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Factors, Nature and Impacts of Slum Dwellers Residential Mobility within the Dhaka City

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ABSTRACT

The pattern of residential mobility varies throughout the world. Slum populations consistently report higher rates of residential mobility than other populations. However, the pattern and the consequences of residential mobility of the slum dwellers are not well studied. Dhaka, the Capital of Bangladesh, has a large population, more than 14 million of which about 1.06 million live in slums with an increase of 60.73 percent in the last 17 years. The objectives of this study are: (1) to identify the significant factors of residential mobility of slum dwellers; and (2) to examine the patterns of residential mobility of slum dwellers in three slums area located in Dhaka. This study further analyzed the impacts of residential mobility on the socio-economic aspect of the slum dwellers. For this research purpose, 267 households from three slums of Dhaka namely Kallyanpur slum, Agargaon slum, and Karwan Bazar railgate slum were selected through non-probability convenience sampling and interviewed. This study found that residential mobility was influenced by factors which are related to life cycle; employment, income and distress; land tenure and homeownership; neighbourhood condition and grouping issues. Among all the studied variables the most five significant factors influencing residential mobility are slum eviction, unavailability of utility services, marriage, changing job and getting homeownership status. It is revealed that the nature of the residential mobility for the surveyed slum dwellers is mainly negative and it poses a significant impact on the socio-economic aspects of life. The findings of the study pave the way to recommend specific measures for the slum dwellers to improve their condition by lessening the negative impacts of residential mobility.

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1. Introduction

Residential mobility is an important personal and societal issue having immense influence on urban planning. The micro approach of movement of households within urban area, defined as residential mobility or intra urban migration, is predominant form of movement in the developed world (Cadwallader, 1992 and Short, 1978). Furthermore, these less dramatic short-distance moves take place within a local housing market (Hedman, 2011) which are deeply intertwined with social relations, socio-economic positions and patterns of daily activities. It is argued that patterns of residential mobility have the power to substantially change the population composition of neighborhoods and potentially also other neighborhood attributes (Hedman, 2011).

Mobility patterns are generally the result of conscious decisions - people choose in which neighborhood to live, even if there are differences in ability to choose. Consequently, in order to understand flows of people between neighborhoods, it is necessary to comprehend the factors that influence households to move (or stay) and that affect their choices of destination neighborhoods. Many pushes and pull factors impinge on a household's decision to relocate and influence the move's timing and location (Fattah, *et. al.*, 2015; Ozo, 1986).

The life-course perspective provides one of the important theoretical frameworks to explain residential mobility as one of the many related aspects of human development. From this point of view, moving or staying is related to life events such as marriage or divorce; birth of children; children leaving home or attending college; change of employer, income, or assets; and retirement. Several studies have found that these life events are potential triggers of mobility (Clark, 2005; Clark and Withers, 1999; Long, 1991). These events can result in dissatisfaction with the current house, such as when a growing family needs more space, or may change the household's aspirations, such as when a better job leads to increased status expectations (Sanga, 2015). Furthermore, homeownership or residential stability may become more or less salient at particular stages of life, such as marriage, birth of a child, or retirement. These life events tend to be correlated with demographic characteristics, such as age, gender, race or ethnicity, socioeconomic status, and so forth, and these characteristics are also associated with the probability of residential mobility. Although residential mobility can be a path to greater opportunity and satisfaction, concern exists that many low-income families move not to better their circumstances but due to unstable housing arrangements and that such moves may have negative consequences. Some studies suggest that frequent moving during childhood undermines educational attainment (Wood *et. al.*, 1993), but other studies have found little or no effect after other risk factors are taken into account (Murphey *et. al.*, 2012). Nevertheless, relocating may disrupt social ties and undermine a family's social capital (Briggs, 1997), and it has a particularly disruptive effect on children when parents provide only modest emotional support and involvement (Hagan, *et. al.,* 1996; Morris, *et. al.*, 2018).

