within two days. A number of three times reading was performed in each lecture room to get an average daily reading. The first reading is taken between 8:00 am to 10:00 am, the second reading between 12:00 pm to 1:00 pm and the third reading between 3:00 pm to 5:00 pm. The measurements taken at the optimal time where students having activities in academic buildings and the measurement procedures also referred to ASHRAE.
The measurements performed using the following tools:
Temperature and relative humidity: Digital Thermo Hygrometer
The intensity of sound: Acoustic noise meter
The intensity of light: Lux light Meter
Air movement: Flow Meter
The concentration of CO2: CO2 Meter
Table 2 shows the standard benchmarks and standards set on the elements of IEQ in academics buildings.

Table 2: The benchmark IEQ measurement elements of academic buildings

IEQ **M**easurement Elements	**Reading Standard Set**
Temperature	23 – 26 °C
Relative humidity	55 - 70 %
Sound	50 - 70 dB
Light	300 - 500 Lux
Air Movement	0.15 - 0.50 m/s
The concentration of CO_2	Below 1000 ppm

(Source: MS 1525:2007 and UNESCO)

6. Result And Discussion

The outcome measurement of IEQ elements in academic buildings in public HEI is summarized in Table 3. These results are based on the average of five readings measurement of academic buildings.
Figure 7 shows the average reading of the internal temperature in the university 's academic buildings . The result shows that only three universities that have set the temperature at a level of 23-26 ° C. Three universities were UniSZA with an average of 25 ° C, UTHM 23 ° C, and UNIMAS with an average of 24 ° C. Other universities are below standard. No one who reads the above university standards. The average university shows average reading between 20-22 ° C. What can be concluded from the results of these measurements is that the geographical factors of universities do not directly affect the internal temperature.
Through the observation in this study, the external temperature does not have a significant impact to the interior temperature. This is supported by the evidence of the outside temperature reading that recorded at 27-31 ºC. This is because all classrooms used a mechanical ventilation system through the HVAC equipment. In addition, the HVAC equipment system used is not environmentally friendly and not energy efficient.

Table 3: Summary of measurement results IEQ in public in Malaysia

No	University	Temperature (°C)	Relative humidity (%)	Sound Intensity (dB)	Lighting (Lux)	Air Movement (m/s)	Thickness of Carbon dioksside CO_2 ppm)
Standard Set		23-26	55-70	50-70	300-500	0.15-0.5	< 1000
1.	UM	21	67	66.2	298	0.1	467
2.	UPNM	22	65	71.6	320	0.1	455
3.	UPM	21	65	71.9	268	0.2	471
4.	UKM	21	71	74.0	323	0.2	466
5.	UIAM	21	66	75.0	285	0.2	482
6.	UiTM	20	65	75.1	337	0.2	477
7.	UPSI	21	70	71.7	272	0.1	506
8.	USM	21	65	66.7	294	0.2	492
9.	UUM	22	71	71.3	320	0.2	505
10	UniMAP	21	67	74.5	303	0.2	470
11	UMK	22	68	79.4	319	0.1	482
12	UMT	20	65	72.5	326	0.2	548
13	UniSZA	25	82	76.1	237	0.1	586
14	UMP	22	73	75.4	337	0.1	696
15	UTM	22	65	72.4	281	0.1	465
16	UTHM	23	74	76.1	264	0.2	476
17	UTeM	21	71	77.4	288	0.2	467
18	USIM	21	69	72.4	307	0.2	469
19	UNIMAS	24	77	78.2	278	0.1	458
20	UMS	22	57	79.3	228	0.1	383

: Readings exceeding the standards set
: Readings below the standards set
: Readings within the standards set

Internal Temperature

This not only can cause discomfort to the occupants for the temperature being too cold, but it is also a waste of energy. However, the number of users in the classroom indirectly influences the internal temperature. For example, too many users capacities can cause the internal temperature to rise. This is because the human body releases heat and thereby affecting the temperature in the lecture room. Therefore, optimal use of space without exceeding the capacity should be given due attention by the management of the property and facilities in public universities.

