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Step by step approach for qualitative data analysis

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ABSTRACT

The application of qualitative techniques is increasing and acceptable among the researchers. However, majority of the researchers and postgraduate students did not consider the importance of giving detailed procedures in qualitative data analysis for better understanding of the qualitative results. There is a need to uncover step by step approach in qualitative analysis for better application of qualitative techniques. This article presented a detailed step-by-step approach for qualitative analysis with the aid of a pragmatic illustration. The analytic process presented employed the example of qualitative data transcribed into narrative data to develop basic themes. The employment of Domain Analysis and Thematic Network analysis in the example given helped basic themes to converge to higher order themes. The article submitted that this approach in qualitative analysis will aid thorough understanding of qualitative data interpretation. This is extremely thoughtful approach for the systematic presentation of qualitative analysis.

1. Introduction

The use of qualitative techniques is becoming more popular and acceptable in the past few decades among researchers (Nazmy, 2016; Braun and Clarke, 2006; Holt, 2010; Hutchison et al., 2010; Peek and Fothergill, 2009; Attride-Stirling, 2001). The employment of qualitative techniques depends on the concept and the objectives of the research as well as the types of information that are needed to achieve the objectives. The exploratory research that depended on the qualitative methods of analysis needed explanation of its deeper meanings and understandings through the subjective views of the respondents (Akinyode, 2017). This is to understand the specific situations, issues and circumstances so as to explain why things actually happen in an environment where the research is being carried out. Literature indicated that many researchers are promoting and applying qualitative techniques which can be termed as

positive step towards a deeper understanding of social and humanity occurrences. However, while these techniques are receiving attention from researchers, majority did not give detailed steps to be taken on how to embark on the analysis for the purpose of better interpretation of the qualitative results.

If the results of qualitative research are to be given better interpretation with the aim of significant and beneficial implementation of the recommendation, the importance of proper understanding of the actual steps to be taken in qualitative data analysis cannot be over-emphasised. However, much attention has not been drawn to the task of how to analyse and present the qualitative data in a logical manner. Certainly, researchers identified the need to report the techniques of data analysis to enhance proper interpretations and assist young researchers in similar research (Fielding and Fielding, 1986; Attride-Stirling,

2001; Braun & Clarke, 2006). Nonetheless, progress in qualitative research literature in the past few decades on different subjects is definitely inspiring (Creswell, 2012b; Miles et al., 2014; Denzin, 2001; Morse, 1994). While some researchers focussed their attention on how to integrate quantitative and qualitative research (A. Bryman, 2006; Alan Bryman, 2007; J. W Creswell & Clark, 2011; Onwuegbuzie & Leech, 2006), some examined the use of the software as a methodology in qualitative research (Hutchison, Johnston, & Breckon, 2010; Jones, 2007). The focus of some researchers was validity in qualitative research (John W Creswell & Miller, 2000; Wagner et al., 2012) while some discussed about different strategies in collecting qualitative data (Corbin & Strauss, 1990; Holt, 2010; Peek & Fothergill, 2009; Roulston, 2010; Walker & Myrick, 2006). Moreover, Attride-Stirling (2001) and Braun and Clarke (2006) studies were limited to thematic analysis approach.

As these techniques are becoming more popular and acceptable in research, it should be certified that, it is applied to enhance robust methodology. However, there is relatively limited guide on how the qualitative method is applied. Agreed with the recent advancement and practice of qualitative analysis, it is imperative to clear that this paper is not trying to limit the sufficient understanding of other researchers on how to analyse qualitative data. Nevertheless, lack of clear and succinct procedures to be taken in the analysis may be frustrating to young researchers (Braun & Clarke, 2006). This necessitates the importance of uncovering step-by-step approach in conducting data analysis approach for easy and better application of qualitative techniques (Attride-Stirling, 2001; Braun & Clarke, 2006). This paper therefore hopes to uncover step-by-step approach in conducting a data analysis through five steps analysis procedures namely Data Logging, Anecdotes, Vignettes, Data Coding and Thematic Network so that the techniques of analysis may be properly interpreted and assist other young researchers in similar research.

This article aims at bridging this research gap and add to the body of knowledge. It details procedure in conducting qualitative data analysis and employs five steps approach in the analysis. The article submitted that this approach in qualitative analysis will aid thorough understanding of qualitative data interpretation. This is extremely thoughtful approach for the systematic presentation of qualitative analyses. The technique in the article provides an empirical example through practical and effective procedures for conducting an analysis in the application of the steps. This enhances logical and systematic steps analysis of qualitative data to facilitate better understanding and interpretation of the research results.

The second section of this paper centres on the literature review that explained the context of qualitative research technique on what qualitative technique is all about and its importance. This is followed by the methodology in order to give brief description of the materials used in the paper. The analytic steps that explained the application of five steps analysis procedures are then presented and discussed in the fourth section of the paper. An empirical example for analytic steps that followed the steps explained in section four using a survey as empirical example in qualitative research technique is the focus of section five before the conclusion in section six.

2. The Context of Qualitative Research Technique

Creswell (2007) described qualitative research technique as a process where the research problem is studied in its natural setting rather than having subjects studied in a laboratory. Collection of information through this method allows for gathering information from multiple sources aimed at understanding the meaning of the problems through the respondents or involved audience. The data collection in qualitative procedures is not restricted by categories but allows for in-depth and detail information (Patton, 1987). Van Maanen (1979) defined Qualitative research approaches as an array of techniques which gives interpretation through decode, describe, translate, and give the meaning that is naturally occurring and not the frequency phenomena. Qualitative research approaches are social or organisational behaviour research approaches that produce results that are not obtain via statistical procedures or other quantification approaches (Naoum, 2008). It is subjective in nature and its meaning and experiences always described verbally. Richards (2005) in his own opinion sees qualitative data as records of observation or interaction that are complex and cannot easily reduce to numbers. People's behaviour research through observation and interview are through qualitative approaches (Johnson and Barach, 2008; Naoum, 2008; Mahmud, 2008). Qualitative approaches give room to a deeper understanding of the subject matters as they exist in their own unique environment (Miles and Huberman, 1994; Miles et al., 2014). Qualitative data can be obtained through open-ended questions which gives opportunity to the participants to provide information that do not restrict the participants' opinion (Creswell and Clark, 2011). The most widely recognized and most widely

used qualitative research approaches are ethnographic, interviews, focus groups and observations.

There are varieties of benefit that can be derived in the use of qualitative techniques. Data collection through qualitative techniques establishes rapport between the interviewee and interviewer. Through this, the interviewer or researcher directs the attention of the interviewee to the material and motivate him or her to carefully answer the questions (McBurney and White, 2007). The questions of which fact could be derived from the respondents or interviewee is the main target in applying qualitative techniques (Johnson and Barach, 2008). It gives room for the researcher to give further and better explanation on questions whenever he takes note that the interviewee misunderstood any question. The advantages of qualitative research approach identified by many scholars include conveniences of the researcher and the respondents, opportunity of taking place at any time, at any place such as respondents' home, on the street, in a respondents' shop or office. Other advantages are face-to-face contact between the researcher and the respondents, taking place in a relaxed and conducive atmosphere, identification of respondents' body language and expressions, accuracy of the data, researcher's control over the pattern of discussion and high response rate (Creswell and Clark, 2011; Dillman, 1978; Erdos and Morgan, 1970; Jackson, 2009; Naoum, 2008; Roulston, 2010; Mahmud, 2008). Cultural anthropology and cultural patterns of a setting gives birth to ethnography as a research approach which gives knowledge of what can be derived from that setting (Johnson and Barach, 2008). Qualitative research questions obviously describe and incline to address questions such as "what" and "how" "to what extent", in what way" (Onwuegbuzie and Leech, 2006). This allowed the collection of information from multiple sources. This prevented data restriction but allowed in-depth information and better understanding through them that gives natural meaning of the phenomenon in a subjective way. This approach obtained data through open-ended questions by face-to-face interview.

Naoum (2008) classified qualitative research approach into exploratory research and attitudinal research. The application of exploratory research is for statement of problems to be cleared and precise when the amount of knowledge on the researched topic is limited. Data collection is usually through interview or focus grouped discussion technique with intention of determining a situation, screening the alternatives and discovering new ideas (Naoum, 2008; Mahmud, 2008). Exploratory research presents the raw data exactly as participants have explained in the open-ended interview, recorded conversation or observation description in the field of study. It gives insights and better understanding about the subject to carry out further investigation. The need for the precision and clarity of the statement of problems on the limited amount of knowledge on a researched topic makes such study to be an exploratory research. The use of attitudinal research evaluate the opinion of the participants, their view and their perception subjectively towards a particular object in terms of variable, factor and question (Naoum, 2008). Generally, the use of theory is less importance in qualitative research approach compared with quantitative approach. Unlike quantitative, no standard terminology or rules about placement of theory at the beginning of qualitative research. It can however be placed towards the end of the study to become the product of the qualitative research. This can serve as hypothesis that quantitative research can test.

3. Methodology

This paper basically employs relevant literature reviews through published researched journal articles, books, conference proceedings, unpublished thesis and monographs. The literature review examined and synthesized underlying subject aimed at identifying issues relating to qualitative research. The relevant literature reviews centred on the subject through Search Engines such as Google scholar, Library of congress, LISTA (EBSCO) and Web of Science core collection (Thompson Reuters). Many literature were consulted through each of these search engines but after winnowing, only thirty-eight were used and quoted in this paper. The selected thirty-eight literature were based on their contents' relevancy to the subject of discussion in this paper. Those that were not directly relevant to the subject were discarded. The analytic process presented employed the example of qualitative data transcribed into narrative data to develop basic themes. The employment of Domain Analysis and Thematic Network analysis in the example given helped basic themes to converge to higher order themes.

This article illustrates the step by step approach in qualitative analysis for better application. In attempt to demonstrate a practical approach, the next section explains the five steps analysis procedures for proper interpretation of qualitative analysis technique. These steps include Data Logging, Anecdotes, Vignettes, Data Coding and Thematic Network. This is followed by an empirical example to elucidate how each step can be implemented in practice.

4. The Analytic Steps in Qualitative Research Technique

Attride-Stirling (2001) divided the qualitative analysis procedure into three main stages and these include the reduction of the text; the exploration of the text and the integration of the exploration. However, it should be noted that there are varieties of ways through which qualitative analyses can be conducted and not limited to this common three-stage process (Attride-Stirling, 2001; Braun & Clarke, 2006). Each of the stages comprises of abstract level of analysis. These can further be divided into stages for better understanding. This article aims at displaying step-by-step approach in conducting a qualitative data analysis through five steps analysis procedures. This is with a view of interpreting accurately the techniques of analysis and assist other qualitative researchers. It is assumed that the preliminary stages in research such as selection of research paradigm, choosing of sampling techniques, participants, development of semi-structured questionnaires if required, data collection, and transcription of field notes have already been completed. The application of five steps analysis procedures as said earlier include Data Logging, Anecdotes, Vignettes, Data Coding and Thematic Network. Each of these is explained in the next sub-sections.

4.1 Data Logging

This is the process through which the raw data from either personal interview, focus grouped discussion, observation or other form of qualitative data collection was recorded in a recorded sheet. The process is also known as data documentation which is the next level after the data collection (Khan, 2008; Easterby-Smith et al., 2008). Data logging meant to serve the purpose of documenting simultaneously the data collected through every form of data collection, researcher's description, feelings, view and insights as well as assumptions and ongoing ideas about the subject matter. The process should be highly interactive that will necessitates the researcher to go back to check against original data (field notes transcripts) to compare occurrences to identify specific issues.

4.2 Anecdotes

This is to streamline the data log to make comprehensive notion of the data collected. It has to be achieved immediately after the researcher get home from the field survey. This takes the narrative form of writing. Khan (2008) saw the Anecdotes as the chronological sequence of transformation actions. This guides the researcher in generating feelings and building the themes. The researcher has to write anecdotes by summarizing the chronological sequence on the narrative explanation given by the interviewee on the subject matter. This can be complemented by the researcher's observation and other forms of data collection like ethnography and photograph. This will help in developing themes.

4.3 Vignettes

Vignette is a useful term in qualitative research to represent narrative or story investigations on the interpretation of person, knowledge or circumstances that the researcher describes. The in-depth description of the setting, participants and themes of qualitative research are the focus of vignettes to establish the credibility of the study. It is a step further deep from anecdotes and reorganizes the multifarious dimensions of its subject for capturing, in a brief representation of the information that needs to be gathered over a period of time (Khan, 2014). This demands more attention and representation of more sense of understanding about the meaning of the research work in order to gives higher level of interpretation. The use of vignettes is to provide as much detail as possible to help the readers having better understanding and get convinced that the account is credible (Creswell and Miller, 2000) through which the readers can make decisions to apply the findings to other settings or similar situations. Vignettes therefore allow higher level of interpretation beyond mere description, higher sense of understanding about the phenomenon and allow the capturing of themes.

4.4 Data Coding

Creswell (2007) and Creswell (2012a) defined coding as the procedure of fragmenting and classifying text to form explanations and comprehensive themes in the data. It is the process through which researcher gather or 'tag' content related to a specific theme or idea (Attride-Stirling, 2001). It aims at reducing the data by sorting out the information transcript into manageable and meaningful transcript segments with the aid of coding framework. Data coding in qualitative research means assigning labels or codes to different sections of text that related with different problems. Miles et al. (2014) described coding as examination of the discrete parts of data for differences and similarities either through 'Open' or 'Axial' coding method. 'Open' coding aims at identifying the discrete concepts while 'Axial' coding is primarily to designate the manner in which links are made in new ways between the

groups and sub-groups (Walker and Myrick, 2006; Corbin and Strauss, 1990; Khan, 2008). Coding helps in separating data into categories (nodes) or themes so that data from different sources can be easily organized and compared. With significant themes coded in this manner, researcher can later examine and retrieve motivating sections and look at them as distinct files.

4.5   Thematic Network

Thematic networks aim at exploring the understanding of a subject or the denotation of an idea not to resolve contradictory explanations of a problem (Attride-Stirling, 2001) which is a means of establishing a thematic analysis of qualitative data. Creswell (2012a) categorized theme as ordinary, unexpected, hard-to-classify and major and minor. According to him, ordinary themes are those a researcher might assume to find, unexpected are the surprised themes which are not anticipated to surface during a study while hard-to-classify themes are those that contain ideas that uneasy to fit into one theme or overlap with several themes. Major one represents major ideas while minor themes are the secondary ideas within the database. The application of Thematic network is a web-like network organizing principle and representing the procedures that were employed from text to interpretation as shown in Figure 1 which was hierarchical level of basic theme, organizing theme and global theme to

show their relationship. However, this technique does not intend or pretend to discern the foundation of arguments or the end of explanations, it simply provided a technique for breaking up text and finding within its explicit explanations and their implicit implication (Attride-Stirling, 2001). The selection of phrases and words depended on research questions which researcher intended to answer. In achieving this, the transcript of the information has to be read repeatedly for proper understanding of the mind of the participants on the subject matter.

Basic theme is the utmost basic or lowest-order that result from the documented data. It demanded to be read within the perspective of other Basic themes in order to make sense beyond its immediate denotation. The combination of two or more Basic themes represent an Organising theme. Organising theme is a middle-order theme that arranged the Basic themes into bunches of similar subjects to condense the principal expectations of a group of Basic themes to reveal what is going on in the texts. Organising theme aims to enrich the meaning and implication of a wider theme that marries several Organising themes. Global theme is a group set of Organising themes seen as macro theme and super-ordinate theme that encompass the principal metaphors in the whole data and a concluding or final theory (grounded up theory). It presents an argument, position and declaration about a given matter or certainty aimed at summarising and making intelligence of bunches of
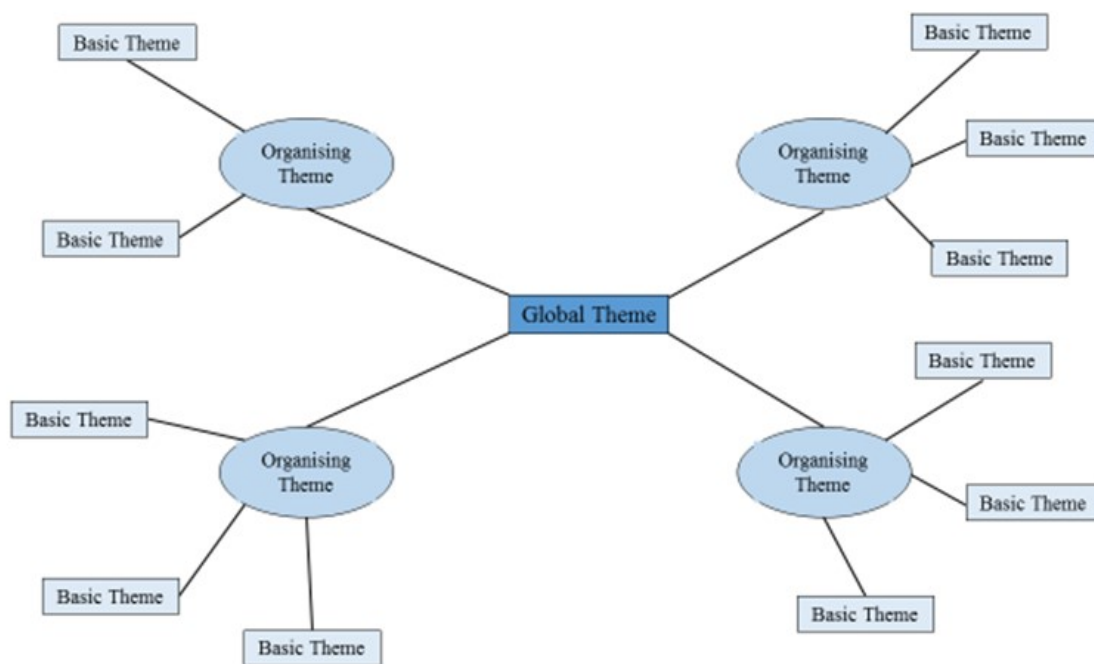
Figure 1: Structure of a Thematic Network (Source: Attride-Stirling, 2001)

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lower-order from the data. It is the summary of the main themes and a revealing explanation of the transcripts that gave the meaning of transcripts as a whole within the context of a given analysis.

5. An Empirical Example for Analytic Steps in Qualitative Research Technique

The illustration used in this article was drawn from the analysis of a survey that focused on factors of affordability in housing in the city of Ibadan, Nigeria (Akinyode, 2017). This aspect of the article highlights the process of analysis and not the content of the interpretation. However, the examples are given where necessary to have meaningful understanding of the processes. This process commence from Data Logging of the interview among 27 participants

5.1 Data Logging

The first step is data logging. In the interview conducted among 27 participants that serves as example in this article, the raw data collected through personal interview, observation and photograph as forms of qualitative data were recorded in a recorded sheet to become data documentation. Researchers' description, feelings, view and insights as well as assumptions and ongoing ideas about the subject matter were also recorded. This was mainly to document the responses from the interview and other forms of qualitative data. The written of these responses was in form of logs that helped in preparing the anecdotes.

5.2 Anecdotes

After the researchers have written down the responses from the participants in form of logs, then they prepared the anecdotes. Anecdotes are the refined version of logs written legibly for the purpose of record. This is the second step in the qualitative data analysis that involved restructuring of the data log to have better understanding of the data collected. In the example given in this article, this was the sequential structuring of transformation activities on housing affordability problems. The researchers summarised the sequential structure of the narrative explanation given by the participants immediately after the data collection to minimise twisting of information and wrote it in form of anecdotes. These were used as the resource to extract references as nodes. This guided the researchers to generate feelings and develop the themes.

5.3 Vignettes

Vignette is the deeper step next to anecdotes that reorganised the diverse magnitudes of the subject for capturing information on the subject matter. The researchers used vignettes to represent in-depth description of collected information in form of narrative story. This was to establish the credibility of the study and have more sense of understanding about the subject to give higher level of interpretation. In the example given in this article, the use of vignettes provided detail to help the readers having better understanding and get convinced that the account is credible. With this, higher level of interpretation beyond mere description, higher sense of understanding about the phenomenon and capturing of themes were achieved. This was to enable the readers make decisions in applying the findings to other settings or similar situations.

5.4 Data Coding

Prior to the analysis of qualitative data, the interview responses were documented in form of 'logs' and later refined into 'anecdotes'. The interview text (anecdotes) through which the researchers gathered and tagged the content related data to a specific theme or idea then became meaningful and manageable text segments. This were used as the resource information in form of open data coding as 'nodes' to extract 'references'. This was to sort, arrange, manage, develop and modify the data. This aimed at preventing inconsistency for thematic development for the purpose of content analysis. The created 'nodes' provided a place to gather and store the relevant pieces of statement defined as 'references'. Based on their similarity, 'codes' created from 'references' allowed 'nodes' to be combined, renamed and deleted in the process of data analysis. At the data coding exercise, the researcher checked the transcription for accuracy and read the data repeatedly to get better understanding of the database. The 'codes' were later verified and refined into smaller numbers of 'refined codes'. However, data coding selected and obtained data carefully to avoid repetition but ignored other data that do not accurately provide evidence for the theme. These were further dissected into contextual meaningful 'keywords' through immersion from which explicit themes were emerged.

Data coding aimed at reducing the data by breaking down the interview text (anecdotes) into meaningful and manageable text segments. It was the process through which the researchers gathered or 'tagged' content related data to a specific theme or idea. 'Nodes' were created to
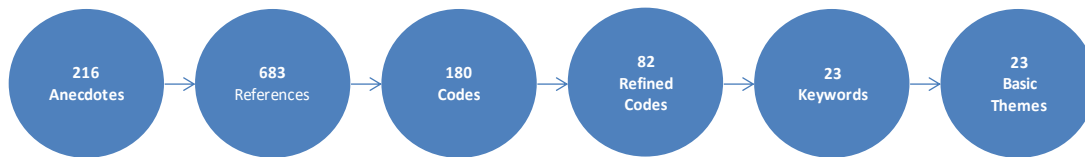
Figure 2: *Refining Qualitative Data into Basic Themes*

gather and store the relevant pieces of statement defined as 'references'. Based on their similarity, 'codes' as the organization of the texts into topics were created from 'references'. The classification of codes was achieved through 'cutting up' of the texts (quotations) and 'pasting' into the created nodes across the interviews. The number of codes was significantly less than that of the references and thus the bulk of data was systematically reduced. These codes were stored in particular 'nodes' (Example in Figure 2). Thus, the main issues discovered in the interview during the course of going through the text were safely stored. These were done to establish the common discourses among all the respondents. At the beginning of the analysis, a total number of 180 'codes' were created from 683 'references' across the 216 anecdotes (27 respondents multiply by 8 questions). This was later verified and refined to 82 'codes' so as to avoid repetition as shown in Figure 2. These were further dissected into 23 contextual meaningful

Table 1: *From Keywords to Basic Themes*

No	Keywords	The Basic Themes
1	Nearness/ Proximity	Proximity to the work-place dictates house location
2	Facility	Users are not satisfied with infrastructural facilities within their residential area in general
3	Educational Level	Users' level of education plays a role in house selection and satisfaction
4	Social	Users ascribe more importance to social prestige and family ties in selecting area of their choice as increased educational level adds to their self-esteem
5	Price	Price determines the type of house they are occupying
6	Low Wage	Low wages of users prevent many from having their personal house
7	Land	Cost of land depends on the location where the land is situated
8	Land Cost	Limited available land increases the cost of land, that affects the values of the house
9	Building Plan	The cost of Building plan preparation, processing and approval puts burden on private developers, which they try to overcome through increased house price
10	House Type	Type of House determines its price, but its value is still an undetermined factor
11	Estate Agent	Involvement of Estate Agent superficially increases the value of the house
12	Land Lord Decision	Landlords' Decision in comparing Lagos market affects the house rents
13	House Situation	Ineffectiveness of housing policy reflects on the housing quality users are building
14	Density	Ineffectiveness of Planning Regulation leads to slum development in newly developing areas
15	Housing Quality	Population increase in urban centre that increases land and housing demand has influence on housing quality
16	Planning Regulation	Conversion of residential house to commercial use leads to housing shortage
17	Housing Demand	Low housing supply resulted from road extension and conversion of residential house to commercial use
18	Housing Shortage	Increase in birth rate and youth migration increase users' population who are seeking for house
19	Housing Supply	Land is too expensive for majority of users
20	Population Increase	There is no more land available in urban centre
21	Expensive Land	The Location of house determines its quality and rents
22	Unavailability of Land	Housing density reflects the users' category with high income households invariably occupying bigger land with less number of housing units
23	Land Speculation	Land speculation through the estate agent becomes problems among users

'keywords' through immersion, from which 23 basic explicit themes were emerged during the preliminary qualitative analysis as shown in Table 1.

5.5 Thematic Network

The thematic network is in three stages and these include basic, organising and global themes. It is the process of exploring the links that exists between the explicit statements and the implicit meanings in respondents' discourse. This provided the tools for the interpretation and organisation of the themes. The development of thematic network started from the basic themes and worked 'inwards' through the organising themes towards a global theme. It is presented and illustrated in a graphic form like web-like nets, to convey the organising principle that creates them, between the outer edges (basic themes) and the inner core (global theme).

5.5.1 Basic theme

The organization of the interview text into different codes at nodes led to exploring the quotations abstracted from the interview context to establish significant and common themes among the respondents. This was done by going through each node to bring out the coded text (quotation) and checking its support across all other sources (interviews). The identification of themes to interpret the code that were significant and those that were less significant were taken into consideration. As the themes were emerging and becoming specific enough to bring out an idea, they were being modified to accommodate the discourse of the majority of the respondents. 23 themes emerged at last in the final analysis as shown table 1.

At this point, a little discussion on explicit and implicit themes can be helpful. Explicit theme is what is obvious from a data. However, for a qualitative researcher, explicitness of data is not enough. There is a search for implicit themes. The expression of the inner meaning of explicit theme is known as implicit theme. While the explicit themes help to make a quick scan of the problems, the implicit themes try to dig deeper and find out the untold stories. Behind every explicit, there are some implicit stories. Though, the number of the implicit themes can be different from the number of the explicit themes but if the objectives of the study are carefully constructed, then, there is likelihood that the number of transformed implicit themes might be the same as the number of explicit themes from which they directly generate. This is a way to reduce complexity. This was

what happened in the example given in this article such that 23 implicit basic themes generated directly from the 23 explicit themes. The Explicit Themes were not uttered but the Implicit Themes emerged through the immersion process directly.

The basic principle in selecting themes at this stage of analysis was simply through 'data saturation' whereby majority of the respondents were saying the same points i.e. referring to the same theme on a particular issue. Majority of the other respondents must support a theme picked up by one respondent before it could be considered as the theme. However, that did not really mean that a theme uttered by only one respondent was discarded. Giving full respect to the nature of qualitative research that values each item rather than the number of the items, those themes were also initially considered before accepting or rejecting. For example, the theme 'housing is cheap in Ibadan' was only mentioned by one respondent and has no support from any other respondent. It was not neglected from the analysis on the grounds that, not enough respondent had seen house rents as cheap and no thorough comparisons and deductions could be obtained, but it was neglected as it did not clearly indicate any significant direction. However, during analysis, it became increasingly common that many themes were repeating. That was why a certain quantitative measure was taken to select a theme. Preference was given to the more common themes under the assumption of looking for common discourses rather than individual narratives or subjective theories.

Moreover, while consideration was given to a data grouping to be saturated if it was replicated in more than 70 percent of the interviews and validated by member checks with the stakeholders, a theme required the support of at least 50 percent of the respondents to be included in the analysis. This was because; respondents may repeat the same thing more than one or two times during the interview that makes the salient points to be more than the number of the respondents. In view of this, data saturation point was considered to be at least 70 percent while the respondent is at least 50 percent. Bearing in mind that a small number of interviewees covered a wide range of housing affordability, care was taken that the selected themes did not enjoy prevalence among one class of respondents (stakeholders), and that they received support across the various stakeholders' groupings. This added a new level of organization to the interviews. Having moved from purely descriptive 'topics', 'categories', and 'codes', this level began the analysis proper by abstracting the coded text from its context and regrouping it into thematic

headings. The 23 significant themes (basic implicit themes) were carried into the next stage of the analysis which was formation of six Organizing themes.

5.5.2 Organizing theme

The procedure of organization and interpretation of the basic themes towards the formation of organizing theme and ultimately to the global theme followed the thematic network method of qualitative analysis (Attride-Stirling, 2001). The 23 basic implicit themes were assembled into unified and coherent structure of six organizing themes according to the fundamental story the basic themes are telling. This was illustrated graphically in a schematic web-like diagram that depicts relevant links as shown in Figure 3. The fundamental matters and discussions shared between 23 basic themes were thereafter identified and expressed through the six Organizing themes.

Though, 23 basic themes derived from the 23 keywords were not documented in any serial during their emergence but followed the way the references were input in the nodes. Nevertheless, there was a need to group them according to their topic in order to derive organizing theme. This was done in two phases. First, the themes that talked about similar topic were grouped. Second, they were put in an order in a way that the preceding one leads or is connected with the following one as reflected in Table 2. For example, three basic themes were grouped to become organizing theme and then put in a sequence. The first one talked about general dissatisfaction about the infrastructure of housing. The following one actually went a bit further and tried to generalize that most physical attributes in these housing are poor, and it is almost taken for granted that affordable houses must be in poor condition. Therefore, the second one is a continuation of the first one. The third one states that if a house has a lower price, it must be lower quality. Therefore, it is a generalized version of the first one, and is almost parallel to the second one. Therefore, the second and the third one can be considered as the continuation of first one. That helped to search for an organizing theme, which can represent in a best possible way to all these three situations. The organizing theme 'The concept of affordable houses is strongly associated with lower quality of houses and associated facilities' is found to be a best representation of the inner meaning or the implicit meaning reflected through those three basic themes collectively. That is how all the six organizing themes were constructed.

However, that was not the end, since the study would also search for a global theme, therefore, after completing the
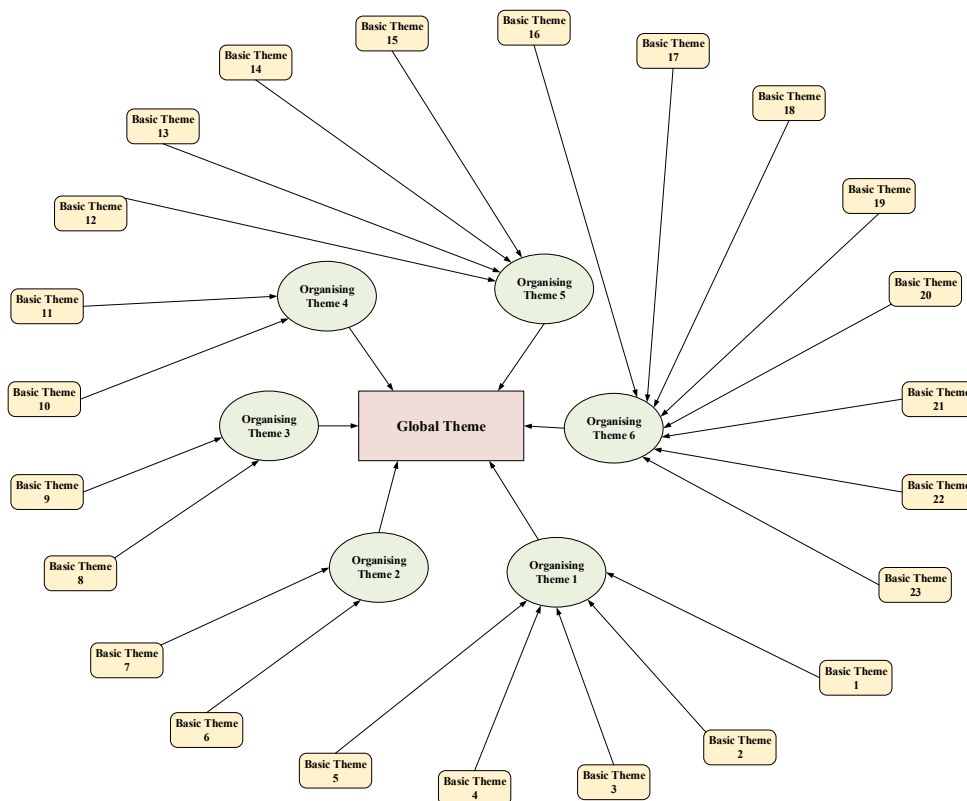
Figure 3: *Thematic network for a global theme*

construction of the six organizing themes, they were also arranged in a sequence, where the preceding one connects to the following one, and the succeeding one would not make sense if the preceding one does not appear. That gave a strong root to search for the global theme. This was the underpinning technique of thematic network.

5.5.3 Global theme

In the example given in this article, themes were organized into coherent summaries of the dissected data and thematic networks was presented as the method of analysis. The themes developed at the coding stage were used as basic themes for thematic networks. A great deal of

Table 2: Generating Organizing Themes from Basic Themes

New No	Old No	Step 3: The Basic Themes	Step 4: The Organising Themes
1	18	Increase in birth rate and youth migration increase users' population who are seeking for house	
2	15	Population increase in urban centre that increases land and housing demand has influence on housing quality	**O1** Housing shortage is not dealt sensibly by government, leading rents of desirable houses to go beyond affordable limit of low income earners
3	16	Conversion of residential house to commercial use leads to housing shortage	
4	17	Low housing supply resulted from road extension and conversion of residential house to commercial use	
5	6	Low wages of users prevent many from having their own personal house	
6	2	Users are not satisfied with infrastructural facilities within their residential area in general	**O2** The concept of affordable houses is strongly associated with lower quality of houses and associated facilities
7	5	Lower house price and lower quality of housing type are significantly correlated	
8	3	Users' level of education plays a role in house selection and satisfaction	**O3** Increase in educational level may not immediately increases afflu-ence, but that increases higher expectation in lifestyle, and hence increases expected quality of housing
9	4	Users ascribe more importance to social prestige and family ties in selecting area of their choice as increased educational level adds to their self-esteem	
10	14	Ineffectiveness of Planning Regulation leads to slum development in newly developing areas	**O4** Physical quality of currently avail-able affordable houses are not controlled enough by building and planning regulations
11	13	Ineffectiveness of housing policy reflects on the housing quality owners are building	
12	8	Limited available land increases the cost of land, that affects the values of the house	
13	10	Type of House determines its price, but its value is still an undetermined factor	**O5** The issue of determining the Value of House is continuously ignored by the government
14	11	Involvement of Estate Agent superficially increases the value of the house	
15	12	Landlords' decision in comparing Lagos housing market affects the house rents	
16	20	There is not much land available in urban centre	
17	1	Proximity to the work-place dictates house location	
18	19	Land is too expensive for majority of households	
19	7	Cost of land depends on the location where the land is situated	
20	23	Land speculation through the estate agent becomes problems among users	**O6** Developers can exploit House price, but government's non-intervention or ill intervention makes it even harder for low-income group.
21	22	Housing density reflects the users' category with high income households invar-iably occupying bigger land with less number of housing units	
22	9	The cost of Building plan preparation, processing and approval puts burden on private developers, which they try to overcome through increased house price	
23	21	The Location of house determines its quality and rents	

interpretative work was done as the themes do not 'speak for themselves'. As such, basic themes were arranged into common subject matters (organizing themes), and these were subsequently re-organized into unifying statement (global theme) which was constructed and represented graphically as thematic networks as shown in Figure 3. This was to give adequate and proper understanding of subjects in discussion or the meaning of an idea through the themes, rather than to harmonize conflicting definitions of a problem. However, the process was not by any means a linear one. There was a need to be constantly checking back, between organizing themes and basic themes, between global theme and basic themes and of course between the global theme and the coded text itself. Furthermore, there was also need to go back to the source of the quotations at both the level of code and the level of context, which required returning to the interview's scripts for proper interpretation.

As mentioned at the beginning of the previous section regarding construction of Organizing themes, where basic themes were put in a sequence after rigorous recursive non-linear process so that the construction of organizing theme makes logical sense. The same was also applied to construct the global theme. The six organizing themes went through rigorous immersion, non-linear method of checking back the interviews, and the basic themes. The target was to find a common theme that can express in a best way to indicate solutions to users' dissatisfaction on affordable housing.

6.   Conclusion

The use of qualitative technique in research requires experiences in answering stated research questions in a better way. It gives detailed, coherent, transparent and consistent evidences about the subject matter. Careful and thoughtful presentation of qualitative research report in a logical manner will make such report to be convincing and acceptable to other researchers and prospective users of the findings. This article aimed at presenting a detailed step-by-step procedure of how to conduct qualitative data analysis for better application of qualitative techniques. The pragmatic illustration presented as example is incomplete as the analytic process does not include the interpretation. Nonetheless, the article has presented the systematic steps of handling qualitative analysis to ease the procedure of the analysis. Through splitting the procedure into apparently defined steps, the prospective qualitative young researchers would be able to follow the steps in a

logical manner for rigorous analysis for better interpretation of qualitative research findings.

Qualitative approach in the research may not necessarily follow any consistent systematic guideline. The point of emphasis by various qualitative researchers is trustworthiness to enhance the acceptability of collected data. Data Collection, Documentation, Analysis, and Interpretation are the classical basic methods of research. The qualitative research process runs through research design, field work and analysis stages (Attride-Stirling, 2001; Braun & Clarke, 2006). While the first two stages are practically straightforward but the logical stage is a highly intuitive, theoretically driven stage that does not take place in a modest linear arrangement. The exploratory and explanatory strength of the research determine the value of qualitative research. Revelation of the analytic process presentation of qualitative analysis in this article through Data Logging, Anecdotes, Vignettes, Data Coding and Thematic Network is imperative step and positive contribution to qualitative research to achieve better qualitative analysis. This is to provide systematic presentation of qualitative analyses to aid thorough understanding of qualitative data interpretation.