Slum populations consistently report higher rates of residential mobility than other populations (Coulton *et. al.*, 2009; Phinney, 2013; Warner, 2016). While it is clear that low-income families move frequently, it is less clear whether residential mobility represents a positive or negative transition for most poor families. Residential mobility can reflect improvements in a family's circumstances, such as buying a home for the first time, moving to be close to a new job, or trading up to a better-quality housing unit or neighborhood. It can also be a symptom of instability and insecurity, with many low-income households making short distance moves because of problems with landlords, creditors, or housing conditions (Lall *et. al.*, 2006). Similarly, staying in place sometimes reflects a family's security, satisfaction, and stability with its home and neighborhood surroundings, but in other cases it may reflect that a family lacks the resources to move to better housing or to a preferred neighborhood (Gramlich, *et. al.*, 1992; South, *et. al.*, 2005). Therefore, it is important to know what the actual reasons of mobility of low-income people are. Residential mobility has both positive and negative impacts on the family members which depends on push or pull factors acting behind the mobility (Murphey, *et. al.,* 2012).

Dhaka, the Capital of Bangladesh, is the most densely populated city in the world (Satu and Chiu, 2017). Being the center of all economic, educational and administrative activities and due to the lack of decentralization policy, people from the whole country tend to migrate to Dhaka. Therefore, many of the immigrants initially concentrate in slums of Dhaka due to low skill, poverty and limited alternatives. According to the latest census, third of its kind in the country on slum dwellers and floating population conducted by the Bangladesh Bureau of Statistics (BBS) in 2014, 2.23 million people live in slums across the country while 1.06 million people live in slums in Dhaka division (BBS, 2014). The poor environmental condition and lack of infrastructures pose negative impacts on the physical and psychological well-being of urban slum dwellers. According to the Habitat for Humanity (2016) slums are defined by overcrowded, unsafe and unhealthy homes with limited or no access to basic services namely water, toilets, electricity, transportation. Such homes are unstable and lack secured land tenure. In the context of Bangladesh, slums are defined as settlements with a minimum of 10 households or a mess unit with a minimum of 25 members and predominantly very poor housing lacking security of tenure with poor environmental services especially water and sanitation. It typically possesses extremely high population density and room crowding where dwellers deprive socio-economic status (Centre for Urban Studies, 2005). The Centre for Urban Studies estimated that the total population of Dhaka's slums was more than doubled between 1996 and 2005, from 1.5 to 3.4 million people (BBS, 1999). The number of people living in slum in Dhaka city is increasing day by day. In last 17 years the number of slum population in Dhaka has increased 60.73%. According to Centre for Urban Studies (1995), a slum may be defined as "a building, group of buildings or area characterized by overcrowding, deterioration, unsanitary conditions or absence of facilities or amenities which, because of these conditions or any of them, endanger the health, safety or moral of its inhabitants or community".

It is evident from the definition of slum that slum dwellers lead a deplorable life. Therefore, it is important to investigate the factors and impacts of residential mobility which is yet to be explored. This research is a pioneering one in the context of Bangladesh and in addition significant one in the context of international literature to develop and share the knowledge on residential mobility of the slum dwellers. This research aims to identify the important factors responsible for residential mobility, the nature of such factors and the impact of mobility on the socio-economic aspects of the slum dwellers. Following this introductory part, the next section depicts the methodology. Later the findings are discussed in brief which is followed by recommendations and conclusion.

2. Methodology

This paper aims to identify the significant factors and nature of residential mobility of slum dwellers of Dhaka. Further, the impact of residential mobility on their socio-economic life has been also investigated. After consulting the relevant literature, important variables are selected for investigating the residential mobility pattern. Table 1 presents the selected variables for analyzing the factors and nature of residential mobility and the consequent impact on the socio-economic aspect of life

Table 1 Variables Considered for Analyzing Residential Mobility

Target	Variables
Factors of residential mobility of slum dwellers	Factors related to life-cycle o Marriage o Birth of children o Domestic violence
	Factors related to employment, income and distress o Movement for job o Home rent
	Factors related to land tenure and home ownership o Home ownership o Slum eviction
	Factors related to neighborhood condition o Utility services o Violence with neighbors o Concern about children o Social safety
	Factors related to grouping o Religion based groups o District of origin
Nature of residential mobility	o Change in job o Change in family income o Change in the availability of utility services o Change in the home ownership status o Change in safety of the movers' family members o Change in social clashes
Socio-economic impact for residential mobility	o Living cost o Neighborhood involvement o Acceptance as community member o Education of children o Balance in income and expenditure

Source: Authors, 2017

Three considerably old public slums at varying locations are chosen for investigation. These are Kallyanpur slum, Agargaon slum, and Karwan Bazar railgate slum. Table 2 presents the basic information about these slums.

