THE EFFECT OF INDOOR ENVIRONMENTAL QUALITY ON OCCUPANT'S PERCEPTION OF PERFORMANCE IN OLD STUDENT DORMITORIES OF UNIVERSITY OF MALAYA

CHU KOK WEI

Dissertation submitted in partial fulfilment of the requirements
for the Degree of Building Surveying

Department of Building Surveying
Faculty of Built Environment
University of Malaya

Dec 2015

Declaration

I hereby confirm that this dissertation was the results of my own work where the use of the materials from other sources has been clearly and correctly stated with its references.

16/12/2015

Date

CHU KOK WEI

Name

BEB120002

Matrix Number

Tuntutan Pihak Ketiga

Projek Ilmiah ini disediakan bagi memenuhi sebahagian daripada syarat keperluan bagi pengijazahan Sarjana Muda Ukur Bangunan oleh Universiti Malaya. Pihak Jabatan Pengurusan Ukur Bangunan, Fakulti Alam Bina, Universiti Malaya, tidak bertanggungjawab atas sebarang tuntutan dari pihak ketiga yang berhubung kait dalam penyelidikan Projek Ilmiah ini.

16 Dec 2015

Disclaimer

This Academic Project is prepared here in partial fulfilment of the requirements for the Degree of Bachelor of Building Surveying by the University of Malaya. The Department of Building Surveying, Faculty of Built Environment, University of Malaya makes no responsibility for any claim from the third party with regards to the production of this Academic Project.

16 Dec 2015

Acknowledgement

First and foremost, I would like to thank my father and my mother for supporting me to pursue a degree in University of Malaya. It would not have been possible for me to produce this dissertation without the constant support from my family.

I am grateful to my supervisor, Dr. Sr Norhayati Binti Mahyuddin, whose understanding, grateful and generous guidance to support me and guide me to work on a topic that was my interest. This dissertation would not have happened without her advice, help, encouragement, and expertise. I would like to thank the lecturers in the department of Building Surveying: Dr. Sr Brit Anak Kayan, Dr. Shirley Chua Jin Lin, Dr. Mohamad Rizal Bin Baharum and Dr. Sr Zuraini Binti Md Ali. Their feedback, insight, and advice was essential and influential throught the process of writing up the dissertation.

I would like to thank my fellow friends and colleagues in University of Malaya who are constantly giving me support and advice. I would like to thank Sepideh who was helping me in distributing and collecting the questionnaires. It would not have been possible for me to finish the dissertation without the help from Sepideh.

Abstract

It is known that the people are spending most of their time indoors and therefore the occupants' performance and well-being are greatly affected by the various aspect of indoor environmental quality. Academic achievement loss occurred in the institutions is the result of stress which causes low achievement of academic excellence. Dissatisfaction and excess workload may result to some extent of stress.

This study documented the essential aspects of the indoor environment which has received the lowest satisfaction from the building users and the factors which is the most important to be considered by the building users. For the purpose of this study, definition of "performance" is the comfort in terms of the ability of the building users to be able to perform their daily tasks or activities, namely taking a rest or studying in a room.

This research is based on quantitative analysis where the feedbacks are collected from the questionnaire surveys given out to the respondents and on-site measurements. The targeting respondents are the students who are living in the old dormitories of University of Malaya, which are First Residential College, Second Residential College, Third Residential College and Fourth Residential College.The scale of perceived satisfaction or dissatisfaction is analyzed by a seven scale factor of like and dislike scale. "User Satisfaction" and "Degree of Importance" are calculated by means of the seven scale factor of likeness scale collected from the

responses of the building users. The data of descriptive analysis analysis, parametric tests, regression analysis and non-parametric test can be obtained by carrying out statistical analysis by means of SPSS.

It was found that noise level, thermal comfort and amount of working space in the room are the aspects that contribute to the least satisfaction of occupants' perception of indoor environment quality. Health level in the room, electrical lighting and amount of working space in the room are the most important aspects to be considered from the perception of building occupants in terms of indoor environmental quality in old student dormitories.

Submission of feedback collected from the building occupants could improve the quality of indoor environment provided that there are lack of satisfaction in the quality of indoor environment. A benchmark can be produced from a pool of analysis in order to provide the requirement and need from the building user in the building design and environment. The findings from this study not only can identify the problems which can result in declining building performance, but also can help the building to last longer in the future.

Abstrak

Adalah diketahui bahawa kebanyakan orang yang menghabiskan sebahagian besar masa mereka di dalam rumah. Maka, prestasi penghuni adalah amat dipengaruhi oleh pelbagai aspek kualiti persekitaran tertutup. Kemerosotan pencapaian akademik yang berlaku di dalam institusi adalah hasil daripada tekanan yang mengakibatkan pencapaian rendah kecemerlangan akademik. Ketidakpuasan dan beban kerja yang berlebihan juga boleh menghasilkan tekanan pada tahap tertentu.

Kajian ini mendokumenkan aspek-aspek penting dalam persekitaran tertutupyang telah menerima kepuasan yang paling rendah daripada pengguna bangunan dan faktor-faktor yang amat penting yang perlu dipertimbangkan oleh pengguna bangunan. Bagi tujuan kajian ini, definisi "prestasi" ialah keselesaan dari segi keupayaan pengguna bangunan untuk melaksanakan tugas-tugas harian mereka atau aktiviti, iaitu merehat atau belajar di dalam bilik.

Kajian ini adalah berdasarkan pada analisis kuantitatif di mana maklum balas yang dikumpul daripada kajian soal selidik yang diedarkan kepada responden dan ukuran tempat-tempat yang dikaji. Responden yang disasarkan adalah pelajar yang tinggal di asrama pelayar Universiti Malaya yang lama, iaitu Kolej Kediaman Pertama, Kolej Kediaman Kedua, Kolej Kediaman Ketiga dan Kolej Kediaman Keempat. Skala kepuasan daripada persepsi kepuasan adalah dianalisis dengan menggunakan faktor skala tujuh yang terdiri daripada skala suka dan tidak suka. "Kepuasan Pengguna" dan "Tahap Kepentingan" adalah dikira dengan menggunakan faktor tujuh skala kesukaan yang dikumpul daripada maklum balas

daripada pengguna bangunan. Data deskriptif analisis, ujian parametrik, analisis regresi dan ujian bukan parametrik boleh diperolehi dengan menjalankan analisis statistik dengan menggunakan SPSS.

Adalah didapati bahawa tahap bunyi bising, keselesaan suhu dan jumlah ruang kerja di dalam bilik adalah aspek yang menyumbang kepada kepuasan yang paling kurang persepsi penghuni terhadap kualiti persekitaran dalaman. Tahap kesihatan di dalam bilik, lampu elektrik dan jumlah ruang kerja di dalam bilik adalah aspek yang paling penting untuk dipertimbangkan dari persepsi penghuni bangunan dari segi kualiti persekitaran tertutup di asrama pelajar yang lama.

Penyerahan maklum balas yang diperoleh daripada penghuni bangunan boleh meningkatkan kualiti persekitaran tertutup dengan syarat bahawa terdapat kekurangan kepuasan dalam kualiti persekitaran tertutup. Tanda aras boleh dihasilkan daripada sekumpulan analisis untuk menyediakan keperluan dan kehendakan daripada pengguna bangunan dalam reka bentuk bangunan dan alam sekitar. Hasil kajian ini bukan sahaja dapat mengenal pasti masalah yang boleh menyebabkan kejatuhan prestasi bangunan, tetapi juga boleh membantu bangunan untuk bertahan lebih lama di masa depan.

Page

List of Tables

List of Figures

List of Abbreviation

ANOVA	-	Analysis of Variance
ASHRAE	-	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
EN	-	European Standards
ISO	-	International Organization for Standardization
PMV	-	Predicted Mean Vote
PPD	-	Predicted Percentage Dissatisfied
SPSS	-	Statistical Package for the Social Sciences
UBBL	-	Uniform Building By-Laws

List of Appendix

CHAPTER 1

CHAPTER 1

Introduction

1.1 Rationale of the Study

It is known that most people spending most of their time indoors. Therefore, indoor environmental quality is very crucial as the performance and productivity of the people in the particular building is greatly affected. Research shows that the time for the people spending indoor are almost ninety per cent (90%) (U.S. Environmental Protection Agency Buildings and the Environment, 2004; B.L. Epstien, 1997).

Many studies show that student's performance and productivity in different buildings is affected by indoor environmental quality due to poor IEQ (Salleh, Kamaruzzaman et al., Lee, Mui et al. 2012, Turunen, Toyinbo et al. 2014, Haverinen-Shaughnessy, Shaughnessy et al. 2015, Sarbu and Pacurar 2015). Therefore, students' satisfaction in the dormitory needs to be taken into account as the student's academic achievement can be improved by their increased satisfaction and productivity.

Various factors in related with the building have resulted in affecting the occupant's performance and wellbeing, namely indoor air quality, ergonomics, temperature and daytime lighting. Human health would be affected by all these

factors which leading to decreasing morale of the occupants and poor academic excellence. A building evaluation is very essential to be conducted by the institution in order to collect the feedback from the building users so as to maintain the academic excellence of the institution. The factors may also compromise the quality of productivity and work if these factors are addressed in not the correct way. The falling of health of the occupants of the building may be resulted by air pollutants, temperature and lighting (Kamaruzzaman et al., 2010).

Academic excellence in the students' performances can be maximized by establishing comfort environment in students' dormitories. Occupants' dissatisfaction is a result of low indoor environmental qualities such as sub-standard indoor air quality, vibration, noise, incorrect lighting and poor seating. The owner may face rising cost in maintaining property due to the reduction in the number of occupants living in the dormitories. Stress is one of the consequences which is contributed by the dissatisfaction and excess workload may result in severe stress. Unclear student descriptions as well as conflict between roles may result in occupant's stress in the dormitories.

1.2 Problem Statement

As the students are going to look for job position in the competitive job market, their learning need to be maximized (Duque & Weeks, 2010; Roberts, 2009). The elements of indoor environmental quality are indoor air quality, thermal comfort, visual comfort, ergonomics, daylight and artificial lighting and space. Student motivation and performance are improved when the room's attractiveness and lightning are enhanced (Strange and Banning, 2001). In addition, research also proved that psychological arousal, density with decreased student achievement and overheated spaces are affected by lighting (Graetz and Goliber, 2002). Low achievement of academic excellence due to stress which leads the institutions to result in loss in terms of achievement. Student losses are a result of stress, which will influence occupants' family members because of lacking in knowledge. Student should make sure that the habitable room is a good environment without stress

(Davis, 2010). Stress is one of the consequences which is contributed by the dissatisfaction and excess workload which may result in severe stress. Unclear student descriptions as well as conflict between roles may result in occupant's stress in the dormitories.

1.3 Objectives

1. To evaluate the indoor environmental quality in old student dormitories
2. To identify the impact of indoor environmental quality towards the occupants' perception of performance of well-being
3. To provide recommendation to improve the indoor environmental quality in old student dormitories

1.4 Aim

The aim of this research is to study the effect of indoor environmental quality towards the occupants' perception of performance in old student dormitories of University of Malaya.

1.5 Scope of Study

This research is targeting the students who are living in old student dormitories of University of Malaya, which are First Residential College, Second Residential College, Third Residential College and Fourth Residential College.