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Barriers to effective use of CAD and BIM in architecture education in Nigeria

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ABSTRACT

This study investigated barriers to the effective use of CAD/BIM in response to the dearth of data from Nigerian schools of architecture relative to information obtained from practice. This is important to bridge the gap between skill sets required in practice and those obtained from architecture graduates. Objectives of the study were to establish barriers that influence effective use of CAD/BIM tools in Nigerian schools of architecture as well as to identify means of addressing these barriers within the curriculum from the perspective of students. A mixed methodology was employed via questionnaire responses from 64 MSc students at the department of Architecture, Ahmadu Bello University Zaria as well as suggestions for improvement. Quantitative data were analysed in SPSS v. 21 for means (M) and Relative importance Index (RII). Suggestions proffered by respondents were assessed using content analysis. Results reveal that requirements for high computer specifications (RII=0.92), expensive cost of computers (0.91), requirements for intensive training (0.81), inadequate integration within the curriculum (0.81), lack of steady power supply (0.77) and time to master skills (0.76) were the most important barriers to effective CAD/BIM use in architecture education. Overall, government and institutional related barriers recorded the highest means (M 3.68 each). The study recommends government action via policies supporting clear BIM standards, local manufacture and assembly of high-tech computers to mitigate importation costs as well as added funding to higher institutions to augment research, power supply and ICT facilities. At departmental level, CAD/BIM tutorials should be integrated within studio sessions as seminars from 200L. At 400L and MSc levels, studio should support collaboration with students from other allied professionals. Recruitment requirements in future also need to include CAD/BIM proficiency to improve quality of teaching staff and learning experience of students.

1. Introduction

In recent years, Computer Aided Design (CAD) including Building Information Modelling (BIM) have become synonymous to beautiful designs, photo-realistic rendered works, cutting edge innovations and effective project delivery in the design and construction industry. For many contemporary architects, it is impossible to commence and complete a project without using CAD and BIM software/ tools. This ideology has been transferred to students in architecture schools who feel inadequate if not highly proficient in using CAD and BIM tools because these tools have become the industry standard worldwide (Iyendo and Alibaba, 2015; Rodriguez, 2014; Senyapili and Bozdag, 2012). Abdiran and Dossick (2016) as well as Foulcher and Gu (2011) note inadequacy of graduates to meet up to increasingly demanding industry standards is partly responsible for the tension and conflict between architects in academia and those in practice. While academics in the past have generally viewed CAD related tools as likely to impede design and innovation (Alcaide-Marzal et al., 2013; Becerik-Gerber et al., 2011; Lu, 2009; Salman et al., 2008), contemporary practice demands effective and

seamless delivery of high-end projects frequently requiring multiple CAD and more recently, BIM software and tools.

Despite on-going debates about the advantages and disadvantages of integrating CAD and BIM within the architecture and design curriculum, the realistic and undeniable fact remains that CAD and BIM tools have become indispensable to contemporary practice in design and construction. Several studies address the most effective strategies of ensuring students are equipped with requisite CAD/BIM related skills (Almutiri, 2016; Abdiran and Dossick, 2016; Botchway et al. 2015; Iyendo and Alibaba, 2015; Alagbe et al., 2014; Aly, 2014; Rosli, Razak, Younus, Keumala and Ismail, 2014; Hancock, 2013; Mandhar and Mandhar, 2013; Ibrahim and Rahimian, 2010; Barison and Santos, 2010; Sabongi, 2009; Juvancic and Zupancic, 2008). Few studies however assess barriers students face to effectively acquire mastery and skilful use of these software and tools. Although barriers to the effective use of CAD/BIM software/tools have been the focus of studies in practice (Chan, 2014; Ramilo and Embi, 2014a; 2014b) and academia (Mandhar and Mandhar, 2013; Ozcan-Deniz, 2016), it is often unclear what the current barriers are within the architecture educational environment from the student perspective especially in Nigeria. Establishing these barriers is important to improve effectiveness of teaching and learning CAD/BIM by students. This ultimately influences employability and quality of graduates entering the labour market.

This paper aims to identify barriers that hamper the effective use of CAD and BIM tools in Nigerian schools of architecture. Objectives of the study are: (a) to establish barriers that influence effective use of CAD/BIM tools in Nigerian schools of architecture, (b) to identify means of addressing these barriers within the curriculum from the perspective of students.

MSc I students (2016/2017) at the department of Architecture at Ahmadu Bello University (ABU) Zaria were selected because the department is the pioneer school of architecture in the country and is currently preparing to convert into a faculty. The MSc class was employed for this study because students have undergone all variances of learning CAD/BIM as taught within the architecture curriculum as well as experienced some form of professional practice through internship programs as part of Student Industrial Work Experience Scheme (SIWES) and National Youth Service Corps (NYSC). The latter is mandatory for graduates of all first-degree programs in Nigeria. A recent study (Gidado & Abdullahi, 2018) employed a similar

population as a justification for assessing BIM awareness in architecture education.

Students at the department of Architecture, ABU are exposed to CAD, specifically AutoCAD and SketchUp from the first year (100L) as part of basic computer skills separate from Basic Design Studio, which targets mastery of manual drafting techniques and skills. Consequently, CAD is largely self-taught and exploratory at this stage, as computer design does not feature in Architectural Design Studio (ADS) assessment in the first year. By the second year (200L), AutoCAD and Revit are taken as stand-alone courses in preparation for the mandatory 6 months Student Industrial Work Experience Scheme (SIWES) in the third year (300L) as AutoCAD is still the industry standard in Nigeria (Ryal-Net and Kaduma, 2015). Students are attached to firms and architectural practices in preparation for the job market and as such should have acquired sufficient mastery of the tools to fit into practice. Many learn the finer techniques of CAD at the end of this period, as local firms are yet to fully employ BIM in practice (Abubakar et al., 2013). The basic principles of CAD/BIM are then built upon in the final undergraduate year (400L), specifically 3D AutoCAD and Revit BIM. Students employ these tools for their design projects and theses during their MSc program. To supplement power supply to the department, a 200KVA generator often provides power during office hours between 8am to 4pm.

The paper is organized in five sections after the introduction. Section two reviews literature on CAD and BIM as well as barriers to the effective use of these tools. This is followed by the methodology in section three and results/discussion in section four. The paper concludes with recommendations and references in sections five and six respectively.

2. Theoretical Background

2.1 CAD and BIM

The acronyms CAD and BIM are often employed interchangeably in part because BIM is a successor and advancement of CAD (Wong et al., 2011). The fundamental difference between the two is based on the computation technology underlying their programming (Guidera and Mutai, 2008). CAD is generally conceived as an automated version of manual drafting (Grabowski, 2010). CAD programs such as Autodesk's AutoCAD, 3D Studio Max, Google's SketchUp (Ramilo and Embi, 2014b) are built on the tradition of hand drafting to mimic building

components (Botchway et al., 2015). They are non-parametric tools largely employed for drafting, visualisation and documentation purposes (Ramilo and Embi, 2014b). BIM software such as Autodesk's Revit simulates intelligent 3D models using parametric building components to mimic real life (Ramilo and Embi, 2014b). "BIM is based on a virtual 3D model of the proposed facility as the sole source of all information about the project" (Czmoch and Pekala, 2014, p. 211). At its essence is collaboration where all documentation of a building such as architectural design, landscape, mechanical and electrical components/ installations, construction, bill of quantities cost estimates, sustainabilty and maintenance details are all contained within a single 3D model with a database syncronising the above documents (Czmoch and Pekala, 2014, Guidera and Mutai, 2008). BIM at its full potential is targeted to be implemented in several dimensions, the first being 3D parametric modelling accepted as a natural extension of the 2D design in the AEC industry (Czmoch and Pekala, 2014). BIM 4D denotes the extension of 3D modelling in time using schedules, division of the project into phases up to product and delivery (Almutiri, 2016). BIM 5D, 6D and 7D involve cost estimating, sustainability and facility management applications respectively. The latter is projected to effectively manage detailed specifications of all project components to aid maintainance and replacement information over the life time of the project (Czmoch and Pekala, 2014).

Due to this overview, BIM is translated either as Building Information Modelling (Rodriguez, 2014; Aly, 2014; Becerik-Gerber, Gerber and Ku, 2011) or Building Information Management (Czmoch and Pekala, 2014; Sacks and Pikas, 2013). Differences regard viewing the model as a product of documents or managing the construction and maintenance process of projects. This dual role of BIM as a technological product and managerial process is partly responsible for issues encountered with effective understanding, uptake and benchmarking within the Architecture Engineering and Construction (AEC) industry (Almutiri, 2016). As a consequence, effective teaching of BIM in AEC schools has been problematic in spite of benefits associated with its use. Almutiri (2016) notes that architects see the benefits of BIM in three basic areas- Efficiency, Presentation and Teamwork.

BIM is seen to assist in producing more efficient projects in terms of speed in information flow as well as reduced costs for producing construction documents (Halttula et al., 2015). It also aids production of photo-realsitic visualisations while fostering competence and teamwork among design professionals. This has generally meant an improved return on investment (ROI) for businesses (Almutiri, 2016) as well as improvement in project delivery (Doumboya et al., 2016). Specifically, BIM is beneficial in marketing new business to clients and construction professionals via high visualisation outputs, reduction in errors and ommisions in construction documents, offering new services, reduction in rework (Almutiri, 2016), easier modalities to share information and collaborative effort across multiple construction teams (Halttula et al., 2015). It also aids owners a better operational efficiency across the lifetime of the project (Doumboya et al., 2016).

Despite these benefits, challenges abound in the effective use of CAD/BIM software in the AEC industry. These include difficulties in adopting the software by older professionals and management (Eadie et al. 2014; Ramilo and Embi, 2014a), inadequate supply of qualified staff to meet specialised skills (Ozorhon and Karahan, 2016), high costs for software and training in line with rapid transformations (Gimenez et al., 2016; Czmoch and Pekala, 2014), scale of cultural changes required for implementation, lack of flexibility (Eadie et al., 2014), supply-chain buy-in (ibid), IT literacy and staff resistance (Bui et al., 2016), legal uncertainties (Almutiri, 2016), interoperability and compatibility issues, lack of practical and standard guidelines as well as unclear benchmarks for practice (Bui et al., 2016; Halttula et al., 2015; Becerik-Gerber et al., 2011). Ramilo and Embi (2014b) categorized most barriers to digital innovation and use of BIM by firms into six common attributes. These are technological, financial, organizational, governmental, psychological and process barriers. Findings from their study reveal that large architectural organizations coped better than small or medium sized firms because of the substantial number of projects with considerable fees that can support innovation as well as collaboration with other firms and institutions. Financial barriers were the most crucial for firms out of the barriers studied.

2.2 Barriers to the effective use of CAD/BIM software and tools in academia

Due to the on going issues of the lack of common standard benchmarks and guidelines or BIM implementation in practice, it is unclear what the content, principles and methods of education are required in AEC curricula (Botchway, Abanyie and Afram, 2015; McCuen, 2014; Sacks and Pikas, 2013; Hancock, 2013; Guidera and Mutai, 2008). Several barriers to the effective use of CAD/BIM in
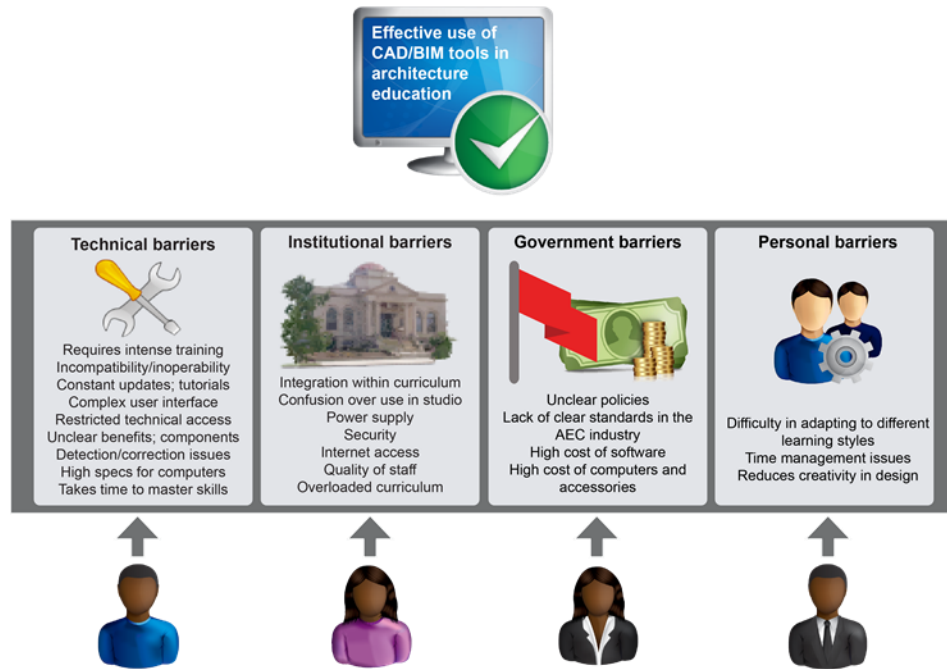
Figure 1: Categories of barriers mitigating the effective use of CAD/BIM in architecture education

academia have been identified in literature (Wong et al., 2011; Hancock, 2013, McCuen, 2014; Botchway et al., 2015; Al-Mutiri 2016; Al-Saati et al., 2016; Bui et al., 2016). These are categorised in this study under four themes namely Technical, Institutional, Personal and Governmental barriers (Figure 1).

Technical barriers to the effective use of CAD/BIM in AEC education involve programming and software development related issues such as error detection and correction by BIM software, limited choices for component databases (Wong et al., 2011), constant need and time to update software and skills (Hancock, 2013), complex user interface and access to training materials (Botchway et al., 2015). Others technical barriers include model development not following construction sequence (Wong et al., 2011), time required to master complex programs as well as hardware/system specifications (Al-Saati et al., 2016). Institutional barriers concern issues within institutions and organizations such as knowledge required to use BIM software as well as low quantity of teaching staff with high levels of practical experience in construction to translate AEC requirements into CAD/BIM teaching modules (Wong et al., 2011). Others are overloaded curricula (Becerik-Gerber et al., 2011), curriculum design/integration (McCuen, 2014), quality of teaching staff/incompetent trainers, unconducive learning

environments, poor power supply, inadequate access to the internet and security (Kehinde, 2016). Governmental barriers largely concern issues regarding national/economic policies notably costs and expenses for software especially in developing countries (Bui et al., 2016) as well as unclear government policies and lack of clear standards in the AEC industry (Abubakar, Ibrahim and Bala, 2013). Personal barriers relate to issues within the sphere of influence of students and teaching staff. These include individual teaching and learning styles as well as personal disposition (Ozcan-Deniz, 2016; Petkowska, 2015; Botchway et al., 2015).

In view of the challenges of effectively incorpoating BIM within the architectural curriculum, Mandhar and Mandhar (2013) proposed a framework of incremental learning from beginner to advanced levels. These are complemented with learning outcomes and desired skill sets. The authors propose that teaching and learning at first year should focus on the basics of modelling and communicate different types of information and understanding of BIM concepts. In the transitional level in the second year, the focus should be building teamwork and collaboration as part of a design team. Realistic aspects of construction with advanced levels of practice and construct protocol should be the focus of learning in the third year.

3.   Methodology

To address the objectives of the study, a questionnaire was designed in three sections. The first section (A) solicits information regarding demographics of the respondents. These include gender, method of presenting their design portfolios-whether manual drafting, CAD or BIM as well as the method CAD and BIM were learnt. Respondents were also required to choose between three alternatives for teaching CAD/BIM: Maintain it as is, Restructure or Remove it completely from the curriculum. Section B required respondents to rate 26 barriers identified in literature on a Likert Scale of 1-5 (1 being not important and 5, very important). These were analysed using means (M), Standard Deviation (SD) and Relative Importance Index (RII). RII is calculated as the ratio of the total actual scores (AS) for each barrier divided by a product of the number of responses and the maximum possible score[1] (Max.PAS). Mathematically, this is expressed as:

$$RII = \frac{\sum AS}{\sum Max.PAS}$$

These were then employed to rank the order of importance of factors in response to the first objective. Barriers with RII values of 0.75 and above were considered highly important for this study. These correspond to ratings in the upper quartile range (75% and above). RII values between 0.50 and 0.74 corresponding to the second quartile (50%-74%) are considered important. RII values below 0.5 (or median) are considered unimportant in this study. Mean values (M) of categories of barriers were also computed. Means of 3.0 and above (3 corresponding to the midpoint on a scale of 1 -5), were considered important for the purpose of this study.

Section C solicited modalities for improvement and suggestions on ways to overcome the challenges students face in school in response to the second objective of the study. This was presented as an open-ended question at the end of the questionnaire. The approach was utilized in place of interviews with respondents as previous experiences with a similar sample revealed that students were more forthcoming in proffering suggestions anonymously. Interviews are not anonymous. Suggestions were proffered in the form of statements, which were analysed using content analysis. Lune and Berg (2017) define content analysis as "a careful, detailed, systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, assumptions and meanings" (p. 182). Because student responses were presented as sentences, themes were adjudged the most useful unit of analyses and not words. A theme is defined as "a simple sentence, a string of words with a subject and predicate" (p. 189). The steps employed to analyse and categorise the qualitative data, adapted from Lune and Berg (2017) are as follows:

- All suggestions (qualitative data) were collated verbatim from the questionnaires into a word document. All suggestions from a single respondent were typed together in the same format the respondent wrote it. These may comprise several separate sentences representing different ideas. A total of 42 sentences were collated.

- Themes were analytically developed and inductively identified in the data. These pertain to specific suggestions, which recur within the text relating to modalities for the effective ways of teaching and learning CAD/BIM in the curriculum.

- Responses were sorted according to these categories by identifying similar phrases, patterns, ideas and commonalities.

- The data was analysed and sorted according to the number of times a theme appears. These are presented as counts (N) and percentages (%).

- Themes were considered in light of findings from section B of the questionnaire as well as from previous research to triangulate trends and disparities. Quotes are provided in italics as specific examples of suggestions from students.

- Findings from rankings and themes were employed to proffer recommendations on ways to improve the effective teaching and learning of CAD/BIM in the curriculum.

4.   Results and Discussion

4.1   Results

Out of 88 questionnaires targeting the entire MSc I class, 64 (73%) were returned and employed for analyses. Demographic data obtained from the respondents reveal

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[1]The maximum score for any factor per respondent is 5 (on a 5 point likert scale). For 63 respondents, maximum possible score = 315

that 53% (N34) were male while 6% (N 4) were female. The relatively high number of male respondents is characteristic of the gender skew in architecture education from previous studies. A large proportion of respondents (N 26, 41%) however did not report their gender (Table 1). CAD remains the most popular method for design presentation (N 52, 81%). Half of the respondents employ BIM and manual-drafting techniques while 70% of the sample is self-taught regarding CAD/BIM use. A third of the sample note departmental courses were the means they learnt CAD/BIM. 80% of respondents (N 51) indicated restructuring the way CAD/BIM is presently taught in the department against five students (8%) who indicated CAD/BIM courses should be maintained as they are. A single respondent (2%) wanted courses removed.

Results from section B of the questionnaire reveal that seven barriers record RII values of 0.75 and above (Table 2). These, in order of importance are high specification for laptops and equipment (0.92), cost of laptops and PCs (0.91), requirements for intensive training (0.81), inadequate integration of CAD/BIM in the curriculum (0.81), lack of steady power supply (0.77), time required to master skills (0.76) as well as lack of standards in the AEC industry (0.75). Majority of the identified barriers (69.2%) were ranked as important as RII values of these 18 barriers fell within 0.50-0.74. The issue that CAD/BIM reduces creativity recorded the lowest RII value of 0.45 below the 0.50 median cut off.

Table 1: *Attributes and Responses*

Gender of respondents	N	%
Male	34	53
Female	4	6
Missing	26	41
Method of design presentation*	N	%
CAD	52	81
BIM	33	52
Manual drafting	32	50
Method of learning CAD/BIM*	N	%
Self-taught	45	70
Private lessons	42	66
Departmental courses	21	33
CAD/BIM courses within the curriculum	N	%
Restructure	51	80
Maintain	5	8
Remove	1	2
Missing	7	10

Table 2: *Ranking of individual barriers to the effective use of CAD/BIM in architecture education*

Barrier	Category	N	Sum	RII	Rank
Requires high specs for lap-tops/equipment	Technical	64	293	0.92	1
Expensive cost of laptops and PCs	Government	63	286	0.91	2
Requires intensive training	Technical	64	259	0.81	3
Inadequate integration of CAD/BIM in the curriculum	Institutional	64	258	0.81	3
Lack of steady power supply	Institutional	63	242	0.77	5
Takes time to master skills	Technical	64	243	0.76	6
Lack of standards in the AEC industry	Government	64	239	0.75	7
Overloaded curriculum	Institutional	63	233	0.74	8
Poor internet access	Institutional	63	233	0.74	8
High cost of software	Government	63	233	0.74	8
Lack of training materials	Technical	64	231	0.72	11
Quality of teaching staff/trainers	Institutional	64	231	0.72	11
Constant need to update software	Technical	64	229	0.72	11
Poor security for laptops & equipment	Institutional	64	229	0.72	11
Difficult to adapt to different learning styles	Personal	62	205	0.66	15
Confusion regarding usage in studio	Institutional	64	211	0.66	15
Complex user interface	Technical	63	206	0.65	17
Time management issues	Personal	63	198	0.63	18
Restricted access to technical information	Technical	59	178	0.60	19
Limited choice for compo-nents	Technical	63	186	0.59	20
Incompatibility/inoperability issues	Technical	61	180	0.59	20
Full range of benefits unclear	Technical	64	188	0.59	20
Overload of materials/tutorials	Technical	63	183	0.58	23
Poor detection and correction technology	Technical	63	174	0.55	24
Unclear government policies regarding adoption	Government	64	175	0.55	25
Reduces creativity in design	Personal	64	143	0.45	26

Overall, government and institutional barriers recorded the highest mean values of 3.68 each. Technical barriers (M 3.37) follow these. Personal barriers (M 2.89) on average, recorded the lowest values and are considered the least important barriers to effective use of CAD/BIM from the sample.

In response to the second objective of the study, seven themes emerged from 42 suggestions proffered by respondents (Table 3). The suggestion to incorporate CAD/BIM at all levels within courses other than Architectural Design Studio (ADS) was the most frequently occurring theme (N 10, 24%). This is closely followed by the need to improve quality of teachers/trainers (N 9,

Table 3: Themes from the content analysis of responses for ways to improve the effective use of CAD/BIM in architecture education

Theme	N	%
Incorporate CAD/BIM at all levels and within	10	24%
Improve quality of teachers and training	9	21%
Encourage use by students for design	6	14%
Add CAD/BIM courses and seminars in the	5	12%
Availability of software/systems/internet con-	5	12%
Create avenues for exposure to more diverse	4	10%
Create awareness of the importance of CAD/	3	7%

21%), encourage CAD/BIM use by students in ADS (N 6, 14%), add CAD/BIM courses/seminars in the present curriculum as well as improve availability of software, systems and internet connectivity (N 5, 12% each). It is worthy to note that all themes suggested by students relate to institutional and technical barriers specifically issues of training, inadequate integration of CAD/BIM courses within the curriculum as well as provision of support infrastructure notably internet connectivity and system components. These barriers were ranked third, eighth and eleventh in Table 2.

4.2   Discussion

4.2.1 Institution and government-based barriers most affect effective use of CAD/BIM tools in architecture education

Results from the study reveal that seven barriers most affect the effective use of CAD/BIM in architecture education with RII equal to or above 0.75 (Table 2). The first two barriers from the results relate to the high specifications for computers required for CAD/BIM use (a technical barrier) as well as costs and expenses in purchasing these computers (a government influenced barrier). Typically, CAD/BIM software operate best on computers with high computational power and graphic card specifications. These are generally expensive for the average student in a public university such as ABU. A recent study identified high cost of equipment and materials as the number one factor influencing the overall academic performance of students of architecture in two public universities (Maina et al., 2017), supporting these results. Unfortunately, most of these computers are imported from foreign countries, often using foreign currencies. With the recent economic recession in Nigeria, students struggle to purchase these high-end computers, implying that a number of students maybe disadvantaged in acquiring the skills expected to be adequately CAD/BIM literate. While these barriers exist in the AEC industry (Gimenez et al., 2016; Czmoch and Pekala, 2014), firms maybe less sensitive to these barriers compared to individual student needs while in school.

Closely related to this point is the intensive training required to master CAD/BIM software ranked third in Table 2. Although a technical issue, the requirement for intensive training also relates to the availability of qualified professionals to within institutions (ranked eleventh). This is most pertinent in a climate of rapid technical improvements and upgrades required in becoming a current and proficient professional (Czmoch and Pekala, 2014). Students encounter difficulties in keeping up costs and time required for learning CAD/BIM. Not surprisingly, students ranked the inadequate incorporation of learning CAD/BIM third alongside intensive training required. This is compounded by epileptic power supply in the institution (ranked fifth), which generally reflects the scale of the problem nationwide. Although supplemented during official school hours, students are often left without adequate power supply in the evenings when they most need it for personal study and learning. Consequently, government and institutional barriers, often out of the sphere of influence of students, present the greatest barriers to the effective use of CAD/BIM in architecture education in three areas: inadequate/high cost of infrastructure (hard/software, power supply, internet connectivity), inadequate integration of CAD/BIM courses within the curriculum and quality of training.

Contrary to earlier debates that CAD/BIM may hamper and negatively influence creativity (Ibrahim and Rahimian, 2010), students ranked this barrier the lowest (Table 2), supporting findings in literature (Ahmad et al., 2013) that the use of CAD/BIM tools does not affect creativity.

4.2.2 Suggestions for improvement target Institutional barriers

Perhaps arising from awareness that some important barriers are out of direct influence of students, suggestions largely targeted institutional adjustments to the curriculum that can be implemented at departmental and institutional level (Table 3). First is the suggestion to incorporate CAD/BIM at all levels and courses. This was the most

frequently occurring theme from the data. This is linked to the suggestion to allow its use from inception of ADS at 200L for design related courses, in line with the framework proposed by Mandhar and Mandhar (2013). Students noted the follpowings:

"CAD/BIM should be incorporated into the architecture curriculum and students should be taught well and instructed to do their designs from 200 level using CAD/BIM software as that is what is being used in the building industry outside school. This will also increase the students chances of employment after school".

"I strongly suggest that CAD/BIM courses be integrated into all levels to familiarize students with the use of the software".

"The effectiveness of CAD/BIM in architecture education can be improved by making CAD/BIM default programs for design and analysis of all design oriented courses at all levels of the architecture program. The effectiveness of this should be checked by timely researches that obtains students' feedback".

"CAD/BIM should be improved in architecture education by incorporating them into the curriculum at an early stage say from 100 level so students understand how the software work. Manual drafting and CAD/BIM should go hand in hand to get better results".

Suggestions also focused on quality of teachers, teaching and training. While this suggestion looks straight forward, solutions may not be as simple as students envision largely because of the general lack of available experts in the use of BIM in the NCI (Abubakar et al., 2013). Awareness of the full capabilities is low even among construction professionals (Ryal-Net and Kaduma, 2015). Comprehensive training in the use of such tools also involves knowledge of teamwork and construction management, which in architecture education at ABU is largely completed in the final year. Consequently, implementing the framework proposed by Mandhar and Mandhar (2013) may only be possible at the last stage of undergraduate studies or at Masters level in collaboration with teams from allied programs in the faculty notably Quantity Surveying, Building, Urban and Regional Planning as well as Geomatics. Notwithstanding, students advised that the department should do the followings:

"Allow only truly qualified lecturers who are passionate about CAD/BIM to lecture students on the subject.

Impartation is much easier, fluid and fun to teach and learn."

"Improve method of teaching".

"Provide adequate training materials along with competent trainers".

Interestingly, while previous feedback suggests that the architecture curriculum is overloaded (ranked eighth, Table 2), students suggest incorporating and adding more CAD/BIM related courses to the curriculum, inferring that students may not view learning CAD/BIM as being burdensome.

"The department should provide more courses to help students learn CAD/BIM"

"Workshops and seminars should be carried out to provide more awareness into the collaborative and integrative capabilities of BIM"

"CAD/BIM courses should be added to the curriculum".

"Extra classes should be organized for intensive training".

This theme was closely followed by suggestions for a wider variety of CAD/BIM tools and provision for software installations, better computers and improved internet connectivity.

"Students should be taught advanced tools like 3dmax, Maya etc not just the basic tools like AutoCAD, Sketchup or Revit."

"Software installation could be done for students/users on first contact"

"At least two different CAD/BIM software e.g. Revit/Sketchup should be taught to undergraduate students plus an additional rendering software e.g. Lumion, Vray e.t.c."

5.   Conclusions and Recommendations

This paper aimed to establish current barriers and challenges students face in the effective implementation of CAD/BIM in architecture education at a Nigerian university. The study also sought the opinion of the students regarding modalities to overcome challenges identified. Results revealed that the most pressing barriers were largely due to government and institutional related

factors. Specifically, students rated high systems specification, high cost of computers, requirement for intensive training, inadequate incorporation within the curriculum, poor power supply, time to master skills as well as the lack of clear standards in the AEC industry as important challenges facing effective adoption of BIM. Similar challenges have been proffered in practice from literature, as most of these are government and institution dependent and heavily influenced by policies at national level or within individual institutions. Suggestions from students target institutionally based modifications notably incorporation of CAD/BIM for all courses and design, improvement of the quality of trainers as well as availability of updated software and better internet connectivity.

Recommendations target both government and institutional barriers. For government barriers specifically effective integration into the curriculum high cost of computers and provision of support infrastructure:

First, it is important that a BIM national policy be made clear in the country as this influences how it is taught in various schools of architecture in Nigeria. This has been advocated in literature and well overdue for implementation (Abubakar, Ibrahim and Bala, 2013). This is better projected through various professional bodies in the NCI as CAD/BIM use is directly within the spheres of influence of government agencies that regulate activities, policies and licensing of built environment professionals. Additionally, agencies such as Architects' Registration Council of Nigeria (ARCON), Quantity Surveyors Registration Board of Nigeria (QSRBN), Council of Registered Builders in Nigeria (CORBON), Town Planners Registration Council of Nigeria (TOPREC) as well as Council for the Regulation of Engineering in Nigeria (COREN) link academia and professional practice to government legislations and are thus better positioned to champion such a cause. Further research on how CAD/BIM is currently employed across academia and professional practice within the Nigerian built environment should be sponsored by such agencies.

Secondly, research and grants targeting local fabrication and assembling of computer systems that support CAD/BIM should be encouraged by government policies in Nigeria. This will not only provide employment for many aspiring entrepreneurs but reduce importation and cut down the cost of hardware and systems requirements. These barriers were ranked first and second from findings of this study.

Thirdly, the issue of funding to universities to augment power and ICT connectivity is paramount in Nigerian public universities as these were ranked fifth and eighth respectively. Power supply has been a recurrent factor mitigating the growth of the educational sector in the country. This finding supports recent revelations by the Vice Chancellor of Ahmadu Bello University that funding, especially to augment power supply was inadequate for the institution (Alabelewe, 2017).

Specific recommendations targeting CAD/BIM courses in the study area to improve integration within the curriculum and quality of training include the following:

- CAD/BIM use should be encouraged from undergraduate level design projects with a proviso after detailed manually produced presentation drawings have been completed and approved by the academic staff and studio mentors. Basic modelling of simple forms need be integrated with design studio sessions as students find it easier to link specific tutorials to design tasks at hand. CAD software such as SketchUp should be introduced at the beginning of ADS in 200L relating to studio exercises for the week.

- The department needs to consider the use of taking up studio sessions for an entire day instead of breaking it up into four-hour daily sessions, as is currently the practice. Such an arrangement is likely to afford time for specific CAD/BIM seminars relating to the studio exercise for that day to be presented at the beginning of the class, in line with suggestions from students.

- CAD/BIM need to be incorporated within lectures for design related courses notably Building Construction, Environmental Science/Building Climatology, Site Planning, Interior design, Building Services and Maintenance offered from 200-400L. Integrating the use of CAD/BIM tools for presentations, assignments and assessment will create avenues for students to be proactive and proficient in learning the tools in preparation for the world of professional practice.

- Teamwork and collaboration through competitions involving allied professionals in the built environment should be encouraged. A few of such design competitions have been successfully hosted in the last sessions, mostly at the request of professional bodies notably the Nigerian Institute of Structural Engineers. This can be incorporated into the final year (400L)

design studio and will go a long way into creating proactive CAD/BIM proficiency among graduates, produce better qualified future professionals who can train others effectively as well as to reverse the fragmented trend of BIM use in the NCI (Odeyale, Olalekan, Kayode, & Abraham, 2016).

- ADS at Master's level should incorporate input from other allied disciplines using BIM such as cost/estimation as well as sustainability and energy studies in future. This will encourage students to explore the other neglected aspects of BIM within the curricula.

- The department needs to pursue a CAD/BIM proficiency policy in future recruitment exercises as practiced by some institutions (Joannides, Olbina and Issa, 2012) to address the issue of quality of training staff.

6. Areas for further research

A limitation of this study was the use of one department of architecture in Nigeria. Further study on modalities on how best to contextualize the framework is required for Nigerian schools offering architecture. It is also important that more studies regarding the integration of BIM into the curriculum be conducted in various Nigerian schools of architecture with the aim of capturing contextual peculiarities of local curricula, as what is advocated globally may not be properly implementable in every context.

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Indoor Environmental Quality performance of mixed-mode ventilated shopping malls in hot-humid climatic region

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ABSTRACT

Studies have revealed important roles quality indoor environment plays on human health and productivity; consequently, its influence on certain shopping behavior has also been well spelt out. In other to keep up with the demand for quality indoor environment, new trend has been evolving in the design of Malaysian shopping malls. From fully air-conditioned to newly designed ones that integrate passive ventilation strategies; and as such operating under mixed-mode ventilation system. These passive ventilation strategies are implemented to reduce energy consumption and also to improve the indoor environment within the mall's indoor space. However, the potentials of these designs in terms of their indoor environmental quality (IEQ) performance have not been studied nor have their advantages been revealed. In this study, occupants' thermal perception and IEQ performance was investigated in two mixed-mode ventilated malls selected based on their design concept ('open' and 'enclosed'). Both subjective and objective measurements were carried out in accordance with the ASHRAE performance measurement protocol for commercial buildings. Five IEQ factors (indoor air temperature, operative temperature, relative humidity, air speed, and carbon dioxide concentration level) were evaluated in the two malls. The results revealed that both malls fell below the ASHRAE comfort requirement but majority of the occupants still found the indoor thermal performance acceptable despite the high indoor air temperature recorded. For both malls, high air speed and low humidity level were recorded. However, higher air movement was still preferred by the occupants while the recorded mean carbon dioxide (CO2) concentration was within the recommended level. The 'open' concept mixed-mode ventilated mall proved superior compared to the 'enclosed' concept by providing a more thermally tolerance indoor environment for its occupants. Generally, results from this study contribute to the knowledge on the advantages of adopting sustainable designs in commercial buildings for improving the indoor environment as well as the health and general well-being of the occupants. The study will open more opportunities for future IEQ studies to be carried out in hot-humid climatic regions.

1. Introduction

Malls, due to their large floor area and huge crowd capacity, are not only faced with energy consumption issues but also other issues ranging from social (e.g. tight competition with regards to services and customers' satisfaction) to environmental issues (e.g. indoor environmental quality (IEQ). These issues one way or the other are interwoven

and have impacts on the malls' performance as well as users' satisfaction. A typical example of a social issue is the shoppers' motivation for visiting a particular mall. Since the mall's strategy is to attract large number of customers as possible, malls do not only compete with each other in terms of their product offerings but also by creating exciting and comfortable indoor atmospheres for users (Anning-Dorson et al., 2013). The competition and market congestion has led developers and mall management into considering alternative methods in order to build more excitement for their customers. These include the incorporation of various entertainment outlets within the mall such as parks, cinemas, etc. (Rajagopal, 2009).

These entertainment outlets are just a fraction among other factors that attract malls' customers. It is evident that there are several other motivating factors that affect shoppers' behavior towards a particular mall, such as their choice of visiting the mall (Anning-Dorson et al., 2013), and their spending behavior (Chebat et al., 2014). These motivating factors have been identified as "the mall's indoor atmosphere" which constitutes the indoor odour (Michon et al., 2005; Singh and Prashar, 2014), lighting, thermal comfort (Rajagopal, 2009; Khayyambashi and Vahid, 2014), acoustic comfort (Anning-Dorson et al., 2013). According to Rajagopal (2009), a mall's indoor comfort is one of the major factors that draw higher customer traffic to malls.

All of the identified motivational factors are connected to IEQ, which is one of the major issues affecting the general well-being of building occupants in terms of their health and productivity (Heinzerling et al., 2013). Consequently, these factors affect the shoppers' shopping behavior in terms of the length of time they spend in the mall (Zafar et al., 2007; Kamarulzaman et al., 2010), the amount of money they spend (Chebat et al., 2014), the likelihood of them returning to the same mall, and their overall satisfaction (Chang and Fang, 2012; Chebat et al., 2014).