Table 2 Area and Population Profile of Study Slums

Location	Kallyanpur Slum	Agargaon Slum	Karwan Bazar Railgate Slum
Physical Area(in 2012)	4.1 ha	1.6 ha	2.0 ha
Land Ownership	House Building Research Institute (HBRI)	Government	Government
Population (in 2014)	8129	1727	2385
Household (in 2014)	2184	487	643

Source: Center for Urban Studies (CUS), 2012; Bangladesh Bureau of Statistics, 2014

This study follows mixed method approach including both qualitative and quantitative analysis. The data for analyzing the condition of considered factors were collected from primary sources through questionnaire interview of the slum dwellers. A semi-structured questionnaire was prepared for conducting survey. This questionnaire is divided into four parts with questions

of the following areas- questions related to socio-demographic information, questions related to factors influencing the slum residents to move or stay, questions related to satisfaction of movers and stayers to identify positive and negative moves; and questions for identifying socio-economic effects on the neighborhood, movers and stayers due to the residential mobility of slum dwellers. The total households of the three case study slums is 3314. At 90% confidence level with 5% confidence interval, the required sample size is 249. However, for this study total 267 household units from three slums (Table 3) were selected for the questionnaire interview which is a representative sample. These samples were selected through non-probability convenience sampling. The adult persons (aged above 21 years) of the households present during the survey were the representatives of the questionnaire interview. The collected data were analyzed through descriptive statistical analysis after processing.

Table3 Sample Size from Three Case Study Slums

Slum Name	Sampling Size
Kallyanpur slum	163
Agargaon slum	23
Karwan Bazar railgate slum	81
Total	267 249 is the required sample size)

3. Result and Discussion

3.1 Socio-Demographic Information of the Respondents

The family size influences the slum dwellers to move their residence in another place or slum where they accommodate comfortably with affordability. Therefore, family size is an important factor which influences residential mobility of slum dwellers. As presented in Table 4, survey data revealed that the maximum family size was 7 with the minimum family size of 2. It is further found that in each household the average number of contributors in family income was 2. The slum dwellers struggle for their survival as their earning is very small. They are involved in many types of work such as day laborers, rickshaw/van pullers, shopkeepers, garment workers, housemaid etc. The average monthly family income was about 7000 BDT (USD 84), where the maximum family income was 16000 BDT (USD 192) and the minimum monthly income was 2000 BDT (USD 24).

Table 4 Socio-Demographic Information of the Respondents

Socio-Demographic Character	Maximum	Minimum	Average
Family size	7	2	5
Contributor to family	4	1	2
Monthly income	16,000 BDT (USD 192)	2,000 BDT (USD 24)	7,000 BDT (USD 84)

Source: Field survey, 2017 * 1 Bangladeshi Taka (BDT)= 0.012 USD

3.2 Mobility Rate of the Slum People

The respondents reported frequent rate of residential mobility. Three families out of every four reported that they had changed their residence several times. As shown in Table 5, most of the movers (81%) were the owners of their house in the previous slum while 19% of movers were renters in their previous dwellings. Although most of them had their own houses in the previous place, they moved on to another place to live because of various reasons such as slum eviction, for better job purposes etc. Data shown in Table 5 had also indicated that about 42% and 29% of the respondents reported residential mobility more than 5 and 10 times respectively. Majority of the movers (57%) moved their residence from one slum to another while rest of them (43%) moved within the same slum.

Table 5 Respondent's Mobility Rate

Respondent's Mobility Rate		Previous Dwelling of Movers		Trend of the Residential Mobility (in last 10-20 years)			Nature of the Residential Movement	
Movers	Non-Movers	Owner	Renter	<5 times	5-10 times	>10 times	Within same slum	From another slum
76%	24%	81%	19%	29%	42%	29%	43%	57%

Source: Field survey, 2017

Table 6 presents that among the three case study slums, Kallyanpur slum shows highest rate (90%) of residential mobility among its dwellers followed by Agargaon slum (72%) and Kawran Bazar railgate slum (48%).