CHAPTER 2

CHAPTER 2

Literature Review

2.1 Occupants' Performance of Well-being

The productivity, comfort and health of students can be affected by the quality of room space. From the study of Gary W Evans, and Rachel Stecker (2004), it was found that "learned helplessness" can be produced in children as well as adults as a result of constantly and severely exposing to uncontrollable environmental factors, such as crowding, air pollution, noises or traffic congestion.

The role of positive or negative emotions have been documented by the clinical psychologists on several individual outcomes together with productivity (Wright et. al., 2002). Low self-esteem, slowed thought process, and reducing motivation were found on the individuals feeling "sad" or "depressed".

It was found that psychological well-being has a positive relation with well-being performance (Wright et. al., 2002). Definition of psychological well-being is the measure of the "pleasantness dimension" of individual feelings. The terms of "active", "enthusiastic", "alert", "and interested" are used in measuring positive feelings, whereas the terms of "afraid", "irritable", "hostile", and "upset" are used in measuring negative feelings (Wright et. al., 2002).

Various factors can be contributing in the aspects of occupant performance and well-being. Such factors comprise indoor air quality, noise, ergonomics, thermal comfort, daylight, and ventilation effectiveness. Definition of Ergonomics by the American Industrial Hygiene Association Ergonomics Committee is application of principles that are applied in a multidisciplinary science according to the psychological and physical capabilities of the people to the modifications or design of the equipment, work places, jobs, and products. Reducing students' discomfort and improving the students' well-being performance are the purpose of ergonomics (DiNardi, 1998).

2.2 Emotion and Affect

The involuntary moods and feelings, vegetative nervous system, cognitions on the internal states and other related external context are the physiological responses which are formed by the complex psychic phenomenon of emotion (Russell & Snodgrass, 1987). It is suitable to practice the framework of Mehrabian and Russell (1974) for practical empirical purposes. The emotions are described with three fundamental underlying dimensions, which are pleasure/valence, dominance and arousal in which related concepts namely beauty or preference are implied. With the usage of introspective verbal scaling techniques, effective quantification of affectional responses are able to be collected in the framework. The mood changing capacity of a stimulus are effectively characterized in terms of attitudes and decisions (Russell & Snodgrass, 1987) and no less than an estimate to further such as physiological responses (Russell, 1988) can be provided. In addition, it is suggested by several studies of Stamps (2000, pp. 114-138), generalizable predications can be observed from the meaningful main trends from the indication of averaged appraisals in spite of existing individual differences.

2.3 Emotional Responses to Colour in Building

There is still a lack of empirically backed knowledge in relation to the effect of colours on emotions in spite of available of many general literature and respective text books. The effect of dimensions arousal and dominance can be predicated with the current state of knowledge. In most cases, it is more arousing to see warm and saturated colours whereas light-dark is corresponded to have influence on the dominance dimension. A lot of physiological data are contributed to support the study of phenomenal observations (Küller, 2001). It is reported the positive relationship between brightness and saturation, whereas the colour-bearing object group is identified to be secondary source to have influence in colour hue (Mehrabian & Russell, 1974, pp. 56-59). It is reported that darker and more saturated floor colours are more favourable in terms of the tendential preferences, whereas ceilings are preferred to be in less saturated and lighter colour (Frieling, 1974).

2.4 Emotional Responses to Architectural Space

Despite the primary dimension of architecture is traditionally deemed in spatial form, there is a lack understanding on the affectional experience of architecture as a result of spatial properties (Giedion, 1941). The fact is that space-related phobias are the result of enormous emotional potential. The size and rate of enclosure are identified as probable primary affectional dimensions of spaces (Franz, von der Heyde, Bülthoff, 2005a; Stamps, 2005 & Joedicke, 1985). The spacious room that is provided with vista into the surroundings and those rooms which has near space protection are more favourable (Appleton, 1988; Newman, 1996). In spite of that, the evidence to back and integrate these findings and theories are still limited. It is found that the individual predisposition plays important roles in the reactions to particular spaces since agoraphobia and claustrophobia are the example of psychoses that is related with phenotypically oppositional space. The relative density and absolute number of spatial differentiations are identified as promising predictor variables in the emotional dimension of arousal (Franz, von der

Heyde, & Bülthoff, 2005b). The framework of general information theory on the environmental preferences and building facades are supported by the observations carried out in the findings (Berlyne, 1972 & Stamps, 2000). In order to improve the dominance of building concerning the effect of spatial form on the dominance of space, increasing scale is suggested by common architectural practice as an effective approach. The properties of the recurrence of symmetries such as repeating architecture style has also contributed in the experienced space dominance.

2.5 Interactions between Space Perception and Colour

The experience and perception of the people are not entirely independent due to the visually expression of colours and spatial dimensions. Some rule of thumbs are required from the architectural knowledge in order to determine the perceived room space that is influenced by colours. In general, the experienced spaciousness are increased by cool, light and desaturated colours, whereas the spaciousness is decreased by dark, warm and saturated colours. The phenomenon of perspective of colour is fitted well by these characterizations (Nemcsics, 1993; Bailey, Grimm, & Davoli, 2006). Regarding applied design of colour, saturated dark colour is recommended to be used extensively in large room (Frieling, 1974).

2.6 Thermal Comfort

According to ASHRAE Standard 55-2004, thermal comfort is "that condition of mind which expresses satisfaction with the thermal environment'. Neither warmer nor cooler is what a building user wish to feel when it is thermally comfortable. However, this definition only apply to an individual but not a group of people as the built environment is shared by a group of people. Standard ISO 7730 determines thermal comfort by the heat-balance approach which determines the range of comfort temperatures which satisfy the thermal comfort of a group of people. The range is determined by indices predicted mean vote (PMV) and predicted

percentage dissatisfied (PPD). Thermal environment is defined by the standard can be influenced by four physical variables (mean radiant temperature, air temperature, air humidity and relative air velocity) and two human related variables (clothing and metabolism rate). In addition, thermal comfort can be achieved by eliminating the discomfort such as draught, high radiant temperature imbalance, too high or too low internal surface temperatures, or high air temperature difference. Meanwhile, an adaptive approach has been proposed by assuming that humans are adaptable to the thermal environment via behavioural adjustments (e.g. dressing in the way that an individual feel the most comfort whether it is in indoor or outdoor), the ability to control the existing environment by closing and opening windows and using shading when there is a need.

An environment with no less than 80% or more of the building occupants accept the thermal comfort is an acceptable thermal environment. A suitable thermal comfort is required in the student rooms in order for them to carry out the daily living activities. The factors which affect the thermal comfort in any environment are temperature, humidity, radiation, ventilation and the quality of air generated from filtration. Individual requirements and various conditions that favour personal preference should be allowed in the setting of thermal environment in the student dormitories. According to Zahran (1972), the best solution in order to match up to the own preference and metabolism of students is taking control of room temperature individually. The air must be flowing clean in a diversified community which consist of smokers and non-smokers, particularly in interior spaces, student lounges and student rooms. The ability of the students in the room to open their windows is very important in order to enjoy the fresh air in the morning (Chiara and Callender, 1980).

2.7 Visual Comfort

According to European Standard EN 12665, visual comfort is defined as 'a subjective condition of visual well-being induced by the visual environment'. In spite of the fact that the visual comfort is determined by the psychological feeling of the people, the evaluation of visual comfort can performed in an objective approach. Visual conditions can be influenced by various parameters such as illuminance, luminance distribution, glare, colour rendering, colour of light, amount of daylight, and flicker rate. In student rooms, the quality of lighting can be determined by the brightness and quantity of the source of lights from the surrounding. As stated by Baird et al (1996), glare problems which are results of poor colour rendering, inadequate illumination levels, lighting systems and inappropriate directional effects can result in impairment of visual acuity. Surplus of required illumination levels may be produced by natural daylight in the event that the windows are properly positioned and glare is removed (Chiara and Callender, 1980).

2.8 Acoustic Comfort

As stated by Navai and Veitch, acoustic comfort is 'a state of contentment with acoustic conditions'. A good acoustic environment is commonly related with getting rid annoyance whereas the term of acoustic comfort is not always mentioned. The quality of the sound environment can be affected by two parameters, which are physical properties of sound itself and physical properties of a room. Sound frequency and sound pressure level in a long-term and short-term period is the parameters to characterize sound. For the physical properties of a room, acoustic comfort is affected by sound insulation, reverberation time and absorption. It is very important to have a good quality acoustical environmental in order for the students to learn, search for information and do mental work in the student rooms. Good sleeping and relaxing environment can be provided with good acoustics environment. The acoustical quality of the students' rooms can be improved by the elements in the rooms such as wall-to-wall carpets, curtains as well as corridors and hallways (Zahran, 1972). Generally, two types of noise are

identified that cause disturbing to the students in the students' rooms, which are the constant background noise reaching the spaces and the spasmodic intrusive noise produced within the area. Engineering services such as lighting systems and HVAC systems, the external environment and the adjacent zones could be the potential sources that causes the steady background noise (Hassanain, 1996). Loud voices, entertainment devices, human activities and machinery are the noises that are produced in the student dormitory. Good planning from one room to another room is the best way to inhibit noise in the students' dormitories.

2.9 Indoor Air Quality

Good indoor air quality is commonly related with lacking in comfort as a result of sensory irritation and bad odour. Definition of acceptable air quality by ASHRAE Standard 62.1 is 'air in which there are known contaminants at harmful concentration as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction'. The requirements for indoor air quality provided by the standards are mostly defined by the conditions where the requirements have to meet the least people which dissatisfied with air quality. The indoor air pollutants are one of the reasons that results in bad indoor air quality such as formaldehyde, volatile organic compounds, tobacco, airborne particles, asbestos and so on. Air polluting substances that may be emitting by the following materials and objects such as plastic materials, chemical based cleaning agents, vehicle exhausts, synthetic building materials (e.g. ceiling board made with asbestos), and etc. Bad indoor air quality may give rise to unhealthy condition of the occupants within a particular building, the symptoms include runny nose, headaches, chest tightness, nose and throat irritation, lethargy, itchy skin and so on. According to the estimation of U.S. Occupational Safety and Health Administration (OSHA), poor indoor air quality has result in loss in business with 14 to 15 minutes per employee per day (U.S. Federal Registrar, 1994).

Besides, it may results in lower productivity of workers, lower quality of work and high absenteeism due to take sick leave. Good air quality should be provided up to the standard of satisfaction in the student rooms. The health of the students could be greatly worsened by poor air quality which leads to increasing reports of absenteeism and decreasing productivity. As stated by Baird et. al. (1996), the factors that need to be considered are air transfer between spaces, specific air pollutants, and circulation of air in individual spaces. The air pollutants can have adverse effect on the air quality due to inadequate flow, the position of exhausts and inlets and short-circuited transfer of air within the building.