An example of environmental issue faced by malls is the indoor contaminants issue. Since malls are normally located in close proximity to main roads, they are prone to attract contamination from vehicles' exhaust (Li et al., 2013). Furthermore, indoor contaminants emitted by different products and chemicals within the mall can exacerbate the problem of poor indoor air quality (Xu et al., 2014). Previous studies have identified these contaminants, their level of contamination, and the exposure risk they pose to both shoppers and retailers (Li et al., 2013; Amodio et al., 2014; Xu et al., 2014). In Malaysia, adults (18 years above) spend about 48% of their leisure time in shopping malls as

shopping constitutes their most popular and affordable form of outing (Zafar et al., 2007). Unarguably, their continuous exposure to indoor contaminants can lead to both short and long-term health effects (Amodio et al., 2014). Since malls generally are huge energy consumers due to their huge lighting load and cooling demand, energy consumption is one additional issue a shopping malls has to face. However, the indoor air quality and occupants' comfort should not be compromise in the pursuit of a building's energy efficiency (Lisa et al., 2015).

Thus, it is evident that a balance needs to be maintained with regard to energy savings, occupants' comfort, and occupants' health and wellbeing in shopping malls. To attain this balance, shopping malls are encouraged to take advantage of natural ventilation and daylighting within their indoor space to reduce energy load from air-conditioning and electric lightings. In response to this, new design trends have started to evolve in the Malaysian shopping malls; for instance, openings are created within the shopping spaces to admit outdoor air into the indoor environment. Thus, operating on both mechanical and natural ventilation in different spaces within the buildings. This practice of combining natural ventilation and mechanical ventilation in a building is referred to as "mixed-mode ventilation", which offers huge advantages for energy reduction while still maximizing comfort (Hamlyn et al., 2012; Huang et al., 2014).

Despite the social and environmental advantages that mixed-mode type of shopping malls can offer, no documented IEQ study has been carried out on this type of malls in Malaysia so far. Although, some IEQ studies have been conducted on shopping malls, almost none has been carried out in hot-humid climatic conditions. In recent years, IEQ studies in malls focused mainly on IAQ (Li et al., 2013; Amodio et al., 2014; Xu et al., 2014; Hu and Li, 2015; Tao et al., 2015), visual (Al-Jubouri, 2012), and acoustic comfort (Della Crociata et al., 2013; Meng and Kang, 2013). A recent study by Karyono et al. (2015) however, looked into thermal comfort in a naturally ventilated market compared to a naturally ventilated cathedral and museum in Jakarta, Indonesia. The study revealed a different spread in comfort range in the three buildings. This is expected as all compared buildings in the study are not of similar typology.

Therefore, this research aims to fill this knowledge gap by investigating the IEQ performances of two mixed-mode ventilated malls in Malaysia. Specifically, the objectives of this study are: (1) to evaluate and compare the IEQ

(thermal comfort and indoor air quality) performances of malls operating on mixed-mode ventilation strategy, (2) to determine the occupants' thermal perception of their indoor environment.

This study provides a better understanding on occupants' expectations and concerns with regard to their indoor environmental conditions. The paper first explains the method used in the study, followed by description of the case study malls. It then presents and discusses the results from both the objective and subjective measurements. The paper concludes with some recommendations for future research.

2. Methods

To fulfil the stated objectives, both objective and subjective measurements were undertaken in accordance with the intermediate measurement level of the ASHRAE/CIBSE/ USGBC Performance Measurement Protocols (ASHRAE PMP) (ASHRAE, 2010). ASHRAE PMP is a set of comprehensive protocols laid down for evaluating the performance of occupied commercial buildings. For the ASHRAE PMP intermediate measurement level, the subjective measurement involves 'right-now' thermal comfort satisfaction survey while the objective measurement involves continuous data logging of several IEQ parameters (ASHRAE, 2010).

The two case study malls were chosen from a list of Malaysian mixed-mode ventilated shopping malls as identified in Ibiyeye et al. (2015) where six presently operating Malaysian malls were identified and grouped based on their design concept. Two types of mixed-mode strategy was identified operating in Malaysian malls which are 'concurrent' and 'zoned', however, 'zoned' is the most adopted mixed-mode strategy (Ibiyeye et al., 2015). Both malls chosen for this study operate under 'Zoned' mixed-mode ventilation strategy, and they were chosen particularly because of their size, location and design concept.

All data for the two malls were collected within the naturally ventilated central space and the respondents of the study were the occupants (shoppers and retailers) within this central space.

2.1 Description of case study malls

2.1.1 Shopping mall 1 (SM1)

SM1 is designed as 'enclosed and open air' concept (Ibiyeye et al., 2015) but will be referred to as 'open' concept for the purpose of this study. It is surrounded by vegetation and low buildings and accessible from major roads. It consists of five blocks in total: a block of four-storey shopping unit and four blocks of three-storey shops with office units and a one-level underground car park. All five

1 = Four-storey shopping unit

2 = three-storey shop and office units

3 = Naturally ventilated central space

4 = Entry points
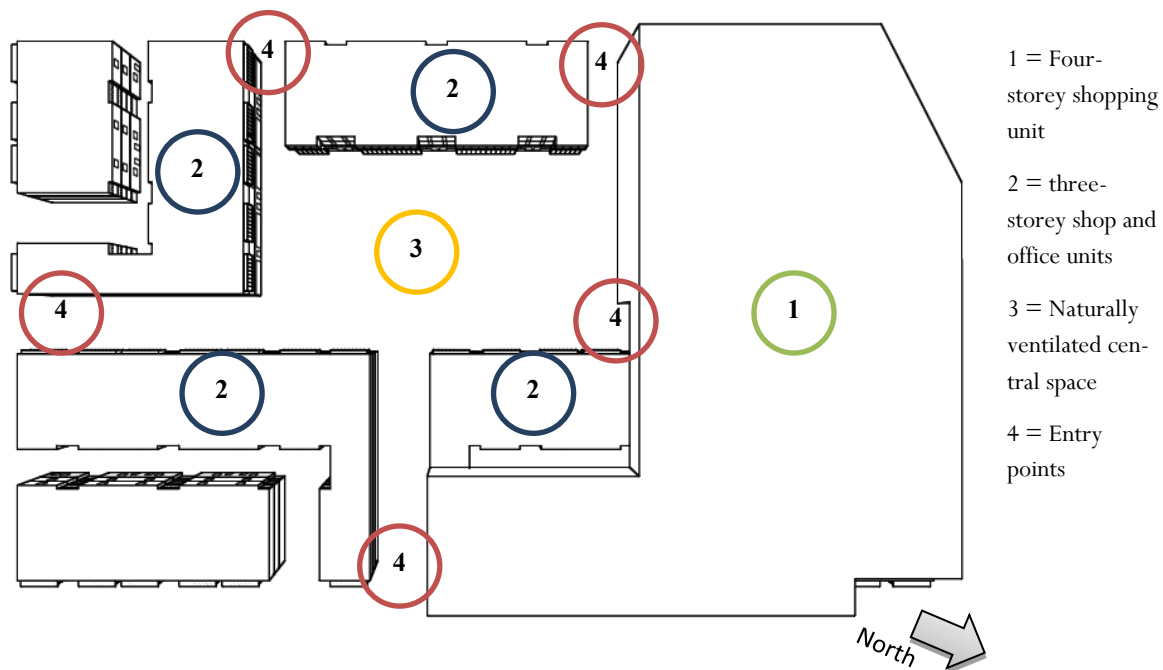
Figure 1: Blocks arrangement in SM1

Figure 2: Exterior (left) and interior views (right) of SM1

blocks of retail buildings are positioned around a large naturally ventilated central space and connected to each other (see Figure 1). The naturally ventilated central space is covered but at the same time opens at five different ends. These openings or entry points are very large (7 to 10 meters in width and extended from the floor to the roof).

Furthermore, the roof of the central space is created higher than the roofs of the surrounding retail buildings, leaving large gaps or openings in between. Within the central space, giant ceiling fans are installed in strategic locations to improve the air circulation. Figure 2 shows the exterior and interior views of SM1.

2.1.2 Shopping mall 2 (SM2)

SM2 was designed as 'enclosed' concept mall (Ibiyeye et al., 2015) and just like SM1, it is also surrounded by vegetation and low buildings, mainly residential and industrial buildings. It is also accessible from major roads. The building is a four-storey shopping unit integrated with retail and office units. This mall is enclosed and provided with a huge naturally ventilated central courtyard (see Figure 3) which is provided with water bodies acting as cooling effect. Similar to SM1, SM2 also have entry points leading to the central courtyard but these entry points are narrower than SM1's and do not open through all floors. Instead, they are just the same height as a door way and

1 = Four-storey shop units

2 = Naturally ventilated central space

Indicates the entry points
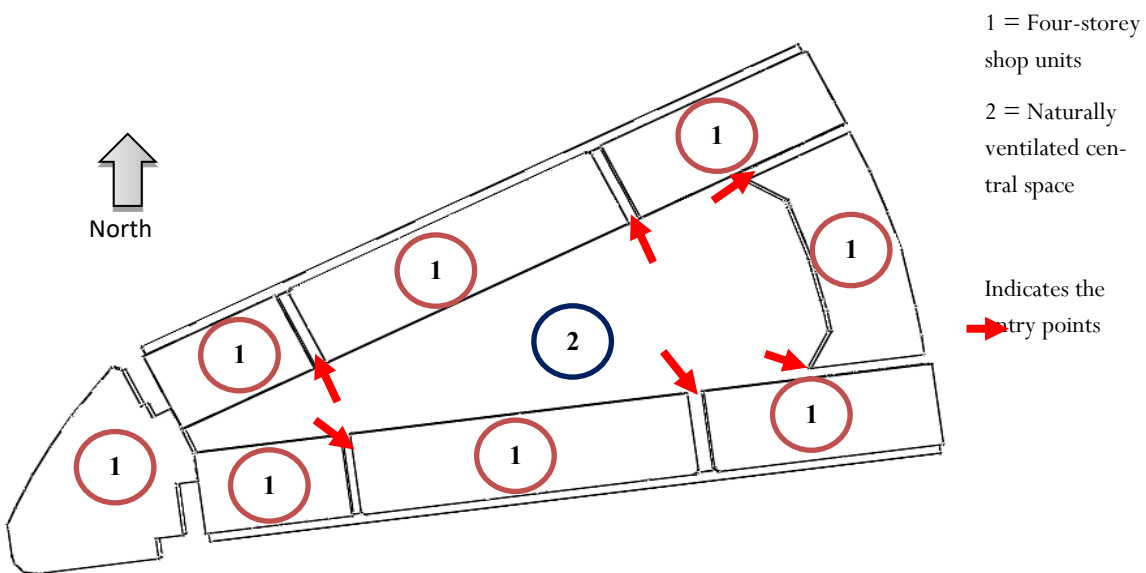
Figure 3: Blocks arrangement in SM2

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Figure 4: Exterior (above) and interior views (below) of SM2.

accessible only through the ground floor.

All around the top most part of the central courtyard is provided with wide openings for ventilation and daylighting purposes (see Figure 4b). And just like in SM1, giant fans are also installed within this central courtyard. The general descriptions of both malls are shown in Table 1.

2.2 Subjective measurement

The general subjective IEQ performance metrics required at the intermediate level was the results of occupants' 'right-now' thermal comfort survey conducted to investigate the occupants' thermal sensation and comfort, thermal acceptability, and thermal preference. The occupants' (i.e. shoppers and retailers) present activity

level and clothing worn were also simultaneously surveyed. The respondents were asked to indicate the specific time that the questionnaire was filled out. This allowed for the physical condition of the space at that specific point in time to be noted and the necessary subjective responses to be matched with the physical instrumental measurements (Della Crociata et al., 2012). The questionnaire is divided into five sections as explained below.

2.2.1 Occupants' background survey

The first section requested information about the occupants' demographic characteristics such as age, nationality, and gender. Specifically among retailers, they were also asked to indicate their work position held. Respondents were further asked to indicate their period of

Table 1: Description of the case study malls

Mall's ID	Description						
	Location	Opening Year	Floors	Total built-up area (sq. ft.)	Develop-ment type	Concept	Ventilation mode
SM1	Bangi	2013	3-4	675,000	Office and retail	Open	Mixed-mode
SM2	Shah Alam	2011	4	700,000	Office and retail	Enclosed	Mixed-mode

stay in the mall, and the frequency of their visits (for shoppers only).

2.2.2 Thermal sensation and comfort

This section aimed to determine respondents' thermal responds and comfort level. A seven-point scale ranging from cold to hot (-3 = cold, -2 = cool, -1 = slightly cool, 0 = neutral, +1 = slightly warm, +2 = warm, and +3 = hot) was assigned to measure respondents' thermal sensation. While, respondents' thermal comfort was measured on a six-point scale of 'very uncomfortable' to 'very comfortable' (1 = 'very uncomfortable', 2 = 'uncomfortable', 3 = 'just uncomfortable', 4 = 'just comfortable', 5 = 'comfortable', and 6 = 'very comfortable').

2.2.3 Thermal acceptability

Questions under this section were designed to measure how acceptable occupants found their present thermal condition. The thermal acceptability scale is usually in a binary response form of 'acceptable' or 'not acceptable', with a question such as "is the thermal environment acceptable?" However, for more powerful statistical analysis, a continuous scale is more preferred (ASHRAE, 2010). Therefore, for this study, a continuous scale of 'clearly unacceptable' to 'clearly acceptable' (1 = 'clearly unacceptable', 2 = 'just unacceptable', 3 = 'just acceptable', and 4 = 'clearly acceptable') was used (CBE, 2015).

2.2.4 Thermal preference

This section aimed to reveal what occupants prefer with regards to the indoor the condition. Respondents were asked to indicate their preference in terms of thermal state and air movement. For the occupants' thermal state, the question "right now, would you prefer to be" was posed and respondents were asked to choose from three options: 'warmer', 'no change', and 'cooler'. For air movement, respondents were required to choose from three options: 'more air movement', 'no change', and 'less air movement'.

2.2.5 Clothing and activity

The last section asked about the clothing worn and activity levels of the respondents. Generally, in field surveys, clothing and metabolic levels need to be estimated to allow indices such as PMV to be calculated and occupants are normally asked about their clothing and activity to aid this estimation (ASHRAE, 2010). For this study, respondents were asked to choose from a list of clothing and activities (as listed in ASHRAE, 2004) to best describe their present clothing and activity level.

2.3. Objective measurement

The performance metrics required at the intermediate level for IEQ building performance are data logging of selected IEQ parameters, such as: indoor air temperature, operative temperature, relative humidity, air speed, and carbon dioxide (CO_2) concentration level. Continuous monitoring of physical data was necessary in order for the local conditions to be known and also for specific condition to be ascertained at the time each "right-now" survey was taken. For this study, 5 minutes logging interval was set for all measured IEQ parameters; however, due to instrument constraint, CO_2 measurement was taken every 15 minutes in each case study mall.

2.4 Data collection process

Both objective and subjective measurements were carried out within the natural ventilated central space of both malls. Measurement positions and location were in line with the ASHRAE standard 55, i.e. they were made in occupied zones of the mall and were taken sufficiently away from the boundaries of the zone and from any surfaces to allow for proper circulation around the sensors. Also, sensors were stationed at a level of 48 inches (1.1 m) above the floor for standing position (ASHRAE, 2004). Both DeltaOHM HD32.3 and HOBO Datalogger were used for this purpose. The DeltaOHM HD32.3 had connecting sensors for recording the air speed, globe thermometer temperature, ambient temperature, and relative humidity, while the HOBO Datalogger could accurately record readings of air temperature and humidity.

The questionnaire survey and all monitoring processes were carried out in both case study malls within the month of March on weekends (Saturdays and Sundays) since malls are generally more visited during the weekends (Hu and Li, 2015; Hassan et al., 2015). And the whole data collection process was carried out within the period of 11 AM − 5 PM. At the end of the survey, a total of 156 completed questionnaires were collected in SM1 and 154 in SM2. Questionnaire forms that were excluded from the analysis were those that were poorly filled out as well as responses from retailers with less than 4 months of occupancy and shoppers with less than 4 months of repeated visits to the

Table 2: Descriptive statistics of all measured physical factors.

Malls' ID	IEQ Factors	Air Temperature (ºC)	Operative Temperature (ºC)	Relative Humidity (%)	Air Speed (m/s)	CO_2 (ppm)
SM1	Mean	33.52	34.33	43.11	0.89	437.88
'open' concept	Std. Dev.	±0.39	±0.79	±1.63	±0.20	±22.05
	Minimum	32.45	33.20	40.35	0.42	413.00
	Maximum	34.36	36.70	46.59	1.42	478.00
SM2	Mean	33.12	33.51	49.35	0.65	438.24
'enclosed' concept	Std. Dev.	±0.77	±0.89	±3.55	±0.11	±19.90
	Minimum	31.58	31.80	43.24	0.41	397.00
	Maximum	34.27	35.08	60.32	0.95	491.00

studied malls (Khalil and Husin, 2009; Jamaludin et al. 2014). Eventually, a total of 144 and 145 responses from SM1 and SM2 respectively were used for the analysis. The obtained data were analysed using SPSS software version 21 and excel spreadsheet. Relevant statistical analyses were carried out to achieve the study's objectives.

3. Results and discussion

3.1 Results from objective measurement

Table 2 represents the descriptive statistics of all measured physical factors in each studied mall. The recorded air temperatures in both malls were generally high. This is an expected observation since the monitored area in both malls is primarily naturally ventilated, although higher air temperature and air speed were recorded in the 'open' concept mall (SM1) compared to the 'enclosed' one (SM2). This could be due to the fact that the 'open' concept mall is more opened and exposed to the outdoor and also provided with wide open entry points compared to those found in the 'enclosed' mall. The wide open entry points are easy and direct link to incoming breeze and contribute to heat gain through direct penetration of sunlight.

The average CO2 levels in the two malls were low and well below the maximum concentration level of 1000ppm, as stated in the Malaysia code of practice on indoor air quality (DOSH, 2010). This indicates that the natural ventilated zone of the mixed-mode ventilated malls is less contaminated with CO2. This is understandable since there is provision for free air circulation between the outdoor and indoor in both malls, thus facilitating high air ventilation rates (Yamamoto et al., 2010; Marr et al., 2012). Moreover, high ventilation rates have been revealed to improve IAQ and reduce contaminations caused by various indoor contaminants (Zuraimi and Tham, 2008; Fisk et al., 2009).

3.1.1 Performance comparison between the two malls

A Mann-Whitney U test (non-parametric equivalent of independent sample t-test) was conducted to compare the performances of the two malls. Table 3 shows the comparison between the two malls. The result reveals no significant difference in air temperature and CO2 performances between the two malls. However, a significant medium-sized difference in performance is evident for operative temperature and air speed while a significant large-sized difference in performance was recorded for relative humidity. This indicates that SM1 performs better than SM2 with regard to indoor relative humidity and air speed. Whereas SM2 performs better than SM1 with regard to indoor operative temperature.

Table 3: Mann-Whitney U test: comparison between both malls

Pair wise comparison		Air Temp. (ºC)	Operative Temp. (ºC)	Relative Humidity (%)	Air Speed (m/s)	CO2 (ppm)
SM1 - SM2	Sig.	0.223	0.017*	0.000*	0.000*	0.834
	Effect size	-	0.22 Medium	0.81 Large	0.38 Medium	-

*Significant at .05
Effect size: r=Z/√n, where Z = Standardised test statistics and n = the number of cases
r = 0.10 (**small effect**); r = 0.30 (**medium effect**); r = 0.50 (**large effect**) (**Cohen, 1988**)

Table 4 Prevailing outdoor weather data for monitoring days

Malls/ stations		Air temperature (^{0}C)	Relative humidity (%)	Wind speed (m/s)	Wind direction (degrees)
SM1/MM	Mean	33.5	50.0	1.2	180
	Minimum	31.7	42.0	0.7	020
Petaling-Jaya station (5th & 6th March)	Maximum	34.9	59.0	1.8	360
SM2/MM	Mean	33.3	53.0	2.7	230
	Minimum	31.2	47.0	1.1	050
Subang station (12th & 13th March)	Maximum	35.1	71.0	5.4	350

3.1.2 ASHRAE Standard 55-2013 psychrometric chart

The mean prevailing outdoor temperature for the period of data collection was sourced for the calculation of the adaptive model for the two mixed-mode ventilated malls and these were obtained from relevant meteorological stations. Two weather stations nearest to the case study malls were chosen for this purpose. The nearest weather station to SM1 is Petaling Jaya Meteorological station, which is about 31.9km away. While the nearest weather station to SM2 is Subang Meteorological station, which is about 11.4 km away. Weather data such as hourly recorded data of temperature, relative humidity, air speed and direction were sourced. Subsequently, the mean, minimum, and maximum values were calculated (Table 4). The psychrometric chart for both case study malls was generated using the free online CBE comfort tool developed based on work at the Center for the Built Environment, University of Berkley (Tyler et al., 2016). The tool allows users to determine whether a certain combination complies with ASHRAE 55 by inputting relevant comfort parameters.

For the two mixed-mode ventilated malls, the adaptive model was used and the inputted comfort parameters were mean operative temperature, mean prevailing outdoor temperature, and air speed. This was in response to various studies that indicated that the natural ventilation zones in a mixed-mode ventilated building could be treated as a purely natural ventilated space (Honnekeri et al., 2014; Luo et al., 2014; Rupp and Ghisi, 2014). Figures 5 and 6 show the psychrometric charts for the two mixed-mode ventilated malls SM1 and SM2 respectively.

Although there is a difference in performance between the two malls with regard to indoor operative temperature, relative humidity and air speed, it can be noticed that none of the two case study malls complied with the ASHRAE standard 55 for thermal comfort in an occupied space during the monitoring period (11am − 5pm). This result supports many studies that have revealed that naturally

Figure 5: Psychrometric chart for SM1

Figure 6: Psychrometric chart for SM2

ventilated buildings in high temperature regions fall below the ASHRAE comfort zone (Nicol and Humphreys, 2002; Cândido et al., 2010; Toe and Kubota, 2013; Kumar, 2015). This was due to the fact that occupants of these buildings used different adaptive measures (e.g. change clothing or use alternative means to achieve comfort like opening the windows) to adapt themselves to their thermal environment. As a result, they could comfortably accommodate a wide range of temperature.

3.2 Survey results

3.2.1 Demographic characteristics

Occupants' information was investigated to analyse their demographic characteristics. Table 5 represents the characteristics of a total of 289 respondents from the two case study malls. The mean age of respondents was 27.38 years, with the minimum and maximum age of 17 and 61 years respectively. Retailers in the two malls had the personal means of control in their workplaces and the two most popular means of control were ceiling and potable fans (see Figure 7). In both case study malls, majority of the respondents were females and also Malaysian citizens and the two main positions held by the retailers were 'sales assistant' and 'managerial/supervisor' positions (Figure 8). In both malls, the average period of occupancy for retailers was twelve (12) months and their average period of stay in their workplace per day was 10.38 hours. However for shoppers, the average of their visitation was 11.49 months (i.e. on average a shopper had been visiting the mall for the past 11.49 months). Also, the average period a shopper spent in the mall was 3.5 hours. Comparatively, this is far less than the average period the retailer spent in his/her
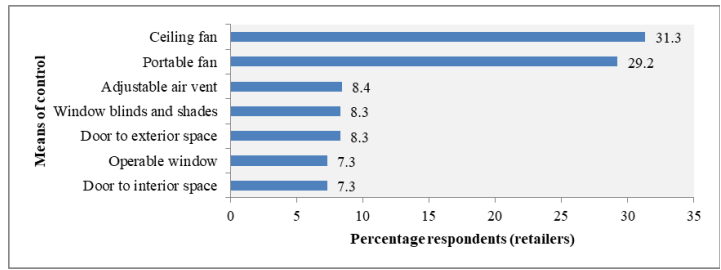
Figure 7: *Retailers' means of control in both malls*

workplace. With regard to the activity rates and clothing worn by shoppers and retailers, the mean metabolic rate in both case study malls was 1.24 met while the mean clothing value was 0.56 clo.

3.2.2 Thermal sensation and comfort votes

Table 6 shows the distribution of thermal sensation and comfort votes across the two case study malls. It can be seen in Table 6 that in both malls, respondents mostly felt 'slightly warm'; however, majority of them still felt 'just comfortable' with their thermal environment. After the thermal comfort scales were grouped into two categories (uncomfortable and comfortable), majority of respondents in SM1 found their thermal condition comfortable (65.3%) while, majority in SM2 (50.3%) found their thermal condition uncomfortable.

3.2.3 Thermal acceptability and preference votes

Table 7 shows the distribution of thermal acceptability votes in both case study malls. It can be seen in Table 7 that majority of the respondents fall under 'just acceptable' category and clearly, very few respondents accepted their

Table 5 *Respondents' attributes*

Variables		SM1	SM2
Sample size		144	145
Means of control		yes	yes
Type of respondents	Shoppers	99	100
	Retailers	45	45
% Gender	Female	70.8	62.8
	Male	29.2	37.2
% Nationality	Malaysian	92.4	95.2
	Foreigner	7.6	4.8
Age in years (N = 289)	Mean	27.38	
Average period of occupancy (months)	Retailers (n = 90)	12.0	
Average period of visiting (months)	Shoppers (n = 199)	11.49	
Average period of stay in workplace per day (hours)	Retailers (n = 90)	10.38	
Average hours spend in a mall per visit (hours)	Shoppers (n = 199)	3.5	
Average clothing value (clo)		0.56	
Average activity rate (met)		1.24	
	SD	8.73	
	Maximum	61.0	
	Minimum	17.0	

Table 6: Distribution of thermal sensation and comfort votes

Thermal sensation	Cold (-3)	Cool (-2)	Slightly cool (-1)	Neutral (0)	Slightly warm (+1)	Warm (+2)	Hot (+3)
SM1	0	0.7%	4.2%	36.8%	37.5%	15.3%	5.6%
				78.5%			
SM2	0	0	4.8%	38.6%	45.5%	10.3%	0.7%
				88.9%			

Comfort	Very un-comfortable	Uncomfortable	Just uncom-fortable	Just comforta-ble	Comfort-able	Very com-fortable
SM1	2.8%	10.4%	21.5%	56.3%	8.3%	0.7%
		34.7%			65.3%	
SM2	1.4%	11.7%	37.2%	45.5%	4.1%	0
		50.3%			49.6%	

thermal condition (7.6% and 0.7% respondents in SM1 and SM2 respectively). In addition, as shown in Table 8, majority of the respondents in both malls preferred a 'cooler' thermal environment (76.4% and 80.0% for SM1 and SM2 respectively). Furthermore, most of them preferred more air movement within the indoor environment (Table 9).

3.2.4 Assessment of acceptability by various scales

In accessing occupants' thermal acceptability, various scales are being developed, namely,1) the middle three scale (-1, 0, +1) of the ASHRAE thermal sensation scale, 2) direct thermal acceptability votes, and 3) percentage responses that falls in the 'no change' category of the thermal preference scale (Kwok and Chun, 2003; Wong and Khoo, 2003). By equating the central three categories of the ASHRAE thermal sensation scale with the impression of acceptability, 78.5% and 88.9% (see Table 6) of the

Table 7: Distribution of acceptability votes

	Clearly unac-ceptable	Just unac-ceptable	Just ac-ceptable	Clearly accepta-ble
SM1	2.1%	16.7%	73.6%	7.6%
	18.8%		81.2%	
SM2	2.8%	23.4%	73.1%	0.7%
	26.2%		73.8%	

Table 8: Distribution of temperature preference

	No change	warmer	cooler
SM1	22.2%	1.4%	76.4%
SM2	18.6%	1.4%	80.0%

Table 9: Distribution of air movement preference

	No change	Less air movement	More air move-ment
SM1	30.6%	1.4%	68.1%
SM2	24.8%	4.1%	71.0%

occupants of SM1 and SM2 respectively were assumed to be satisfied with the thermal condition. With this, the ASHRAE's 80% thermal acceptability criterion was almost met in SM1, while this criterion was met in SM2.

The direct votes of acceptability for SM1 and SM2 were 81.2% and 73.8% respectively (See Table 7). The direct vote of acceptability in SM1 was higher than the central three categories of the ASHRAE thermal sensation scale. This shows that there are people who voted beyond the center three categories in SM1 but still find their environment acceptable. On the contrary, the direct votes of acceptability in SM2 was lower than the central three categories of the ASHRAE thermal sensation scale; hence, it is an indication that there are people who voted within

the center three ASHRAE categories in SM2 and yet find their environment unacceptable. This result pattern shows that not all respondents that votes within the middle votes of the ASHRAE thermal sensation scale find their thermal environment comfortable. Similar pattern was observed in Kwok and Chun (2003); Wong and Khoo (2003); Daghigh et al. (2009); hence, it is sensible to argue that people in the tropics voting in the extreme categories of the ASHRAE scale may not necessarily be experiencing thermal discomfort.

Compared to the other two modes of acceptability assessment, the thermal preference scale appears to be the most stringent measure of thermal acceptability, with only 22.2% and 18.6% of the respondents in SM1 and SM2 respectively indicating that they preferred no change (See Table 8). These findings clearly show that different measures of acceptability can produce generally different results.

Even though SM2 performed better than SM1 with regard to the indoor operative temperature, the psychrometric chart indicates that none of the two case study malls complied with the ASHRAE standard 55 for thermal comfort in an occupied space during the monitoring period. However, the survey reveals that SM1 fulfilled the ASHRAE's 80% thermal acceptability (while using the direct votes of acceptability). In the case of SM2, the ASHRAE's 80% thermal acceptability was almost met. Once again, this results confirm the wide spread believe that people in the hot climatic condition who occupy naturally ventilated spaces can adapt to wide and higher range of indoor temperature changes.

3.2.5. Occupants' thermal neutrality

Griffiths (1990) proposed a method in which the comfort temperature can be computed from a small data sample. Griffiths made the assumption that the increase in temperature for each scale point on the thermal sensation scale was effectively 3 ^{O}C for a seven-point scale (i.e., 1 = cold, 2 = cool, 3 = slightly cool, 4 = neutral, 5 = slightly warm, 6 = warm, and 7 = hot) as the case in this study. This indicates that for each thermal sensation vote away from neutral, he subtracted or added 30C from the actual temperature at the time to obtain the neutral temperature (Nicol et. al, 2012). Griffiths (1990) thus deduce the neutral temperature (Tc) from indoor air temperature (Ti) and the corresponding thermal sensation votes in this relation:

$$Tc = Ti + 3 (4 - C)$$

Where Tc represents the neutral temperature; Ti represents the indoor air temperature that corresponds with the time each respondent vote on the thermal sensation scale; C represents the respondents' thermal sensation votes.

However, the above relationship is based on the theoretical relationship between comfort parameters obtained in a climate chamber study. This relationship was therefore criticised and the equation was revised thus:

$$Tc = Ti + 2 (4 - C)$$

Therefore, equation (2) was used to calculate the neutral temperature for the three case study malls. The average value for each parameter in each case study mall was used.

For the SM1 ('open' concept mall), by using the above formula, we found Tc = 31.93 ^{O}C. Similarly, for the SM2 ('enclosed' concept mall), Tc = 30.59 ^{O}C.

In the 'open' concept mall thermal neutrality was found to be 31.93 ^{O}C, indicating that users of the 'open' concept mall could tolerate higher indoor air temperature compared to users of the 'enclosed' concept mall.

In summary, despite the higher indoor temperature recorded, the 'open' concept mall can still provide its occupants with a more thermally comfortable indoor environment compared to the 'enclosed' concept mall. This is evident in the high percentage of occupants who voted comfortable and found their indoor thermal condition as acceptable. Also, the occupants' high indoor temperature tolerance as demonstrated in their thermal neutrality. To some degree, the reasons why the occupants of both malls are expected to be tolerant of high indoor temperature are twofold: 1) considering the fact that the studied spaces in both malls are naturally ventilated and 2) occupants in both malls are provided with means of personal control mainly by ceiling and portable fan. As indicated by Djamila et al. (2013), the acceptance of high thermal condition by occupants of naturally ventilated spaces can be explained by the relationship that exist between them and their means of control. Occupants' adaptive ability can escalate primarily due to the excessive dependence on the use of fans to relieve thermal discomfort and as supported by Nicol (2004), indoor temperature above 30 ^{O}C can be tolerated by occupants if fans are used as a means of improving their thermal condition.

Despite the similarities between both malls in terms of them been naturally ventilated and the provision of personal control, the 'open' concept still proved superior to the 'enclosed' concept mall. The high indoor temperature tolerance as demonstrated by the occupants in the 'open' concept mall could be further explained by the high recorded indoor air speed. The average air speed recorded in the 'open' concept mall was higher than the 'enclosed' concept by 0.24 m/s. According to Nicol (2004), air movement is an essential factor in determining comfort in hot-humid climate so much so that an increase in air velocity above 0.1 m/s can significantly raise the comfort temperature.

Despite the higher indoor air speed advantage that the 'open' concept mall has over the 'enclosed' one, majority of its occupants still prefer higher air movement. This is similar to the observation from a study on subjects in naturally ventilated spaces under hot-humid climatic condition by Cândido et al. (2008) where even under air speed above 0.5 m/s majority of the respondents still demanded for increased air movement. This can be explained by an argument from Szokolay (1997) who confirmed that under a hot thermal condition, indoor air speed of 1 m/s would be considered pleasant by occupants as comfort could be achieved through psychological cooling effect enhanced by the evaporation of sweat from the skin surface. Szokolay further added that an indoor air speed of 1.5m/s would be considered more acceptable. Unfortunately, none of the two mixed-mode ventilated mall succeeded in attaining this stated air speed values.

4. Conclusion

This paper has revealed the IEQ performances of two mixed-mode ventilated malls by conducting both objective and subjective measurements. From the objective measurement results, the two malls recorded high indoor air temperature range. However, for the CO_2 concentration, the two malls performed well as their CO_2 values are within the recommended range. Both malls recorded high air speed values but the recorded air speed in the 'open' concept mall is higher compared to that recorded in the 'enclosed' concept mall. From the subjective measurement, the results have revealed that both malls fell below the ASHRAE comfort requirement. Yet, thermal acceptance in both malls was high with higher acceptance for the occupants in the 'open' concept mall. Although the recorded air speed was high for both malls, majority of the occupants still preferred higher air movement. Furthermore, occupants' neutral temperature

for the 'open' concept mall was significantly higher than the neutral temperature for the 'enclosed' concept mall.

In conclusion, an 'open' concept mixed-mode ventilated mall can potentially provide its occupants with a more thermally tolerant indoor environment due to the higher indoor air movement advantage compared to an 'enclosed' concept mall. This study has been able to prove that for natural ventilated spaces, the air movement is very essential in elevating occupants' thermal condition. Therefore, mixed-mode ventilated malls should ensure that their indoor spaces receive adequate air movement within their natural ventilation zones by adopting a more open design that allows for direct and close link to the outdoor. By allowing easy exchange of air, required air movement for body cooling will be established within the indoor space.

This study was only carried out in two case study malls in Malaysia located within the state of Selangor and the federal territory of Kuala Lumpur and as such, not a representative of all shopping malls operating in Malaysia. Further study is recommended to include malls from other locations in Malaysia and also incorporate a larger number of survey respondents.

This study provides a better understanding on occupants' expectations and concerns with regard to their indoor environmental conditions. The results can potentially be used to help designers in creating malls that are more efficient in resources and also safer and healthier for people and the environment.

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Familiarity Factors of Street Features in Pedestrian Wayfindings

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ABSTRACT

From an origin point to a destination point, good wayfinding process requires familiar recognition on the street environment. However, the unclear reasons of identifying street features to determine a route to the destination influences a pedestrian to select the wrong turn, walk in longer distance, and lost his direction. This paper aims to identify the factors that influence pedestrian familiarity, familiar or unfamiliar, in people wayfinding. Two hundred questionnaires were collected in Teluk Intan, Perak, Malaysia. Quotations from 30 interviews were used to triangulate the findings. Factor analysis available in IBM SPSS version 21 was used in exploring the familiarity factors for wayfinding. The finding suggests three factors influenced pedestrian to familiar with the street environment, which the factors are characteristic, attraction, and interest of street features. While, the duplication design of street features, error in defining the position of street features and form similarity of street features influence pedestrian to become unfamiliar with the street environment. This paper implies that the physical form of street features gives impact to pedestrian familiarity. Consideration of the three factors that influence pedestrian to familiar with the environment can improve how pedestrian experience in street network especially wayfinding.

1. Introduction

In a street network of a town, pedestrians start scanning the environment, organize their position, locating the destinations, recognize the street features, and refine the route to the destination. Indirectly, they have involved with wayfinding. Wayfinding involved with the ability and process of locating the destination by using route. It is the psychological process of pedestrian in referring, recognizing, judging, defining, and deciding the environment to find the route (Anwar and Amalia, 2017; Carlesimo et al., 2015; Gimbel, Brewer, and Maril, 2017; Lingwood et al., 2018; Moskat et al., 2018; Wan Mohamad and Said, 2017; Wang and Cheng, 2018; Zijlstra et al., 2016). At the same time, it requires ability to identify, plan, move, and reach the destinations (Gimbel, Brewer, and Maril, 2017; Lingwood et al., 2018; Zijlstra et al., 2016). Therefore, wayfinding is defined as the behavior and cognitive process of finding route to the destination in the street environment. However, the reviews is still lack on the connecting cognitive process to behavioral process.