Figure 8 shows (see appendix) the average measurement of the internal relative humidity in academic buildings. The result shows that there are seven universities which show a reading exceeds the standard set which is 55-70 %. Seven universities were UniSZA; readings averaged at 82 % , UMP 73 % and UKM , UUM and UMP respectively at 71 % , and UTHM with 74 %, UNIMAS with a reading of 77% . Other universities show a reading at a standard set. In overall, there is no university that indicates the moisture reading in a building that is too dry that can cause a negative effect. Based on this figure, the relative humidity has a direct correlation with the internal temperature of the building. Temperature and relative humidity readings in UniSZA, UMP and UNIMAS show at a high level.

Such a situation is not good in providing comfort to the occupants and the building structure. The effect to occupants is a sticky sweat and this will decrease students' focus on teaching and learning activities. This has been supported by Balaras (2007) in the previous studies which states that things like this happen because of the increase of water content in the air. The impact on the building structure and the material will make it easy to breed microbiology in damp conditions that will subsequently damage the building structures. This also can shorten the lifespan of a building structure (Kamaruzaman J. et al .,2009). In addition, the high humidity can also affect the color of paint on the building texture and will cause mold. The electronic equipments for R & D activities such as audio systems, transmission equipment screen (OHP) and other related equipments in laboratories are very sensitive to humidity and shall be affected when the indoor humidity is prolonged. This will directly increase the cost of maintenance and hinder the quality of activities in the academic building.

Interior Lighting

Figure 9 (see appendix) shows the average reading for interior lighting in the university's academic buildings. The result shows that, of 20 universities, there are only 9 universities which show a reading within the standards of 300-500 Lux. The universities are, UMP (337 Lux), UKM (323 Lux), UPNM (320 Lux), UiTM (337 Lux), UUM (320 Lux), UniMAP (303 Lux), UMK (319 Lux), UMT (326 Lux), and USIM (307 Lux). The Other universities showed readings below a standard set, however, no university shows excess in the level of the standard sets.

Based on the researchers' observations, there are several factors that can cause the rate fall below the level of prescribed slighting standards. Among them are bulbs that did not work and no maintenance that has been done despite it has been going on for quite some time. From the feedback of the interviews, this has went on for almost a month, even though reports have been made to the management of assets and facilities, but no action taken. In addition, there are bulbs not working properly. This is likely due to the life span of the bulb that is out of date but still in use.

The building orientations that are difficult to justify the light passes position also give the impression of a low lighting situation. Most happened to the old academic building that fostered more than 30 years. This may give an impact to the residents with problems such as limited vision, eye pain that may cause to lost in focus when the teaching and learning in progress. This case needs to be given deep concern as it will decrease the students academic productivity. This is supported by Lewy et al. (1982), which states adequate lighting, capable of improving productivity, qualities, user spirit, and energy saving. In the context of the academic buildings as well, Hakim et al. (2006), describes that, lighting system is an important factor in the provision of facilities for the learning space.

Sound Intensity

Figure 10 (see appendix) shows the average intensity of internal noise in public academic buildings . The result shows that only 2 universities indicate the reading at a specified level of 50-70 decibels (dB). The two universities are UM with an average reading of 66.2 dB and 66.7 USM. Other universities show the reading exceeds the standard set, but no university falls under standard sets.

Noise pollution in buildings is caused by two main factors, namely, the noise from the outside and the sound from within the building itself. Interference from external noise occurs in attendance from surrounding areas such as vehicle noise, industrial, construction, natural sounds such as the sound of the waves and the beach. This is true in some universities such as UMP, UTHM, UMK, UMT, UniSZA, and UMS. In another situation, noise from the outside of the building penetrates into the building through a window that is not functioning properly also contributes to noise pollution.

Noise disturbance from the building occurs due to a mechanical ventilation system equipment that emits high-pitched sounds that disrupt the occupants in the building. According to NIOSH, the noise from mechanical equipment cannot be sustained for more than 8 hours. In addition, the noise from the residents' activities also contributes to the increase in the intensity of the noise in the building.