2.10 By-laws and Guidelines

Uniform Building By-Laws 1984 is an extension of the Street, Drainage and Building Act 1974. The Minister or State Authority is allowed to exercise his/her power to draft the following by-laws under Section 133 of the Street, Drainage and Building Act 1974. As stated in Section 39 Natural ventilation and lighting, natural ventilation and natural lighting with one or more windows that is having an overall area of at least 10% of clear floor area shall be provided for every room that is designed, used for or adapted to be business, residential or other purposes except hospitals and schools and the rooms shall have openings of having the ability of free continuous passage of air of at least 5% of such floor area. As mentioned in Section 41 Mechanical ventilation and air-conditioning, the Local Authority may waives the relevant building by-laws that is in related with natural lightings, natural ventilation and heights of room when there is intention of installing permanent mechanical ventilation or air-conditioning. Under Third Schedule of UBBL 1984, the fresh air ventilation together with filtered, recirculated and conditioned air of residential building shall comply with the requirements of ASHRAE STANDARD 62-73 with not less than 0.14 cmm per occupant. Under Section 42 Minimum areas of rooms in residential buildings, the area of all other rooms shall be at least 6.5 m^2 and it shall be more than 2 m for the width of every liveable room in a residential building. It shall be at least 2.5 m for the height of living rooms and bedrooms in residential buildings.

As suggested by Standards for Houses in Multiple Occupation, the residential colleges in University of Malaya are categorized as House in Multiple Occupation (HMO) as they are not less than 3 storeys high, more than 5 tenants living in the residential college and the occupants are sharing bathroom, toilet or kitchen facilities with each other (Standards for Houses in Multiple Occupation, 2004). If the number of persons sleeping in a housing unit is more than the tolerable number with respect to the number and floor area of the rooms of the housing unit available for sleeping purpose, it will results in the contravention of the space standard. No action shall be taken of a child under one year old and one-half of a unit shall be used to reckon a child of one years old or over. For the bedroom where common living room available with floor area of 16.5 m^2, not more than 3 occupants are allowed to occupy the room for the habitable purpose (Standards for Houses in Multiple Occupation, 2004).

CHAPTER 3

CHAPTER 3

Research Methodology

3.1 Sampling

This research is based on qualitative analysis by using simple random sampling technique. Alternative approach of probability sampling method is not used in this study due to limitation of time and resources. The researcher will seek for permission letter to enter the buildings to be considered as case study. After permission letter is received, the researcher will distribute the questionnaires by visiting the rooms of the selected buildings. The process will go on until the researcher has obtained 85 respondents who are willing to take part in this research. A set of paper is given out to each respondent and requested to complete the survey. The target respondent is the student who is living in the old student dormitories in University of Malaya. The mode of distributing the questionnaire is paper survey which allows the researcher to collect the survey instantly after the respondent has completed the given questionnaire. In addition, response rate of paper survey is considerably high as compared to online survey because the probability for a respondent refuses to fill in the survey is very low. At least 20 students who are living in each building are targeted as respondents.

3.2 Building Description

The research of this study is carried out on the old student dormitories in University of Malaya. The range of the study is limited by some parameters such as age and building operation of the building so as to ensure the data are comparable and coherent. Only buildings of age more than 50 years are selected in the study. A general rule of thumb is that a building with more than 50 years is considered as old building (Georgio Department of Natural Resources, 2015). The buildings selected are operated fully in service and fully occupied.

First Residential College is one of the oldest residential college in University of Malaya and it was built in 1959. There are totally five blocks, where three blocks are provided for female students and two blocks are provided for male students. In total there are 802 tenants staying in First Residential College. Second Residential College is built in 1958 and it has 4 blocks in total where 2 blocks are provided for each of the male and female students respectively. The number of tenants living in second residential college is 700. Third Residential College is built in 1962, which is one of the oldest dormitories in University of Malaya. It is open to both undergraduate and postgraduate and it has 740 tenants in total. There are totally five blocks in Third Residential College, where three blocks are provided for female students and one blocks are provided for male students. Fourth Residential College is built in 1963 and it accommodates 700 postgraduate and undergraduate students in four blocks. Table 3.2.1 shows the descriptions of the buildings chosen as case study. Table 3.2.2 shows the summary of the details of room in old student dormitories.

Table 3.2.1 Descriptions of the buildings chosen as case study

Dormitory	Built	No. of blocks	No. of tenants
1st Residential College	1959	5	802
2nd Residential College	1958	4	700
3rd Residential College	1962	5	740
4th Residential College	1963	4	700

Source: https://www.um.edu.my/student-life/accomodation/residential-colleges

Table 3.2.2 Summary of the details of room in old student dormitories

Criteria	First Residential College	Second Residential College	Third Residential College	Fourth Residential College
Floor area	17.15 m^2	17.15 m^2	17.48 m^2	16.8 m^2
Ceiling height	2.9 m	2.9 m	2.9 m	2.9 m
Existing occupants	3	3	3	3
Type of window	Louvre windows	Louvre windows	Casement windows	Casement windows
Number of leaves of window	6	6	4	6
Total size of opening	3.2 m^2	3.2 m^2	2.55 m^2	3.41 m^2
Ventilation	1 ceiling fan	1 ceiling fan	1 ceiling fan	1 ceiling fan
Type of electrical lighting	2 fluorescent lamps	2 fluorescent lamps	2 fluorescent lamps	1 fluorescent lamp
Color of the room	White	White	White	White and green
Orientation of external façade (on the other side of façade with corridor	North	North	South	South
Direction of wind	East to west	East to west	East to west	East to west
Management	KK1 Administration	KK2 Administration	KK3 Administration	KK4 Administration

Source: Fieldwork (2015)

3.2.1 First Residential College

The dimension of room in the student dormitory of First Residential College is 3.5 m x 4.9 m. The floor area of the room is 17.15 m^2. The ceiling height is 2.9 m. The number of students staying in the room is 3 people. The windows are located at the only one side of the room where the study table is located. It is noticed that the windows are operable and the users have the ability to switch on or off the windows to control better amount of daylight. There are total 2 type of windows available in the room, which are louvre windows that can be switched on and off and louvre

windows that cannot be operated which are above the operable louvre windows. The size of the each window is 59.5 cm x 116 cm. The total size of opening can be calculated as 3.2 m^2. There are two lightings located in the room where each of them are fitted on the wall next to the study table. The type of lightings are fluorescent lamp. The color of the room is white. The orientation of external façade is facing to the north and the direction of wind is blowing from east to west. The management body of First Residential College is KK1 Administration. Figure 3.2.1 shows the exterior view of Block D of First Residential College. Figure 3.2.2 shows the interior view of room in Block D of First Residential College. Figure 3.2.3 shows room layout in Block D of First Residential College.

Figure 3.2.1 Exterior view of Block D of First Residential College

Source: Fieldwork (2015)

Figure 3.2.2 Interior view of room in Block D of First Residential College

Source: Fieldwork (2015)

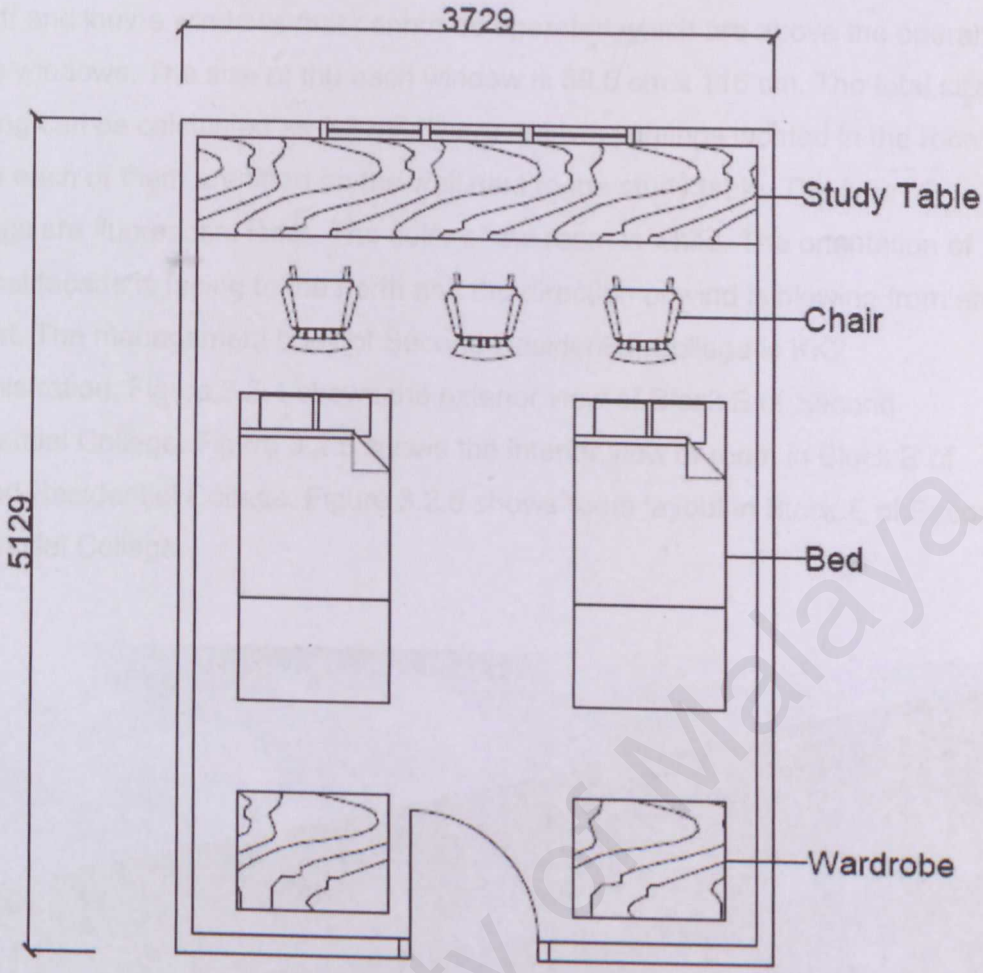

Figure 3.2.3 Room layout in Block D of First Residential College

Source: Fieldwork (2015)

3.2.2 Second Residential College

The dimension of room in the student dormitory of Second Residential College is 3.5 m x 4.9 m. The floor area of the room is 17.15 m^2. The ceiling height is 2.9 m. The number of students staying in the room is 3 people. The windows are located at the only one side of the room where the study table is located. It is noticed that the windows are operable and the users have the ability to switch on or off the windows to control better amount of daylight. There are total 2 type of

windows available in the room, which are louvre windows that can be switched on and off and louvre windows that cannot be operated which are above the operable louvre windows. The size of the each window is 59.5 cm x 116 cm. The total size of opening can be calculated as 3.2 m^2. There are two lightings located in the room where each of them are fitted on the wall next to the study table. The type of lightings are fluorescent lamp. The color of the room is white. The orientation of external façade is facing to the north and the direction of wind is blowing from east to west. The management body of Second Residential College is KK2 Administration. Figure 3.2.4 shows the exterior view of Block E of Second Residential College. Figure 3.2.5 shows the interior view of room in Block E of Second Residential College. Figure 3.2.6 shows room layout in Block E of Second Residential College.