The efficiency in wayfinding depends on the pedestrian's familiarity with the street environment, either familiar or unfamiliar. Familiar is the intuition from pedestrian's knowledge to recognize the street environment while unfamiliar is on the contrary (Wang et al., 2018). Familiar of pedestrians with the environment influences them to define a better route to the destination. Familiarity is related with the information gain by pedestrian. Familiar pedestrians depend on their internal sources, which are the information on street features that they

remember (Hami and Tarashkar, 2018). Hence, they move in the familiar environment according to their hypotheses about the route, deduct the route that they not prefer, and follow their instinct (Wang et al., 2018). Therefore, the street features such as landmark function as reference for them which contribute to their spatial information, thus directional information such as signage are not useful (Suzer, Olgunturk, and Guvenc, 2018; Wang et al., 2018). Meanwhile, fail to recognize the street environment exposes pedestrian to become unfamiliar. Due to the new development or new experience to the environment, the information of street features gained make them confuses to decide which turn to select or route to use in reaching the destination (Suzer, Olgunturk, and Guvenc, 2018). Hence, unfamiliar pedestrian depends on external sources such as signage or asking others to gain information in deciding the direction (Hami and Tarashkar, 2018; Wang et al., 2018). Therefore, unfamiliar pedestrians can misinterpret with the information gain from others, accordingly expose them to make mistake or lost direction. The reviews presents the limitation in defining why pedestrian experience unfamiliarity.

However, street network of a town often exposes wayfinder to become unfamiliar with the environment. Accordingly, Mandel and LeMeur (2018) presents four difficult situations in wayfinding. Firstly, lack of spatial information presented by about positions, locations, and directions. Secondly, the information gained in the street does not match with their memory on the place. Next, difficulty in asking other pedestrians limits the information gathered. Lastly, there is no external source such as maps or mobile navigation systems available during

travel. Therefore, this paper aims to identify the factors that influence pedestrian familiarity, familiar or unfamiliar, in their wayfinding. By identifying the factors of familiarity, the better design consideration of street features for pedestrians to experience better wayfinding as a guide to architects, landscape architects, and urban planner. This paper hypothesizes that street features in small town are multi-dimensional in familiar and unfamiliar environments. Hence, the null hypothesis is street features in small town are uni-dimensional in familiar and unfamiliar environments. Pedestrians' familiarity, familiar and unfamiliar, is measured in exploring their perception on the street features during searching for information to define the route to the destination.

2.   Methodology

2.1   Survey Questionnaire

This paper employed survey questionnaire as the main instrument to collect statistic information on perception of pedestrian wayfinding (Cohen, Manion, and Morrison, 2007). Survey questionnaire was used to measure two parameters, namely, (a) diversity of street features, and (b) familiarity in wayfinding. Diversity of street features consists of collecting points, landscape elements, buildings, and streets elements. The street features (n=10) are landmark, square, jetty, walkways, stalls, park, special buildings, trees, shrubs, and grassed area. The street features are commonly identified in Malaysian small town as suggested by Wan Mohamad and Said (2016). Meanwhile, familiarity in wayfinding refers to pedestrians' perception on how the street features make them familiar or unfamiliar with the street environment. Hence, each street feature was assessed on how it can assist or confuse the pedestrian in their wayfinding process.

Based on Dual Process Theory by Evans and Stanovich (2013), the street features are judged by pedestrian according to intuitive and reflective process which are developed from human cognition. Intuitive means pedestrian feels unfamiliar with the street features that reflect to the recollection of the information to find the right route. While, reflective process means pedestrian feels familiar with the street features that reflect pedestrian to select the right route spontaneously. Therefore, the questionnaire consists of two questions: (a) which level do street features help you to recognize the way to the destination? and (b) which level do street features make you confused and lost in the way to the destination? The answer was in Likert scale. The scale used to assess the level of street features in influence pedestrian to familiar were (1) highly not assist, (2) not assist, (3) assist, and (4) highly assist. While, the scale for pedestrian to assess the street features that may confuse them in wayfinding were (1) highly not confuse, (2) not confuse, (3) confuse, and (4) highly confuse.

Based on Fowler's sampling error formula (Creswell, 2012), percentage of sampling error for 100, 200 and 300 are 10%, 7% and 6%, respectively. By comparing percentage of sampling error for 100, 200 and 300, there was a difference by 3% between sampling size 100 and 200 while 1% for sampling size 200 and 300. Considering the worthwhile to collect the sample according to the percentage of sampling error, this study used 200 as sample size for survey questionnaire with 7% of sampling error and 93% of confident interval.

On February, 2014, the survey was conducted on 200 pedestrians who travel in Teluk Intan, Perak, Malaysia which was decided according to Fowler's sampling error formula 1988 (Creswell, 2012). Located in northern region of Malaysia peninsular and southern of Perak, Teluk

Intan is a small town with population of 41,701. The town was founded by Sir Archibald Edward Harbord Anson during colonial era 1882. After Malaysian independence 1957 until present, the town is authorized by Malaysian Government with total area of 72 hectares which consists of old and new zones where old zone area listed as historical town conserved by Federal Department of Town and Country Planning Peninsular Malaysia (2006).The survey was conducted at 20 collecting points of the most visited points identified by Wan Mohamad and Said (2016) which are two shopping malls, a landmark, a square, a jetty, two taxi stations, two bus stops, two playgrounds, two parks, three banks, and four stalls. The survey was conducted with help of two trained assistants which were the former students of Landscape Architecture program, Universiti Teknologi Malaysia who graduated in 2011. Permission letter provided by Faculty of Built Environment, Universiti Teknologi Malaysia was used to gain the cooperation from respondents and to declare that the information obtained are officially confidential and only used for this research (Creswell, 2012). This study used Cronbach alpha to measure reliability according to the internal consistency of the data collected (Cresswell, 2014). Accordingly, the values of Cronbach alpha for familiar and unfamiliar were 0.853 and 0.833 respectively. This means the questionnaire used in collecting the data for measuring perception of pedestrian familiarity was reliable because the values of Cronbach alpha in within 0.7 to 0.9 (Tavakol and Dennick, 2011).

The data of survey questionnaire were analyzed using exploratory factor analysis to define the factors that influence pedestrian to be familiar or unfamiliar with the street features (Costello and Osborne, 2005; Froman, 2001; Matsunaga, 2010). This study exploring the factors that affect pedestrian familiarity after perceiving street features in the town environment. Hence, exploratory factor analysis is an appropriate analysis tool to evaluate pedestrian perception in exploring the factors. The analysis involved with two tests: (a) Kaiser-Meyer-Olkin (KMO), and (b) Bartlett's test. Hence, this analysis was used to test the hypothesis of this study, which is street features in small town are multi-dimensional in familiar and unfamiliar environments. The hypothesis was accepted when p-value less than 0.05 ($p<0.05$) and indicates that results are significant. In extraction and rotation, the number of factors that influences pedestrian perception on street features was defined according to Kaiser Criterion suggested by Costello and Osborne (2005) with eigen values greater than 1.0. Accordingly, the results of factors were interpreted based on the items factors collected.

2.2   Interview

This paper employed interview method to obtain specific knowledge of pedestrian experience wayfinding in street network of small town (Cohen, Manion, and Morrison, 2007). Face-to-face interview session was conducted on 30 pedestrians who travel to two points, wet market and bus stop in Teluk Intan, Perak, Malaysia. As discussed by Gillham (2005), 30 is the sufficient sample size for the interview. The information used to support or explain the findings interpreted form the analyses. They were asked with the semi-structured questions which developed from the results of statistical analysis (Kumar, 2014). The interview sessions were conducted in Malay and lasted between 10 to 15 minutes. The interactions between researchers with the participants were recorded by using MP3 Digital Recorder. The data from interview was analyze using content analysis to examine and verify of the content gathered from pedestrians' responds in experiencing wayfinding in Teluk Intan, Perak (Matthews and Ross, 2010). The data were transcribed verbatim in Malay and translated into English. Then,

the transcripts were categorized according to the parameters measured to explain the obtained results from factor analysis. Accordingly, the quotations from this content analysis were summarized to support the findings.

3.   Results and Discussion

Data from survey questionnaire were analyzed using factor analysis to identify the factors of street features that influence pedestrian wayfinding. The analysis is used to determine the street features belong to the sets of factor. Hence, the set of street features explain the reasons of pedestrian recognize the route or confuse with the direction to the destination.

Table 1 presents that the values of KMO measurement for familiar and unfamiliar environment is 0.858 and 0.829, respectively, within range 0.6 to 1. Therefore, the result suggests that the analysis possesses the strong interrelationship to identify the factors for familiar and unfamiliar environments (Tabachnick and Fidell, 2014). Accordingly, the data from 200 pedestrians are sufficient to determine the factors.

Table 1 KMO and Bartlett's test for familiar and unfamiliar environment

Description		Familiar	Unfamiliar
Kaiser-Meyer-Olkin Measure		0.858	0.829
Bartlett's Test of Sphericity	chi-square	1200.603	1127.509
	df	105	105
	p-value	0.000	0.000

For Bartlett's test, Table 1 shows that both p-value for familiar and unfamiliar environments achieve the significant level where p-value less than 0.05 which is 0 (Chua, 2008). Hence, the null hypothesis is rejected. This suggests that street features in small town are multi-dimensional for familiar and unfamiliar environments. These means the set of street features possess factors in influencing pedestrians to familiar or unfamiliar with the street environment. Loading from pattern matrix of principle component analysis is assessed to define and interpret the factors that influence wayfinding process. Therefore, the discussion on factors is divided into two: (a) familiar, and (b) unfamiliar.

3.1   Factors for Familiar

Table 2 presents three factors that influence pedestrians to familiar with the street environment, namely, Factor 1, Factor 2, and Factor 3.

Table 2 indicates that Factor 1 consists of four street features which are

Table 2 Loadings of street features for familiar environment

Street Features	Factor 1	Factor 2	Factor 3
Shrubs	0.828		
Grassed Area	0.823		
Trees	0.809		
Walkways	0.419		
Square		0.711	
Landmark		0.672	
Stall		0.616	
Park			0.767
Special Building			0.615
Jetty			0.402

shrubs (0.828), grassed area (0.823), trees (0.809) and walkways

(0.419). According to the street features, shrubs, trees, and grassed area possess prominent characteristic (Figure 1). For instance, the red color of the flowers emphasizes the prominent characteristics of Bougainvillea spp. (Bougainvillea) at Sekolah Street. The green-yellow color of Ficus benjamina (Weeping Fig) leaves attracts pedestrians' attention to recognize Ah Cheong Street. The green character of grass, Axonopus compressus (Cow Grass) is planted in a huge space attract pedestrian to remember. The brightness color of leaves develops pedestrians' attentions to the shrubs, trees, and grassed area to record the spatial orientation. As a result, they tend to refer to the area when experience the environment again. This suggests that the prominent characteristic of the street features influences pedestrian to recognize route. Some pedestrians commented that:

"This flower (Bougainvillea) easy remained me with this street (Sekolah Street)."

"You can easily see this trees (Weeping Fig) when walking along this street (Ah Cheong Street)."

"There always held the events at this place (playfield)."

The children feel familiar to the environment when encounter the features with characteristics that appear according to bright color (Helvacıoğlu and Olguntürk, 2014). However, the finding identifies a difference that color can accentuate the characteristics of street features as the factor in influencing pedestrian to familiar with the environment, which not only for children.

The characteristic of walkways is stimulated by the facades of old and new buildings where pedestrians influence to remember the route to the destination (Figure 1). As commented by a pedestrian;

"This town (Teluk Intan) becomes special because it has these buildings (by showing the facades of old zone)."

The facades of historic buildings give meaning to the locals (Carmona, 2014). However, the finding modifies that the characteristics of walkways and facades of buildings associate with pedestrian recognition to recognize the route to the destinations. Accordingly, Factor 1 is defined and interpreted as prominent characteristic of street features as a factor for pedestrian to familiar with the street environments.
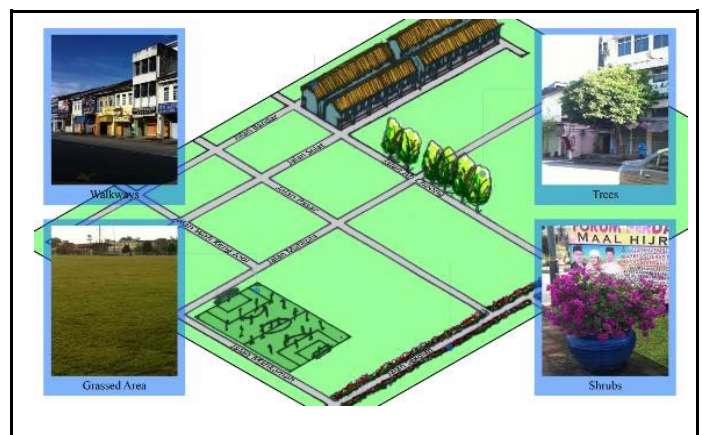
Figure 1 The prominent characteristic of street features influences pedestrian to familiar with the streets

In Table 2, three street features generate in Factor 2, namely, square (0.711), landmark (0.672), and stalls (0.616). Square is a tourism spot in Teluk Intan. The place is used by the locals or tourists as a gathering point. Attached with Menara Condong which is the landmark of Teluk Intan makes square as a significant gathering (Figure 2). Built by British in colonization era which was a water tank for the town, Menara Condong is now a clock tower and recognized as a historical building in Malaysia. While, stalls become popular among the locals because it sells local dishes as Mee Rojak and Mee Kicap. The recognition of the locals on the street features makes the places as an attraction and well known. As stated by a pedestrian;

"This is the gathering point for tourists (pointing at square and Menara Condong (landmark)."

"The best Mee Kicap Stall is at food court near Pasar Street."

As a result, square, landmark and stalls assist in pedestrians to recognize street environment and route to the destinations. Landmark represents as attraction for navigation (Ferretti et al., 2013). But, the finding indicates that square and stalls are also included as the street features evoked pedestrian attraction to the environment. Therefore, Factor 2 is defined and interpreted as place of attraction influence pedestrian to familiar with the street environment.

Figure 2 *The attractiveness of street features influences pedestrian to familiar with the street environment*
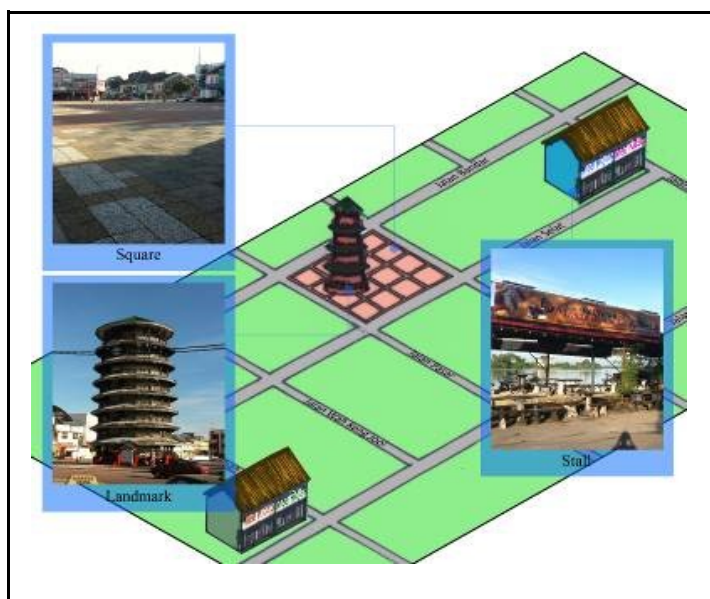
Table 2 presents three street features identified in Factor 3 which are park (0.767), special buildings (0.615), and jetty (0.402). According to Figure 3, the street features associated to create interesting feeling for pedestrian which stimulated by the design and function. Park is the highest loading in influencing pedestrian to familiar with the street environment. Landscape architect designed park to offer space for recreation in group. Thus, park becomes useful places for the locals to interest activities such as jogging, aerobic exercise, and family gathering. While, special building such as hospital, police station, or shopping mall provides services and necessities for health, security, foods, and daily needs. The necessities provided by shopping mall fits with local needs. This makes shopping mall as an interesting place by the locals. Similarly, Teluk Intan jetty connects the locals with other places such as Sembilan Island through Perak River interest the locals with the feature. Hence, the jetty is a significant street feature to recognize in Teluk Intan. For instance, some pedestrians said that;

"My family and I always visit the park during weekend for recreation."

"After The Store, there is a junction. We take right to Sekolah Street."

"After Teluk Intan Jetty, there a junction with traffic light, take right."

Park, special buildings, and jetty, the only feature in the town, hence, encourages pedestrians to recognize the direction to the features. For example, pedestrians are guided to recognize the route when perceived the jetty at Mahkamah Street (Figure 3). Pedestrian gain knowledge on jetty though their experience on using it. The recognition of park, special buildings, or jetty consequently oriented pedestrian to define direction to the destination when perceived the features.

Figure 3 *The interesting street features in influencing pedestrian to familiar with the street environment*

Routes were selected according to features that always used by pedestrian such as well-known streets (Holscher, Tenbrink, and Wiener, 2011). However, the finding identifies that well known streets occur when pedestrian experience the streets by using special buildings or jetty.

Park, special buildings, and jetty contribute pedestrian recognition as interesting elements in small town. Therefore, Factor 3 is defined and interpreted as the interesting elements in influencing pedestrian to familiar with the street environment.

3.2 *Factors for Unfamiliar*

Table 3 presents three factors that influence pedestrians to unfamiliar with the street environment which are Factor A, Factor B, and Factor C.

Three street features are accumulated on Factor A, namely, walkways (0.714), stall (0.542), and park (0.534). In Teluk Intan, the street

features are built by local authorities at various locations. Teluk Intan possesses with 117 walkways consisted of five-foot walkways at old and new buildings. The walkways are built in front of the old and new buildings' façades to provide walking space for pedestrians when travel in the town. This means the walkways depend on the buildings. The numbers of

Table 3 *Loadings of street features for unfamiliar environment*

Street Features	Factor A	Factor B	Factor C
Walkways	0.714		
Stall	0.542		
Park	0.534		
Landmark		0.741	
Square		0.728	
Jetty		0.565	
Special Building		0.527	
Shrubs			0.855
Trees			0.809
Grassed Area			0.748

walkways in old and new buildings make the environment look similar (Figure 4a). For instance, the similar environment of walkway in Intan 5 Street with walkway at Intan 6 Street confuses pedestrians. Similarly, the town possesses fourteen stalls which provided at Bandar Street, Syed Abu Bakar Street, Pasar Street, and Sekolah Street (Figure 4b). Therefore, their process to define route to the destination is interrupted when encounter walkways and stalls. Some pedestrians commented that;

"Both buildings in this area look similar to me. So, no differences if I walking here (walkway) or there (walkway of another building)."

"I thought this is the right way, this stall looks similar with another stall which selling the similar dishes."

Hence, the similarity in physical appearance of the street features generates pedestrians' memory to misjudge the information. Similar design in two different areas brings difficulty to pedestrian in recognizing the identity of the streets (Suzer, Olgunturk, and Guvenc, 2018). However, the finding explores further that the similarity in design of street features brings the similar effect for pedestrians to recognize the street environment, which influence them to feel unfamiliar with the streets.

Meanwhile, the impact of park is different. Pedestrian confuses with the street environment after perceiving the duplication of softscape and hardscape in park such as shelters, pavements, and benches. The landscape elements are provided by local authority with a similar design. For instance, benches in the park at Teluk Intan-Bidor Street are similar with the benches in another pocket park at Speedy Street. The similarity is according to material and color used such as pebble-washed finish and yellow (Figure 4c). Hence, pedestrian could presume the park at Teluk Intan-Bidor Street is the pocket park at Speedy Street when perceived the landscape elements in the park. As a result, the similarity associates to the error route selection in the wayfinding process. A pedestrian described about park;

"In this park, we can find benches and trees which look similar with other park at Speedy Street."

The idea of 'cloned' streets decreases pedestrian's recognition on the streets (Carmona, 2014). But, the finding describes further that the similarity in design of street features in street environment induces

a) Similar design of walkways

b) Similar design of stalls

c) Similar design of benches in parks
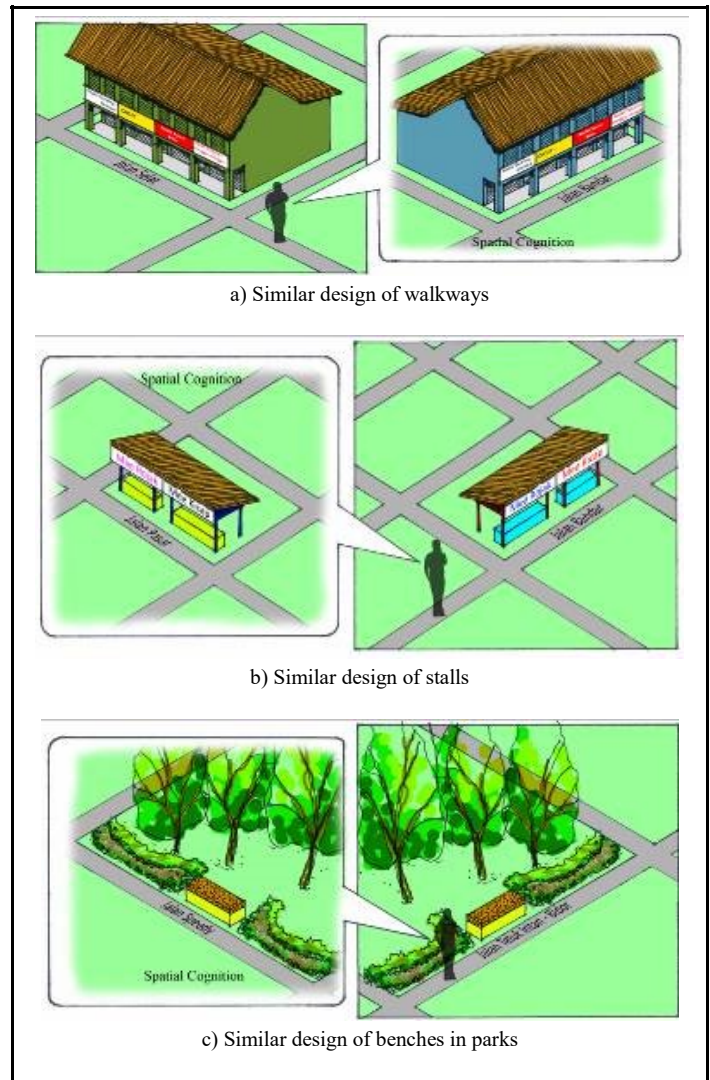
Figure 4 *Design duplication of walkways, stalls, and park confuses pedestrian to define route*

pedestrian to unfamiliar with the streets. Therefore, walkways, stalls, and parks define and interpret Factor A as design duplication of street features associates to interrupt pedestrian wayfinding process.

On the other hand, Table 3 presents four street features accumulated on Factor B which landmark (0.741), square (0.728), jetty (0.565), and special buildings (0.527). Landmark, square, jetty, and special buildings are the recognized features by the locals, but not excluded to interrupt pedestrian during travel. The confusion occurs due to the positions of the street features with pedestrian. Positions of pedestrian are various. For instance, pedestrians who recognize the landmark from Position A which commonly travel with regular route (blue route) could confuse with to decide another route from Position B (Figure 5). They could misjudge the route when assume Position B is Position A and decide to travel with the route that they remember (purple route). Hence, they could select the wrong route (red route). The situation associates to pedestrian experience bad wayfinding where he could loose by taking the wrong turn. As mentioned by some pedestrians which experience position error with landmark, square, jetty and special buildings;

"I have experience the situation when I take the wrong turn at Menara Condong because I am usually travel from other directions."

"Square looks similar from this direction with other direction which sometimes misinterpret the route."

"Sometimes, I misused the route when I travel at jetty from different directions. It happens when I think of something else."

"Yes, I experience it when I lost my focus when walking at The Store."

Human brain creates errors when encounter changes of viewpoint in different positions which cause by the angular displacement of the view frame and objects (Sulpizio et al., 2013). However, the finding identifies that pedestrians' recognition to the street features according to their experience when view from different positions reflects their wayfinding especially in deciding route. The situation occurs due to their concentration during perform the wayfinding when lost focus on

Figure 5 Design duplication of walkways, stalls, and park confuses pedestrian to define route

the route. Therefore, Factor B is defined and interpreted as error positioning when perceiving street features influence pedestrian wayfinding process in the street environment.

Lastly, three street features accumulated on Factor C, namely, shrubs (0.855), trees (0.809), and grassed area (0.748). The street features in Teluk Intan grow naturally while some were planted by local authority. The planting provide shade, cool the town, beautify the townscape, and create the sense of direction. However, similar species planted in different locations creates confusion to pedestrians. Pedestrians could misinterpret a location with another location when depends on a species of trees, shrubs or grass. The similar forms of trees, shrubs, or grass are in texture, color and size of flowers, fruits, leaves, and branches. Moreover, the planting changes when it grows. The changes on appearances make the environment harder for pedestrians to remember. For example, trees at Sekolah Street, Pterocarpus indicus (Angsana Tree), are similar with the trees at Changkat Jong Street. The similarity in green leaves, yellow flowers, and brownish trunk with huge form confuses pedestrian to define both streets (Figure 6a). A pedestrian commented that;

"I confuse with the trees because it look similar with other trees."

And the similarity also found at shrubs and grassed area (Figure 6b&c). For instance, some pedestrians said that about shrubs and grassed area;

"All shrubs look similar to me."

"I think both playfield look similar, huge and green."

The similarity in form of trees, shrubs and grassed area confuse pedestrian to define street with another street which planted by the similar species. The similarity of old and new information negatively influences pedestrian performance due to the overlapping information gained (Woollett and Maguire, 2010). But, the finding adds that the overlapping information from similarity forms of trees, shrubs and grassed area is created by its existence in different locations, not between old and new. Accordingly, trees, shrubs, grassed area, define and interpret Factor C as the similarity forms of the street features in influencing pedestrians to become unfamiliar with the street environments.

4. Conclusion

This paper found that three factors influence pedestrians to familiar with their route to the destinations. Firstly, the prominent characteristic of street features can influence pedestrian to recognize the route because the prominent character is easily to recognize and remember. Secondly, the street features which known as place of attraction by the locals such as landmark influence pedestrians to

a) Similar form of trees in two different locations

b) Form of shrubs in two different locations looks similar

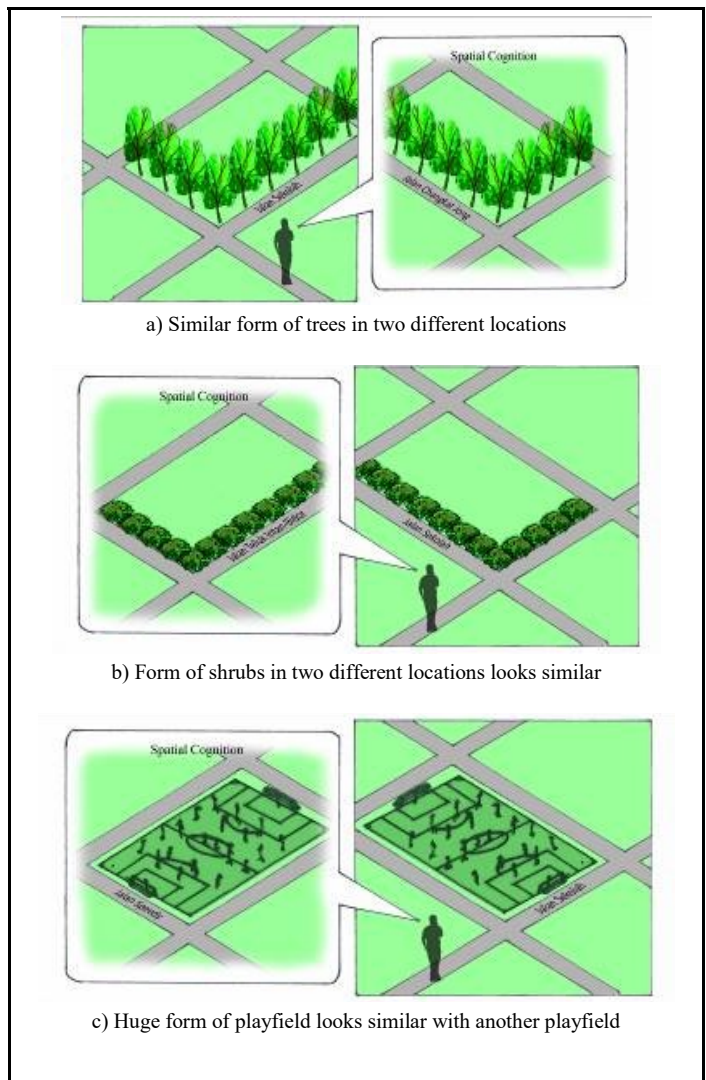c) Huge form of playfield looks similar with another playfield

Figure 6 The similarity in forms of trees, shrubs and grassed area confuse pedestrian with the street environment

familiar with the street environment. Lastly, street features with the interesting elements can evoke pedestrians' attachment to the features which leads pedestrian to know more about the features.

Besides, this paper also indicates three factors influence pedestrians to unfamiliar with the street environment. Firstly, pedestrians are interrupted during wayfinding when encountered street features with design duplication in different locations. Secondly, pedestrians experience error when perceived street features in various positions. Lastly, pedestrian confuses to define route when encountered street features with similar forms from other locations.

Therefore, in providing environment for pedestrians to experience better wayfinding, a town requires to have street features that possess prominent characteristics, well-known street features as attractions places, or provided interesting elements. While, to reduces mistakes or lost during travel, the provided street features require to avoid possess duplication design of street features in different locations, various position on perceiving well known street features, or similarity forms of street features.

The street features are influential features to determine pedestrians' familiarity on the street environment. Accordingly, rigor investigation is required especially in defining the index of wayfinding for each street features. Therefore, studies on quality of street features to influence pedestrians' familiarity in wayfinding in small towns are recommended.

Acknowledgment

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Awareness and Perception of Office Property Users on Green Building in Lagos, Nigeria

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ABSTRACT

This study examined the level of awareness, medium of awareness and the perceptions of office property users on Green building and their features in Lagos, Nigeria. The study sampled 352 office property users of 176 properties in the property portfolio of Estate Surveyors and Valuers in Lagos. Data was collected with the use of questionnaire administration. Using frequency counts and measures of relative perception index, the study revealed that majority of the users were not aware of green building. Only 23.6% were aware, and the predominant medium of awareness among these few was the Television. It was also revealed in the result that most of the users perceive green building as more of an environmental concept costing more to build and operate. The study concluded that there is need for more sensitisation on green building. Also, a balance information spread, especially on the social and economic benefits of green building is important for successful implementation of green building in the study area.

1.   Introduction

In the world over, there have been incessant symptoms manifesting in the environment vis-à-vis global warming, sea level rise, depletion of the ozone layer, climate imbalance, etc. These environmental issues have recently heightened consequent to several human activities that exploit rather than conserve the environment (Boyd, 2007). The startling rate at which the environmental hazards are mounting suggests that the environment is being endangered and might not be safe, especially for the upcoming generations if actions are not taken now.

The built environment is a major contributor to the environmental imbalance (USGBC, 2009; UCL Energy Institute, 2015). Growing awareness about the adverse impacts of use of resources on the environment and concern for national energy security in different parts of the world have therefore led to the momentum to bring about transformation in the construction industry for achieving improved sustainability. This is most evident in the introduction of "green building" concept with its major focal point on ensuring that during building related activities, the environment is conserved and building users' comforts are maximized at the least cost possible (US Green building council, 2003; UKGBC, 2009).

Green building practices are becoming increasingly recognized as a way of mitigating CO2 emissions and energy consumption, with environmental, economic, financial, and social benefits accruing. In the advanced countries of the world, several advances are being made by policy makers and government organizations to ensure that green building become mainstream but in Nigeria, among other emerging nations, the pace of green building practices is slower than its contemporaries. Several factors are responsible for this, the most important being inadequate information on the awareness and perception of stakeholders about green buildings, what it stands for, the benefits accruable and what this change in building practices will cost (Olaleye et al, 2015; Tathagat and Dod, 2015).

Widespread consensus on the need for green buildings does not necessarily result in extensive implementation of its practices. Although many stakeholders agree with green building principles, many are yet to grasp their meaning, and fewer have translated this into action (Khalfan, 2006). Mansour and Radford (2014) considers two levels of interaction with a green building: *Initial Perception* and *Extended Interaction*. Initial perception is primarily influenced by the information accessible in the public. Examples of information media that shape initial perceptions include word of mouth anecdotes about the building, media stories, published information, awareness of certification and past experiences with buildings generally. At the second level of interaction (extended interactions), the building stakeholders' experience in the building enhance a clearer picture of the advantages and disadvantages of the building. This includes the evaluation of building competency in terms of some functional and non-functional issues.

Following Mansour and Radford (2014)'s line of thought, green building adoption in Nigeria could be shaped by the information accessible to the stakeholders from various information media and the way this information are being processed in minds could be influenced by past experiences on buildings generally. Oladokun and Ojo (2012) reports that commercial properties in Lagos often pose building, operations and management problems like high cumulative

maintenance problems, electricity and plumbing needs, higher cash flow requirements and cost of construction. Stakeholders are therefore likely to seek better choices like green building, depending on how much information (on how this will better their experience) is available to them and how this information is perceived, interpreted and understood by them. According to Esa (2011) creating awareness is the first and biggest step to ensure that green buildings are here to stay. To communicate effectively to the stakeholders on green solutions to building related challenges, there is need to investigate their level of awareness and current perceptions on green buildings.

Among the stakeholders involved in green building investment, Miosander, Markkula, and Eraranta (2010) point out the importance and leading role of the consumer/users. The authors highlight consumer governing role, and reconfirm the consumer's position as a powerful market force whose interests and perceptions shape the success of green building adoption. There is therefore need to focus on the end users whose changes in demand pattern affects the operations of other relevant stakeholders.

The need to particularly focus on awareness of office property users is informed by the potential contribution of green building to office operational activities (Newsham et al., 2013). MCO Real Estate (2015) records an increasing supply of office properties in Lagos with proportional increase in occupancy rate. This constitutes potential demand for green building in Nigeria. The extent to which this latent demand can be pulled is dependent on the extent of information available, especially on office property users' awareness and perception.

Existing studies (Oladokun et al, 2010; Nwokoro and Onukwube, 2011; Otegbulu, 2011; Abolore, 2012; Oyewole et al, 2012 Olaleye et al, 2015; Komolafe and Oyewole, 2015; Nduka and Ogunsanmi, 2015 and Komolafe et al, 2016), especially in Nigeria have attempted to bridge the information gap on green building. Many however left out users' perceptions despite the importance to adoption of green building practices in Nigeria. This study therefore attempts to fill this gap by examining the awareness and perceptions of office property users on green building. Result from the study is useful in approaching awareness campaign successfully in Nigeria. It will also help in planning result oriented green building investment and implementation strategies in Nigeria.

2.   Literature Review

Perception and awareness of green products has long been studied in the field of marketing which eventually established a sub discipline known as green marketing. In building design and construction practices, perception of green building has received little attention in the literature; instead, numerous studies discuss the users' satisfaction and comfort in green buildings through post occupancy evaluations (Altomonte & Schiavon, 2013; Baird & Field, 2013; Hitchings, 2009; Huang et al., 2012; Lee & Guerin, 2009; Liang et al., 2014). Some of the few existing studies on perceptions on green building include Webb (2005)'s study which inquired into how those that are spreading the message about green buildings in Downtown Orlando area communicate it to stakeholders and the impact of their mode of communications on opinions about green buildings. Using questionnaires targeted at building professionals and potential home buyers, the study discovered that all green building experts hammered more on energy efficiency. In addition, when green buildings were presented as programs targeted at the environment or a form of government intervention, support for green buildings decreased. The findings of this study suggest that public support for green building concepts could be achieved when explained without an association to other public policy issues.

WBCSD (2007) examined the perceptions and attitudes of building professionals and corporate owners and tenants in eight countries (Brazil, China, France, Germany, India, Japan, Spain and the US) on green building. Based on in-depth physical and telephone interview of a total of 1468 respondents across the countries, the study revealed a relatively high level of awareness in all eight countries but low level of actual involvement in green building practices. Also, the respondents generally overestimated the cost premium of green buildings. This study however left out private users in their survey whose opinions are also important in shaping green building adoption.

Brown and Cole (2008) investigated, in a commercial setting, occupants' knowledge of building environmental features and systems, and awareness of control and feedback opportunities available to them. Using a web-based survey to capture knowledge levels as compared to an expert baseline for six office buildings of varying degrees of energy efficiency in the UK, the result reveals that respondents had a poor level of knowledge about how the building worked. In general, respondents were moderately satisfied with the overall comfort of the building environment (rating average 4.95 out of 7).

Jamison (2008) examined the awareness and perception of Washington state residents on green building. Through a random survey of 268 residents in the state, the study discovered that majority of the state residents could hardly identify with the existing green building programs. The study further revealed that many of the residents were only aware of the environmental features of green building and majority claimed ignorance on the meaning of green building. This study, though similar in focus, is based on a more developed economy than Nigeria.

AlSanad, Gale, and Edward (2011) explored the present knowledge, level of awareness and acceptability of the Kuwait's construction industry stakeholders to adopting the concept of green building. This study found out that the level of awareness of sustainability and green construction is considered to be in the "moderate" to "good" range. In Samarasinghe (2012) the awareness of features in green home and the people's perceptions towards living in green home in Sri Lanka was examined. Using both descriptive measures, regression and correlations between variables, the study discovered that building or purchasing green home did not only depend on people's awareness of green features but also determined by health consciousness, the environmental values, socio-economic constrains and habits of people.