This is supported by Prasher et al, (2003) who pointed out that the activities of the human himself contributes to noise pollution. In overall, academic buildings do not have the characteristics of a perfect sound distraction absorbent. Excessive noise can cause health effects and performance of the occupants.

Such interference could result in lower acceptance of teaching activities presented by the lecturers by the students. This is supported by Hakim et al. (2005) stating that the sound was very influential in the learning process. Noisy conditions and reverberant sound during the learning process will reduce the study concentration. In terms of health, it can cause an impact on psychological health and consumer ear as pointed by Lebo and Oliphant (1968).

Air Movement

Figure 11 (see appendix) shows the average movement of indoor air in the academic building. The standard reading was set at 0.15-0.5 m/s. The study shows that, only eleven universities show readings at standard sets. The universities are UPM, UKM, IIUM, UiTM, USM, UUM, UniMAP, UMT, UTHM, UTeM and USIM with all recorded readings of 0.2 m/s.
The Indoor air movement associated with ventilation systems and internal buildings in this research involved a sample of all the mechanical ventilation systems through the HVAC equipment.

Therefore, indoor air movement is influenced by the function performed by the air conditioner. Failure of HVAC equipment functioning properly can affect the internal environment such as the chemical composition of the atmosphere has not changed accretion spores and fungi that can affect the structure of the building and increase the amount of moisture in the building.

Readings air movement is under prescribed standards can cause indoor air composition does not change with the new air. The air exchange rate in mechanically ventilated buildings must occur at a rate 12 to 15 times per hour.

Therefore, if the low air movement, indoor air is difficult to replace will cause the composition of polluted air, especially carbon dioxide (CO_2) and humidity caused by the inhabitants of the water vapor through the process of respiration in the building. According to Sulaiman (1988), the movement of air critical to the process to keep all the comfort temperature, humidity, and oxygen in a space with clean air to enter the space to replace dirty or used air.

Concentrations of Carbon Dioxide

Figure 12 (see appendix) shows the average concentrations of carbon dioxide (CO_2) in the internal university academic building. The results showed that all universities set reads of 1000 ppm (part per million). This indicates an internal CO_2 concentration in academic buildings are in good condition showing the highest reading recorded was 696 ppm in the UMP and the lowest reading recorded was 383 ppm in UMS.

The presence of CO_2 concentrations in the air that is too high can affect bad to occupants of the building. Based on observations, the number of users exceeds the capacity of classroom space utilization has resulted in increased CO_2 concentration readings. This is because, in the respiratory system, human release of gases, especially CO_2. While the concentration of CO_2 in university classrooms is still manageable, attention should be given, especially in the number of user capacity in order for the classrooms to be well controlled and effective. Low concentrations are better as it affects the health of building occupants and productivity. High concentrations of CO_2 can cause a person to feel sleepy due to lack of oxygen (O2) into the body, thus causing residents to lose focus on the process of learning takes place in the lecture.

IEQ **Influence** on the **P**rocess of Teaching and Learning

A survey of 500 respondents was conducted to support scientific measurement. A total of 25 samples from each universities were chosen which representatives of occupants of academic buildings i.e. students and lecturers.

Figure 13 shows the percentage of respondents view on IEQ affects teaching and learning activities in universities. The results of the survey indicated that 81% or 413 respondents of 500 respondents said 'yes', while 13% or 64% of respondents said 'no' influence and the rest 23 respondents or 6% said not sure. Some express the opinion that IEQ certainly has an impact on teaching and learning activities.

Effects of IEQ Levels to the Health of Consumers

Figure 15 shows examples of the effects of IEQ levels to consumer health. A total of 171 of the 328 respondents gave an example of specifying the main effects are fever, cold and cough. This is due to the bad air quality to facilitate the spread of the flu virus to attack users. 65 respondents stated it caused eye pain such as a reddish and painful, 29 respondents expressed discomfort body, 25 respondents expressed skin peeling and 38 respondents easily become short of breath. What can be seen, these examples make a person unable to pay attention and had to leave the class and lead the process of seeking knowledge is stunted.