Figure 3.2.4 Exterior view of Block E of Second Residential College

Source: Fieldwork (2015)

Figure 3.2.5 Interior view of room in Block E of Second Residential College

Source: Fieldwork (2015)

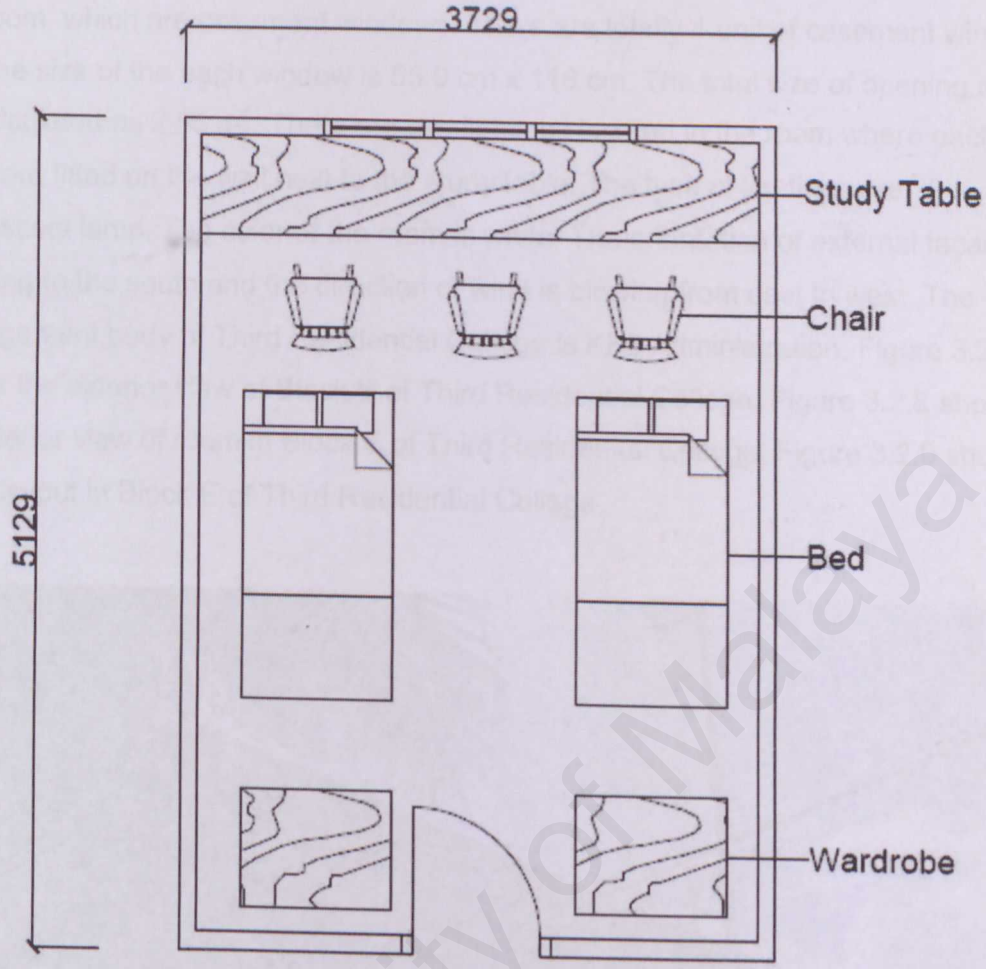

Figure 3.2.6 Room layout in Block E of Second Residential College

Source: Fieldwork (2015)

3.2.3 Third Residential College

The dimension of room in the student dormitory of Third Residential College is 3.8 m x 4.6 m. The floor area of the room is 17.48 m^2. The ceiling height is 2.9 m. The number of students staying in the room is 3 people. The windows are located at the only one side of the room where the study table is located. It is noticed that the windows are operable and the users have the ability to switch on or off the windows

to control better amount of daylight. There are only one type of window available in the room, which are casement windows. There are totally 4 unit of casement window and the size of the each window is 55.0 cm x 116 cm. The total size of opening can be calculated as 2.55 m^2. There are two lightings located in the room where each of them are fitted on the wall next to the study table. The type of lightings are fluorescent lamp. The color of the room is white. The orientation of external façade is facing to the south and the direction of wind is blowing from east to west. The management body of Third Residential College is KK3 Administration. Figure 3.2.7 shows the exterior view of Block E of Third Residential College. Figure 3.2.8 shows the interior view of room in Block E of Third Residential College. Figure 3.2.9 shows room layout in Block E of Third Residential College.

Figure 3.2.7 Exterior view of Block E of Third Residential College

Source: Fieldwork (2015)

Figure 3.2.8 Interior view of room in Block E of Third Residential College

Source: Fieldwork (2015)

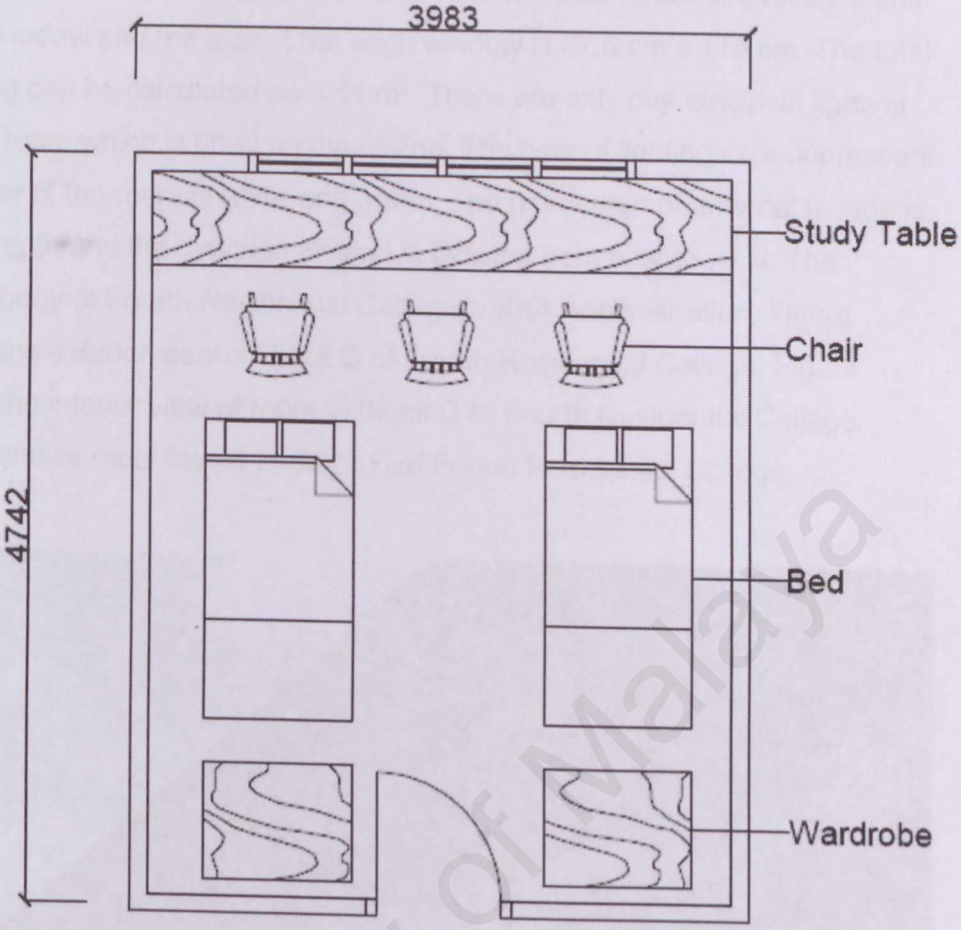

Figure 3.2.9 Room layout in Block E of Third Residential College

Source: Fieldwork (2015)

3.2.4 Fourth Residential College

The dimension of room in the student dormitory of Fourth Residential College is 3.5 m x 4.8 m. The floor area of the room is 16.8 m^2. The ceiling height is 2.9 m. The number of students staying in the room is 3 people. The windows are located at the only one side of the room where the study table is located. It is noticed that the windows are operable and the users have the ability to switch on or off the windows to control better amount of daylight. There are only one type of

window available in the room, which are casement windows. There are totally 3 unit of casement window and the size of the each window is 67.0 cm x 116 cm. The total size of opening can be calculated as 3.41 m^2. There are only one electrical lighting located in the room which is fitted on the ceiling. The type of lightings are fluorescent lamp. The color of the room is white and green. The orientation of external façade is facing to the south and the direction of wind is blowing from east to west. The management body of Fourth Residential College is KK4 Administration. Figure 3.2.10 shows the exterior view of Block C of Fourth Residential College. Figure 3.2.11 shows the interior view of room in Block C of Fourth Residential College. Figure 3.2.12 shows room layout in Block C of Fourth Residential College.

Figure 3.2.10 Exterior view of Block C of Fourth Residential College

Source: Fieldwork (2015)

Figure 3.2.11 Interior view of room in Block C of Fourth Residential College

Source: Fieldwork (2015)

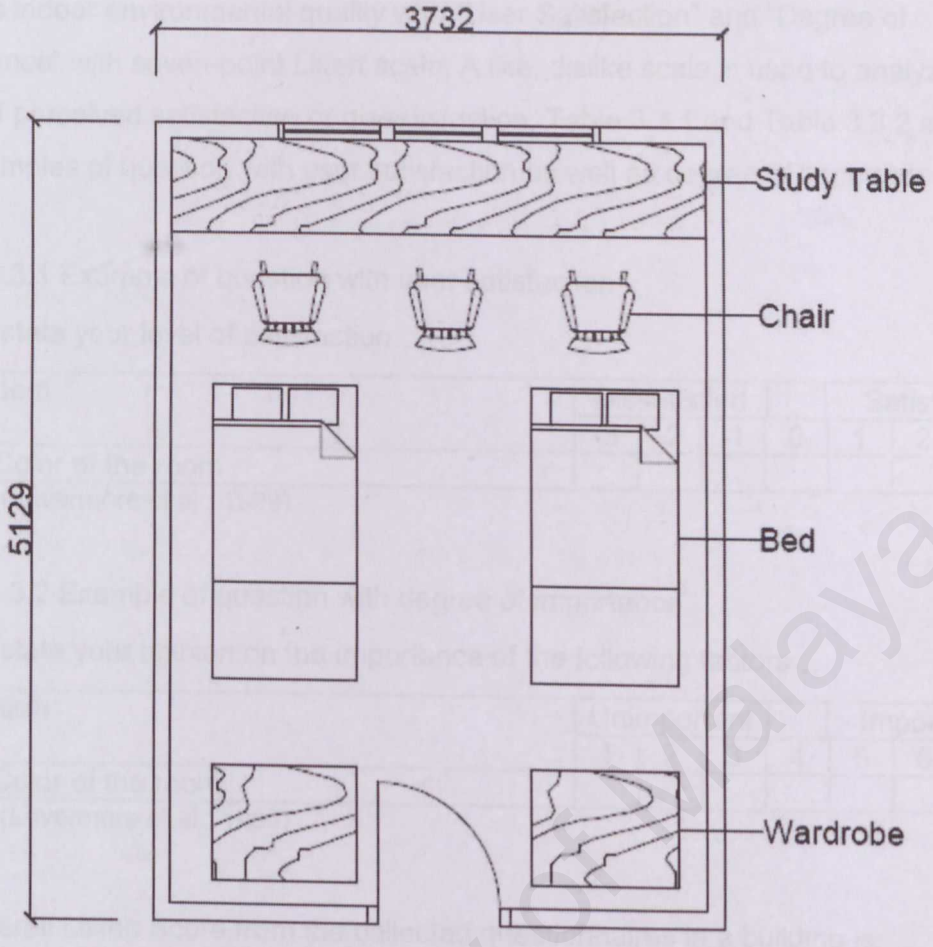

Figure 3.2.12 Room layout in Block C of Fourth Residential College

Source: Fieldwork (2015)

3.3 Measurement Procedures

The satisfaction level regarding the performance of the building can be obtained from the feedback of occupants' perception of the building. The user fingerprint and score can be produced from the questionnaire to determine the assessment of occupant's perception by using the method which is developed in UK (Levermore et al., 1999). Due to the fact that this method is originally used in UK, the questions have been amended to fit in the condition of Malaysia. There are five

questions regarding social background of the occupants and 20 factors in related with the indoor environmental quality with "User Satisfaction" and "Degree of Importance" with seven-point Likert scale. A like, dislike scale is used to analyze the scale of perceived satisfaction or dissatisfaction. Table 3.3.1 and Table 3.3.2 show the examples of question with user satisfaction as well as degree of importance.