Khalfan et al. (2015) examined the perceptions towards environmental, social and economic benefits of sustainable construction amongst contractors in the state of Victoria, Australia. The study adopted descriptive statistics. Findings revealed that perceptions towards the social and economic aspects of sustainable construction were positive, with about 60% of responses demonstrating positive perceptions. Client demand, associated costs of sustainable construction materials and practices and perceptions of employees and workers were perceived as barriers towards implementation of sustainable construction practices. The results also showed that some of the drivers of sustainable development and construction were the availability of environmentally friendly (green) material; financial incentives to clients and contractors; government policy for implementation; and overall environmental awareness within the industry.

A few of Nigeria studies on the subject matter include Ameh, et al (2007), Waniko (2014), Nduka and Ogunsanmi (2015) and Bungwon et al (2016). Ameh et al (2007) discovered that built environment professionals in Nigeria were aware of sustainability principles and sources of information on sustainable building practices were mostly

personal research. Waniko (2014) assessed Nigerian built environment professional's familiarity with green building. The study found that a higher percentage of the respondents were aware of the green practices.

Nduka and Ogunsanmi (2015) investigated the construction professionals' perceptions on green building awareness and accruable benefits in construction projects in Nigeria. The study revealed that most of the building industry professionals in Nigeria were familiar with green building principles and the inherent benefits. The study recommended the establishment of Green Building Council of Nigeria (GBCN) for awareness creation and introduction of guidelines, tools and techniques that will drive green building practices for future project.

Bungwon et al (2016) assessed the level of awareness of property managers and other built environment professionals on green or sustainable buildings in Kaduna, Nigeria. Using qualitative methods, the study revealed low level of awareness by property managers and other built environment professionals. Lack of technological advancement, failure of professional bodies to enlighten their members on new innovations, lack of expertise knowledge of green building and lack of interest from real estate developers were discovered as the major barriers to green building awareness.

It is apparent from the above studies that research on users' awareness and perception has not featured much in existing literature, especially in Nigeria. Most existing researches are tailored towards building professionals and contractors A few existing researches on users are based on post occupancy experiences as noted before. In this study, the awareness of users is examined and their perceptions on green building is studied.

3. Research Method

The target population for this study is office property users in Lagos, Nigeria. The users were reached through the Estate surveyors managing the properties they were occupying. The 2014 directory of the Nigerian Institution of Estate Surveyors and Valuers indicates that there are 440 estate firms in Lagos. One-fifth of the total number (88) was selected randomly and two office properties with detailed management records were selected from each of the sampled estate firms. This totals 176 properties sampled for survey. On each of the selected office properties, two users were purposively sampled, making 352 users. Information were elicited from the users through self-administered questionnaire distributed to the office property users.

The data elicited include users' level of awareness on green building, medium of awareness and perceptions about the features of green building when compared with same property not built to a green standard. From existing literature (Webb, 2005; Jamison, 2008), thirteen distinct indicators of green building which are in line with the triple bottom line concept of sustainability (economic, social and environmental aspects) were coined out for enquiry on users' perceptions of green building features. These features are lower utility costs, cost efficiency, energy efficiency, availability of parks, green belts, hiking trails and landscaping, healthy indoor air, building with recycled materials, more convenient living conditions, higher construction cost, lower environmental hazards, preservation of natural resources, water efficiency, durability, ease of maintenance and use of high-quality materials.

In order to confirm the robustness of the questionnaire and ensure that the instrument has an adequate and representative set of items, the researchers sought the input of experts. Interviews were conducted on the experts to ascertain whether instrument items are adequate to address the research objectives. The experts agreed that the research items are relevant and offered useful suggestions for improvement. Subsequently, the instrument was refined as suggested by the experts before the data collection was undertaken. Out of the 352 questionnaires distributed, 241 were retrieved constituting 68.5% response rate.

Data collected were analyzed using frequency counts, percentages, mean and relative perception index. Frequency counts and percentages were used to analyze the data obtained on level and medium of awareness of green building while mean was used to analyze data on users' perceptions on green building features. To arrive at the mean values, users were asked to rank the variables measuring their perceptions on a five-point likert scale, with weight 1 representing "much less"; 2, "somewhat less"; 3, about the same; 4, "somewhat more" and 5, "much more". The weights assigned to each attribute were multiplied by the frequency of response to the attributes. This is in turn summed together to get the total weight value (TWV) for each feature. The total weight value, when divided by the total frequency of response on each feature gives the mean value for the features as expressed below.

$$\text{(Mean value (MV)} = \frac{TWV}{\sum_{i=1}^{5} F_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where

TWV = total weight value and

F= total frequency of response

The relative preference index on perceptions for each feature was computed by dividing the mean value by the highest weight attributable to each feature, in this case, 5. This is further illustrated in the equation below

$$RII = \frac{MV}{A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where MV= mean value and

A= the highest weight attributable to each feature: 5

This is then used to rank the features in descending order based on their responses.

The use and suitability of mean value and relative preference index for study of this nature is supported by earlier studies (Johnson and LeBreton, 2004; Badu, Owusu-Manu, Edwards, Adesi and Lichtenstein, 2013) as it aids in finding the contribution a particular variable makes to the prediction of perceptions on green building both by itself and in combination with other predictor variables.

4. Results

The result of this study is discussed in line with the three major focal points of this study as presented in Tables 1 to 3. The first section deals with the level of awareness of the users. This is followed by discussions on the medium through which the users were aware of green building. The concluding part of the result deals with the perceptions of the users on the features of green building.

4.1 Level of Awareness of Green Building

Table 1 presents the result on the level of awareness of users of green building. The table reveals that 15 (6.2%) of the users were very much aware of green building; 42 (17.4%), slightly aware and 184 (76.4%) unaware of green building features. This result indicates that majority of the users were unaware of green building and this is in contrast with some existing Nigerian studies (Ameh et al, 2007; Nduka and Ogunsanmi, 2015) which recorded considerable awareness of building professionals on green building in Nigeria. The non-commensurate level of awareness between users and building professionals could have therefore limited incorporation of green building strategies by the professionals whose activities depend on users' perceptions.

Table 1 Users' Level of Awareness of Green Building

Levels of Awareness	Users Frequency	Percent
Very much aware	15	6.2
slightly aware	42	17.4
Not aware	184	76.4
Total	241	100.0

4.2 Medium of Awareness of Users on Green Building

Table 2 shows the medium of awareness of the users of green building. The table reveals that 47.4% were aware through the Television medium, 24.6% through Websites, 15.8% through friends and family and 12.3% through Newspapers and Magazines. This result shows that majority of the users who were aware of green building got to know about it through the Television. The result conforms with past findings of Jamison (2008) on the Eastern region of the Washington state that users had both initial and follow up contact with green buildings through television adverts.

Table 2 Users' Medium of Awareness of Green Building Features

Medium	Frequency	Percent
Television	27	47.4
Web site	14	24.6
Friend/family	9	15.8
Newspaper/Magazine	7	12.3
Total	**57**	**100.0**

4.3 The Perception of Users on the Features of Green Building

Having inquired into the level and medium of awareness of the respondents about green building, the perceptions of users about green building features and its characteristics when compared to conventional buildings was also sought in order to provide information that will help

in predicting their likely reaction to the adoption of green building in the absence of full intimation with the features. The parameters used were coined out from the features of green building in line with relevant literature. Tables 3 shows the result obtained.

The result as presented in Table 3 indicates that "Lower environmental hazard on green building" attracts a mean value of 4.573; "Preservation of natural resources", a mean value of 4.52, "Availability of parks, greenbelts, hiking trails and landscaping", 4.402; "healthy indoor air", 4.338; "higher construction cost of green buildings", 4.324; "Use of recycled materials in green building", 4.268 and "More convenient living conditions", 4.235. "Water efficiency of green building" has a mean value of 4.207; "Energy efficiency", 4.191; "Use of high quality materials, 4.124; "Durability of green building", 4.072; "Ease of maintenance", 3.83; "Lower utility cost", 3.389 and "Cost efficiency", 3.335.

From the relative perception index, it can be observed that the three features that the users attribute most to green building are its environmental friendliness (Relative perception index (RPI)- 0.9146), tendency to preserve natural resources (RPI- 0.904) and availability of parks, greenbelts hiking trails and landscaping (RPI- 0.8804) in descending order of magnitude. These features are more of environmental features and this therefore implies that users' perceptions are more skewed towards the environmental stand point relative to social and economic stand points. Webb (2005)'s study also has a similar findings as the study discovered that majority of stakeholders in Orlando perceived green building to be more of a program targeted at the environment or more of a government policy. This adversely affected their support for green buildings.

The result also shows that the three least perceived characteristics of green building are its ease of maintenance (RPI- 0.766), lower utility cost (RPI- 0.6776) and cost efficiency (RPI- 0.667) in descending rank order. This finding validates that of Bond and Perrett (2012) who discovered in their study in New Zealand that users perceived green building to be less cost effective than conventional buildings.

Also, it can be observed from the table that the mean values of majority of the green building indicators were above 4 (out of 5). This suggests that users have the right perspective on most of the features of green building. It is however noteworthy that the modal response across the rating scales on most of the indicators fall on "Somewhat more" and this is reflected in the mean values; as most mean values were closer to 4.

5. Conclusions

This study has discovered a low level of green building awareness

Table 3 Users' Perception on the Features of Green Building Compared to the Same House That is Not Built To a "Green" Standard

5: Much more; 4: Somewhat more; 3: About the same; 2: Somewhat less; 1: Much less									
Frequencies									
Green Building Indicators	5	4	3	2	1	Total	Mean	RPI	Rank
Lower environmental hazard	125	93	0	0	0	218	4.573	0.9146	1
Preservation of natural resources	115	106	0	0	0	221	4.52	0.904	2
Parks, greenbelts, hiking trails, landscaping	95	117	7	0	0	219	4.402	0.8804	3
Healthy indoor air	76	141	2	0	0	219	4.338	0.8676	4
Higher construction cost	68	134	2	0	0	204	4.324	0.8648	5
Built with recycled materials	68	124	13	0	0	205	4.268	0.8536	6
More convenient living conditions	52	169	0	0	0	221	4.235	0.847	7
Water efficiency	42	161	0	0	0	203	4.207	0.8414	8
Energy efficiency	37	157	0	0	0	194	4.191	0.8382	9
High quality material	39	157	13	0	0	209	4.124	0.8248	10
Durability	15	164	2	0	0	181	4.072	0.8144	11
Easy to maintain	23	131	2	26	0	182	3.83	0.766	12
Lower Utility cost	29	80	15	63	1	188	3.388	0.6776	13
Cost efficient	11	123	0	40	20	194	3.335	0.667	14

among the users and the low level of adoption of green building features in the study area can largely be traced to this. Rohracher (2001) noted that the largest barrier to green building is not developing the technology necessary but disseminating it broadly. If green building adoption is to be widely disseminated in the study area, the primary start point is widespread sensitization about the concept and its potential tendencies of constituting solutions to much of the challenges on the use and operation of building features.

Most of the few users that were aware of green building got to know about it through Television. Other information media like Newspapers, Magazines and websites are as well closer to most users in the study area; harnessing these media also is a plausible means of enhancing widespread awareness as a wider range of users and investors can be reached. Word of mouth according to Shrum, McCarty and Lowrey (1995) and Parasuraman (2000) can only be effective as increasing number of investors and users realize and are convinced of the advantages of building green. The lower level of awareness creation through this medium (family and friends) as revealed by this study could be traced to low green building practices in the study area. With increased use and adoption of green building practices however this medium could enhance wider spread if users and other stakeholders are convinced of the advantages.

Most of the users have the impression that green building is more about environmental consciousness and the result from their response shows that the users were more expectant on the environmental benefits of green building. The users particularly had misconceptions about the utility cost of green building as most of them perceive that green buildings cost more to build and operate. This will likely influence their willingness to adopt green building as majority of consumers that will prefer green features given this belief are the environmental conscious consumers. The reason for users' impression about green building in this direction can be traced to the assertions of Sayce et al., (2010) that much of the literature and indeed government and intra-governmental responses have focused on environmental protection and in particular issues surrounding energy and more recently, carbon. According to Bennett (2006), limited understanding of the benefits of sustainable buildings has been a key inhibitor, as many have the perception that whilst it costs more to build or fit out buildings to a sustainable standard there is little to be gained financially to warrant the extra expense. To enhance better response to green building adoption in the study area, there is need to balance the information spread on green building features to cover the social and more importantly, the economic benefits accruable. This will attract the interest of other stakeholders (beyond only the environmental conscious ones), especially when they see it as a viable investment venture.

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The Application of Rainwater as Architectural Design Elements For Green Technology Solution In Low Rise Office Building

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ABSTRACT

Performance of workers in terms of productivity level is determined by many related factors including a comfortable work space. Nevertheless, the discussion on the condition of work space environment namely in low rise office buildings and its related issues on thermal comfort in Malaysia are fairly new and is not well addressed. Past studies indicate that low rise offices found in many well-developed countries tend to utilize air conditioning as easiest ways to create a comfortable work space and to cool down the building interior. This factor had indirectly contributed to the increment of energy consumption namely in urban areas due to the rise of air condition consumption from 40% to 60% annually. As a result, contributed to the formation of urban heat island (UHI) which affect community's environment and quality of life involving health and comfort. The objective of this paper therefore is to discuss and propose approaches on how to apply rainwater elements in architectural design for achieving thermal benefits through passive cooling. This is vital as Malaysia receives large amount of rainfall throughout the year in which this nature resources may provide advantages as sustainable source in cooling down the building temperature. For this purpose, case study as research strategy is adopted using mixed methodology combining qualitative and quantitative method. To conduct the data analysis, ECOTECT simulation and small field experiments are performed to investigate the cooling effect in low rise office building. Findings indicate that low rise office building which integrates rainwater elements in architectural design potentially improve the building thermal performance thus reducing building's energy demand for space conditioning. This study is important as by adopting appropriate methods in addressing ecology issues will not only provide a comfortable living environment to the users but also established referential guideline in low rise office design.

1. Introduction

The cumulative negative effects from urbanisation such as pollution and production of waste heat from human activity, namely the usage of air conditioners and internal combustion engines had led to an environmental phenomenon called the urban heat island (UHI) (Stone Jr & Rodgers, 2001). The UHI factor occurs due to the rise in temperature in man-made area favourable in cities since their surfaces are prone to release large quantities of heat. Hence, directly impacted not only to residents of urban-related environments, but also humans and their associated ecosystems located far away from cities. Past scholars agreed that this matter occurred due to arising issues in the building industry which portrays buildings design that lack in energy and resources savings as well as built form that inharmonic with the local climate and surrounding environment(Stone Jr & Rodgers, 2001). As a result, led to significant non-operational savings and decrease of human productivity as well as lack of comfort among users notably in homes and

workplaces. Nevertheless, the most effected building types are workplaces like office buildings since they are mainly located in central urban districts(Stone Jr & Rodgers, 2001). According to scholars, there are various approaches that can be adopted by construction sectors to conserve the environment notably in workplaces involving usage of efficient energy, proper management of indoor quality environment, usage of recycle materials and renewable resources that minimize emission of toxic substance and waste as well as practical adaptation of innovative design with minimal building operational and managing costs(Kibert, 2016). However, there is lack of discourse in discussing the issue of minimal design cost to produce a sustainable office building design using green technology solution like rainwater in the Malaysian context. To date, literature much highlights on aspects like thermal comfort (Kwong, Adam, & Sahari, 2014) and daylighting (Zain-Ahmed, Sopian, Othman, Sayigh, & Surendran, 2002), the implementation of mechanical ventilation system (Syazwan Aizat, Juliana, Norhafizalina, Azman, & Kamaruzaman, 2009) and natural ventilation for cooling factors (Daghigh, 2015), energy management

and maintenance(Elyna Myeda, Nizam Kamaruzzaman, & Pitt, 2011), building life cycle assessment covering material production(Darus et al., 2009), construction, occupation, maintenance, demolition, and disposal of office building (Cabeza, Rincón, Vilariño, Pérez, & Castell, 2014) as well as built form design shape and orientation for energy efficiency (Bay & Ong, 2007). The scope of this paper therefore, is to highlight the utilization of rainwater as passive cooling agent to naturally cool the office building rather than using large scale of energy consumption in the areas of air conditioning to mechanically lower the indoor room temperature. This is because past studies indicated that in average most of office building in urban context tend to consume high usage of electricity than the recommended usage about 135 kWh/m2/year for commercial sectors, out of which 57% was used on air conditioning system and 17% by lighting 19%, followed by other equipment which is 24% (Saidur (2009). According to past study, '*the Energy Commission, Malaysia also reveals that the commercial sector is the second largest consumer of the total energy use in Malaysia (32%) after the industrial sector (48%)*' (Taib et al., 2010; 153).Therefore, the use of rainwater is viewed as the best measure to produce an environmentally friendly office building notably in the Malaysian context due to the abundant rainfall that is received in Malaysia which is about 2500mm annually in Peninsular Malaysia, while 5080mm a year in Sabah and Sarawak (Lim & Samah, 2004). This large number of rainwaters provides many advantages in which its implementation can be used for indoor plumbing, cooling or heating purposes, landscape watering and others. At present, consideration only much given to the usage of collecting rainwater for reducing water supply into building for toilet usage, watering and irrigating plants rather than for areal climate control and cooling purposes. Hence there is a need to improvise and innovatively utilize the usage of rainwater for saving energy consumption to cool the buildings. There are two main objectives of this study. First, is to identify the suitable rainwater architectural design strategies to achieve thermal benefits through passive cooling. Second, is to highlight the importance of rainwater as passive cooling strategy for short- and long-term usage towards energy saving consumption in low rise office buildings. For the benefit of the study and to fulfil the above objectives the next section will firstly define the meaning of rainwater in building design by elucidating on the characteristic and type of rainwater as natural cooling agent in building followed by the discussion on architectural elements using the application of rainwater system and its purposes to strengthen the need of the study.

2. Literature Review

2.1 Definition and the importance of rainwater in building design

Rainwater is a natural resource that can be easily collected from surrounding context like rivers, deep pit, drains, reservoir as well as from roof structures in building. The usage of rainwater had been acknowledged as part of architectural design since the early Greek architecture period when scholars discover that there were descriptions of outlet systems of rain water in the chart concerning kavediums which highlighted the five types (kinds) knowns as the Tuskian, the Corinthian, the four columned, the flowing and the roofed which exemplifies different methods of rain water channelling and diversion (Zayats and Murgul (2015). Since then, the practice of rainwater harvesting or method to collect rainwater runoff during raining time is widely accepted till modern context as cost saving methods of self-supply of water in buildings for daily usage (Zayats and Murgul (2015). Nevertheless, in realising its natural importance and physical quality characteristics in terms of volumetric heat capacity as quick heat

absorber, water usage also need to be considered in building design for passive cooling purposes and areal climate control(Breesch, Bossaer, & Janssens, 2005). According to scholar, there are three methods of passive cooling approach which are – evaporative cooling, direct evaporative cooling and radiant cooling that can be adopted in building design(Santamouris & Kolokotsa, 2013). These three approaches of passive cooling are important to explain as it uses water as basic medium for heat dissipation for cooling strategies and are referred to as main indicator in analysing the case study.

2.2 Methods and types of passive cooling approaches in building design by using rainwater

The term passive cooling is defined as building design approach that focuses on heat gain control and heat dissipation in a building in order to achieve balanced indoor environment with low or no energy consumption (Kamal 2012). In other words, passive cooling is preventing excessive heat from entering the interior (heat gain prevention) or by removing heat from the building using (natural cooling) methods that utilizes on-site energy, available from the natural environment, combined with the architectural design of building components, rather than mechanical systems to dissipate heat (Kamal 2012). In brief, the purpose of passive cooling serves four main aspects to produce building with much indoor comfort, adopt low maintenance, emphasis on zero energy consumption; implement low running cost towards promoting a healthy environment. To achieve indoor passive cooling and to promote heat sink , scholars outlined four promotion of heat transfer involving the circulation of outdoor air (heat transfer mainly by convection through openings); using the (night) sky concept (heat transfer by long wave radiation through the roof and/or other surface adjacent to a building; ground (heat transfer by conduction through the building envelope) and water (heat transfer by evaporation inside and / or outside the building envelope) (Kamal 2012).In elaborating the above, there are several passive cooling techniques involved like solar shading, insulation, induced ventilation techniques, radiative cooling, evaporative cooling , earth coupling and desiccant cooling that can decrease cooling load in building up to 50% to 70% (Kamal 2012). From all the above, evaporative and radiative cooling techniques will be highlighted in this study as rainwater is involved in both methods to help in releasing heat out of the building.

2.3 Evaporative cooling techniques

Evaporative cooling is a methods of exchanging heat in the air by vaporisation of water droplets on wetted surfaces (Heidarinejad, Bozorgmehr, Delfani, & Esmaeelian, 2009). Simple ways to induce evaporative cooling in a building such as designing a fountain or water feature into a building space or orientate the building near pond or lake. This may also include the use of mist jets in a dry space to elevate the temperature. In brief, evaporative cooling technique is induced in two ways; directly (by evaporation) or indirectly (by contacting the indoor air with surface that previously cooled by direct evaporative) (Heidarinejad et al., 2009). Thus, in order to achieve evaporative cooling and cools the surrounding, the sensible heat must come along with the presence of wind and water to cool the air. This water may be tapped from rainwater resources as rainwater is the most easily available self supply of source and cost saving (Heidarinejad et al., 2009). In other words, evaporative cooling happens when liquid (water) evaporate into air. Then the air cools any substance that touch or in contact with it as diagrammatically shown in Figure 1.
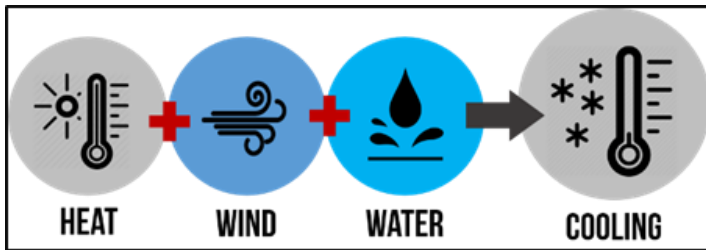
2.4 Direct evaporative cooling

Figure 1 Evaporative cooling definition in conceptual diagrams

Direct evaporative cooling is way to cool air mechanically or non-mechanically. The hot air is blown through wet medium (water-saturated) and the hot air is cool by evaporation process(Wu, Huang, & Zhang, 2009). Direct evaporative cooling elevate moisture in the air when the sensible air temperature (dry bulb temperature) is reduced, while the lowest air temperature (wet bulb temperature) is maintain (Wu et al., 2009). The air that have been humidified and cooled is then moved into the building.

2.5   *Indirect evaporative cooling*

This type of cooling happens when the secondary air which is cooled by water is introduce into heat exchanger. The cooled secondary air acts to cools the primary air(Costelloe & Finn, 2007). The cooled primary air is then cool the building space. Indirect evaporative cooling does not elevate the humidity of surrounding air(Costelloe & Finn, 2007). Thus it is the most suitable for hot-humid climate of Malaysia.

In applying the evaporative cooling method, passive downdraft evaporative cooling (PDEC) and roof surface evaporative cooling (RSEC) system can be applied in building design. Applications incorporating PDEC technology can be categorized into three different types according to evaporative devices: wind tower, a PDEC tower with pad, and a PDEC tower with spray (Janakkumar 2017). Referring to Janakkumar (2017; 284-285),*'the cooling performance of these applications is dependent on various factors such as climatic conditions, tower configuration such as the height and cross-sectional area, volume of the water and air, and types of evaporative devices. Physical tower configurations of these systems are similar to each other. However, the cooling capacities of these systems are different, and PDEC towers with evaporative devices are known to be better than conventional wind tower. PDEC towers are thus classified into these three different types in that the cooling capacity and system response to cooling demand substantially change due to the presence of evaporative devices and their types such as wetted pads and sprays'.* According to Kamal (2012; 93), '*passive downdraft evaporative cooling systems consist of a downdraft tower with wetted cellulose pads at the top of the tower. Water is distributed on the top of the pads, collected at the bottom into a sump and recirculated by a pump. Certain designs exclude the recirculation pump and use the pressure in the supply water line to periodically surge water over the pads, eliminating the requirement for any electrical energy input. In some designs, water is sprayed using micro-nisers or nozzles in place of pads, in others, water is made to drip. Thus, the towers are equipped with evaporative cooling devices at the top to provide cool air by gravity flow. These towers are often described as reverse chimneys. While the column of warm air rises in a chimney, in this case the column of cool air falls. The air flow rate depends on the efficiency of the evaporative cooling device, tower height and cross section, as well as the resistance to air flow in the cooling device, tower and structure (if any) into which it discharges.*'

The roof surface evaporative cooling (RSEC) system, on the other hand in accordance to Kamal (2012; 93-94) much involved '*-roof surfaces that can be effectively and inexpensively cooled by spraying water over suitable water-retentive materials spread over the roof*

surface'. Kamal (2012; 93-94) also added that,'*-as the water evaporates, it draws most of the required latent heat from the surface, which acts as a radiative cooling panel for the space, thus lowering its temperature and reducing heat gain. The indoor temperature gets lowered without elevating the humidity level. The solar radiation falling on the water film is utilized in water evaporation and thus being prevented from entering the room below. Besides, evaporation also cools the air above the roof. The cool air slides down and enters the living space through infiltration and ventilation, providing additional cooling*'.

Even though both PDEC and RSEC system are costly to assemble at the initial stage, the application of both systems in the long run are proven to be economically practical and sustainable as both uses available natural resources which can be in form of rainwater and air to operate the system for building interior cooling purposes.

2.6   *Radiant cooling techniques*

Radiant cooling is the process of radiation and convection to remove sensible heat in buildings by using cooled surface. To achieve this, systems known as hydronic is applied which used water to cool the radiant surface. In other words, this hydronic system involves cooled water between the temperature of 2-4°C below the desired indoor air temperature that are circulate in pipes through specially-mounted panels or a building's floor or ceiling to provide thermal comfort in building interior spaces (Gwerder, Lehmann, Tödtli, Dorer, & Renggli, 2008). According to building technologists, there are there are two primary types of radiant cooling systems. The first type is systems that deliver cooling through the building structure, usually slabs. These systems are also named thermally activated building systems (TABS)(Gwerder et al., 2008) The second type is systems that deliver cooling through specialized panels(Gwerder et al., 2008).
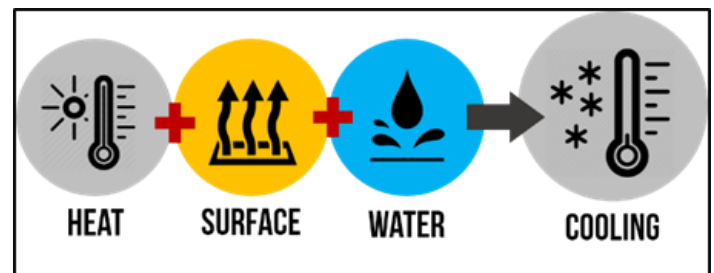
Figure 2 Radiant cooling definition in conceptual diagrams

Systems using concrete slabs are generally cheaper than panel systems and offer the advantage of thermal mass, while panel systems offer faster temperature control and flexibility(Gwerder et al., 2008).

Figure 2 clearly indicates that water element namely rainwater can be used to cool the building to provide comfortable temperatures for building users. Based on this understanding, next section will elaborate on several design strategies that related to the evaporative and radiant cooling techniques that can be applied in office design in the Malaysian context. This is important as the discussed the design strategies using rainwater for passive cooling then will be tested and analysed on its effectiveness using mock-up model building design to see its appropriateness in the local climate.

2.7   *Design strategies using rain water application in relation to passive cooling techniques*

In designing a sustainable building to accomplish passive and low-energy usage, there are many strategies using rainwater that can be adopted (Sun et al., 2013). However, the easiest applicable strategy that can be applied involving low cost in terms of installation and maintenance is to create pleasant environment using natural resources like rainwater (Macias, Gaona, Luxan, & Gomez, 2009) . Many scholars agreed that , it is wise to implement various systems for passive cooling strategies in a building which highlight the usage of rainwater as its main source like the usage of roof pond with water collected from rainwater (Spanaki, Tsoutsos, & Kolokotsa, 2011), provide ample space for roof garden that is watered by rainwater harvesting (Saadatian et al., 2013), have water hardscape and softscape obtained from rainwater by integrating it with building structural elements (Daglio, 2014) as well as have cooling wall run by rainwater flow at strategic exterior locations (Castell, Martorell, Medrano, Pérez, & Cabeza, 2010). All of the above will be explained in turn. Following this, the relevance of each systems and their relationship with the building spaces and form making by using example of mock up case study will be discussed in the subsequent section.

2.8   Roof pond

According to scholar, roof structure is the most vital element of building envelope to establish passive measures in architectural design as it is directly exposed to solar radiation and heat load. Since, roof contribute to almost up to 30% to 50% of heat load in building hence, it is wise to shade, insulate , vegetate and have flowing water at the roof to regulate heat gain. Nonetheless, using water is an ideal choice due to its thermal mass which is cheap, non toxic, with large volumetric heat capacity. Historically, the origin of roof pond system was introduced by Harold Hay in the late 1960's but in recent context many variety and comprehensive design of roof pond system was established by designers. In discussing on the subject of roof pond for passive cooling, scholars had outlined that there are 8 typologies of roof pond system involving –open roof pond, roof pond with movable insulation, roof pond with floating insulation, walkable roof pond, roof pond with gunny bags, shaded roof pond, ventilated roof ponds, and closed roof pond (Sharifi & Yamagata, 2015). However, the benefits of using roof ponds lies in its cooling processes which utilizes indirect evaporative cooling and radiant cooling. From the cooling effect of evaporation on the surface and radiation to the air, the roof pond will act as heat exchanging material to the building spaces and structure below it such as roof ceiling. Through this roof ceiling structure, radiation and convection will take place to cool the indoor space when the ceiling is thermally in contact with the roof pond above. From this understanding, the implementation of roof pond is seen much suitable in hot and humid country since it will not increase the humidity in the air. Nonetheless, in the tropical context like Malaysia, closed roof pond type is seen much effective to be adopted. This is because the effective characteristic of roof ponds for hot and humid country should be closed at day time and opened during night time. The free water surface in the pond is exposed starting at 7 P.M. by opening the roof to the sky and closing it during the day starting from 7 A.M. The water in the pond is cooled by radiation during the night and by evaporation all day long. Heat gain in the water is reduced by prevent it from solar radiation and natural ventilation during the day (Krüger, Cruz, & Givoni, 2010).

From the roof pond experiment done by (Krüger et al., 2010) in hot-humid climate of Maracaibo, the indoor temperature of the tested room is 2°C cooler compared to the other tested room without roof pond above it. The use of rainwater for the roof pond is really important as the conventional roof that use evaporative cooling system require large amount of water daily to cool down the roof temperature(Krüger et al., 2010). Other than this method, study done by (Cheikh & Bouchair,

2004) highlighted that closed roof pond covered by an insulation layer known as the "evapo-reflective roof pond" is also suitable. According to (Sharifi & Yamagata 2015; 9),' *this roof pond is supported by a concrete deck over which a water pool, filled with small pieces of rock, is placed. An unventilated air layer separates water pool from the upper roof which is a flat aluminum plate "painted with titanium-based pigment" to enhance its reflective properties. The system reflects incoming solar radiation during daytime hours. At night, temperature of the water pool is higher than that of the aluminum plate. As this is a closed roof pond, the water vapour does not leave the system. The vaporized water condenses and falls back into the water pool. This way, heat is transferred outside the system. Radiation between the two humid internal surfaces of the system enhances heat exchange'*. To supply water to this roof pond, rainwater harvesting system can be used and reuse it for the roof pond as passive cooling purpose.

2.9   Roof garden

Roof garden has many benefits. Besides functioning as decorative elements, roof garden whether in small or larger scale are utilized for temperature control, hydrological values, recreational and ecological opportunities. The implementation of roof garden in a building also gives effect to thermal performance of indoor space. Saadatian (2013) defines roof garden as living roofs, eco-roofs, vegetated roofs, or planted roofs. Plants is used on roof to enhance its performance and also its appearance. Santamouris (2014) explains that plants on roof garden will act as insulation as the plants provide shades to the roof. The substrate layer of the plants that lies on a roof structure will slow down the heat transfer from exterior while taking in heat from interior spaces underneath. This process shows that the plants on top of roof garden will act as a thermal mass. In this case, the building is cooled down by the process of evapotraspiration that takes place (Santamouris 2014). One of the case study on roof garden conducted by Rumana (2009) proves that the green roof can lower the indoor temperature more than uncovered roof. From their experiment done at one of hostel in Universiti Teknologi Malaysia (UTM), 4°C to 5°C reduction in the indoor temperature during day when the green roof is implemented on it. Both indoor and outdoor environment of the building get the thermal benefit from the implementation of green roof on rooftop.Thermal performance of roofing system can be improve through the use of green roof. Roof garden will provide insulation and shading. Besides, the rainwater that collected through rainwater harvesting system can be used to irrigate the plants on the roof garden. This can reduce the water supply for the building hence cools the building as well.

2.10   Water hardscape and softscape features

Fountains, waterfalls, ponds, waterspouts, waterfalls, water gardens are classified as water hardscape and softscape features consist of static or moving water. Since ancient history, the implementation of water features in buildings and monuments had been adapted to provide comfort for humans and to cool its surroundings such as the Hanging Gardens of Babylon and the Chand Baori Stepwell (O'Connor 2000). In recent years, scholars found that the presence of water on top of ground surface material will reduce the surface temperature significantly regardless of its color (Bakar & Malek, 2015). In addition the microclimate of surrounding area will also gains benefits from the use of water features as it will increase the amount of water needed to enhance the evaporation process. This can lower the surrounding temperature easily(Bakar & Malek, 2015). The fall of temperature from hot to cool can also be affected by the building distance from any water feature or water body. This is because, water bodies are noted to be the best absorbers of radiation, which exhibit very little thermal

response(Wong, Tan, Nindyani, Jusuf, & Tan, 2012). This is because water comprised of four important properties which susceptible as radiation absorbers and sensible as heat transfer element. According to scholar, water demonstrate little thermal response since it is a good penetration substance that allows short wave radiation transmission to considerable depths; permits easy mixing like the process of convection that allow heat gains or losses to be spread throughout a large volume; helps in the process of evaporative cooling which is efficient as latent heat sink, as well as has a large and exceptional thermal capacity (Coutts, Tapper, Beringer, Loughnan, & Demuzere, 2013). Due to these properties, Jusuf (2009; 1) stated that, "*this make the surface temperature of water bodies cooler than that over the land*". Previous scholars also indicate that the presence of water bodies effect a city air temperature. A study conducted by Murukawa (1991) highlights that there is a big difference of air temperature between the river and the city area in Japan which is about 3 - 5°C. This proves that cooling source of the surrounding microclimate is greatly influenced by water elements like the existence of flowing river. Hence, the choices of building site near the water bodies gives many advantages to the building microclimate and also act as temperature control.

2.11   Water wall and cooling wall

Water wall is also defined as curtain or sheet of falling water and act architectural feature for building and landscape design. In other words, a water wall is the flowing of water over an architectural surface, such as hard or opaque surfaces which allows the material that is beneath the water to show through the flowing water. In most cases, the bottom of the water wall is a reservoir which is located to collect the water as it flows down from the water wall. The water in the reservoir is then pumped back to the top of the water wall to complete the circuit. This water wall is a low energy consumption fountain, **s**ince it needs minimal pressure and flow for proper operation as the water is easily obtained from rainwater harvesting technique. In many cases, the wall is illuminated from the back, or the front, to further enhance the aesthetics of the feature. Water wall may block the heat from entering the building interior space. As a result, this reduce the building indoor temperature to make it more comfortable for the building occupants. Water wall is an effective solution for maintaining indoor or outdoor temperature and reduce energy consumption. In addition to water wall, cooling wall is also important to control increased surface temperatures and create cooler urban environments. Cooling wall is typically made of pipes that allows inlet and outlet of water flow. Referring to study done by scholars, this cooling wall can be made of porous pipe-shaped ceramics known as PECW (Passive evaporative cooling wall). The PECW is capable of absorbing water and allows wind penetration, thus reducing its surface temperature by means of water evaporation (He, 2011). In other words, the cooling wall has the ability of capillary force to absorb the water up using the ceramic pipes. In brief when the air passes the PECW, the air is cooled naturally. Hence the air temperature nearby the cooling wall area is reduced to a minimum value by several degrees namely during hot daytime (He, 2011). The water used for this cooling wall is tapped from rainwater harvesting system.

From all of the above discussed system for passive cooling using rainwater –only the roof pond and roof garden will be discussed in depth and are chosen as the main focus to investigate its suitability in low rise office building. This is because the roof pond and bare soil concrete roof (greenery roof) are seen as the most appropriate for the Malaysian context since its operating cost are minimal, significantly can reduce the roof surface temperature and heat transmission into the building and also utilize rainwater to irrigate and run the system. Moreover, the suitability of the Malaysian humid and hot climate all

year round with an average rainfall of 250cm a year and average temperature is 27 °C (80.6 °F) with two monsoon winds seasons, the Southwest Monsoon from April to September, and the Northeast Monsoon from October to March will allow passive cooling to occur when involving these both design strategy- (roof pond and garden), since they utilizes the evaporative and radiant cooling methods to function naturally. Although scholars highlighted that there are drawbacks like -water leakage, water hardness and scaling, mud accumulation at bottom in dusty areas and rusty metallic surfaces nonetheless, proper installation, anticipation and compensation by the building designers and users may overcome this matter.