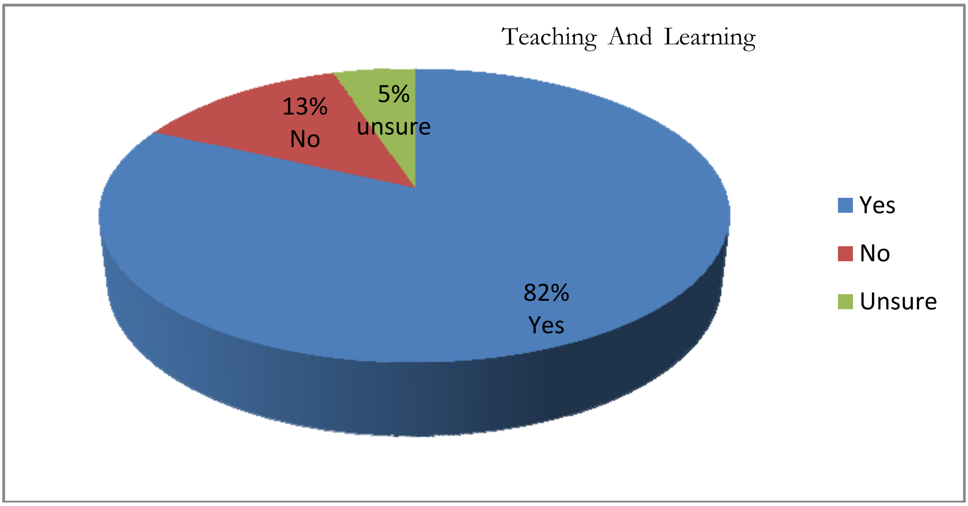

Figure 13: *IEQ influence teaching and learning process*

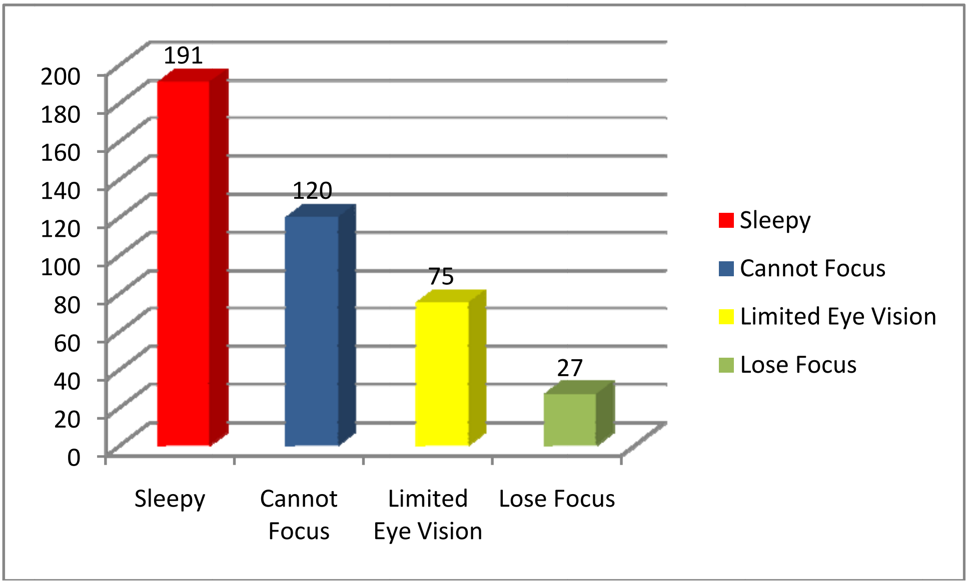

Figure 14: *The effects of IEQ on Teaching and Learning Activities*

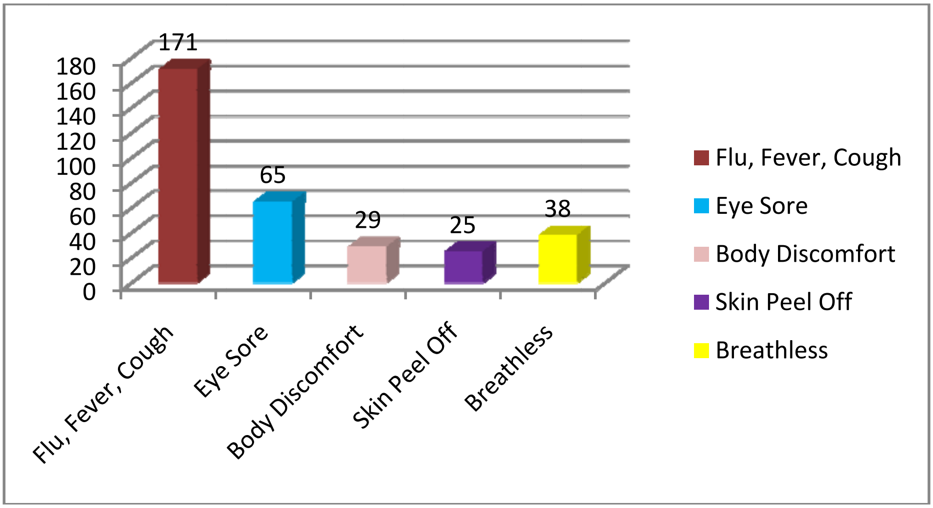

Figure 15: *IEQ effects on the health of consumers*

Recommendations for Improvement of IEQ

Figure 16 shows the respondents' views and recommendations on the improvement of IEQ. A total of 128 respondents, or 25.6 %, have expressed their opinions and suggestions regarding maintenance. 54 respondents or 10.8 % were related to green technology, 78 people or 15.6 % provides insight to improve the ventilation system in the building, 71 respondents or 14.2 % suggested the construction materials in the building must be of quality, 67 or 13.4 % of the respondents suggested that the optimum use of space. In addition, 27 respondents or 5.4 % indicated by creating the appropriate layout of the