Table 3.3.1 Example of question with user satisfaction

Please state your level of satisfaction…

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Color of the room							

Source: (Levermore et al., 1999)

Table 3.3.2 Example of question with degree of importance

Please state your opinion on the importance of the following factors…

No.	Item	Unimportant				Important		
		1	2	3	4	5	6	7
1	Color of the room							

Source: (Levermore et al., 1999)

The Overall Liking Score from the collected questionnaires in a building is:

$$FLS = 100\left(\frac{\sum_{j=1}^{m} i_{j,k} l_{j,k}}{mni_{max} l_{max}}\right) \quad (1)$$

Source: (Levermore et al., 1999)

Where j = questionnaire number

k = question number

i = importance rating $1 \leq i \leq 7$

i_{max} = maximum value of i, (7)

l_{max} = maximum liking rating l (+3)

l = liking rating $-3 \leq l \leq 3$

m = number of filled in questionnaires

The liking and importance scores for each of the factors are multiplied and normalized to derive overall liking score. The score is calculated between +100 and -100. The positive scale indicates the liking and importance and the negative scale indicates disliking and unimportance. A neutral position is indicated as zero.

3.4 Data Collection

The collection of data is starting from the period between 1 November 2015 and 15 November 2015. Once the responses are received, the responses are recorded and updated in the computer system. Microsoft Excel is used to organize the data in a spreadsheet. The data is tabulated into rows and columns separately. The data is transferred from Microsoft Excel to SPSS to carry out regression statistics, descriptive statistics, factor analysis, one-way ANOWA test and t-test.

3.5 Data Analysis

The data collected is tabulated and analyzed by using Microsoft Excel and IBM SPSS. The first part of the data analysis is about the user satisfaction fingerprint where it provide comparisons for the factors to be considered in indoor environmental quality in terms of the perceived satisfaction of occupants. The second part of the analysis is carried out to obtain the perceived degree of importance in terms of factors in the design of dormitory. By using SPSS, statistical analysis can be carried out to obtain the data of descriptive analysis, regression analysis, parametric tests and non-parametric tests. The total of 20 variables in the survey can be simplified to produce various factors using factor analysis. After the factors have been identified, the computed t-test and one way ANOVA test are able to be carried out to test the hypothesis and p-value. Comparison between different factors is carried out by using tabulation and charts.

CHAPTER 4

CHAPTER 4

Results and Discussions

4.1 User Satisfaction Fingerprint

Figure 4.1 indicates the audit of 'User Satisfaction Fingerprint'. Most of the bars are pointing on the right side of the graph as shown. Generally this shows that the feedback of user satisfaction of the indoor environmental quality is positive.

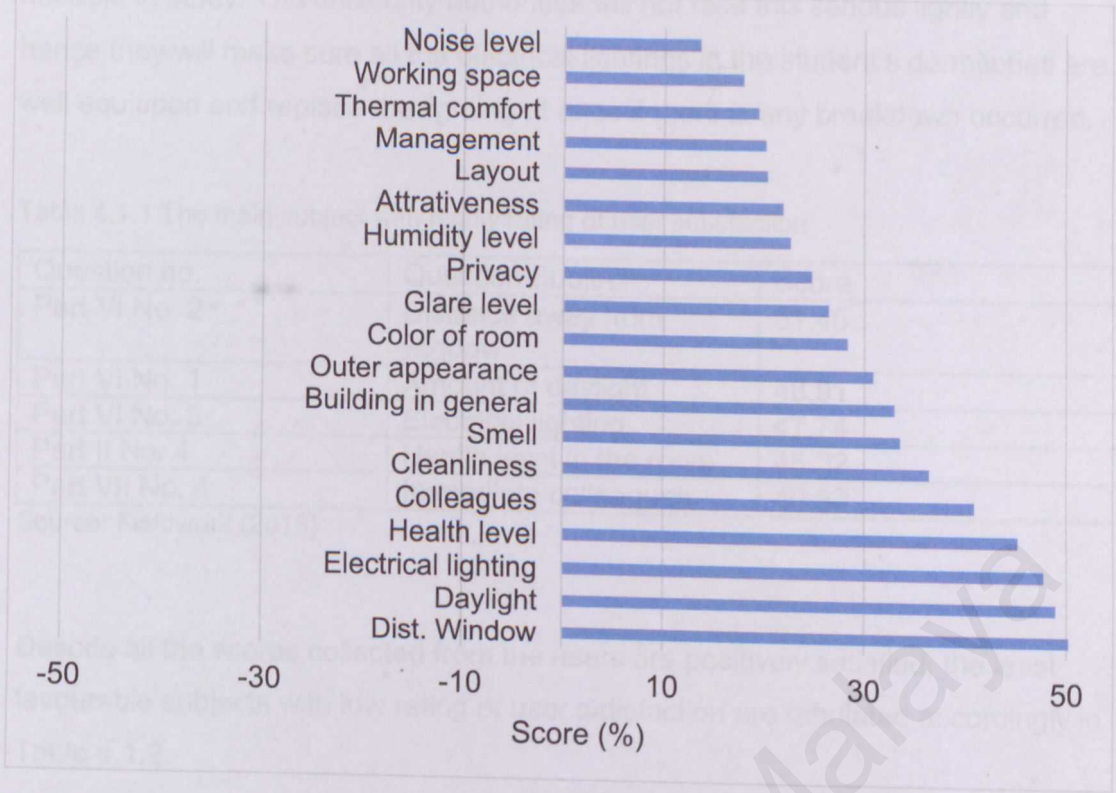

Figure 4.1 Audit likeness fingerprint

Source: Fieldwork (2015)

Table 4.1.1 shows the main subjects with highly rating of user satisfaction. Distance away from the window is the subject that achieves the highest scores. This is due to the students' rooms are small and the seats of students are arranged next to the window. Based on the site observation, it was found that most of the students' desk are in front of the windows. The second highest rating are the amount of daylight in the room. However, penetration of sunlight is still observed to the buildings via other openings like ventilation access. The openings such as the window allow the sunlight to penetrate through resulting in the brightening of the room during daytime and making convenience for the students to read and study. The electrical lighting is the third element with more favourable in terms of user satisfaction. Electrical lighting is essential as the students need to study and focus during the night with good quality of electrical lighting. If there is no good quality of electrical lighting, the performance of the students may be affected since they are

not able to study. The university authorities will not take this serious lightly and hence they will make sure all the electrical lightings in the student's dormitories are well equipped and replace the lighting at once if there is any breakdown occurred.

Table 4.1.1 The main subject with highly rating of user satisfaction

Question no.	Question Subject	Score
Part VI No. 2	Distance away from window	51.46
Part VI No. 1	Amount of daylight	48.91
Part VI No. 3	Electrical lighting	47.74
Part II No. 4	Health level in the room	45.22
Part VII No. 4	Immediate colleagues	40.93

Source: Fieldwork (2015)

Despite all the scores collected from the users are positively satisfied, the least favourable subjects with low rating of user satisfaction are tabulated accordingly in Table 4.1.2.

Table 4.1.2 The criteria with low rating of user satisfaction

Question no.	Question subject	Score
Part III No. 1	Noise level	13.58
Part VII No. 1	Amount of working space	17.90
Part III No. 3	Thermal comfort	19.44
Part VII No. 2	Management of building	20.18
Part V No. 4	Layout of interior design	20.37

Source: Fieldwork (2015)

Noise level is the criteria which received the lowest rating of user satisfaction in all the buildings. The typical noises generated in the student dormitories are loud voices, entertainment devices, human activities and machinery. Any activity conducted in the room will affects the other roommate which will results in any inconvenience. The disturbing and annoying music will affect the students to have difficulties in sleeping. In addition, the noises produced from the HVAC systems such as old ceiling fans can contribute to the noise level in the room. The reason behind this is the fans in the student dormitories are very old and produce noise when it is switched on. The second criteria which has less favourable rating of user satisfaction is amount of working space in the room. The rooms in the residential

colleges with more or less 17 m^2 are in compliance with the Standards for Houses in Multiple Occupation. They are also in compliance with the requirement of UBBL 1984 where the area of all other rooms are more than 6.5 m^2. It is common for the high expectation of the youngsters as their demand for space are considerably high. Thermal comfort is the third criteria which has low rating of user satisfaction. This is because there is no cross ventilation of wind in the building. The wind is blowing from east to south whereas the windows are installed on the north and south of the buildings. This is resulting in low circulation of air in the room. The fourth criteria which has less favourable rating of user satisfaction is management of building. Perhaps this is not a surprise as the students who are the youngsters have the higher expectations when it comes to the review of management of building. In reality the perceived performances of the services are always lower than the expectations of the students. Last but not least, one of the criteria with low rating in terms of user satisfaction is the layout of interior design in the room. The cause of this issue is the juniors are required to sleep on the double decker bed whereas the senior is allowed to use single bed. This biased decision has resulted in the students to have unsatisfactory perceptions on the quality of living in the dormitories.

Based on the collective feedback on the user satisfaction, a designer shall take the noise level in the room into account when designing a dormitory. Sound absorption material should be used in the room to reduce background noise and avoid the noise from escaping. In addition, the designer should emphasize on the planning of amount of working space in the room in order to provide fair and just services. The air movement will be increased if more openings and windows are provided and hence more fresh air are provided in the room. The building owners of the dormitory should take the students seriously and improve their services accordingly as the students are the future of our nation.

4.2 Perceived Degree of Importance in Terms of Factors in the Design of Dormitory

Figure 2 indicates the level of average scores of degree of importance that is collected from a total of 85 respondents in all the buildings. When the level of average importance scores goes higher, the higher the ranking of average scores of degree of importance by the occupants. As shown in Figure 2, health level in the room is indicated as the most important factor. It is noticed that the occupants are aware of the importance of building design would impact on the health level of any individual in the room. Indoor environmental quality is essential to the health of the occupants in the building because the occupants spend most of his/her time to stay within the building. It shows that electrical lighting is the second important factor. Electrical lighting is essential to the students as it generates lighting source at night to enable the students to carry out daily activities such as studying, learning, reading and other activities in the room. Without the electric lighting, the students are not able to study at night and consequently will result in loss of academic achievement. The third, fourth and fifth important factors are the amount of working space, layout of internal design in the room and the management of building respectively. There are variations in terms of the occupants' perceptions in the degree of importance of factors. For example, the factor of amount of daylight is ranked 11th as the factor of glare level is ranked 15th. The authors noted there are correlation in the ranking of the importance of the factors. For example, air movement is ranked 7th out of 22th and thermal comfort is ranked 8th out of 22th. Glare level is ranked 15th out of 22th and distance away from window is ranked 16th out of 22th. Apparently, the factors of colour, attractiveness and outer appearance of building that fall under the aesthetic group are perceived as the least important factors in the design of dormitory. Perhaps due to the payment for the rental is not much, there is no necessity for the students to have very good services in the students' dormitories. In addition, the expectation of the students for the aesthetic value of the design of dormitories is not that high.