Nevertheless, the adaptation of roof pond and roof garden utilizing rainwater for passive cooling purposes to increase thermal comfort in buildings are still likely seen to be less adopted in the context of Malaysia as many designers and builders tend to overlook on this matter due to lack of interest and knowledge(Taib, Abdullah, Fadzil, & Yeok, 2010). Although there are offices buildings in Malaysia that applied this green roof and roof pond concept but the numbers are still few and not widely implemented. Moreover, there are lack of efficiency in implementing the roof garden and roof pond in building design which makes it unusable, impractical and un functional to serve the user needs. Furthermore, the application did not compliment to the requirement of microclimatic conditions like thermal comfort but instead merely for aesthetical purposes (Taib et al., 2010). In addition, there is also limited research focusing on the potential of roof garden and ponds particularly in office design in Malaysia's tropical climate (Taib et al., 2010). This study will look this matter in depth by proposing a medium low rise office building to be located in Medini, Iskandar for Suruhanjaya Air Johor Berhad that applies the roof garden and roof pond as design solution for both aesthetics and thermal comfort purposes. Both of these passive cooling strategies that uses rainwater system will be tested for the purpose of developing new framework approach to highlight its importance. To understand this the next section will elaborate on the method used to analyse the significant roof garden and roof pond by using single proposed design as case study. This study used a single case study as the research strategy to provide much in depth empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident or considered likely to provide a good explanation (Yin, 2011).

3.   Case study – proposed medium low rise office

To conduct the analysis, the researcher had proposed and designed low medium rise office building for Suruhanjaya Air Johor Berhad on a piece of 1.1 acre land in medina Iskandar beside the emerald lake (Figure 3). The site is surrounded by commercial comprised of Shops, offices and private school and residential homes.The proposed building is divided into three zones which are public zone, education and training zone, staff and researcher zone. Public zone includes water education gallery, multi-purpose gallery space, mini auditorium, café, recreation area and also rooftop garden. The education and training zone are occupied by classrooms and workshops for weekly and monthly water education training for registered members. This zone is considered as semi-public zone and can be assessed by registered members only. The other zone is the staff and researcher zone. This zone is classified as the private zone in this building. Spaces included in this zone is staff/trainer lounge and rooms, researchers' room, laboratory and also the management office. In doing the spaces' massing for this centre, the public zone is designed near and towards the lake to enhance the use of lake as recreational spot and also to

Figure 3 Proposed Iskandar Water Education Centre

enhance the effect of passive cooling by the water body into the main public spaces which are the gallery and the auditorium. The other two zone is located on the upper part, far from the public spaces to avoid noise.

4. Design strategies

In implementing the passive cooling technique using rainwater in this proposed building, the rainwater runoff from the roof are collected by series of ramp like water channel. The ramp is ended at the rainwater harvesting tank located at the building basement. The filtration process took place in the basement and the filtrated water is then pumped up to the rooftop to be distributed throughout the building for supplying the roof pond, irrigation purposes for the roof garden and cooling wall. Water wall and water features surrounding the building central area also used filtered water to operate. Integrated roof pond and roof garden is implemented in the design because these two elements greatly contribute for passive cooling effects. The roof garden and roof pond are placed above the two main public spaces which are the gallery and the auditorium so that the interior of the building will be less heated and well insulated to reduce cooling energy consumption for this building. Furthermore, both of this space are covered by huge area of roof which are exposed and received radiance heat loads from the sol-air temperature and direct solar insolation which increases the mean radiant temperature. According to Mintorogo (2015; 26) , '*this is because the roof receives the greatest heat radiant impacted than other parts of the building façade. The sun's ray will produce thermal heat on a surface that is absorbed or reflected by roof materials which increases the outer surface temperature of the roof by 30 to 40 degree Celcius'*. To lessen the radiant heat, the roof pond and garden therefore, are placed above both of these spaces. The closed roof pond type is adopted as it is the most appropriate selection for hot and humid climate to reduce cooling loads from rooftop. Water cooling wall is also applied at the exterior building side which is affected by radiant from the evening sun. The water-cooling wall obtained its flowing water pumped from the roof pond and water harvesting tank. Existence of water features in a building can contribute to the effective evaporative cooling for the surrounding microclimate of the building. Therefore, a large wading pool provided at the ground floor will give additional cooling effect for the exterior and interior building. In fact, the location of the building nearby the natural lake also have a positive effect for achieving passive cooling strategies. Nevertheless, for the benefit of this study, the importance of roof garden and roof pond for medium low-rise office building will be

further explained in the methodology section using Ecotech simulation and small field experiment to justify the findings.

5. Methodology

To conduct the analysis on the roof garden and roof pond two method are used which to justify the findings. The first method is simulation analysis and the second is small scale field experiment. Both of these methods will be explained in turn below. The simulation analysis is conducted refereeing to testing technique established by past scholars (Saeid, 2011). Saeid (2011) work is referred as she adopted the usage of computer simulation known as Ecotect to measure the selected parameter which is the solar radiation of the roof as well as the heat transfer from the roof into the building. Her method is suitable for this study, as the aim of this paper is also to measure the radiation value on the proposed building roof area.

5.1 Method 1: Simulation analysis

The aim of the simulation analysis in this study is to identify the efficiency of integrated roof garden and roof pond for building based on the difference in intensity of solar radiation striking on external surfaces of different roof treatment. For that matter, ECOTECT Analysis 2011software is used in this study. Base model for this study is done in Sketch Up Pro 2104. The model is taken from the massing model of the proposed medium low-rise office building established by the researcher. The roof of the auditorium and gallery is used in this study since these two areas has the largest roof area which prone to radiant heat and both of these roof areas are placed the roof garden and the roof pond as passive cooling system strategy for the building. The simplified model of the two main part of the building is shown in Figure 4 and Figure 5.
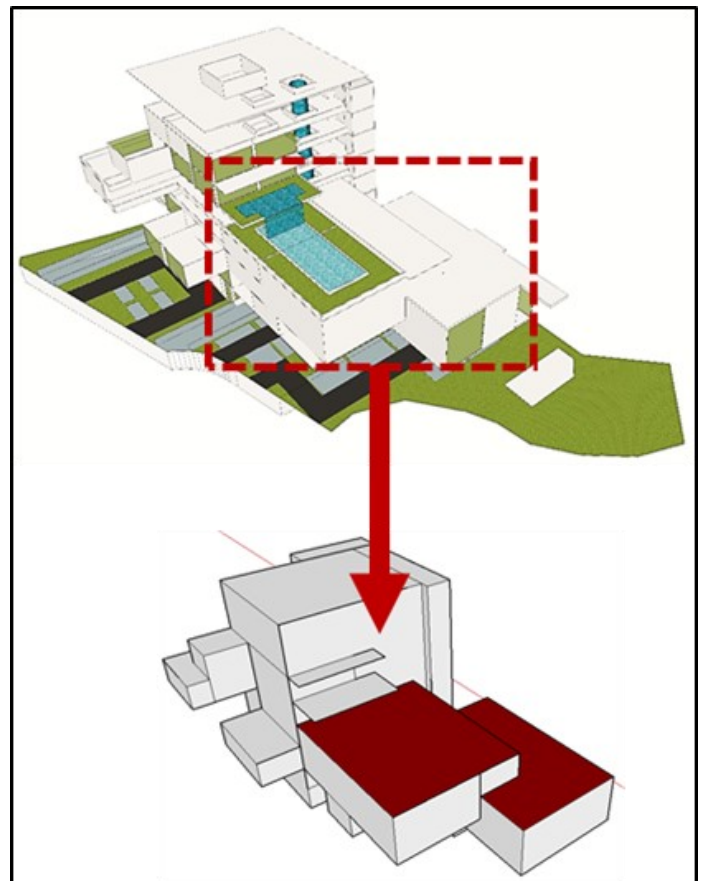

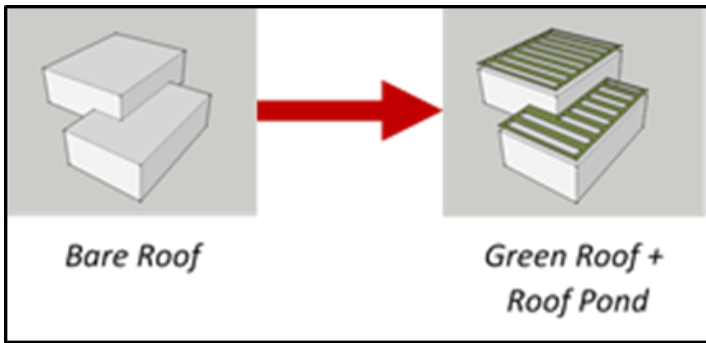*Figure 4 Massing Model and Base Model of the proposed building*

Figure 5 The Base Model

To resemble the roof garden and roof pond, the base model is added with shading device and some voids (to ensure solar radiation can pass through). These shading devices will act as green roof and roof pond on the study area. The shading device will take up around 40% to 50% of the roof area. The model is then imported to ECOTECT Analysis software and the radiation value of the proposed roof area is analysed.

5.2   Method 2: Small-scale field experiment

To support the simulation analysis, a small-scale field experiment is conducted to find the condition of thermal performance level and indoor space temperature in the gallery and auditorium when the roof garden and roof pond are placed above these spaces. This experiment is conducted based on past scholar methodology done by Gonzalez & Givoni (2004). Although there are various method introduced by scholars this particular method is referred to as their study much refer to the same tropical climatic context as case study like Malaysia and in defining the role and importance of roof garden and pond in building design. To obtain the findings, three identical testing boxes are needed to compare the indoor temperature changes between testing box with roof pond system and without roof pond system (bare roof), and with roof garden. The testing boxes were made of corrugated box board with the measurement of 210mm x 210mm x 300mm. the roof overhang is measured 50mm for all four edges to protect the wall. The inner parts of the boxes are lined with 6mm polystyrene sheets to protect the absorption of heat via the walls. The roof part is not

covered with polystyrene sheets in which the roof pond system and roof garden are located.

To resemble the roof pond system, two air tight plastic bags with (5 inch x 4 inch in size) are filled with water at room temperature. The plastic bags were then placed at the top of one box (Figure 7). To resemble the roof garden layer of grass on soil is placed at the top of the other box. The other box is without any insulation to resemble bare roof. The three boxes have two small openings measured 150mm x 50mm on top of the North and South side of the walls to mitigate the heat inside the boxes. Data loggers were installed in the boxes. Three set of (4-channel data logger) is used in this experiment to provide RTD based precision temperature recorder in which the retrieved data are then link to windows software to be tabulated in table format.

Data Logger 1
In BOX A : Roof Pond Box. (indoor and surface temperature)

Data Logger 2
In BOX B : Bare Roof Box. (Indoor & surface temperature)

Data Logger 3
In BOX C: Roof garden (with grass) (indoor and surface temperature)

Since temperature condition in Malaysian context do not differ much from month to month, and the daily range of temperature is small, hence the test was done on the hottest day in the month of February, March, April and May at an open field. This is because all these months had shown the highest and warmest temperature recorded for the past three years (2014 to 2017) which is between the maximum of 32 to 33 degree Celsius. The measurement however was taken during the hottest month which is in April (refer to the meteorology Malaysian report) and in three days in a row which no rainfall occurs from sunrise - 6 am until sunset -7 pm. This is important to get the exact reading of the radiant heat absorbed by the roof with pond, roof garden and bare roof. Comparative analysis then is made to indicate which condition are much better whether the roof pond with rain water supply, irrigated roof garden with rain water, or bare roof concrete without any

Figure 6 Preparation of Testing Box

Figure 7 Plastic bag filled with water that act as roof pond

Figure 8 Preparation of Testing Box at site. Box A (right) and Box B (left)

insulation. The interior temperature with different roof condition is also recorded, compared and analysed without the disruption by any mechanical ventilation effect.

6. Results

This section focuses on measurement results of the simulation analysis and field experiment done to identify the thermal performance and efficiency of integrated bare roof, roof garden and roof pond.

Table 1 The results of the experiment

MONTH	TIME	TEMPERATURE (°C)			
		DATA LOGGER 1 (ROOF POND)	DATA LOGGER 2 (BARE ROOF)	DATA LOGGER 3 (GREEN ROOF)	DATA LOGGER 4 (OUT-SIDE – OPEN FIELD)
April **Day 1**	600	28.120	28.212	28.113	28.713
	700	28.882	28.923	28.887	28.921
	800	28.716	28.811	28.718	28.812
	900	29.221	29.271	29.229	29.349
	1000	30.149	32.339	30.221	32.376
	1100	29.300	30.697	29.221	30.700
	1200	29.276	29.757	29.271	29.760
	1300	29.471	29.572	29.346	29.543
	1400	29.371	29.466	29.346	29.450
	1500	29.296	29.391	29.346	29.400
	1600	29.296	29.371	29.351	29.383
	1700	29.271	29.371	29.331	29.376
	1800	29.296	29.396	29.315	29.372
Day 2	600	28.148	28.312	28.131	28.413
	700	28.615	28.878	28.712	28.923
	800	28.716	28.822	28.718	28.827
	900	29.321	29.421	29.329	29.439
	1000	30.151	32.527	30.112	32.625
	1100	30.123	30.624	30.221	30.645
	1200	30.276	30.557	30.271	30.660
	1300	30.471	31.447	30.346	32.543
	1400	30.321	30.442	30.256	30.450
	1500	30.216	30.331	30.246	30.412
	1600	29.411	29.821	29.421	29.883
	1700	29.353	29.643	29.441	29.689
	1800	29.334	29.587	29.423	29.669
Day 3	600	29.110	29.121	29.100	29.325
	700	29.210	29.454	29.211	29.543
	800	29.243	29.522	29.232	29.544
	900	30.612	30.772	30.712	30.877
	1000	31.100	31.121	31.009	31.322
	1100	31.522	31.779	31.432	31.855
	1200	31.722	31.701	31.271	31.760
	1300	32.471	32.572	32.346	32.543
	1400	30.371	30.466	30.346	30.450
	1500	31.296	31.391	31.346	31.489
	1600	30.296	30.351	30.371	30.383
	1700	29.612	29.712	29.523	29.779
	1800	29.296	29.315	29.396	29.372

6.1 Result 1: Simulation analysis

By using ECOTECT Analysis software, average daily radiation analysis has been run to calculate the amount of solar radiation that strikes on the external surface of the study roof area. The simulation results are as follows.

Based on the simulation results shown above, it clearly seen that the average radiation drop when the roof area is covered with shading device that act as roof garden and roof pond. The yellowish colour at the bare roof surface in the figure shows that the intensity of solar radiation is higher. While at the shaded roof surface, orange and purple to bluish colour appeared. This explain that the intensity of solar radiation strikes on the surface is lower compare to the bare roof surface. On the external surface of the roof, the simulation result shows that by installing integrated roof garden and roof pond, the radiation absorb by the roof surface is decrease hence will have a potential in lowering the internal temperature of the study area.
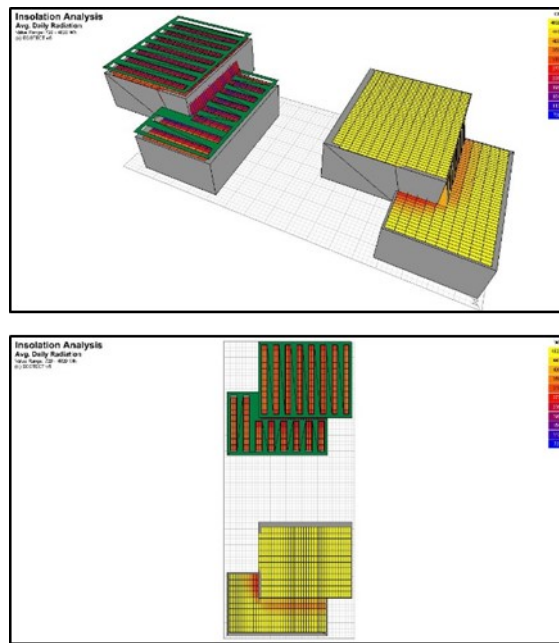
Figure 8 Figure showing the results of the experiment

6.2 Result 2: Small-scaled field experiment

By using HOBOware Software, the data from the HOBO data logger is then collected and analyse. Figure 9, 10 and 11 show the results of the experiment.

Based on the graph shown in Figure 9, 10 and 11, during the hot peak hours around 1200 P.M. until 1600 P.M. (critical time for afternoon and evening sun), the difference in indoor temperature between the three boxes can be clearly seen. The temperature inside Box A (roof pond) with Data Logger 1 and Box C (grass roof) with Data Logger 3 are slightly cooler than Box B (bare roof) with Data Logger 2. The presence of roof pond and grass roof on top of the roof affect the indoor temperature. The indoor temperature) drop from maximum 2.0°C to minimum 0.5°C. The significant result is shown at day 2 where Box A with roof pond on top and Box C have indoor temperature at 30°C, while the outdoor temperature is 32°C.

7. Discussions

This section attempts to discuss the study by summarizing major findings of the study. From the two methods; simulation analysis and field experiment, the results shown from both methods can be combined. From the results, it shows that :

- integrated roof garden and roof pond will absorb lower solar radiation and decrease the indoor temperature below it.

- bare roof will absorb higher solar radiation and this affect the indoor temperature of the space below.

Figure 9 Graph showing the results of the experiment

Figure 10 Graph showing the results of the experiment

Figure 11 Graph showing the results of the experiment

- from the small experiment done, the temperature drop is about 1° C when using roof pond and green roof.

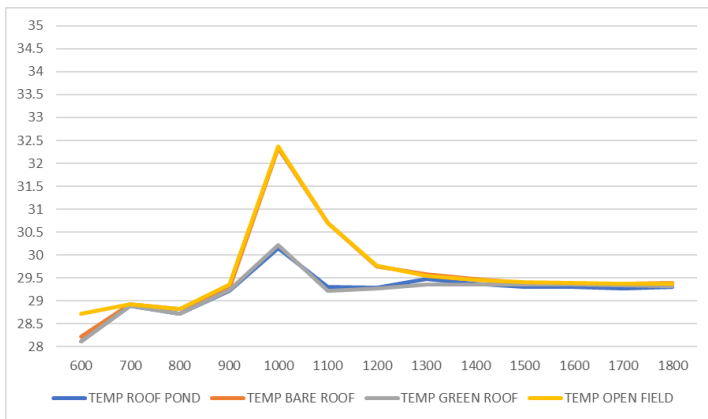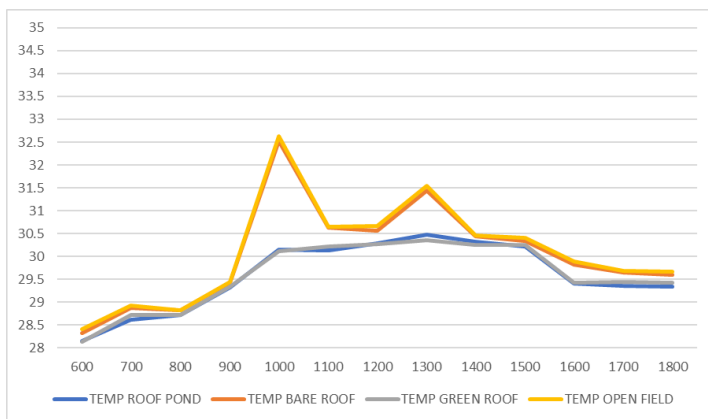Time and weather's condition are the major limitation for this research. Most of the data collected cannot be used because of bad weather condition due to raining season in the evening. Therefore, it is recommended that future research could look further into this area in order to strengthen and compliment this research.

8. Conclusions

Integrated roof garden and roof pond have potential to improve the thermal performance of a roofing system through shading, insulation, evapotranspiration and thermal mass. Thus reducing a building's energy demand for space conditioning. Thus, harvesting rainwater do helps and improve building performance by using the collected rainwater as part of passive cooling agent to improve the thermal performance while saving water. Others strategies also play important role in boosting up the cooling effect that can gain through passive cooling techniques from rainwater architectural design elements. Rainwater therefore should be utilizes as it is the best measure to produce an environmentally friendly office building notably in the Malaysian context.

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Dual Formal and Informal Transport Modes towards Quasi-Seamless Transit in a Developing City

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ABSTRACT

Dual formal and informal transport modes have been complementing one another in Bandung City for more than four decades now. The issue appears due to inability of formal transport to provide adequate services to the citizens. However, this accompaniment has brought Bandung City to a quasi-seamless transportation process as both transport modes play their roles as a continuum. Amid insufficient public transportation system in Bandung City, the informal transport modes have properly paired their formal transport counterparts. This study was conducted in Bandung City, Indonesia, by profiling the transportation users, observing the characteristics of both formal and informal transports, and acquiring the relevant secondary information at city and national levels. The study found that within the issue of appropriateness of few modes of informal transport such as becaks and ojeks, they have shown their contribution to the state of quasi-seamless transit process in the city as well as their impacts to reduce the CO_2 emission in comparison to formal fossil fuel-based transportation.

1. Introduction

Formality and informality in many sectors are frequently seen as a dichotomy (Rothenberg et al, 2016; Schindler, 2014; Günther & Launov, 2012). This view has created a clear boundary between the two and resulting in discontinuity of the policies to handle this duality. This dichotomous view is in fact true to some extents if it is examined along several dimensions of formal sector vis-à-vis informal sector as illustrated in Table 1. Different outlook sees that formal sector and informal sector are rather a continuum than a dichotomous entity (Verreynne et al., 2016; Nadin & Williams, 2012). This view argues that in the formality there is certain degree of informality. In similar manner, the informality to some extents contains

formality. It is therefore an in-between area present which links informality and formality. This opinion also argues that an informal sector can be transformed to formal sector by certain mechanism. The transformation of informal sector to formal sector is also not a binary process rather a gradual process that passes through grey area between the two sectors. Another argument on this continuum is that informality appears due to incapability of formal sector to provide its full service (La Porta & Shleifer, 2014). A visible example on this case is that jobs in urban informal sector are created because formal sector unable to create formal jobs. Although informal sector is predominantly available in developing countries, it is, however, not necessarily that informal sector is a domain of cities in

Table 1 *Informal and Formal Sectors Dichotomy*

Dimension	Formal Sector	Informal Sector
Economic Standing	Middle and Upper Class	Lower Class, Poor
Political Influence	Strong, Empowered	Weak
Legitimacy	Legal, Regulated	Illegal, Unregulated
Society and Culture	Modern	Traditional
Internal Organization	Orderly, Vertically Integrated	Less Structured, Horizontally Integrated
Assets and Capitalization	Intensive	Minimal
Financing and Credit Access	Commercial Banks	Family and Loan Sharks
Technology	High Tech	Low tech
Skill Levels	Knowledge-Based, Cognitive	Labor-Based, Adaptive
Legal Status	Registered	Unregistered

Source: Cervero (2000), Lubell (1991), Portes et al. eds (1989), Sarosa (1993).

developing countries (Cervero, 2000; La Porta & Shleifer, 2014; Sinclair, 2017).

Although informal sector is not domain of cities in developing country as argued by Cervero (2000), but undeniably, cities in developing countries are predominant harbor of informal sector for one strong reason, which is the characteristics of informal sector is perfectly compatible with the conditions of developing countries (Günther & Launov, 2012; Pugh, 2013). A city in developing country is therefore the focus of discussion on formality and informality particularly in transportation sector.

In the transportation sector, formality and informality are also present. Formal transportation mode, to a great extent, is more preferable by city authorities over informal transport because of its regularity. Although the complementary roles of informal transport cannot be totally ignored (Kumar et al., 2016). Informal transport services are also notable for their role as "gap fillers". They exist in large part to fill the service that voids left unfilled by formal public transport operators (Cervero, 2000). Poor transportation infrastructure, particularly road facilities, lack capabilities of city authorities to develop a strategic plan for better formal transportation which can lead to traffic congestion and air pollution, are generally occur in formal transport mode. This situation stimulates informal transport to take a role as gap filler. In line with this, formal transport services cannot also satisfy increasing demand for travel (Enoch, 2016). This situation, and by considering the essential role of informal transport, is therefore essential in a sense that government must support the informal and formal public transport by providing well-articulated policies to improve the performance of operations and services (Aworemi et al., 2008).

Articulation of informal and formal policies to improve the performance of transportation services towards an acceptable level is necessary (Walters, 2013). The high level of transportation performance will also affect urban environment condition, such as better-off urban air quality (Yusop & Permana, 2016). The policies are targeted to address transportation sector with urbanization and land use as its backward linkage and environment as forward linkages. Although the nexus of urbanization, land use, transport and environment is not linear, but by considering only the strongest connection among the elements of nexus, the nexus is safely regarded as linear (Permana et al., 2015). The linearity of transport modes either informal or formal transport is maintained. In view of this circumstance, Bandung City has been selected as study area providing the complexity of the dynamic interplay between informal and formal transports in this city which leads to present condition of urban environment.

2. Study Area

Bandung City, the study area, is approximately located on 107O East and 6O55' South at the altitude about 650 above mean sea level. The present area of the City is 16,767 hectares and is geographically located in the center of West Java Province (refer to Figure 1). Urban expansion of Bandung City has been undergoing in an inconceivable pace during the period of 1970-1980. In many Indonesian big cities including Bandung, the annual population growth during this period accounted for 2.4 to 3.0 percent (Simmons, 2000). With this growth, Bandung suffered from the pressures on land, infrastructure and services. In this period, the residential area has been expanded by about nine percent. This expansion was predominantly underway in the Southern periphery, since this area is relatively flat compared to the others. Amid the threats from annual

flooding, however, the expansion to this area and to the eastern part were still the best, due to availability and readability of the land for expansion. The urban expansion in this period accounted for forty-five percent with respect to total city area. The expansion has significantly created motorized transport dependent citizens, and further affects transport energy consumption and environment issues in this city.

A significant expansion of the urban area, which was marked by considerable residential development, occurred during the period of 1990-2000. Total urban area has expanded by about sixty-three percent during this period. In the same period, the residential area has also expanded by about 145 percent. At the end of 2000, the length of urban roads was only about 932 km (CDPA, 2003) and the number of cars was 451,957 units. It showed that the length of road per unit vehicle was only 2.0 meter, and it also indicated that traffic congestion becomes a usual incidence for the citizens of Bandung. The economic losses due to traffic congestion (in terms of energy and environmental losses) in Bandung were about US$ 700,000 per day (Tamin, 2004). This showed the importance of urban expansion which generates traffic congestion and eventually leads to degradation of air quality.

The problems inefficient and inadequate public transportation and growing number of private vehicles, degradation of air quality and other urban environmental problems in Bandung City have been important issues for quite long time. However, local authorities are still struggling with fundamental issues on public transport and illegal para-transit, and paying less attention to solving overall problems of urban transportation in the city. As a result, problems created by urban transportation system are now leading towards point of no return and therefore its level of irreversibility is high.

Urban transportation system in Bandung City is generally denoted by significant contribution of private transport over public transport, discomfort public transport despite extensive routes, and concentrated destination for work travel. Although legally banned to operate on main roads in the city, the operation of informal transport such as becak (non-motorized three-wheelers), ojek (motorbike taxis), and horse-pulled wagon are still visible. The interplay of formal and informal transport connotes current urban transportation system in Bandung City. In terms of public transport, Table 2 shows the characteristics of formal and informal public transports in Bandung City.
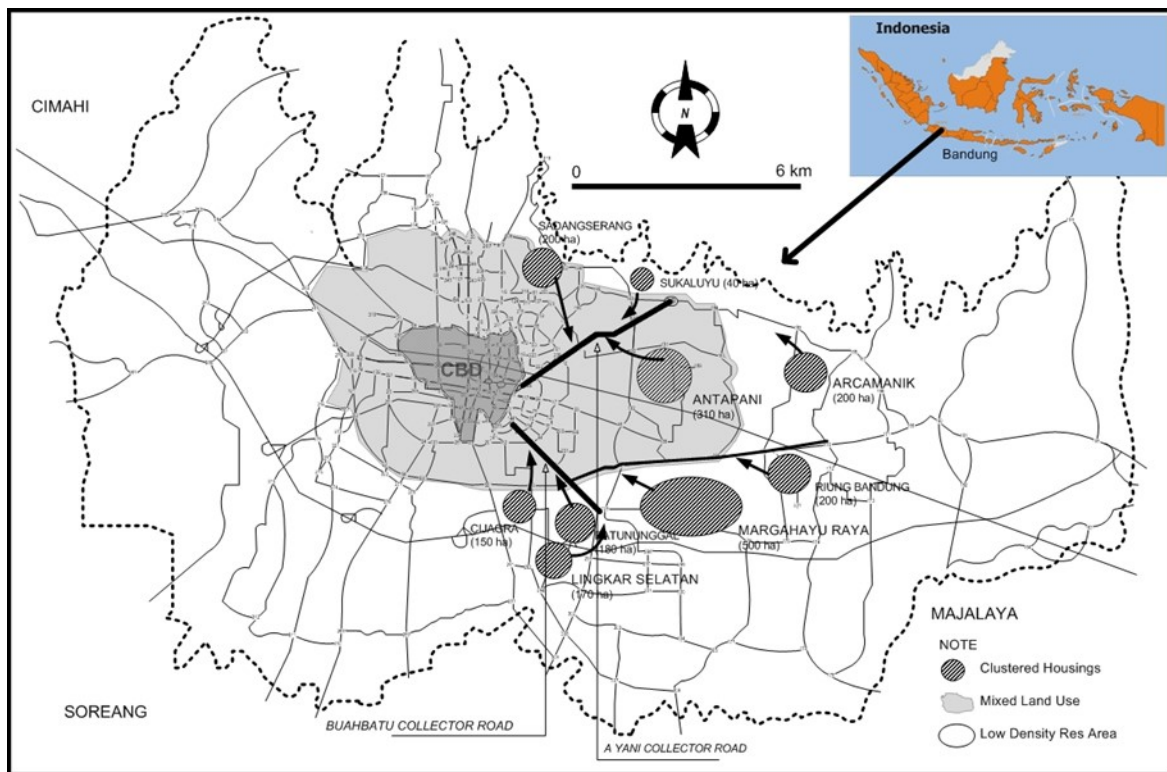

Figure 1: Bandung City, the Study Area

Table 2 Formal and Informal Public Transports in Bandung City

Aspect	Formal Public Transport	Informal Public Transport
Service Delivery	Designated, fixed and personalized routes	Personalized routes, adaptive
Schedule	Semi-fixed, passenger-driven	Flexible, passenger-driven
Reliability of service	Inconsistent to reliable depending on type	Inconsistent to semi-reliable
Vehicle Capacity	4-seat to 40-seat passengers	2-seat passengers
Vehicle Type	Motorized	Non-motorized and motorized
Ownership	Public and Private	Private, individual
Market Perspective	Monopolist (public), Entrepreneurial (private)	Entrepreneurial, individual
Labor	Semi-skilled	Semi- to non-skilled labor
Organization	Bureaucracy, route associations	Individual, social associations
User's social status	Low to medium income	Low to medium income
Fare structure	Fixed, standardized	Variable, non-standardized

Source: Format is adapted from Cervero (2000)

Formal and informal public transports are both needed in an urban transportation system. The informal transport modes generally operate in the street where the operation of formal transport modes is unavailable. These two transport modes can actually complement each other to form a smooth quasi transit system for the comfort of travelers if only city authorities have a willingness to facilitate it. Formal and informal transport modes, as discussed in preceding section, should be accommodated in articulated policies, so they can synergize to constitute better urban transportation system.

3. Present Formal Transport Modes in Bandung City

Formal transport mode is seemingly the backbone of transportation sector in Bandung City, for a reason that presently, informal transport mode is not officially recognized by city's legal system. Present city regulation is yet preventing this transport mode to operate. Despite this legal issue, formal transport particularly *becak*, is still presently operating underground amid frequent 'clearing operation' to avert *becaks* operating in city. From social viewpoint, *becaks*' drivers have the right to earn money in the city. But from legal viewpoint, city authority argues that, according to city's bylaw, *becaks* are indecent transport mode and therefore should not be allowed to operate. In this social-legal dilemma, legal aspect takes precedence over social aspect, although do not 100 percent applies. Unlike organization of formal transport, unclear organization of informal transport has also been used by city authorities to legitimize their action in restraining becaks in Bandung City.

3.1 Organization

Formal transport modes in Bandung City consist of public inter-city and intra-city buses, inter-city trains, taxis, *angkots,* private cars, and private motorcycles. Inter-city public buses are owned mostly by private companies. The only inter-city and intra-city public buses owned by government is *Damri*. The private companies formed a sole organization so called *Organda* (Organization of public land transport entrepreneurs). This is a legal organization run by themselves in which all members are entrepreneurs (not companies) of the public land transport.

Intra-city public bus in Bandung City, in different manner, is exclusively and monopolistically run by *Damri*, a state-owned company. Due to this ownership, *Damri* is not a member of *Organda*. Similarly, inter-city trains are operated monopolistically by PTKA, a state-owned company, for the whole country. There are two types of ownership for taxis in Bandung City. First, taxi is owned by individual but among the owners, they form an association under same taxi name. Second, taxi is owned by company. There are presently nine taxi names/companies operating in Bandung City. *Angkots* are owned by individuals but the owners form an association so called *Angkot* (City Transportation). The name of *angkot* is then becoming popular name public vans in this city.

Inter-city bus, taxi and *angkot* are members of *Organda*. *Organda* is organization for the entrepreneurs of public transportation. Uniquely, the drivers of this public transportation are member of labor union of *Organda*. Between *Organda* and Labor Union of *Organda* is sometime confronting each other due to different interests. This case

particularly occurs in taxi Company. The owners of taxi (members of *Organda*) intend to hike the fare, but taxi drivers (members of Labor Union of Organda) against this decision, because from the driver's side, the increase of fare means significant reduction of customers and therefore less income. This happens because the fees must be submitted by the taxi drivers to the owners were based on fix daily rate, for example, IDR 500,000.00 (USD 40) per day.

The fare of all public transport modes is determined by the government based on *Organda's* proposal and other factors. Fare differentiation for different public transportation system reflects comfort and convenience of the transport modes. Fare is also an important determining factor of the market. It usually follows that individual income defines the choice of transport modes.

3.2   Market

There is certainly market segregation of urban transport users, particularly in public transport users. By using interval income of USD 150, the result of recent survey in the study area shows that private vehicles are mostly (72 percent) used only by middle to upper income earners, which is those whom their income more than USD 450/ month. The users of private motorcycles are those with income more than USD 300/month (91 percent). Majority (more than 50 percent) of the users of formal public transport, meanwhile, is clustered as follows as reflected in the survey results:

- Taxi (including Grabs and Uber); 65 percent of the users earned income of more than USD 300/month
- Air-conditioned public bus; 87 percent of the users earned income of more than USD 150/month
- Non-air conditioned public bus; the users are coming from all strata of income;
- *Angkot*; the users are coming from all strata of income;
- Intercity air-conditioned bus; 67 percent of the users earned income of more than USD 150/month
- Intercity non- air conditioned bus; the users are coming from all strata of income;
- Intercity air-conditioned train; 71 percent of the users earned income of more then USD 300/month
- Intercity non-air conditioned train; the users are coming from all strata of income.

From the above facts, *angkot* and non-air conditioned public bus are the most frequently used public transportation in the city. This fact urges the authority to

appropriately attend to these types of public transport modes, particularly in supply side. Angkots, in fact, is out of the authority's hand to control since they belong to individual owners, although control is still possible to some extent. For public bus, the city authority can still have control on the supply side of the services, since the DAMRI bus is owned by the government.

3.3   The Supply Side: Operations and Operators

Public bus with crowded passengers at public bus (non air conditioned bus) is common scenery in public transport in Bandung. This does occur not only during peak rush hour but also during 'normal' hours. Ageing fleets of non-air conditioned DAMRI buses are also significant issue of public bus transport mode in the city. In different way, the supply of *angkot* is abundant and over capacity, because suppliers are actually individuals. In some cases, these individuals formed an informal organization to get better bargaining position against *Organda* or city government as regulator.

There are presently 193 public buses (with about 5,700-seat capacity) and 8,811 *angkots* daily operating in city (about 65,000 seats). This capacity is equivalent to about 1.4 million passenger-kilometer traveled. This seems sufficient to accommodate the need of transport in city, however, present quality of services discourage people to use these two public transports. The regulators, operators, and operation systems need to be improved.

3.4   Working Environment

There are two persons that serve the passengers in a public bus, 1 driver and 1 conductor. The driver and conductor usually wear uniform provided by the company. For *angkots*, there is only driver to serve the passenger and no uniform for *angkot's* driver. The dress code for public transport is not regulated by city authority rather internal regulation. The service time of public bus is 6:00am to 21:00pm. There are normally two shifts of working hours. Driver and conductor of public bus therefore work for 7.5 hours per day on rotational basis meaning morning shift for today and evening shift for next day.