learning environment in the classroom. A total of 32 respondents or 6.4 % indicated that the selection of campus locations must be consistent with the external environment more relaxed and has no impact on IEQ in buildings. Remaining 43 respondents or 8.6% state no specific/various. All the views of the respondents are very important to improve IEQ facility management in order to create a good learning environment.

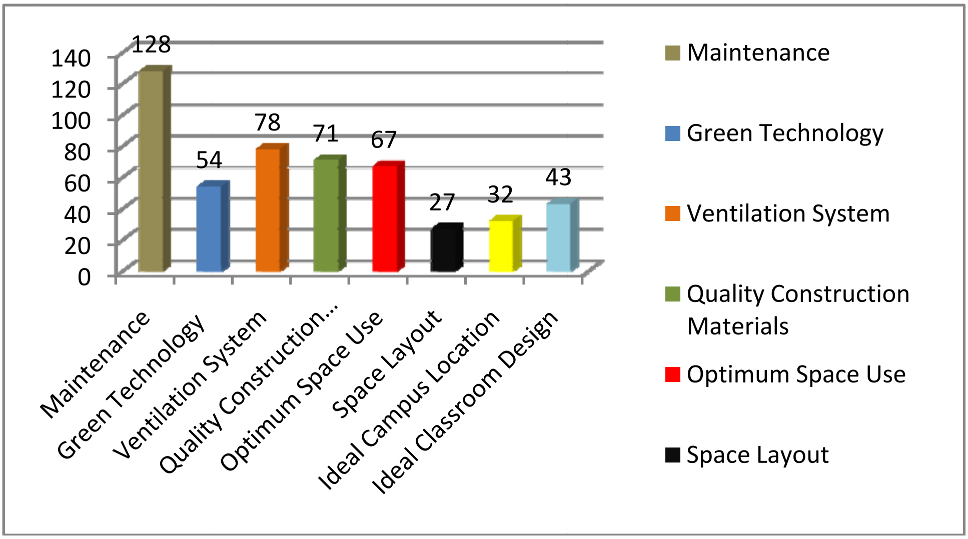

Figure 16 : *Opinions and suggestions for improvement of IEQ respondents in academic buildings*

Conclusion

A study of academic performance of IEQ in buildings HEI is particularly important in ensuring that teaching and learning space is in a comfortable and conducive environment. These studies are expected to contribute to the raising awareness of IEQ performance in academic buildings on campus to create a sustainable campus.

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