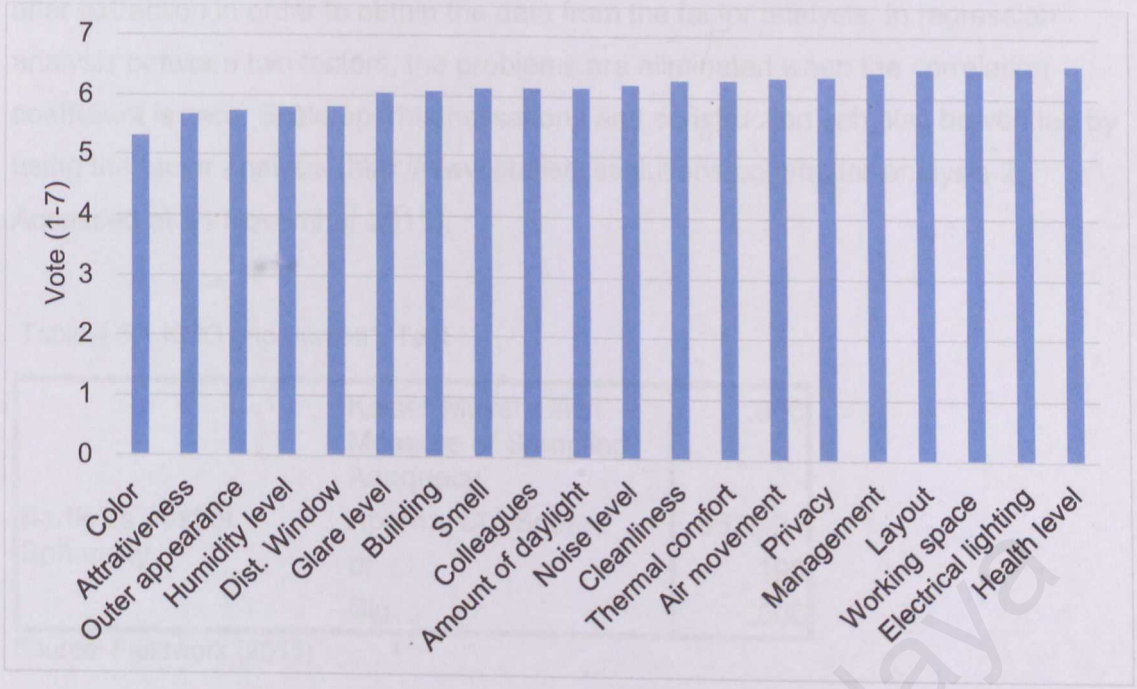

Figure 4.2 Level of average importance scores

Source: Fieldwork (2015)

4.3 Factor Analysis

A number of researchers have using factor analysis to identify the effects of various factors that affect the occupants' satisfaction in terms of local environment matters (J.C. Vischer, 1989 & F.H. Rohles et. al., 1995). Despite the researchers are widely using the prediction models and analytical hierarchy process, the evidence of validity of measures can be provided by making use of other models such as instrument development, psychometric theory, and research, statistics and design (Chiang and Lai 2002, Lee and Burnett 2006, Han, Yang et al. 2009, Lai, Mui et al. 2009).

The factor analysis is an explorative analysis where the information in a model is reduced by means of decreasing the dimensions from the observations. The purpose of factor analysis is to simplify the data in which the number of variables in the predictive regression models are reduced. The factors are rotated

after extraction in order to obtain the data from the factor analysis. In regression analysis between two factors, the problems are eliminated when the correlation coefficient is zero. Scale operationalisations and construction can also be verified by using the factor analysis (http://www.statisticssolutions.com/factor-analysis-2. Accessed at 24 November 2015).

Table 4.3.1 KMO and Bartlett's Test

	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.806
Bartlett's Test of Sphericity	Approx. Chi-Square	963.421
	df	190
	Sig.	.000

Source: Fieldwork (2015)

The correlation matrix among the 20 items is analysed in order to determine the factorability of the data in this study. It is found that the sampling adequacy is satisfied when the figure of the Kaiser-Meyer-Olkin measure of sampling adequacy is 0.806 since it is greater than 0.5 (Table 4.3.1). Varimax rotation is used in the process of principal component extraction. Five-factor solution can be produced from the number of factors extracted. It is suggested in Kaiser's criterion to select the variables with those eigenvalues more than one. Five factors is identified from the true number of implicit dimensions in the scree pot (Figure 4.3.2). Only five factors have been identified as the eigenvalue of factor six is less than one.

Table 4.3.2 Total variance explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	7.962	39.811	
2	2.079	10.393	
3	1.576	7.879	
4	1.320	6.601	
5	1.095	5.473	
6	.868	4.342	74.499
7	.818	4.092	78.591
8	.647	3.234	81.825
9	.522	2.610	84.435
10	.478	2.388	86.823
11	.444	2.218	89.042
12	.387	1.934	90.976
13	.337	1.684	92.660
14	.317	1.583	94.242
15	.287	1.434	95.676
16	.254	1.269	96.945
17	.222	1.110	98.055
18	.184	.921	98.976
19	.116	.582	99.558
20	.088	.442	100.000

Extraction Method: Principal Component Analysis.

Source: Fieldwork (2015)

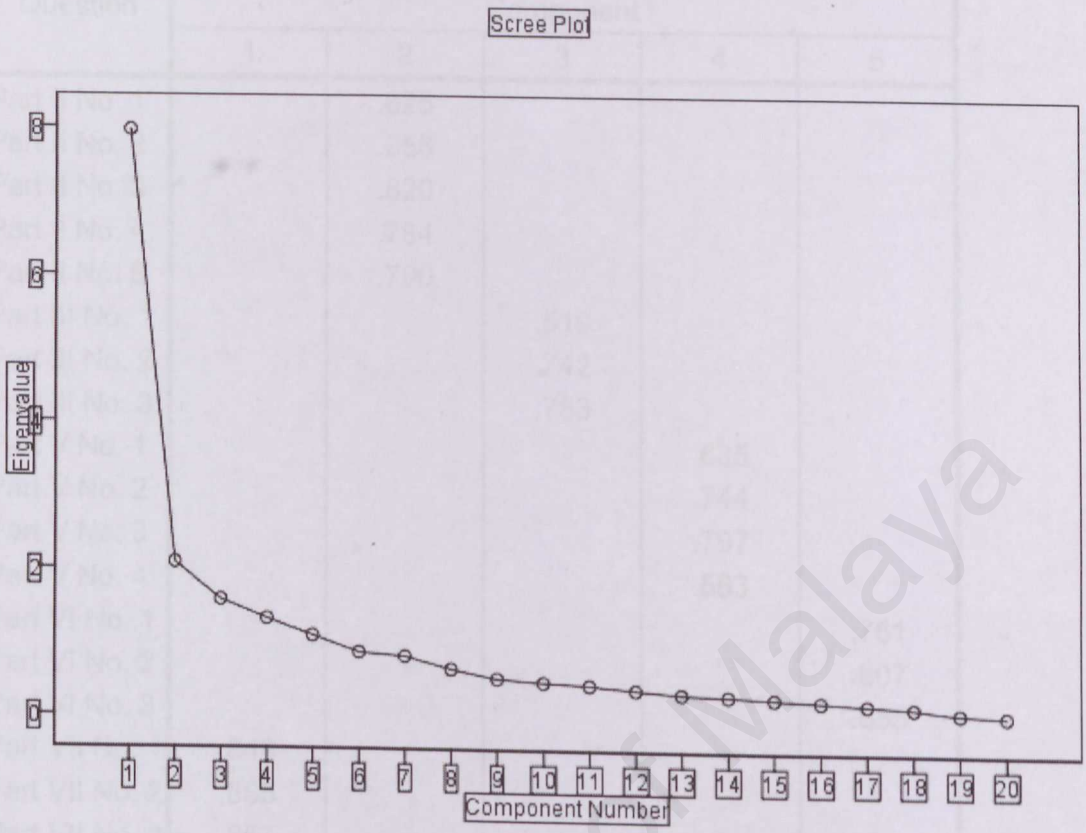

Figure 4.3.1 Scree plot of eigenvalues against all factors

Source: Fieldwork (2015)

The variables can be identified from the analysis of the communalities. High values of communalities can be observed in the Table 7 and most values are found to be greater than 0.6. Hence it is to say that the factor solution is adequate to identify the variables. In Table 4.3.1, the eigenvalues are observed to be identified for the five factors where the range is from 7.962 to 1.095. Principal component analysis is used in this study to identify the component of each variable as shown in Table 4.3.3. The variables are sorted by size and grouped with suggested interpretative labels.

Table 4.3.3 Rotated Component Matrix

Question	Component				
	1	2	3	4	5
Part II No. 1		.625			
Part II No. 2		.656			
Part II No. 3		.820			
Part II No. 4		.764			
Part II No. 5		.790			
Part III No. 1			.519		
Part III No. 2			.742		
Part III No. 3			.783		
Part V No. 1				.635	
Part V No. 2				.744	
Part V No. 3				.797	
Part V No. 4				.563	
Part VI No. 1					.761
Part VI No. 2					.807
Part VI No. 3					.655
Part VII No. 1	.848				
Part VII No. 2	.865				
Part VII No. 3	.857				
Part VII No. 4	.734				
Part VII No. 5	.576				

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Source: Fieldwork (2015)

Table 4.3.4 shows groping of variables sorted by size. Factor one is identified as air quality which consists of the variables such as smell, the amount of air movement, the health condition, humidity level and the cleanliness of the room. Factor two is identified as intrusion which consists of the variables such as thermal comfort, glare level and noise level in the room. Factor three is titled with Intrusion which consists of the variables such as outer appearance, attractiveness, colour and layout of internal design in the room. Factor four is identified as lighting which consists of the variables such as the distance away from window, the amount of daylight and electrical lighting in the room. Factor five is identified as general which

consists of the variables such as management, privacy, amount of working space, immediate colleagues and building in general.

Table 4.3.4 Grouping of variables sorted by size

Factor 1: Air quality			
1	0.82	Part II No. 3	Smell in the room
2	0.79	Part II No. 5	Amount of air movement
3	0.76	Part II No. 4	Health condition when in the room
4	0.66	Part II No. 2	Humidity level in the room
5	0.63	Part II No. 1	Cleanliness and maintenance of the room
Factor 2: Intrusion			
1	0.78	Part III No. 3	Thermal comfort in the room
2	0.74	Part III No. 2	Glare level in the room
3	0.52	Part III No. 1	Noise level in the room
Factor 3: Appearance			
1	0.80	Part V No. 3	Outer appearance of building
2	0.74	Part V No. 2	Attractiveness of the room
3	0.64	Part V No. 1	Colour of the room
4	0.56	Part V No. 4	Layout of internal design in the room
Factor 4: Lighting			
1	0.81	Part VI No. 2	Distance away from window
2	0.76	Part VI No. 1	Amount of daylight
3	0.66	Part VI No. 3	Electrical lighting
Factor 5: General			
1	0.87	Part VII No. 2	Management of the building
2	0.86	Part VII No. 3	Privacy of you in the room
3	0.85	Part VII No. 1	Amount of working space of you have in the room
4	0.73	Part VII No. 4	Immediate colleagues
5	0.58	Part VII No. 5	Building in general

Source: Fieldwork (2015)

4.4 The Analysis of Total Variance

A further analysis is carried out on the differences of each factor that contributes to the occupants' satisfaction in indoor environmental condition according to the six factor scores produced. One-away ANOVA and t-test are carried out by using SPSS to identify the significant differences of the mean scores that are sorted in five group.