In different way, *angkot's* drivers have no regular working time. They can work whatever and whenever they like as long as their daily mandatory deposits are fulfilled. The amount of deposits is negotiable (between *angkot's* owner and driver) depending on *angkot's* age. However, the daily deposits are presently between USD 15 (for older *angkot*)
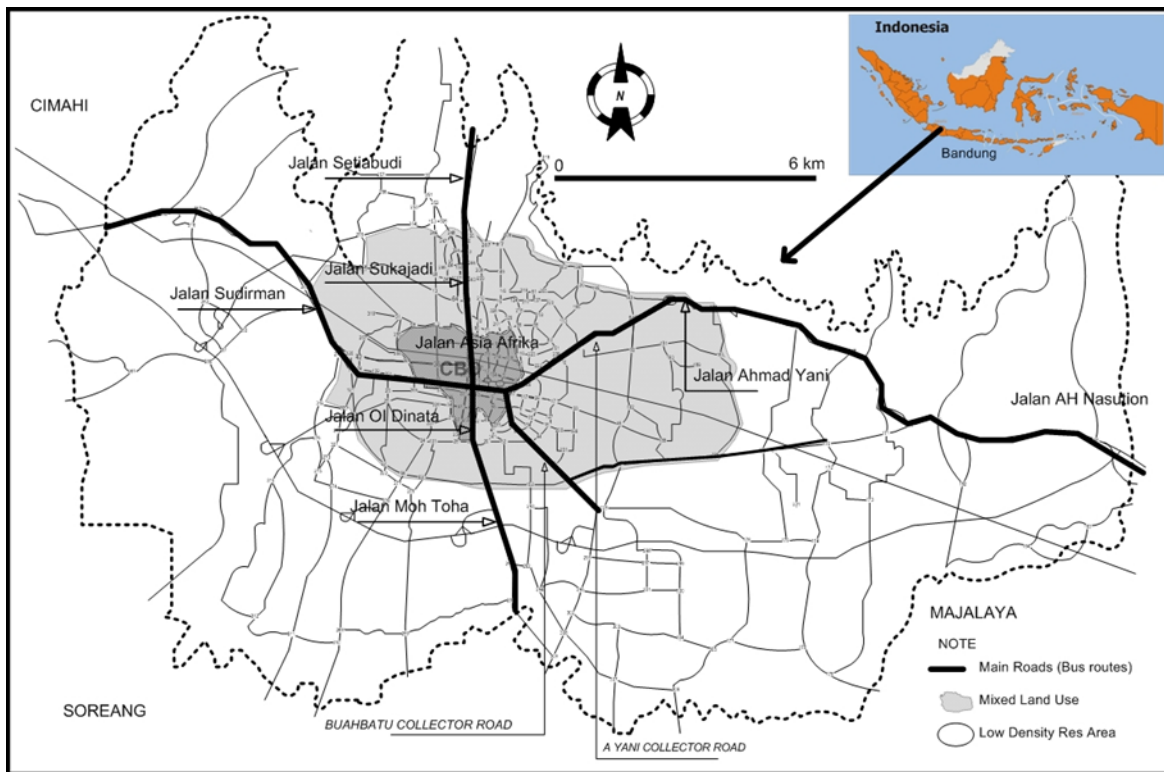
Figure 2 *Main Roads – Public Bus Routes*

to USD 25 (for newer *angkot*). *Angkot* drivers earn money from the remaining money they earn deductible from gasoline expense. Drivers of public transport are the most exposed persons to air pollution along with traffic police. However, there is no report on this matter available.

3.5 Operating Characteristics

Public buses routes are generally on main axes roads of city as shown in Figure 2, while *angkot's* routes are on secondary roads. It has fewer routes (15 routes with total length of 311.1 km) in comparison to *angkot's* (35 routes with 542.7 km).

As shown in Figure 2, city public buses serve a route obviously on main and important roads in east-west direction e.g. Jalan AH Nasution – Jalan Ahmad Yani – Jalan Asia Afrika – Jalan Sudirman, and south-north direction e.g. Jalan Setiabudi – Jalan Sukajadi – Jalan Gardujati – Jalan Oto Iskandar Dinata. In the same time, smaller vans (Angkot) serve other secondary roads. Almost whole city parts are served by Angkots and this has created a quasi transit system where bus' routes and angkot's routes are connected at many points. There are actually numerous potential advantages from the integration of informal and formal transport towards better services of these two transport modes to the users.

3.6 Gender User's Profile

As discussed in paragraph 3.1.2., the users of public buses and angkots are generally low to middle income earners. In terms of gender, sampling survey on angkot and public bus users shows that almost similar percentage of women and men exist. Women counted for 48.2 percent while men about 51.8 percent including both air conditioned and non-air conditioned buses. However, for air conditioned public bus, women outnumbered men users, which is 53.0 percent for women against 47.0 men. No gender survey on taxi's passengers was carried out.

The presence of formal transport, with current quality of service, has contributed to the movement of citizens within the city to accomplish their travel purposes. However, travel purposes of the citizens cannot be served completely without the presence of informal transport. It is because formal transports serve only certain routes and may not cover all areas of the city. The presence of informal transports is therefore necessary.

4.   Present Informal Transport Modes

The informality in this study is singularly attributed to 'recognition by the authority' or legal status of the transport modes. With this definition, there are two major types of informal transports in Bandung City, namely *becaks* (three-wheeled non-motorized transport modes) and *ojeks* (motorcycles taxi). Horse-pulled carts are not discussed further for the reason that this kind of informal transport are now gradually vanishing. Amid legal warning from the authority upon the illegal operation of *becaks*, the numbers of *becaks*, which are presently operating in many city alleys, are considerably large. Interview with 20 *becak* drivers shows that presently about 3000 to 4000 *becaks* exist and actively operating in city. There is no hard proof in this particular case. The legal or illegal controversy of *becaks* as one of transport modes in the city is actually rooted from the unavailability of decent jobs offered in the city for unskilled workers. Creating more job opportunities and improving skill of the workforces are possible response to this issue. The authority meanwhile does not do something to cope with this issue. Repressive action has been the easiest option chosen by the authority to deal with becaks problem in city.

For longer distance and hilly areas, where *becaks* cannot operate, *ojeks* (motorcycle taxi) are normally operated. There is no data on the number of *ojeks* which presently operate in city, however, according estimate by some *ojeks* drivers, about 2000-2500 *ojeks* are presently exist. Similar with *becaks*, *ojeks* operate in alleys. The *ojeks* seems more fortunate in comparison to *becaks*, because city authority neither recognizes nor prohibits the operation of *ojeks* within the city.

Those above two informal transport modes are focus of discussion of this study. The discussion consists of organization, market, working environment and other aspects which are necessary to understand.

4.1   Organization

Since informal transport modes are illegal in nature, there is no formal legal organization which binds the owners and the drivers of informal transports. Informal association within the owners or the drivers are formed for one reason, they have same destiny. They consider themselves as outsider because of their feeling of exclusion in the mainstream. In fact, their voices have never been heard by the authority, except during mayor's election. With frequent clearing operation undertaken by special police force under city government, they consider the force as their natural enemy. With this kind of feeling, it is socially difficult to embrace them into urban development mainstream. Their wishes are actually very simple, recognition by the authority and opportunity from the authority. This needs to be included in the policy on urban poverty. With their nature of informality and images of poverty stigmatized to them, their market is different from formal transport modes.

4.2   Market

Formal transports users are to include middle upper income earners as well. Informal transport users are mostly low income earners, and to some extent middle income earners. This market's segmentation may cause in a difficulty for informal transport users and drivers to improve their socio-economic condition. For information, all becaks drivers are urban poor and more than 90 percent of ojeks drivers are also categorized as urban poor. With such condition, working environment is also poor.

4.3   Working Environment

Informal transport drivers have no certain working hours. They sometimes work on round-the-clock basis. They will stop their work whenever two things achieved; tired or they think they earn 'enough' money for the day. 'Enough' for them is totally different with others, although it is difficult to define 'enough'. On average, their daily income for driving becaks is not that proper. It is only about IDR 50,000 to 100,000 (USD 4 to 7) per day with 5-10 operating hours and 15 to 25 kilometer traveled per day. This can only be achieved at relatively flat geographical areas. Almost similar story on poverty exists in ojeks operation. Interview with 20 ojeks drivers showed that their daily income were IDR 75,000 to 150,000 (USD 5 to 10), with travel distance about 25 to 50 kilometer per day. It looks above poverty line, however, if their income is divided with their household's size (mostly above 5), result shows that they are in an extreme poverty condition. World Bank's criterion on poverty is USD 1 per day per person. Low income, bad working environment and uncertain operating areas are the most significant issues of informal transport modes.

4.4   Operating Characteristics

Informal transport modes operations are generally characterized by the followings conditions as shown in Table 3.

Table 3 *Operating Characteristics of Informal Transport Modes*

Aspect	Becaks	Ojeks
Operation Area	At junctions and within residential areas	At junctions and within residential areas
Topography	Flat only	Flat and hilly lands
Working hours	24 hours	24 hours
Basic Fare	Negotiable, for 1 km distance is about IDR 15,000 (USD 1.0)	Negotiable, for 1 km distance is about IDR 10,000 (USD 0.8)
Farthest distance	About 5 km	None
Max no of passengers	2 adults	1 adults and 1 child
Power	Human	Engine
Safety	Uncertain	Uncertain
Legal basis	Illegal	Not recognized by the authority

Operating characteristics of informal transports can be further formalized if city authority wishes to formally recognize them and included them into formal and legal city regulation. However, with current mindset of the authorities, it seems difficult that informal transport particularly *becaks* to be included in formal transport. Present mindset of the authorities considers *becaks* as indecent transport mode and therefore indecent jobs for the drivers. This is main factor that hampers the recognition of informal transport as a mode of urban transportation system and the operators as well. Simultaneously, city government is not capable to provide job opportunities amid high unemployment rate in Bandung City.

4.5 Operator Profiles

Informal transports are owned by people with low to middle income level, but the drivers are mainly the poor. *Becaks*, for example, are owned by individuals. In most cases, *becaks* drivers are also the owners. About 80 percent of the samples show that *becaks* drivers are also the owners. In same way, about 90 percent of *ojeks* drivers are the owners. If the majority of *becaks* drivers have education at primary school level, the *ojeks* drivers have higher education level. Most of them have high school education background. *Becaks* drivers admit that their jobs are indecent jobs. This is the only choice they have, because they have no other skill to look for jobs that are more appropriate. Similarly, *ojeks* drivers are not intended choice. They choose this job because of easy to enter and no skill is required, as long as they can legally ride the motorcycles.

4.6 Gender User's Profile

Users of informal transports are generally low to middle income earners. In terms of gender, sampling survey on *becaks* are majority women. It accounted for 78.5 percent while men about 21.5 percent. For *ojeks* users, men outnumbered women users, which is 64.0 percent for women against 36.0 men. Regarding user's satisfaction, with two choices satisfy and dissatisfy, about 53 percent of the *becaks* users express their satisfaction with the services because *becaks* are able to provide door-to-door service. However, only 48 percent of samples of *ojeks* users are satisfied with the services of *ojeks*.

5. Environmental Impacts Created by Formal–Informal Transportation System

The most visible environmental impact of generated by transport is obviously air pollution. Monitoring undertaken by West Java and Bandung City Environmental Protection Agency shows the tendency of degrading air quality in the city over time. The major contributor of air pollution is transportation sector. Monitoring of air quality data to understand the extent of contribution of transportation sector to air pollution were carried out by means of mobile air quality monitoring laboratory (MAQML) at ten monitoring points. Because of its mobile nature, the MAQML could be operated anywhere. The data were acquired by employing MAQML. The measurement was undertaken by parking the MAQML at the road-side, and then MAQML observed the air quality. At the same time, traffic volumes were simultaneously analyzed.

The ambient air quality was monitored in hourly basis during 8:00 to 16:00 hours for seven consecutive days. There were eight-hour interval data samples, with minimum, maximum, and average parameters. Eight air pollutants viz. SO, CO, O3, HC, Non CH4, CH4, SPM and SOx were monitored. Fifteen points of the air quality monitoring stations across the city were actually available, however considering the incompleteness of data records,

Table 4 *Air Quality at Selected Points in Bandung*

Selected Monitoring Points	Year of Monitoring	Traffic Vol (PCU)	Air Pollutants (ppm)					
			SO$_2$	CO	NOx	O$_3$	HC	PM (mg/m^3)
Leuwipanjang	2003	6,835	0.042	3.000	0.080	0.045	1.940	151.61
	2002	1,974	0.040	2.067	0.043	0.031	1.409	126.40
Cicaheum	2003	6,471	0.050	3.601	0.102	0.030	1.970	115.20
	2002	2,730	0.048	2.890	0.096	0.031	1.730	133.60
Elang Raya, Cibeureum	2003	3,430	0.046	1.703	0.059	0.053	1.302	128.80
	2002	1,266	0.034	1.960	0.047	0.053	1.240	98.67
Margahayu Raya	2003	610	0.023	1.400	0.043	0.038	1.130	96.77
	2002	258	0.027	1.059	0.006	0.054	1.078	60.53
Sarijadi KPAD	2003	2,460	0.033	1.178	0.054	0.039	1.020	85.45
	2002	665	0.024	2.278	0.022	0.056	0.700	102.30
Buah Batu	2003	4,891	0.043	4.290	0.128	0.037	2.310	153.79
Cibiru	2003	4,310	0.033	2.400	0.063	0.031	1.370	102.40
	2002	1,431	0.043	1.618	0.059	0.032	0.796	120.80
Ujung Berung, Rumah Sakit	2003	1,733	0.030	2.054	0.052	0.030	1.353	69.60
	2002	575	0.032	0.261	0.012	0.031	0.173	45.26
Ahmad Yani, PERSIB	2003	4,936	0.052	3.650	0.072	0.037	1.880	108.00

only ten points were considered (Table 4). Establishment of the correlation is undertaken by employing ordinary least square non-linear regression. A study conducted by Zhongan et al. (2002) has attempted to rationally correlate traffic and emission intensity. This study resulted in a following rational correlation.

$$E_p = \sum_{i=1}^{n} L \times N_i \times F_{pi}$$

Where Ep is emission intensity of a line segment (gram/hour/km), L is length of road researched (km), Ni is traffic flow, number of vehicles of type i passing through the road segment (vehicles/km), i is vehicle type (1 to n) and Fpi is emission factor of vehicle type i (g/km). The dissimilarity between Zonghan's and this study is that Zonghan considers the source of emission at a line domain while this study observes a point domain to assess the quantity of emission.

Contribution of informal transports to air pollution is much less than formal transport or even positive in terms of air quality improvement. For *ojeks,* with engine capacity of the motorcycles used for *ojeks* operation is 100-125 cm3. Understanding engine capacity is to comprehend the emission factor in order to be able to calculate the emission discharged by *ojeks*. With this size of petrol engine, the emission factor is found to be 0.0729 kg of CO2 per kilometer traveled. For petrol private car up to 1.5 liter engine size, the emission factor is 0.1831 kg per kilometer traveled (http://www.defra.gov.uk).

With above emission factor for CO2, the contribution of *becaks* or *ojeks* in the reduction of CO2, if both are substituted by private vehicles, are shown in Table 1. Presently there is a potential reduction of emission of CO2, means improvement of air quality, within Bandung City, of more than 5,000 kg of CO2 if *ojeks* substitute motorcycles for travel purpose of the citizens within their residential

Table 5 *Contribution of Informal Transport in CO$_2$ reduction*

Non-motorized transport modes	Total Daily travel for whole city (km)	Kg of CO2, as substitute of motorcycle travel (e=0.0729kg/km)	Kg of CO2, as substitute of private cars of 1.5 liter engine size (e=0.1831kg/km)
Becaks	70,000	5,103	12,817
Ojeks	84,375	0	9,298
TOTAL potential reduction		5,103	22,115

Table 6: *Distribution of thermal sensation and comfort votes*

Thermal sensation	Cold (-3)	Cool (-2)	Slightly cool (-1)	Neutral (0)	Slightly warm (+1)	Warm (+2)	Hot (+3)
SM1	0	0.7%	4.2%	36.8%	37.5%	15.3%	5.6%
				78.5%			
SM2	0	0	4.8%	38.6%	45.5%	10.3%	0.7%
				88.9%			

Comfort	Very un-comfortable	Uncomfortable	Just uncom-fortable	Just comforta-ble	Comfort-able	Very com-fortable
SM1	2.8%	10.4%	21.5%	56.3%	8.3%	0.7%
	34.7%			65.3%		
SM2	1.4%	11.7%	37.2%	45.5%	4.1%	0
	50.3%			49.6%		

areas. If becaks and ojeks will be able to substitute private cars, this number is higher of more than 22,000 kg of CO2 per day. This is a significant amount of contribution.

Table above counts only CO2 emission, together with other GHG emission, the contribution of informal non-motorized transport is quite significant. If the operating area of this non-motorized transport mode is expanded, the contribution will be even larger. The issue is now, how to settle the controversy. It is definitely difficult to solve since numerous social factors involve. Some thoughts on compromising the controversy are useful to consider. These thoughts include:

Allow non-motorized transport modes e.g. becaks or bicycles taxi to operate legally within the residential areas in city

Design non-motorized transport modes in such a way that is able to nullify the image of indecent job

Table 7: *Distribution of acceptability votes*

	Clearly unac-ceptable	Just unac-ceptable	Just ac-ceptable	Clearly accepta-ble
SM1	2.1%	16.7%	73.6%	7.6%
	18.8%		81.2%	
SM2	2.8%	23.4%	73.1%	0.7%
	26.2%		73.8%	

Table 8: *Distribution of temperature preference*

	No change	warmer	cooler
SM1	22.2%	1.4%	76.4%
SM2	18.6%	1.4%	80.0%

Table 9: *Distribution of air movement preference*

	No change	Less air movement	More air move-ment
SM1	30.6%	1.4%	68.1%
SM2	24.8%	4.1%	71.0%

Control the number of this transport modes by creating comparable alternative job for unskilled workers

Provide adequate facilities for this transport mode such as terminal at a connecting point with motorized transport modes.

Urban air quality degradation clearly goes hand-in-hand with the increase of number of vehicle on roads. Coping strategies to deal with this issue may include emission control, promotion of non-motorized transport, encouraging the use of public transportation instead of private transportation, discouraging unnecessary travel, or other strategies which generate co-benefits among the measures. These strategies should preferably be

accommodated in environmental management measures of the city.

6. Present Environmental Management Measures

The forms of environmental management measures are generally command and control, economic instruments and suasive measures. Similar situation can also be applied for environment issue generated by transportation sector. Present instruments pertaining to environment and transport are summarized in Table 6.

6.1 Legal Settings for Formal Transport

Transportation system in Indonesia including Bandung is mainly based on Law on Traffic and Overland Transportation, LTOT (22/2009). There is no specific regulation at city level regarding traffic management and transportation in Bandung. In the absence of city regulation, the national law (LTOT) is the main regulation to be guided in Bandung. This law is uniformly valid all over the country. The objective of this law is to achieve the traffic and land transportation system that is characterized by safe, secure, fast, free-flow, order, regulated, comfort

Table 6 *Summary of Present Policy Instruments (Law and Regulation) pertaining to Transportation and Environment*

Level of Directives	Name of the Policy Instruments			Major Gaps Identified in the Nexus
	Land Use	Transportation	Environment	
National	Law on Spatial Plan and Management (26/2007) - LSPM	Law on Traffic and Overland Transports (22/2009) –	Law on Environmental Management (32/2009) - LEM	Law on Traffic and Overland Transports, and Law on Environmental Management are loosely connected to Law on Spatial Plan, as a result, partial and uncoordinated activities of the nexus exist.
	Government Regulation on National Spatial Plan (26/2008) - RNSP		Min of Environment (MoE) Decree on Ambient Level of Motorized Vehicle Emission (20/2017)	Law on Spatial Plan and Management enacts more on guidance on "land allocation" and lack of guidance toward sustainable development.
			MoE Decree on Emission Standard of Stationary Sources	LTOT provides insufficient guidance on transportation, and transportation management is not well addressed. The environmentally sound transport is not addressed.
			MoE Decree on Blue Sky Implementation in the Priority Areas	LEM and all its derivative regulations are adequate to address air pollution problems, but more coercive rather than inductive nature.
			MoE Decree on Air Pollution Standard Index	Blue Sky Policy is half-hearted policy, it requires strong enforcement to implement.
			Guidelines on Air Pollution Control of Mobile and Stationary Sources	
City	City Regulation on General Plan on Spatial Management of the City of Bandung (18/2011)	Not available in Bandung City. But nation-wide LTOT is applied.	Not available in Bandung City. But some derivatives of the nation-wide regulations are applied.	General Plan provides too generic guidance and does not address the sustainable interconnection of the land use-transportation-environment nexus.
				Detailed Spatial Plan provides "house-keeping" kind of land use guidelines, and no significant direction toward sustainable city.
	City Regulation on Detailed Spatial Plan of the City of Bandung			No specific guidance on the traffic management in the city toward better urban environment. City transportation system is not sufficiently addressed.
				Control on pollution particularly urban air pollution is not well addressed.

and efficient. A transportation system that is able to integrate all transport modes and support the growth and distribution of development is the main objective of this law. The law, however, provides weak connection to spatial and environmental sectors or other sectors associated with this instrument. Since environment is the most influenced sector, therefore, minimizing impacts of transportation on the environment must actually be addressed here, however messages on how to minimize the impacts is inadequately envisioned by the instrument. This gap needs to be abridged, and it must be reflected in the proposed instruments.

There must be sets of guidance and guidelines to achieve the objectives, particularly those associated with land traffic management. Traffic management should actually improve the traffic flow, reduce emissions per vehicle kilometer traveled as well as enhance urban mobility. In principle, it consists of supply and demand traffic management. In the supply side, traffic management is intended to increase speeds of existing traffic volume that follows existing traffic volume without modifying it, while demand side desires on the improvement of speed by reducing traffic volume. These all detail guidelines are required to avail in Bandung. In fact, Law on Traffic and Overland Transportation provides no sufficient guidance on that. The law does not adequately guide efficient traffic toward less congestion in urban area, rather discussing and regulating traffic signaling and rule-breaking punishment. The law also does not address the environmental traffic that is expected to link this law with environment law. This issue is raised since the initiators of the law are Indonesian National Police Department and Ministry of Transportation, although interdepartmental and inter-sectoral discussion were undertaken, but still the key messages of the instruments were heavily affected by the initiators.

Present policy instruments pertaining to environment actually provide sufficient guidance toward better air quality. However, implementation of the instrument is insufficient, since law enforcement is the weakest points among the process. With insufficient law enforcement the environmental degradation is steadily decreasing over time, this is among other reflected in the degradation of urban air quality. In addition, some instruments do not clearly guide toward the objectives of improving urban air quality and environmental condition in general.

Presently, the highest level of direction on environment is Law on Environmental Management (23/1997). The objectives of this law are to achieve sustainable development by considering the need of current and future generation, and to undertake environmental management which is balance, concordance and suitable in the achievement of sustainable development.

This law generally addresses issues on traffic associated environment, while addressing the needs of further regulation for specific purposes. To complement the law, some complementary regulations have been promulgated. These regulations are mainly in the form of Minister of Environment Decree. Ambient level of car emission, emission standards, blue sky policy, air pollution standard index and guidelines on the control of air pollution were also addressed adequately.

The weakness point of these instruments is on the implementation process. Due to weak implementation at city level, a lot of Indonesian cities are alarming in urban air quality. Example of the weakness is the implementation of Blue Sky Policy. This policy was a half-hearted-like policy, since the implementation was only in the form of appealing and encouraging people. Yet the implementation of this policy was in voluntarily basis. Another example was emission test. The test was undertaken intermittently without clear plan to continue this good practice. The emission test was also compulsory for public transport, but numerous polluting bus and other public transport vehicles were still operated on road.

Policy instruments on urban air quality concern are seems adequate with respect to the extent of guidance. Sources of air pollution are sufficiently addressed. However, the instrument does not cover all sectors those have strong connection with urban air quality. The messages on urban planning and transportation are not addressed at all. The messages are heavily concentrated on natural and anthropogenic relationships, because this is a significant issue in Indonesia. Emission control is addressed but more focused on end-of-pipe strategy rather than root-cause problem solving. This is again because of the initiators of the instruments was Ministry of Environment without adequate consultation with other sectors such as urban planning and transportation departments. This inadequate connection must be appropriately solved, and it must be reflected in the proposed comprehensive strategy in order to improve urban air quality.

As the conclusion on this policy analysis, it can be said that traffic related environment policies are abundant (and sometimes redundant) and relatively completed in

comparison with land use and transport related policies. However, implementation is the weakest point. This leads to the environmental degradation, including the degradation of urban air quality in the most Indonesian cities.

It seems from Table 6 that present instruments pertaining to transportation and environment are mainly on command and control aspect. In fact, this is true since there are no economic instruments or suasive measures in place. Economic instruments at city level have never been employed so far in Bandung City for urban and environmental management. Some suasive measures are occasionally employed for particular purpose, but these measures are not permanently institutionalized. The presence of gaps in the policies or instruments of formal transport have probably contributed to present conditions of transportation and environment. This should be

appropriately addressed in by future legal instruments, and mainstreamed in the present legal systems.

6.2 Legal Setting for Informal Transport

Present legal systems of transportation and environment for Bandung City including its implementation systems leave considerable holes and gaps which created present condition of transportation and environment in Bandung City. The terms of 'formality' shall actually give the impression that formal transport is well equipped with adequate policies and instruments. The fact is in contradiction with what 'out to be'. It can therefore be imagined that the informality of informal transport is inadequately facilitated with appropriate policies or instruments. The informal transport like *becaks*, for example, even receives systematic harassment from the city authority through regular law enforcement which forbids

Table 7 *Possible Plans and Policy Instruments at Urgent Stage*

Level of Directive	Components	Nature of the Policy Instruments/Plans	Objectives	Targeted EMM
City	Air Pollution	Emission control attached to car licensing	To improve urban air quality by enforcing vehicle to comply with the emission standard	Command and control (CC) for formal transport
	Transportation Management	MLRT Public Transport	To discourage people to use private car	CC for formal transport
		Kancil small wheeled transport	Provide low emission small public transport	CC for formal transport
		Becaks, tricycle transport	To reduce air pollution within residential area	CC for informal transport
		Ojeks, two-wheel transport	To reduce air pollution within residential area	CC for informal transport
		Park and ride system	Support MLRT and reduce number of vehicles operating within the city	CC for formal transport
	Land Use and Urban Planning	*Rukan* development	To obtain proximity between housing and jobs	CC for Urban development – formality
		Ruko development	To obtain proximity between housing and jobs (for commercial people)	CC for Urban development – formality
		Masyarakat Jalan Kaki, Majaka	To create pedestrian people by providing pedestrian friendly environment	Suasive Measure (SM) for community development - informality
	Public Awareness	Education for *becaks* and *ojeks* drivers	To create communities with high awareness particularly on transport, energy and environment	Suasive Measure for community development at large
		Awareness on transportation, environment and energy use		

becaks to operate within city, or they have to face severe penalty.

This condition is possible due to the presence of City Regulation No. 3/2005 which states:

"Dalam rangka mengatur kelancaran arus lalu lintas, Pemerintah Daerah dapat menetapkan jalan satu arah, jalan bebas becak, jalan bebas sado/delman, jalur bebas parkir dan kawasan tertib lalu lintas pada jalan-jalan tertentu yang rawan kemacetan"

Literally meaning, that for the purpose of smooth traffic flow, Government of Bandung City has the right to declare one-way traffic, *becaks* free zone, horse-pulled cart free zone, parking free zone, and zone of regulated and ordered traffic at certain streets where traffic congestion frequently occurs. The statement seems not too furious for *becaks*, however in the implementation, all streets in Bandung City are declared as *becaks* free zone. *Becaks* will not allow operating, failure to follow this rule, will face penalty such as capturing *becaks* without having opportunities to defend before the court.

The recognition of two-wheelers *ojeks* is unclear, whether this informal transport mode is recognized by city authority or not. No clear policy on this kind of informal transport, however, daily treatment from the authority on this two-wheeler motorized *ojeks* shows ambivalence. On one hand, city authority does not formally recognize this transport mode, it means at any time *ojeks* may face clearing operation from city streets. On the other hand, city authority closes its eyes on the operation of *ojeks*. This long time ambivalence has led to growing number of motorized two-wheel *ojeks*.

Informal transport such as *becaks*, *ojeks*, and horse-pulled wagons have not been accommodated appropriately by the city. City Regulation No 3/2005 is still effective as a ground to clear every eyesore in city. Illegal street vendors are the most suffering side of city's stakeholders in comparison to informal transport sector. They need to be accommodated appropriately since they are also stakeholders of city, however it seems that city accommodates only stakeholder which has strong economic power. This gap, if not carefully handled, will be a latent pressure to city in the whole which in turn will hamper the achievement of sustainable urban development.

Various gaps identified in present formal-informal transportation require attention from city authorities to improve transportation and environment situation in Bandung City. The gaps should ideally be bridged by accommodating formal and informal transportation system. However, this issue will not be properly considered by the authorities without convincing them on the advantages of informal transport, if they are properly managed. One significant advantage of the informal transport that the authorities must know is environmental benefit contributed by informal transport. Analysis on informal transport, particularly non-motorized transport like *becaks*, shows that presently *becaks* contribute to the reduction of 5,000-12,000 kg of CO_2 per day, considering their numbers and operating areas. The contribution is equal to the reduction of 1.8 to 6 million kg of CO_2. This is only contribution of CO_2; other pollutants such as SO_x, NO_x, hydrocarbon, CO are not yet calculated. This figure should be understood by the authorities and by other city stakeholders prior to design environmental management measures toward better urban environment.

7. Implications on Environmental Management Measures

Discussion on urban transportation system cannot avoid its backward and forward linkages. Land use as one of direct backward linkages and environment as one of the forward linkages. This field has been sufficiently researched (Banister et al, 1995; Breheny, 1995; Anderson et al 1996; Kenworthy and Hu, 2002; Hickman and Banister, 2007). A comprehensive EMM should therefore addresses these backward linkage e.g. land use and forward linkage e.g. energy and environment, and also covers three possible conventional measures e.g. command and control, economic, and suasive measures. The EMM can be policies or instruments depending on the suitability for particular purpose at particular place. With such backward and forward linkages, the identification of possible policies will attempt to explore all possibilities related to land use, transportation and its associations for the purpose of improvement of urban air quality in the city of Bandung.

7.1 Possible Urgent Environmental Management Measures

In general, it is recommended that city specific policy instruments and plans produced by "city specific scenario" are recommended to carry out in the first phase, since this scenario is the most viable within few years to come. It can also include plans or policy instruments those recommended by "comprehensive and progressive scenario" under short-term time frame.

The recommended plans and policy instruments is presented in Table 7. However, by considering present technical and financial capability of the Government of Bandung City, the only presently doable plans are recommended to implement at the very beginning of the development phase. Implementation of the policies are particularly prioritized to those which having higher degree of implementability as well as having more synergized co-benefits. The more co-benefits are expected to have multiplier impacts for the improvement of the urban environment of Bandung City.

This recommended policy instruments or plans are intended for immediate actions, although the time-frame of the implementation is medium (1-2 year) or long-terms (2-5 years). A comprehensive management measures, although difficult to achieve, are also proposed. Do nothing or business as usual scenario is not considered, since nowadays city authorities should do something for the improvement of urban environment the city.

The recognition of informal transport with modifications are also proposed to achieve win-win solution, in which *becaks* would be recognized as one transport mode in city and the drivers would not regarded as indecent jobs. In the

Table 8 Recommended Comprehensive and Progressive Plans and Policy Interventions (second stage)

Level of Directive	Components	Nature of the Policy Instruments/Plans	Objectives	Targeted EMM
National	Air Pollution	Standard of Compliance of Vehicle Emission	To reduce emissions from mobile sources	CC for formal and informal transport
City	Air Pollution	Economic incentives and disincentives e.g. fuel tax	To reduce the need of motorized travel	Economic Instrument (EI) for formal transport
		The Use of low emission fuels (CNG, LPG)	To reduce the emission from mobile sources	CC for formal transport
		Temporary command and control on the implementation of the existing regulation	To achieve smooth transition	CC for formal and informal transport
	Transportation (TDM)	Application of Area Licensing Fee	To discourage traffic at certain areas	CC for formal transport
		Application of Vehicle Quota System	To control the number of private vehicles ownership	CC for formal private transport
	Transportation (TSM)	Guidelines on Appropriate Traffic Management	To achieve better traffic mechanism	CC for formal and informal transports
		Provision of traffic infrastructures		EI for formal and informal transports
		Guidelines on appropriate parking system		CC for formal and informal transports
		Provision of appropriate mass rapid transportation system	To encourage the use of public transport	EI for formal transport
	Land Use and Urban Planning	Redevelopment and Revitalization of the CBD	To achieve efficient and harmonious urban development characterized less pollution and energy-efficient transport	CC for formal urban development - formality
		Promotion of Mixed-Use development and high density residential		
		Redevelopment of Bandung Sub-center and urban containment		
		Promotion of the neighborhood type development		
		Development Incentives and Disincentives		EI for urban development - formality
		Command and Control		CC for formal urban development

long term, *becaks* can be gradually replaced by modern non-polluting small urban transport mode in the future such as electric Tata Nano cars cheaply produced by India.

7.2 Comprehensive long-term Environmental Management Measures

Implementation of the recommended policy instruments or plans cannot be undertaken at once. By keeping and maintaining the momentum of simultaneous and continuous actions toward the improvement of urban air quality in Bandung City, the subsequent phase can be planned. Similar consideration with the first phase is undertaken. The short-term and long-term plan should be pursued in a continuous basis to ensure that these two terms of proposal are well articulated.

For that purpose, following the first stage, in the next stage, comprehensive and progressive policy instruments or plans are recommended. The implementation is undertaken according to given time-frame. The interventions which are addressed by the conclusion must be reflected in the recommendation. With this consideration, in the second phase, the recommended plans or policy instruments as resulted by the comprehensive and progressive scenario are presented in Table 8.

All possible interventions are proposed, but by using the degree of implementability, preliminary economic analysis and the creation of possible co-benefits, the proposed interventions are screened. Those policies are, in principle, doable and implementable to certain degree with respect to current condition, in the sense that political will of the government and citizen awareness are now enshrining. The policies or instruments for formal and informal transports including its backward and forward linkages are expected to create a synergy towards better urban environmental conditions of Bandung City on the way to livable city and sustainable city.

8. Conclusions

Informal transport if it is managed appropriately may complement formal transport in providing more comfort urban transportation system in Bandung City. Formal transport which in Bandung's case is predominated by non-motorized transport such as *becaks* and also motorized transport two-wheel *ojeks*, are able to contribute to the betterment of urban environment, since these two modes, particularly *becaks*, do not emit or less pollutants. The

problem now in Bandung City is recognition of these two informal transport modes. So far, city authority does not recognize these two informal transport modes.

Environmental management measures which can be manifested or implemented in various forms such as plans, policies or instruments should accommodate these two formal and informal transport modes towards better urban environment. Although transportation is key policy arena for EMM in this study, but proposed EMM should also address land use as backward linkage of transport, as well as energy and environment as forward linkage in order to be able to provide comprehensive EMM to achieve better urban environment towards livable city. Some forty to fifty years ago, Bandung City was famously attributed as Parijs van Java (Paris in Java) and Flower City, but now Bandung is notoriously as congested city. This situation cannot be tolerated. This study is expected to contribute to the improvement of urban environment in Bandung City.

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A contextual parsing of big data values to quantity surveyors

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ABSTRACT

Big data is the new generation of technology designed for organizations to economically extract value from large volumes of a wide variety of data through high velocity capture, discovery, storage and analysis. Manifest as the frontier of 21st century technology, big data instigate superior business return. This lure businesses to zealously capitalize big data. In correspond, professionals too are charting their way to improve customer value with big data. Leading research in this area accede maximization on big data; revolutionized the norm of medical and accounting profession. Despite the substantial value, big data uptake from the quantity surveying profession recognized subtle. Contrarily, construction stakeholders swiftly embrace modern technology in their construction value chain. This invoke a change in data landscape thus, present an urgent call for professionals, especially quantity surveyors to recognize the change, embrace and reap the big data benefit. This paper aims to expand big data knowledge from the context of quantity surveying profession as an approach to soothe the big data and quantity surveying gap. This paper identifies generic big data value from professional perspective and explore big data value from the quantity surveying context. Aligning to the blurry big data paradigm in the quantity surveying context, this research adopts quantitative research with desk study on 28 papers and framework analysis through 15 semi-structured interviews with big data industry expert with quantity surveying background. This research found that big data values are consistent across profession albeit the difference on how big data is maximized. Other than that, the paucity of quantity surveying big data pursuance seen as repercussion of infancy big data state in the construction industry. However, this research insinuate quantity surveying profession are in strategic position to move forward with big data.

1.   Introduction

The Industrial 4.0 revolution changes the overall ecosystem across different industry and as part of this movement, the ecosystem in the construction industry face challengers. While the benefit of IT is astounding and not limited to its previous role as an external input to solve technical problem (Benson, Bugnitz, & Walton, 2004), IT is indeed a double-sward edge. The application of modern technology such as internet of things causes industry plenary disruptive impact. Big data emerge in 1997 by researchers to portray the problem of large data volume (Addo-Tenkorang & Helo, 2016; Cox & Ellsworth, 1997).