Table 4.4 One-way ANOVA and t-test on mean scores that are sorted in five group

Sample	N		Air Quality	Intrusion	Appearance	Lighting	General
Gender		t	13.97**	4.73**	4.65**	1.50	1.11
Student		t	1.07	0.32	0.05	0.35	1.19
Nationality		t	-	-	-	-	-
Race		F	2.56**	1.28	2.94**	0.98	1.65
Dormitory		F	0.17	0.77	0.33	2.35*	1.51
Hours spent		F	0.97	0.23	0.21	1.15	6.64**

F: F ratio oneway analysis of variance; t: t-test for independent samples.

* $p < 0.01$.

**$p < 0.05$.

Source: Fieldwork (2015)

4.4.1 Analysis One: Gender

The questionnaire has two groups: group one – female (n=40) and group two – male (n=45).

The t-test for independent samples found highly significant differences at the 1% level of significance, in the factor scores of "Air Quality", "Intrusion" and "General". Higher mean score of the "male" group indicates that the "male" group has a greater preference.

The mean score of the "male" group is higher than the "female" group in the factor scores of "Air Quality" and "Intrusion". This means that the "male" group is satisfied with the factor scores of "Air Quality" and "Intrusion". However, the mean score of the "female" group is higher than the "male" group in the factor score of "Appearance". This shows that the "male" group has a higher satisfaction perception on the factor scores of "Appearance", "Management" and "Lighting".

4.4.2 Analysis Two: Student

There are two subgroups based on the group of student: group one – undergraduate (n=82) and group two – post-graduate (n=3).

The t-test for independent sample found no significant difference in all the factor scores.

The mean score of the "undergraduate" group is higher than the "post-graduate" group in the factor scores of "Air Quality", "Intrusion", "Appearance" and "Lighting", indicating that the "undergraduate" group is satisfied with the factor scores. Meanwhile, the mean score of the "post-graduate" group is higher than "undergraduate" group in the factor score of "Management", implying that the "undergraduate" group is satisfied with "Management" factor score.

4.4.3 Analysis Three: Nationality

There is only one subgroup which is "Malaysian".

The ANOVA test and t-test are unable to be carried out since there is only one subgroup.

There is no international students staying in the first, second, third and fourth residential colleges. Majority of the students staying in the residential colleges are local student from Malaysia. Most international students would like to stay in tenth and twelfth residential colleges as the facilities and services provided are much better as compared to the remaining residential colleges and the university policy is encouraging the international students to stay in tenth residential college.

4.4.4 Analysis Four: Race

There are seven subgroups based on the race of student: group one – "Malay" (n=35), group two – "Chinese" (n=37), group three – "Indian" (n=9), group four – "Kristang" (n=1), group five – "Indian Muslim" (n=1), group six – "Iban" (n=1) and group seven – "Bumiputera" (n=1).

The ANOVA test found highly significant differences at the 1% level of significance in the factor scores of "Air Quality" and "Appearance".

In terms of "Intrusion" factor, the mean score of "Malay", "Chinese" and "Kristang" is higher than "Indian", "Indian Muslim, "Iban" and "Bumiputera". The perceptions of the large group such as "Malay" and "Chinese" and the small group, "Kristang" are overall satisfactory with the factore score of "Intrusion".

4.4.5 Analysis Five: Dormitory

There are four subgroups based on the dormitory: group one – "First Residential College" (n=21), group two – "Second Residential College" (n=20), group three – "Third Residential College" (n=20) and group four – "Fourth Residential College (n=25).

The ANOVA test found high significant difference at the 5% level of significance in the factor score of "Lighting".

In terms of the factor score of "Lighting", the mean scores of "Third Residential College" and "Fourth Residential College" are higher than "First Residential College" and "Second Residential College". There are sufficient openings in Third Residential College and Fourth Residential College to allow the daylighting to enter the room.

4.4.6 Analysis Six: Number of Hours Staying in the Room

There are five subgroups based on number of hours staying in the room: group one – "Less than 1 hour" (n=0), group two – "1-3 hours" (n=3), group three – "3-5 hours" (n=9), group four – "5-8 hours" (n=33), group five – "More than 8 hours" (n=41).

The ANOVA test found high significant difference at the 1% level of significance in the factor score of "General".

In terms of the factor score of "General", the mean score of "1-3 hours" is significantly higher than the rest of the group. It is noticed that the students who stay lesser time in the room are more satisfied with the management of building. This means that the students who stay lesser time in the room are usually outdoor and they appreciate the facilities and services provided by the management of building.

CHAPTER 5

CHAPTER 5

Conclusion

5.1 Conclusion

This paper presents a study of indoor environmental quality in four dormitories in University of Malaya by means of a set of questionnaires. A comparison of data and results is carried out based on the questionnaires. A combination of factors scores allow all the variables in the questionnaires to be condensed into five factors. The information is extracted from the analysis towards the factor of gender, student job, building and the hours spent in the room. It is reported that the noise level, working space and thermal comfort, have the least user satisfaction. The most important scores in terms of factors in the design of dormitory are health level, electrical lighting, working space, layout of internal design in the room and management of building. The user satisfaction fingerprint can be condensed to five factors by using a combination of factor scores. Validity of the user satisfaction fingerprint and the double Likert methodology is shown in this study.

From the on-site survey and site visit, the typical noises generated in the student dormitories are loud voices, entertainment devices, human activities and machinery. The noises produced from the HVAC systems such as old ceiling fans can contribute to the noise level in the room. The designer of the dormitory needs to take account of the noise level and reduce the noise level by installing soundproof material in the room. It is not a surprise to find that working space is addressed as

one of the most dissatisfied factors in indoor environmental quality. The rooms in the residential colleges with more or less 17 m^2 are in compliance with the Standards for Houses in Multiple Occupation. They are also in compliance with the requirement of UBBL 1984 where the area of all other rooms are more than 6.5 m^2. It is common for the high expectation of the youngsters as their demand for space are considerably high. Thermal comfort is reported to be one of the most dissatisfied factors in terms of indoor environmental quality in the dormitory. This is because there is no cross ventilation of wind in the building. The wind is blowing from east to south whereas the windows are installed on the north and south of the buildings. This is resulting in low circulation of air in the room. The designer shall make use of the design of the orientation of the building to utilise the effect of cross ventilation in order to produce thermal comfort. Good quality building materials should be used in the design of the designer in order to maintain the value of the property. If the building tenants are satisfied with the indoor environmental quality in the building, the demand for the other user to wish to move in the building will increase.

5.2 Recommendation

The designer of the dormitory needs to take account of the noise level and reduce the noise level by installing soundproof material in the room. The building owner needs to have a good planning on the allocation of the students in one room. Good quality building materials should be used in the design of dormitory. The purpose of design intents is primary to play a role in providing a comfortable and productive atmosphere to the building occupants. The information on the comfort and needs of building users can be collected from a pre-design charrette by collecting responses from the building occupants prior to the design stage. Quality of indoor environment could be improved by submitting the feedback that collected from the building occupants to the building owner if there is a need to implement change in the quality of indoor environment. A benchmark can be produced from a pool of analysis in order to provide the requirement and need from the building user in the building design and environment. The findings from this study not only can

identify the problems which can result in declining building performance, but also can help the building to last longer in the future.

List of Reference

A. Montzamani, W. Mike, F. Nicol., 2012. Aircraft noise, overheating and poor air quality in classrooms in London primary school. Building and Environment, 52, pp. 129–141

Appleton, J., 1988. Prospects and refuges revisited. In Environmental aesthetics: Theory, research, and application (pp. 27–44). New York: Cambridge University Press.

ASHRAE Standard 55-2004. Thermal environmental conditions for human occupancy. Atlanta: American society of heating, refrigerating, and airconditioning engineers; 2004.

ASHRAE Standard 62.1. Ventilation for acceptable indoor air quality. Atlanta: American society of heating, refrigerating, and air conditioning engineers; 2007.

Bailey, R. J., Grimm, C. M., & Davoli, C., 2006. The real effect of warm-cool colors. Tech. rep. WUCSE-2006-17, Department of Computer Science and Engineering - Washington University in St. Louis.

Baird, G., Gray, J., Isaacs, N., Kernohan, D. and Mcindoe, G., 1996. Building Evaluation Techniques, New York, McGraw-Hill

Berlyne, D. E., 1972. Aesthetics and Psychobiology. New York: Appleton.

Chiang, C.-M. & C.-M. Lai, 2002. "A study on the comprehensive indicator of indoor environment assessment for occupants' health in Taiwan." Building and Environment 37(4): 387-392.

Chiara, J. and Callender, J., 1980. Time Saver Standards for Building Types, 2nd edn, New York, McGraw-Hill.

Cowan J. P., 1994. Handbook of environmental acoustics. New York: Van Nostrand Reinhold

Davies, H., 2010. The Psychological and Physical Needs of Workers Impacting Office Design, In: Proceedings of the RICS Foundation Construction and Building Research Conference, 2-3 September 2010, COBRA, London, England: 1-15.

de Dear R, Brager GS. Developing an adaptive model of thermal comfort and preference. ASHRAE Trans 1998;104(1):145-67

DiNardi, S. R., 1998. Ergonomics. In DiNardi, S. R. (Eds.), The Occupational Environment-Its Evaluation and Control (726-775). Fairfax, Virginia: American Industrial Hygiene Association.

Duque L. C., & Weeks, J. R., 2010. Towards a model and methodology for assessing student learning outcomes and satisfaction. Quality Assurance in Education, 18(2), 84-105. doi:10.1108/09684881011035321

E. Wyse, S., 2012. Which is More Effective: Paper-Based Surveys or Online Surveys?. SnapSurveys. Retrieved from http://www.snapsurveys.com/blog/which-is-more-effective-paper-based-surveys-or-online-surveys/

EN 12464-1. Light and lighting - lighting of work places - part 1: indoor work places. Brussels: European committee for standardization; 2002.

EN 12665. Light and lighting e basic terms and criteria for specifying lighting requirements. Brussels: European committee for standardization; 2002.

Epstien, B .L., 1997. Pollutants Clouding Environment Review.

Franz, G., von der Heyde, M., & Bülthoff, H. H., 2005a. An empirical approach to the experience of architectural space in virtual reality: Exploring relations between features and affective appraisals of rectangular indoor spaces. Automation in Construction, 14(2), 165–172.

Franz, G., von der Heyde, M., & Bülthoff, H. H., 2005b. Predicting experiential qualities of architecture by its spatial properties. In B. Martens & A. G. Keul (Eds.), Designing Social Innovation: Planning, Building, Evaluating, pp. 157–166 Cambridge, MA. Hogrefe and Huber.