In 2011, McKinsey & Company report disclose a peculiar big data gain across industries. Consistent with this report, big data spur organization's productivity improvement, customer experience, business cost reduction, expediting competitive advantage as well as driving new business opportunities to organizations (Forbes Insights, 2015; Groves, Kayyali, Knott, & Van Kuiken, 2013; McAfee & Brynjolfsson, 2012). Relating to this, Brown, Chui, & Manyika (2011) argues data-driven decision making as the main value of big data. This enables organizations to move towards proactive innovation, giving them more control on the industry's market to combat future risk occurrence while offering optimized solutions (Chen, Chiang, & Storey, 2012; Kiron, Prentice, & Ferguson, 2014; World Economic Forum,

2011). Pioneer report 'Big Data: The Next Frontier for Innovation, Competition and Productivity by McKinsey & Company discrete clarity towards big data across organizations. This report indicate positive uptake on big data in organizations of different industry such as healthcare, public sector administration, retail and manufacturing (Manyika et al., 2011). More importantly, this report postulate organizations are positioning themselves through maximization of transparency, experimentation to discover needs, supported decision making process and new business innovations through big data. Besides contextualizing correlation towards big data potentials mentioned, big data is a universal technology which can be applied across organizations.

To date, organizations are embarking on big data on an aggressive scale, globally. Big data hailed as the face of new technology revolution. The significant of big data do not rest upon mere connotation on forms of big data potential in organizations neither across industries. High profile news and magazines as well as industry leader and government reports declaring financial return on big data investment. Big data offers 5% to 6% higher profitability to organizations (McAfee & Brynjolfsson, 2012) and in the case of Amazon, big data recommendation engine secure 30% increase of overall total sale (The Economist, 2011). From a wider landscape, the Centre of Economics and Business Research (CEBR, 2012) publish an

anticipated £24 billion revenue to the UK economy through big data. These serve concrete evidence on big data; reinforce organizations confidence and desire to strategically move forward with big data.

Over the years, IT governs changes among professionals. Interestingly, the post 2008 research shows that medical and accounting profession moved towards embracing the technological change and pursue big data. Medical profession evolved from being doctor dominance profession towards patient centered healthcare, personalized healthcare and ubiquitous healthcare. Accountants on the other hand, taking a leap towards maximizing non-financial information source for fraud detection and live auditing. Taking advantage on the surge of demand on big data, accounting profession are emerging towards professions role expansion as data valuator as we speak (Association of Chartered Certified Accountants, 2013; Chawla & Davis, 2013; Digital News Asia, 2013; Dynamic Markets, 2012; Groves et al., 2013b; IBM, 2012, 2013b; Knowledgent, 2014; Manyika et al., 2011; Murdoch & Detsky, 2013; Savage, 2012; Zenger, 2012). With big data, professionals can deliver more values to customer; moving passive, reactive and supportive roles towards proactive approach in delivering services.

Big data is seen as a double-sword technology; delighting customer needs while enriching organizational and professional value. From the perspective of the construction industry, current research indicates a positive adaptation of technological innovations by construction stakeholders. KPMG (2016) and Lasrado (2018) unveil computer aided design (CAD), virtual reality (VR), building information modelling (BIM), cloud computing as well as IoT lead technology; sensors, drones, radio frequency identification (RFID) and global positioning system technology usage trend post year 2000. Current technology is characterized by its capability to overcome human limitations and better understanding of work process. This shows that IT function has greatly moved from a communication medium and facilitating administrative work as emails and Windows application towards capitalizing IT in improving productivity and work process. Although agreeing positive potential streaming from current technological trend in the construction industry, from a second point of view, technological advancement changes the landscape on data generation and availability in the construction industry. This is argued to change the context of data; previously driven by documented data on papers, technology application in work processes generates data in digital format. Changes in data creation calls for perhaps, different approach on understanding the difference of what it means to the construction industry, managing and maximizing data.

Remain in the infancy stage, big data research in construction industry context pioneered by Bilal et al., (2016), Chen, Lu, & Liao (2017) and Hafiz et al., (2015). Academic research is exploring the context of big data from the construction industry perspective. More recent research explores on the potential of big data however, signalling an alarm for construction stakeholders, especially quantity surveying professionals to strategically manage and maximizing the value of big data (Ismail, Bandi, & Maaz, 2018; Maaz, Bandi, & Amirudin, 2018).

In relation to the progress made by other professionals in medical and accounting, these research advert minimal amount of research is currently undertaken to guide quantity surveying profession to move forward with big data. Hence, compared to other professionals, this implies paucity on big data in the context of professionals in construction industry, especially, quantity surveying profession. Relating on the issues of paucity of quantity surveying profession on big data and the changing landscape of data in construction industry, this research aims to expand big data knowledge from the context of quantity surveying profession. The context of this paper is part of an on-going research; however, this paper adds to this knowledge by; 1) Identify generic big data value from professional perspective and 2) Exploring the value of big data for quantity surveyors.

2. Research Methodology

This paper is founded on no single perspective on idea of multiple realities ontological point of view. Due to the research context conducted in the infancy stage development of big data in construction context as well as paucity in big data research addressing to specific quantity surveying profession (QS), this research stems on interpretivistic epistemology and moderated qualitative approach is deemed suitable for this research to give emphasis on words instead of data computation (Bryman, 2004). This paper address on the importance of exploring big data from the QS perspective, not creating a final establishment on this area of research but instead, expanding the establishment of knowledge.

Data supporting the first objective in this paper is derived based on desk study research. To gain comprehensive data search, google scholar databased was used with 'Big Data Potential', 'healthcare' and 'accounting' keyword with Boolean OR. Specification on 'healthcare' and 'accounting' were based on initial readings in relation to the area of this research. It is found that among professionals, medical professionals were avid and advanced big data adopter while accountant are professionals with progressive pursuance on big data. Thus, selection of both professions believed to reflect differences (if any) and eradicating bias towards the findings on generic big data value. More importantly, both professions are seen similar to QS profession. During the early technology adaptation across sector, doctors, accountants and quantity surveyors were among the profession with less progressive technology adaptation.

Data were then filtered according to its relation to the research context and 28 sets of data discussion big data value were gathered. The second and final objective were conducted through in-depth, semi-structured interviews of 15 QS professionals involved in the big data initiative at national level through snowball sampling. The first respondent was identified during Statistics, Indices in Construction & Automation (SICA) Forum 2017. Data are transcribed and analysed using framework analysis, similar to priori objective.

Framework analysis was used to improve the transparency and robustness of this study (Ritchie & Spencer, 1994). Transcribe data are analysed throughout data collection period between May-July 2018. Data saturation was achieved during the tenth interview as respondents are constantly describing similar context identified in the previous interviews, however, the remaining five interviews were conducted to gain elicit understanding on big data. The five stage in framework analysis; familiarization, identifying thematic framework, indexing, charting and mapping and detail process interpretation in stages facilitated researcher flexibility in extracting critical insights while paving transparency credibility Braun & Clarke (2006). The first four stages of framework analysis were assisted by Nvivo and descriptive coding strategy popularized by (Saldaña, 2009) and detail process interpretation were conducted based researcher emerging thoughts supported by data findings and theoretical big data research analysis.

3. The generic big data value

Professionals across sectors are moving towards adopting big data to improve service to clients. Desk study findings on 28 sets of journal and whitepaper were analyzed and presented in Table 1. Table 1 presents the generic big data value based upon two profession currently maximizing on big data. Analysis reveals four big data value across the

Big Data Value	Area	Authors
		Accountant
Process improvement	Self-service data retrieval	Hathaway (2014) and Vasarhelyi, Kogan, & Tuttle (2015)
	Predicting risk management	Chan (2003) and Mittermayer (2004)
	Managerial accounting	Warren, Moffitt and Byrnes (2015)
Transforming or revolutionizing profession	Integrated and standardized reporting	Association of Chartered Certified Accountants (2013) and Hathaway (2014)
	Live auditing	Digital News Asia (2013)
New opportunities creation	Data value validation	Association of Chartered Certified Accountants (2013)
	New data source integration	Basoglu & Hess (2014), Cao et al, (2015), Elkins, Derrick, Burgoon, & Nunamaker (2012), Girshick, Donahue, Darrell, & Malik (2014), Holton (2009), Mayew & Venkatachalam (2012), Metaxas & Zhang (2013), Radhakrish-nan, Divakaran, & Smaragdis (2005), Torpey, Walden, & Sherrod (2009) and Torralba, Fergus, & W, (2008)
		Doctor
Process improvement	Patient-disease profiling	Groves, Kayyali, Knott, & Van Kuiken (2013), Knowledgent (2014), Murdoch
	Healthcare standardization	& Detsky (2013) and Manyika et al, (2011)
Creating better services	Ubiquitous healthcare	Groves et al, (2013) and IBM (2012)
	Personalized healthcare	Chawla & Davis (2013), IBM (2012, 2013b), Knowledgent (2014), Manyika et al, (2011), Murdoch & Detsky (2013), Savage (2012) and Zenger (2012)
Transforming/ revolutionizing profession	Proactive healthcare	Groves et al, (2013), IBM (2012, 2013b), Knowledgent (2014), Murdoch & Detsky (2013), Savage (2012) and Zenger (2012)
New opportunities creation	Data extension to pharmacy sector and medical claim	Raghupathi & Raghupathi (2014)

profession which includes process improvement, creating better services, transforming or revolutionizing profession and new opportunities creation.

Accountants and doctors share two common big data value which are process improvement and better services. In terms of process improvement, by connecting inventories with RFID, big data provide value through self-service data retrieval. This enable accountants to ensue inventory checking, improving work efficiency and productivity while reducing job repetition (Hathaway, 2014; Vasarhelyi et al., 2015). Furthermore, data analytics helps accountants to see the overall picture, generalize patterns and trends to provide better advice to organization managers and leaders and adds value to organizations (Cao et al., 2015; Warren et al., 2015). Moreover, trends and patterns assist accountants to prepare financial analysis based on non-financial data. Aligning to this, accounting report released by Association of Association of Chartered Certified Accountants (2013) attest task automation does not diminish the role of an accountant but instead, equips accountants with better capability to explore new roles such as advising the suitable non-financial data to be incorporated with strategic investment decisions for managers and leaders or exploring data sharing boundary within organizations and externally. Similarly, big data capability in handling large and various data sources enables healthcare standardization. Coupled with clinical information profiling based on patient's data delivered in real time, this guide coordinated approach for more reliable and affordable diagnosis (Groves et al., 2013a; Knowledgent, 2014; Murdoch & Detsky, 2013). Hence, findings infer towards maximization of automation in big data as well as capability in handling data with big data characteristics (large volume, variety and real time data) leads towards process improvement for professionals' service to client.

The context of creating better services is further addressed through big data capability to revamp conventional healthcare methods and skew towards ubiquitous (Groves et al., 2013a; IBM, 2012) and healthcare (Chawla & Davis, 2013; IBM, 2012, 2013; Knowledgent, 2014; Manyika et al., 2011; Murdoch & Detsky, 2013; Savage, 2012; Zenger, 2012). Instead of retroactive practice approach, doctors can analyse real time patient's data and predict patient's healthcare status remotely through ubiquitous healthcare. This increase healthcare system efficiency. For example, patient's body temperature and

electrocardiogram can be monitored virtually through wearable device signal without having to stay admitted which mitigate problems such as hospital cramp. On the other hand, personalized healthcare is the way forward as doctors can tailor best treatment options according to patient's biological needs. This enables doctors to deliver better service and taking a leap change from the traditional practice. In other words, professionals can move towards delivering better service through big data because big data facilitate instant data access as well as comprehensive data access in early decision-making stage. However, none of the data sets analysed address the context of creating better service from the accounting perspective.

Consistent themes were found in the literature describing big data as a form of technology which invites profession transformation or revolution. From the accounting perspective, Bourmistrov and Kaarbøe (2013) argues traditional budgeting techniques are pinned upon an inward focus and lack of creativity. New data sourced exploration through big data allows the development of integrated and standardized reporting. New forms of data such as user experience input of using accounting technics or format can be further accessed. This provides a clearer perspective on company performance, better indicator for growth and value creating as well as transparency. Next, big data is seen to improve audit process through live auditing. Pricewaterhouse Coopers Malaysia (PwC) uses big data to review transactions in micro perspective digitally instead of reviewing transaction documents which are prone to accuracy problems. Various data source enable accountants to easily spot anomalies and focus on the root cause (Digital News Asia, 2013). Chan (2003) and Mittermayer (2004) discuss the ability of predictive analytics to assist accountants in analysing positive and negative risks to address accurate future investment opportunity risks. On a similar stance, Manyika et al, (2011) proffers that data analytics helps to promptly detect healthcare pattern locally and globally. By this, doctors are well informed on the local need of healthcare services analyzing patient's data and hospital records. Therefore, delivering proactive healthcare service and transforming the healthcare services. However, few authors offer an alternative interpretation from the patient's perspective. Big data allows patients to be proactive in tailoring their lifestyle towards a better healthcare management as patients are equipped with information on their health status (by using sensor technologies) while doctors monitor in virtual. This transforms healthcare quality through

patient empowerment (Groves et al., 2013a; IBM, 2012, 2013; Knowledgent, 2014; Murdoch & Detsky, 2013; Savage, 2012; Zenger, 2012).

With regards to creating new opportunities, research on big data has shown that professions are likely to form new roles, providing a significant differentiation towards the conventional services and practices. One noticeable new role for the accounting profession that would create a new revenue stream as well as skill expansion is data valuation. Research on data valuation practice becomes relevant as more companies are appreciating data as an asset and compete based on data (Association of Chartered Certified Accountants, 2013). In 2012, 20% companies are incorporating data as an asset in their balance sheet and data valuation service becomes more relevant for big corporations (Dynamic Markets, 2012). Hence, data valuation service is relevant to the current as well as future market and most importantly, the numbers show that there is a potentially large demand and optimistically, an unsaturated market. However, Raghupathi & Raghupathi (2014) raised a significant supposition where big data enables doctors to share patient's health details to improve research and development of new drug. The integration of healthcare data and research data from pharmacist reduces trail failure, increases treatment match and adverse effect detection. Another aspect on new opportunities being brought forward through integration of real time data and patient's healthcare record, enabling health insurers to have a better overview in understanding and resolving claim as well as minimizing fraud claim (Raghupathi & Raghupathi, 2014). The advancement of big data does not only create new opportunities but creates a value-added chain for medical profession such as pharmacist and medical insurer. Through data integration and analytics, the process of drug development by pharmacist and health insurer is further revamped enabling speedy and safe drugs development as well as delivering right value to patients while improving transparency.

This section concludes by offering four common opportunities of big data for professionals which are process improvement, offering better services, transforming or revolutionizing the profession and creating new opportunities. While detailed research by Comuzzi & Patel (2016), Du, Li, & Zhang (2014) and New Vantage Partners (2012) on big data from organizational context argues that decision making being the biggest impact of big data, this section expands the context of big data value in generic without any emphasis of criticality on any.

4.   The big data value for quantity surveying profession

While findings generic big data value from the profession context value were addressed in the previous section, this section implies findings on big data value in specific to QS profession perspective. Descriptive and pattern coding analysis indicates four consistent dominant codes describing big data value from the understanding of delivering comprehensive insights, data driven decision making, productivity improvement and data commercialization. Figure 1 represent word cloud visualization on the dominant codes' findings.

4.1   Comprehensive insights

Analysis on exploring the value of big data for QS profession avulse descriptive codes describing value derived upon insights comprehensiveness. Based on second layer coding analysis, findings indicate a consistent pattern in the codes. These codes were re-coded based upon the understanding of 'data centralization', 'true reflection' and 'visualization'.

Analysis of 'data centralization' code describes the big data as a

Figure 1 *Dominant codes for big data value from QS profession context*

technology with allows QS professionals to access large volume of data. Big data is viewed as a system which hosts large volume of data, accessed on a single platform and can be accessed virtually across time and geographical expansion. Codes analysis indicates several big data characteristics based on interviewee's perspective such as platform hosting large volume of different data forms and sources. The list below indicates current available data types in the construction industry.

- Bill of quantities (BoQ)
- Operational cost
- Maintenance cost
- Construction project data (project type, project detail, contractor data)
- Procurement data
- Construction waste data
- Building information modelling data
- Sensor data
- Land cost
- Advertisement cost
- Authority requirement and policy
- Construction index
- Productivity data

Detail analysis on 'data centralization' code elucidate several issues in the construction industry. The construction industry is known as a silo practiced industry. As an effect to this, construction stakeholders across construction industry do not confront towards data sharing. 'Private and confidential' in-vivo codes consistently recognized across transcribes. Most construction organizations react negatively to 'data sharing' culture and shy upon the idea of data privacy and confidentiality. While this conjures towards the understanding of data as a valuable commodity among construction stakeholders, most quantity surveyors result towards capitalizing personal relationship to access data. Reflecting to this issue, big data value is seen to derived upon data centralization benefit to quantity surveyors. Codes analysis further emphasize on alternative for data access whereby big data facilitate QS professionals to access data which were previously hard or seems impossible to access. From the perspective of work process, data centralization allows accessibility across time and geographical horizons. Hence, analysis indicates that QS professionals are facilitated by early data access in addressing construction projects. For instance, a

respondent interviewed (code: Q) mentioned on current estimating and project financial planning pursuance is limited up to delivery of construction building. Estimates rarely incorporate costings on building facilities management costs reason being; limited data access. However, with big data, data across construction life cycle can be accessed in a centralized platform, hence, enabling access on data of latter project stage. In short, delivering more comprehensive insights as well as better service value to construction stakeholders.

Next, detail analysis on 'data centralization' codes in emphasised consistent interpretation of national data standard. Big data enables QS professionals to have a national data standard. A respondent (code: B) had highlighted on the issues of inconsistent and data misinterpretation across construction stakeholders, even within QS professionals. Based on the respondent's experience as an academic as well as an industry practitioner, the respondent observed differences on simple interpretation such as gross floor area (GFA). Respondent B had further indicated that the value of big data can be understood through data centralization and standardization of data context managed throughout data processing stage. This allows QS professionals as well as construction stakeholders to have a universal understanding, encouraging smooth communication between those parties.

Next, detail analysis on 'true reflection' pattern coding interprets the understanding of big data allowing QS professionals to access data that are trustworthy, free from perspective bias; representing current industry context authenticity. Respondents were seen to describe this value in relation to the issue of current data access are of clouded genuinely. With an experience working with a contractor and consulting firms, respondent F had noticed bias between a quotation submitted to contractor and consultants by suppliers over the same materials or work items. Thus, data received by QS professions perhaps, depends on sector position influence and were not the true reflection of industry context. However, big data is supported by strict data processing and management ethics. Data management process allows standardization on data as mentioned above while data filtering process allow data context to address any 'off' data or data that do not conferred to the current data accumulation value or understanding. This allow insights generation to be free or with minimal bias. Other interviewees postulate similar respond where bias in data tempers QS professional's capability to address comprehensive advice during tendering stage. Thus, this implies that the value of big data to QS professionals can be further understood through improvement on analysis capability such as accessing contractor's tendering strategy. Moreover, genuine data helps constitute towards setting 'par' data values on construction resources believed to channel healthy competition culture in the construction industry.

Findings on 'visualization' consistent codes addressed that the value of big data is rooted upon big data technological features. Albeit all interviewees described on the importance of technological element within the context of big data pursuance, only those with deep big data knowledge such as interviewees with exposure on technological and statistical knowledge mentioned on data visualization value. For instance, taking from big data initiative mentioned by respondent Q, PCE-PREMO system provides data interpretation in the form of comparison take and percentage differences. This allows fast and better comprehensibility of insights context. Respondent H further describe graphical presentation on insights on system interface or big data dashboard allows simplification on data representation.

Pattern coding facilitates researcher capability to analyse data according to framework analysis especially during charting and mapping stage. 'Data centralization', 'true reflection' and 'visualization' codes expand

and increase deep contextual understanding on our early findings based on descriptive coding strategy. This research ratifies the value of big data to QS profession in delivering comprehensive insights. Pattern coding interprets comprehensive insights value driven through the capability of QS professionals to access large and variety data across time and geographical horizons in genuine context with universal interpretation across construction stakeholders and simple yet engaging data insights representation.

4.2   Data driven decision making

Initial scoping on the value of big data for QS profession indicate consistent findings on codes describing analytical decision making driven by solid data basis. Codes were further addressed with 'Data driven decision making'. Analysis indicates that this value is consistently described along with 'guesstimate' issue highlighted by interviewees. Currently, QS professionals are reported to practice 'guess-timate' or several other terms such as rule of thumb', 'magic wand' and 'experience' to manage or predict uncertainty as part of decision-making process prior to delivering services. These terms express the understanding of QS professional practicing gut-feeling decision making. Consistently, respondent D, H, M and F argue the need for this profession to skew away from 'guess-timate' as decisions are made based on personal opinion, secluded upon grey areas of decision-making process. 'Guess-timate' decision making implies risks towards service output such as advice to clients as decisions are derived based on dubious basis and desultory understanding.

The context of big data, managing uncertainty further expanded with perspective of respondent I, Q, B, N and G. The respondent's understanding on uncertainty resides on 'variables' that differs according to project peculiarity, constantly changing and are not within QS's control during the process of decision making in completing job scope. They highlight on 'variables' (or also known as factors) which are known as 'constants' in big data analysis process. While previously most QS practice guess-timate, respondent H excerpt indicates 'variables' function in big data system helps QS professionals to have analytical computational degree of uncertainty, leading them to better manage uncertainty areas which are prone to guesstimates practice, thus, reducing QS professionals favouring guesstimates practice.

Consistent pattern code on 'integrative system' were found as part of respondent's discussion on 'data driven decision making' context. This can be further understood by respondent's discussion on two big data initiative; PCE-PREMO and Construction Cost Modelling (CCM). Detail analysis on indicates both initiatives indicates three dominant components big data initiative function in Figure 2.
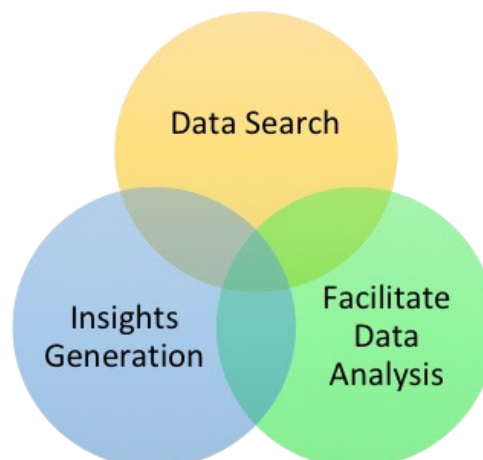

***Figure 2** Big data dominant components*

Data search describe the process of QS searching for similar cost data through data mining process while analysis process describes adjustment on cost data to suit current project needs. Insights generated is the auto generated output on which instantly support QS professional decision making. It is viewed that this process connotes the idea of data driven decision making as stage of work process is supplemented by analytical form of analysis. Further supported by respondent F and C discussing on the properties of data management which secures ensure data quality and reliability. Moreover, data analysis process is conducted through standardized methodology. This implies that each of the three big data process in producing are corroborated with credible data and process clarity; connoting the idea of data driven decision making at each layer. Thus, the increase the quality of decision making by QS professionals.

Data driven decision making supports the ability to replace experience based and subjective judgment to soothe human errors in work scope and move towards data driven analytical approach decision making. This further implies that big data offer QS professionals with tangible and analytical path in making job scope decision.

4.3   Productivity

Analysis of descriptive data in identifying thematic framework indicates an emerging understanding of productivity improvement in QS professional services. Transcribed data are coded with 'productivity' code describing two consistent and dominant patterns on the understanding of prompt and easy data reference and automation. Both patterns further conjure towards (process) and time improvement.

Findings on prompt an easy insights generation centres around the terms 'click', 'drag', 'click and drag' 'automization', 'easy' and 'simple' mentioned by respondent E, P, I, D and Q. Emphasis on the terms reflects towards the significance of technology features of big data. Big data technological features allow simple maneuver on big data systems for QS professionals. Extending to the findings of three dominant components of big data initiative mentioned above, data indicates second layer of interpretation related to process and time improvement. While previously findings were discussed along the line of facilitating data driven decision making, the same understanding paved Interviewee's perspective on productivity.

Through big data, data search process is simplified as QS professionals can access a single platform encompass variety of data. Upon data access, QS professionals can then straight away analyze the available data according to project or client's needs in the same platform. Duplication such as data extraction from big data platform to normal excel sheets prior to manual analysis can be eradicated. Adjustment on data according to QS professional's peculiarity can be done while each of analysis steps can be traced. Finally, big data allows automated insights generation whereby, final output can be access instantly for each adjustment made during data analysis. In short, insights generated are the reflection of data adjustment and analysis. Most importantly, these findings evoke upon process facilitation leading towards time savings throughout overall process.

Respondent C further connotes technological features bolstering clarity on data analysis process. Respondent C discussed on the common issue faced in a consultancy practice whereby, not only that normal estimating practice requires long duration of 1 to 2 weeks, lengthy time were taken by superiors or subordinates to check on work done supporting QS services. This is because superiors or subordinates needs to understand on how decision or conclusions were made. With big data, estimating process time can be reduced up to 60% whereby, QS professionals in Public Works Department Malaysia can now generate estimate within 1 to 2 days with big data initiative.

Similar to findings on visualization, analysis on 'automation' codes were discussed by respondents which are more familiar with big data and statistics with better technology knowledge. Respondent Q, H and J describes big data as an intelligent and self-regulating system. Findings further indicates a correlation on 'automation' codes to 'BIM' codes whereby, respondents suggest on BIM maximization allows automated data sourcing for big data initiatives. From a second point of view, this implies BIM as a foundational pursuance prior to big data. Besides the understanding of automated data sourcing, respondent Q and H gives emphasis towards the overall big data context; advanced big data initiative founded by system intelligence through the application of advance statistical based technology increases the insights value in terms of accuracy, reliability. For instance, both respondents described Machine Learning and Artificial Intelligence as forms of advanced statistical based technology allowing the system to self-regulate and improve its intelligence capacity. Respondent H explicitly described that the accuracy and reliability of insights generation of any big data initiative depends on the quality, accuracy and reliability of data supporting big data analysis process. Data supporting big data analysis are known as factors or variable which are adjusted by QS professionals during data analysis process to reflect project or client's needs. To achieve such quality, accuracy and reliability of data supporting big data analysis, constant updates were needed to ensure data capture are robust and are the true industry reflection.

All other respondents however, highlighted on the paucity on current big data pursuance. Current big data pursuance such as Construction Cost Modelling, Tender Price Index and Life Cycle Costing were not planned with the application of advanced statistical technology except for PCE-PREMO. Artificial intelligence adopted in PCE-PREMO allows this system to access large data from different system, changing the analytical computation structure of origin system to cater towards analysis needs in PCE-PREMO. For instance, change of concrete price is PCE-PREMO is dependent on the price fluctuation of sand, crusher run and cement. Should QS professional changes the quantity of concrete needed in PCE-PREMO by 10%, data is automatically linked to another system which will compute cost difference based on the suitable mixing constant incorporating price fluctuation of sand, crusher run and cement. This form of extensive and large data analysis requires advanced statistical technology adaptation such as artificial intelligence. However, in relation to current big data initiative pursuance, none of the big data initiative mentioned embodies automated self-regulating and intelligent system properties. This implies an adaptation paucity on advanced statistical technology of big data. With big data, maintenance of big data initiative does not require technical experts as systems are governed automatically.

Findings indicate understanding on productivity value to QS professionals entails further clarity on data driven decision making context, whereby, analogical understanding on data driven decision making core process instigate understanding on productivity value. Hence, productivity can be understood from the understanding of improvement on work process, specifically on time context. Despite issues on technological paucity limiting the capability of QS profession to maximize productivity value on work process, respondent's perspective which recognized the potential of BIM and advanced statistical technology implementation to improve productivity big data value reflects towards positive big data growth for QS profession in the near future.

4.4   Data commercialisation

Further analysis based on the understanding of data silo, confidentiality

and accessibility issue as well as non-data sharing culture. Discussion convolutes towards the value of big data facilitating prompt and easy alternative for QS profession to access data. From business context, respondents view these issues as gaps to be addressed. These gaps were also specifically mentioned by respondent M and C. Hence, adjourn to the understanding of data demand from QS profession. Data coded with 'Data commercialization' further relate to interpretation of data embodies competitive value in the construction industry. Based upon respondent's perspective, this implies that the value of big data for QS profession can be seen from opportunity of data commercialization.

Findings based upon respondent J, Q, G, K and F excerpt indicates data as a valuable commodity where big data offers technological capability to maximize the value of data while allows QS professionals to acquire construction data through subscription basis. Data commercialization through subscription basis allows QS profession to found new revenue stream. From business perspective, this indicates big data pave QS profession new business opportunity.

5. Discussion

This study reported in this paper emphasize on the importance of understanding the value of big data from QS professional context and what it means in relation to the generic big data value addressed by other profession. Understanding big data value from both generic and specific context is believed to allow comprehensive big data understanding for audience, especially, quantity surveyors. This discussion is founded based on comparison analysis between findings on objective 1 and objective 2 allowing critical context integration from both theoretical and industry stand. Besides addressing towards completing the final stage of framework analysis this discussion moderate on internal validity and reliability on the research finding. Table 1 adopts findings on big data opportunities addressed in Table 2 with findings from respondent's perspective described. In general, comparison analysis shows theoretical and industry perspective are found to be consistently addressing similar context. However, transforming or revolutionizing big data value yet to be addressed from the QS professional perspective.

Analysis indicates process improvement big data value from theoretical perspective correlates towards comprehensive insights, data driven decision making and productivity big data value from the QS profession perspective. Correlation between process improvement and comprehensive insights value can be understood from the context of equipping professionals with capability to handle large data from various format and sources with emphasis of standardization throughout big

Table 2 Comparison analysis on big data value

Big Data Value	Service Area	Findings
Process improvement	Self-service data retrieval	Comprehensive Insights
	Predicting risk management	Productivity
	Managerial accounting	
	Patient-disease profiling	Data Driven Decision Making
	Healthcare standardization	
	Firm management efficiency	
	Strategize case handling	
Creating better services	Case handling and firm management	Data Driven Decision Making
	Ubiquitous healthcare	
	Personalized healthcare	
	Client-lawyer relationship	
Transforming/ revolutionizing profession	Integrated and standardized reporting	Not addressed
	Live auditing	
	Proactive healthcare	
New opportunities creation	Data value validation	Data Commercialization
	New data source integration	

data process. With big data, medical professionals now handle large and various form of patient and clinical data facilitated by standardized medical system across organizations. Groves et al., (2013a), Knowledgent (2014) and Murdoch & Detsky (2013) indicates that these form of capability increases the quality of treatment delivered by doctors. As for QS professionals, big data eradicates issues relating to data access, confidentiality and non-data sharing through centralization access of construction data sourced from multiple perspective. Data such as Bill of Quantities can be sourced from both contractor and consultants allowing QS professional to grasp decisions based upon multi-perspective interpretation. Extending to this, big data allows accountants to promptly spot generalized pattern, trends as well as overall picture on financial status (Cao et al., 2015; Chan, 2003; Mittermayer, 2004; Warren et al., 2015) while industry findings indicates QS profession easy access to genuine data from multiple perspective through data centralization.

Comparison analysis in Table 2 indicates data driven decision making value from industry perspective consistently address similar context towards process improvement and creating better services of the theoretical stand. Interrelation of context between data driven decision making and process improvement can be seen from Cao, Chychyla, & Stewart (2015) and Warren et al, (2015) Groves, Kayyali, Knott, & Van Kuiken (2013), discussion on predicting risk management, strategize case handling and patient disease profiling services areas. With big data, accountant and medical professionals confers towards more accurate prediction on financial management and trading risks as well as better forecast on patient's treatment success risks. This is because big data skew professionals toward decision making based upon vast information access. Not only that, their decisions are based upon risks and opportunities that are analytically founded, enabling them to increase clarity in predicting the results output as well as increasing decision making quality through accuracy and reliability. In terms of creating better services big data value from theoretical perspective, context of similarity can better be addressed through Chawla & Davis (2013), IBM (2012, 2013b), Knowledgent (2014), Manyika et al, (2011), Murdoch & Detsky (2013), Savage (2012) and Zenger (2012) discussion on personalized healthcare. Authors discussed on big data facilitating doctors with detail diagnosis on patient and carefully suggest forms of treatments based on patient's biological needs. From the QS profession context, similar context was addressed through the discussion of variable significance in data driven decision making section which allows QS professionals to offer more accurate and reliable advice to clients.

Thirdly, big data help professionals to improve work productivity. Hathaway (2014) and Vasarhelyi et al., (2015) mentioned on self-service data retrieval. She described the usage of modern technology such as RFID for accountant to automatically manage inventory. However, from the QS perspective, the same is understood from the context of QS professional's ability to instantly access data and manage data analysis on a single platform, resulting 60%-time improvement on work process. Both processes describe on the value of productivity through big data whereby, professionals can eradicate repetitive of duplication of work as well as strategically improve and shorten overall work process. Nonetheless, discussion on productivity are commonly entangled with elements of automation while from the QS perspective, automation discussion scope is addressed as part of data driven decision making context. However, this does not convolute towards understanding bias but the opposite, it clarifies the context of productivity in relation to profession's progress in big data pursuance. Perhaps, accounting profession is much more advanced in terms of big data pursuance whereby accountants adopt and assimilate modern

technology as part of their work process chain, enabling larger work scope area to be automatically replaced hence, greater output value in terms of productivity.

Next, findings reflect that big data value is not limited towards better understanding on work context, transparency and analytical analysis on decision making, but expands towards creating alternative in boosting professional's value; financially. Theoretical findings indicate that professionals commonly generate value strictly towards traditional services such as book keeping on financial management or treating patient. However, with big data, accountant and doctors can expand towards new revenue generation stream. Association of Chartered Certified Accountants (2013) and Dynamic Markets (2012) discussed on the advancement of big data adaptation in the financial sector allow accountants to grow towards new service such as data valuation; ciphering data monetary worth. Medical profession seen to share their data to pharmaceutical companies to allow faster and effective drugs development and diagnosis (Raghupathi & Raghupathi, 2014). In similar, findings in section 4 indicates the potential of construction data commercialization for QS profession, not only geared towards improving overall QS professionalism service credibility but, adding towards new revenue steam.

Finally, no correlation was made to transforming or revolutionizing big data value from the theoretical stand as findings from transcribed indicates none of the respondents mentioned or described this context. However, this conjures towards issues highlighted by respondents in productivity section. While discussion indicates that some interviewees have deep understanding on big data by postulating the possibility of BIM connection and adaptation of advanced statistical technology to improve the productivity value, research position on technology paucity is further clarified through this discussion. Discussion on auditing and proactive healthcare indicates that professionals require maximization of modern technology as part of big data pursuance. Both cases show that optimum value of big data can be achieved when both parties; insights from big data champion (initiator) and big data users collide. For instance, live auditing and proactive healthcare is founded upon big data system which understand user's data pattern. Anthology of user data will then be further analysed with current real-time user data using advanced algorithm to generate valuable insights. In short, it can also be deduced that new data stream such as user's data allows transformation or revolutionizing big data value.

This research further agrees with Ahmed et al (2017), Chen, Lu, & Liao (2017) and Singh (2017) connoting big data research in construction industry is at infancy. Extending to this, the infancy stage of big data leads towards limitation of QS professional's pursuance on big data. Nonetheless, this does not mean that there is minimal capability for QS professionals to maximize big data. Instead, this indicates that progressive call towards modern technology implementation and understanding of big data is critical for QS profession to move forward with big data. Hence, this section expands the context of understanding big data value specifically from QS profession point of view. Analysis posit consistent big data value across professions despite differences in context on how value is derived. This is because context or service area depend upon professional's work sector. The findings further adjourn towards big data as a universal form of technology (Manyika et al., 2011) and maximization of big data value owed to professional's capability and strategic pursuance.

6. Conclusion

This paper aims to expand big data knowledge from the context of QS profession. Rapid pursuance on big data research across industry and

professional sectors creates a gap to delineate big data from QS profession perspective. The criticality of this study is further emphasized by the modern technology wave uptake in the construction industry which results towards change in data landscape. This calls for professionals, especially QS profession to be equipped with capabilities to reap the advantage of this technological wave. Big data is here and not something of the future thus QS profession must be prepared.

Findings of this research indicates four generic big data value across professions. Those are process improvement, creating better services, transforming or revolutionizing profession and new opportunities creation. Data based on 15 interviews with QS profession big data experts reveals generic big data values were addressed in similar context despite differences in the way big data values were described and established. Specific big data values such as comprehensive big data insights, data driven decision making, productivity improvement and data commercialization opportunity correlates towards the generic findings except for transforming or revolutionizing profession. In relation to previous research, this research believes that the paucity is reasoned to the infancy stage of big data adaptation in the construction industry.

Most importantly, findings indicate that the specific big data value recognized are related towards improving current services offered by QS professionals. This can be clearly seen through discussion on big data value in presented in the foregoing section. Each big data value is discussed concurrently or emerged in relation to embodied issues in the construction industry. From a second point of view, big data is seen to soothe or offer alternative to limitations faced by QS professional in delivering paramount service to client. This infer that each specific big data value is targeted towards managing QS professional's core service hence, strategic positioning for this profession to capitalize big data. Despite rests upon infancy stage, should big data continuously embrace by QS profession, this profession is geared with impetuous leap in advancing big data.

This study has shown that big data is relatable and can be further maximized by QS professionals. However, with an eye moving forward with big data, future research should address the potential areas of big data application in QS profession context. In relation to the above, development of big data in the construction industry context, specifically adaptation on modern technology in construction value chain is deemed to furnish synergistic impact on QS profession big data maximization. It is also critical to note that the application of five analysis stages of framework analysis facilitate data coding process in the sense that it gives a structure to enable concurrent weaving of generic big data value based on theoretical point of view and data gathered from the respondents. Other than that, framework analysis method helps to provide transparency in qualitative analysis.

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