Frieling, H., 1974. Farbe im Raum: Angewandte Farbenpsychologie [Color in space: Applied color psychology]. München, Germany: Callwey Verlag. Giedion, S. (1941). Space, Time and Architecture. Cambridge, MA: Harvard University Press.

G.J. Levermore, 1994. A questionnaire and rating score method for occupants' assessment of indoor environment, University of Manchester.

Georgia Department of Natural Resources, 2015. What makes a property historic. Retrieved from http://georgiashpo.org/faq_what_makes_a_property_historic

Giedion, S., 1941. Space, Time and Architecture. Cambridge, MA: Harvard University Press.

Graetz, K. A. & Goliber, M. J., 2002. Designing collaborative learning places: Psychological foundations and new frontiers. New Directions for Teaching and Learning, 92, 13-22.

Han, J., et al., 2009. "A comparative analysis of urban and rural residential thermal comfort under natural ventilation environment." Energy and Buildings 41(2): 139-145.

Haverinen-Shaughnessy, U., Shaughnessy, R. J., Cole, E. C., Toyinbo, O., & Moschandreas, D. J., 2015. An assessment of indoor environmental quality in schools and its association with health and performance. Building and Environment, 93, Part 1, 35-40. doi: http://dx.doi.org/10.1016/j.buildenv.2015.03.006

ISO 7730. Moderate thermal environments e determination of the PMV and PPD indices and specification of the conditions for thermal comfort. Geneva: International organization for standardization; 1993.

Joedicke, J., 1985. Raum und Form in der Architektur : Über den behutsamen Umgang mit der Vergangenheit [Space and Form in Architecture]. Stuttgart, Germany: Kraemer.

Kamaruzzaman, SN; Zawani, MA; Zuraidah, MD; PITT, M, 2010. Occupant feedback on indoor environmental quality in refurbished historic buildings.

Küller, R., 2001. The architectural psychology box of infinite knowledge. In Aesthetics, well-being and health: essays within architecture and environmental aesthetics (pp. 129–142). Aldershot, UK: Ashgate.

Lai, A. C. K., et al., 2009. "An evaluation model for indoor environmental quality (IEQ) acceptance in residential buildings." Energy and Buildings 41(9): 930-936.

Lee, M. C., Mui, K. W., Wong, L. T., Chan, W. Y., Lee, E. W. M., & Cheung, C. T., 2012. Student learning performance and indoor environmental quality (IEQ) in air-conditioned university teaching rooms. Building and Environment, 49, 238-244. doi: http://dx.doi.org/10.1016/j.buildenv.2011.10.001

Lee, W. L. and J. Burnett, 2006. "Customization of GBTool in Hong Kong." Building and Environment 41(12): 1831-1846.

Mehrabian, A. & Russell, J. A., 1974. An Approach to Environmental Psychology. Cambridge, MA: MIT Press

Nemcsics, A., 1993. Colour Dynamics: Environmental Colour Design. London, UK: Ellis Horwood.

Newman, O., 1996. Creating Defensible Space. Washington: US Department of Housing and Urban Development

Roberts, L. W., 2009. Measuring school facility conditions: An illustration of the importance of purpose. Journal of Educational Administration 47(3), 368– 380. doi:10.1108/09578230910955791

Rohles, F.H., Woods, J.E., Money, P.E., 1995. Indoor environment acceptability: the development of a rating scale, ASHRAE Transactions 95 (1)

Russell, J. A. & Snodgrass, J., 1987. Emotion and the environment. In Handbook of Environmental Psychology, (pp. 245–280). New York: John Wiley and Sons.

Russell, J. A., 1988. Affective appraisals of environments. In Environmental aesthetics: Theory, research, and application (pp. 120–132). New York: Cambridge University Press.

Salleh, N. M., Kamaruzzaman, S. N., Riley, M., Ahmad Zawawi, E. M., & Sulaiman, R., 2015. A quantitative evaluation of indoor environmental quality in refurbished kindergarten buildings: A Malaysian case study. Building and Environment. doi: http://dx.doi.org/10.1016/j.buildenv.2015.11.002

Sarbu, I., & Pacurar, C., 2015. Experimental and numerical research to assess indoor environment quality and schoolwork performance in university classrooms. Building and Environment, 93, Part 2, 141-154. doi: http://dx.doi.org/10.1016/j.buildenv.2015.06.022

Stamps, A. E., 2000. Psychology and the aesthetics of the built environment. Boston, MA: Kluwer

Stamps, A. E., 2005. Isovists, Enclosure, and permeability theory. Environment and Planning B: Planning and Design, 32, 735–762.

Standards for Houses in Multiple Occupation, 2004. Scottish Executive. Edinburgh.

Turunen, M., Toyinbo, O., Putus, T., Nevalainen, A., Shaughnessy, R., & Haverinen-Shaughnessy, U., 2014. Indoor environmental quality in school buildings, and the health and wellbeing of students. International Journal of Hygiene and Environmental Health, 217(7), 733-739. doi: http://dx.doi.org/10.1016/j.ijheh.2014.03.002

U.S. Environmental Protection Agency Buildings and the Environment, 2004. A Statistical Summary. US EPA Green Building Workgroup, retrieved June 21, 2009 from http://www.epa.gov/greenbuilding/pubs/gbstats.pdf.

Uniform Building By-Laws 1984. MCD Publishers Printers. Kuala Lumpur.

University of Malaya (2015). Retrieved 29 November 2015, from https://www.um.edu.my/student-life/accomodation/residential-colleges/

Vischer, J.C., 1989. Environmental quality in offices. New York: Van Nostrand Reinhold.

Wright, T. A., Cropanzano, R., Denney, P. J., Moline, G. L., & Park R., 2002. When a Happy Worker is a Productive Worker: A Preliminary Examination of Three Models. Canadian Journal of Behavioral Science, 34(3), 146-150.

Zahran, M., 1972. College Housing: An Arena of Involvement and Conflict, Beirut Arab University, Lebanon.

APPENDIX A

Surveys

Questionnaire – The effect of indoor environmental quality on occupants' perception of performance in old student dormitories of University of Malaya

Instructions

Please check the box ☑ that best corresponds to your answer for each question below.

Part I Background Information

1. Gender:

   ☐ Male ☐ Female

2. Student:

   ☐ Undergraduate ☐ Post-Graduate

3. Nationality:

   ☐ Malaysian ☐ International

4. Race:

   ☐ Malay ☐ Indian

   ☐ Chinese ☐ Others:_____

5. Where are you staying now?

   ☐ 1st Residential College ☐ 2nd Residential College

   ☐ 3rd Residential College ☐ 4th Residential College

6. In a typical day, how many hours you stay in your room usually?

☐ <1 hour ☐ 1-3 hours

☐ 3-5 hours ☐ 5-8 hours

☐ >8 hours

Part II Perceptions of the air quality of the room

Please state your level of satisfaction based on the rating (strongly dissatisfied, -3 to strongly satisfied, 3)

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Cleanliness and maintenance of the room							
2	Humidity level (high dense water vapour in air)							
3	Smell in the room							
4	Your health when in the room							
5	Amount of air movement (stale or windy)							

Please state your opinion on the importance of the following factors in the design of dormitory (strongly unimportant, -3 to strongly important, 3)

No.	Item	Unimportant				Important		
		-3	-2	-1	0	1	2	3
1	Cleanliness and maintenance of the room							
2	Humidity level (high dense water vapour in air)							
3	Smell in the room							
4	Your health when in the room							
5	Amount of air movement (stale or windy)							

Part III **Perceptions of the intrusion of the room**

Please state your level of satisfaction based on the rating (strongly dissatisfied, -3 to strongly satisfied, 3)

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Noise level							
2	Glare level in the room							
3	Temperature (thermal comfort)							

Please state your opinion on the importance of the following factors in the design of dormitory (strongly unimportant, -3 to strongly important, 3)

No.	Item	Unimportant				Important		
		-3	-2	-1	0	1	2	3
1	Noise level							
2	Glare level in the room							
3	Temperature (thermal comfort)							

Part IV **Perceptions of the appearance of the room**

Please state your level of satisfaction based on the rating (strongly dissatisfied, -3 to strongly satisfied, 3)

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Color of the room							
2	Attractiveness of the room							
3	The outer appearance of your building							
4	Layout of internal design i.e, sitting, study desk and bed							

Please state your opinion on the importance of the following factors in the design of dormitory (strongly unimportant, -3 to strongly important, 3)

No.	Item	Unimportant				Important		
		-3	-2	-1	0	1	2	3
1	Color of the room							
2	Attractiveness of the room							
3	The outer appearance of your building							
4	Layout of internal design i.e, sitting, study desk and bed							

Part V Perceptions on the lighting of the room

Please state your level of satisfaction based on the rating (strongly dissatisfied, -3 to strongly satisfied, 3)

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Amount of daylight							
2	Distance you are away from window (Very far, -3 to very near, 3)							
3	Electrical lighting							

Please state your opinion on the importance of the following factors in the design of dormitory (strongly unimportant, -3 to strongly important, 3)

No.	Item	Unimportant				Important		
		-3	-2	-1	0	1	2	3
1	Amount of daylight							
2	Distance you are away from window (Very far, -3 to very near, 3)							
3	Electrical lighting							

Part VI General Perceptions of the room

Please state your level of satisfaction based on the rating (strongly dissatisfied, -3 to strongly satisfied, 3)

No.	Item	Dissatisfied				Satisfied		
		-3	-2	-1	0	1	2	3
1	Amount of working space you have in the room							
2	Management of building							
3	Privacy you have in the room							
4	Immediate colleagues							
5	Building in general							

Please state your opinion on the importance of the following factors in the design of dormitory (strongly unimportant, -3 to strongly important, 3)

No.	Item	Unimportant				Important		
		-3	-2	-1	0	1	2	3
1	Amount of working space you have in the room							
2	Management of building							
3	Privacy you have in the room							
4	Immediate colleagues							
5	Building in general							

APPENDIX B

Authorization Letter

UNIVERSITI
MALAYA

UM.B/606/BS
23 November 2015

KEPADA PIHAK YANG BERKENAAN

Tuan/Puan,

KEBENARAN MEMBUAT KAJIAN DAN MENDAPATKAN MAKLUMAT

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pelajar di bawah ialah pelajar Program Ijazah Sarjana Muda Ukur Bangunan, Fakulti Alam Bina, Universiti Malaya. Pelajar ini sedang menjalankan kajian bagi penyediaan tesis kursus **BCEC 4280 – Project Academic**. Sehubungan dengan itu, pihak kami memohon jasa baik tuan/puan untuk membenarkan pelajar di bawah membuat kajian serta mendapatkan maklumat di organisasi tuan/puan.

Nama Pelajar	**No. Matrik**
Chu Kok Wei	BEB 120022

3. Sebarang kemusykilan dan pertanyaan boleh diajukan kepada Dr. Norhayati Mahyuddin di talian 03-7967 2455. Kerjasama dan perhatian pihak tuan/puan amat dihargai dan didahului dengan ucapan terima kasih.

Sekian, terima kasih.

Yang benar,

***Sr* NORHAYATI MAHYUDDIN, PhD**
Ketua
Jabatan Ukur Bangunan

Fakulti Alam Bina
Universiti Malaya, 50603 Kuala Lumpur, MALAYSIA • Tel: (603) 7967 5320 / 6899 • Faks: (603) 7967 5713 • Website: www.um.edu.my