Table 6 Comparison of Residential Mobility Rate among the Slums

Slum area	Kallyanpur Slum	Karwan Bazar Railgate Slum	Agargaon Slum
Number of the sample households	163	81	23
Movers percentage	90%	48%	72%

Source: Field survey, 2017

3.3 Factors of Residential Mobility of Slum Dwellers

In this section the factors that greatly influence the slum dwellers to take their decisions regarding residential mobility are identified. The important factors identified and discussed are related to: (1) Life cycle; (2) Employment, income and distress; (3) Land tenure and home ownership; (4) Neighborhood conditions and (5) Groupings.

3.3.1 Factors Related to Life Cycle

Marriage, birth of children, domestic violence etc. are most of the significant factors of life cycle events. As Figure 1 presents, according to the survey, marriage is found as a moderately significant factor affecting residential mobility. 18% of respondents found marriage as one of the determining factors which justified the decision to move into a new place. Birth of children was found as a less dominant factor in slum residential mobility which influenced 7% of the respondents. A new place with better environment than the current one for the newborn is the main motivation for such residential move. In the slums, domestic violence also leads to break down of the family which sometimes results in residential move. About 2% of the respondents reported residential mobility on this ground.

3.3.2 Factors Related to Employment, Income and Distress

The factors related to employment, income and distress influence the movers among the slum dwellers to a great extent. It includes those factors like movement for job and difficulty in paying home rent. About 16% of the respondents reported that the distance of the working place from their living place was the main reason for their residential mobility. Housing rent is considered as one of the important factors of residential mobility. Some respondents marked it as a major factor to residential mobility. Only 19% of the total respondents from all three slums were renters (refer to Table 5). However, Figure 1 presents that 16% and 8% of the respondents identified job and housing rent respectively as the main reason of their move.

3.3.3 Factors Related to Land Tenure and Home Ownership

Land tenure and home ownership are playing significant role in the movement of slum dwellers. In Dhaka, slums are located on lands owned by the government, semi-government organizations and individuals which lead to eviction. Generally, whenever a slum is evicted, the dwellers shift their residence to a nearby slum or take shelter temporarily with their relatives. According to the survey, 65% of the respondents identified slum eviction as the cause of their residential mobility. Other than land tenure, about 19% of the respondents who were renters in the previous slum reported that they consider home ownership as one of the major reasons for residential mobility.

3.3.4 Factors Related to Neighborhood Conditions

There are several factors such as unavailability of utility services, violence with neighbors, welfare of the children and safety; which are related to neighborhood conditions and significantly influence the residential mobility of the slum dwellers. The unavailability or poor quality of utility services makes the living condition of the slum unhygienic and leads to the spread of diseases resulting in poor health. The survey data revealed that 34% of the movers changed their residences due to unavailability of the utility services. Other than poor utility service, 9% and 5% of the movers identified safety and violence respectively as their major reasons of residential mobility. Only 2% of the respondents moved from their earlier residences for the welfare of the children.

3.3.5 Factors Related to Groupings

Religion based groups and the district of origin of the slum dwellers are considered under the factors related to groupings affecting residential mobility. Muslims and Hindus are the main religious community living together in the slums. Only 1% of the respondents reported that they shifted their residences due to religious clash among the neighbors. Bangladesh is characterized by regional imbalance and skewed urbanization pattern which lead to migration of the unskilled people in the sums of primate

city, Dhaka. However, in the slums people who originate from the same district tend to group together. These groups are sometimes involved in serious conflicts which influenced weaker and vulnerable segment of the people to move out from the slums. About 8% of the movers reported that they shifted from the previous slums due to the conflict that arose from the district groups.

Figure 1 presents the overall factors affecting the residential mobility according to the surveyed respondents. The main reason for residential mobility was slum eviction (65%), followed by unavailability of utility services (33%) and marriage (18%). Factors related to safety on the other hand, such as domestic violence (2%) and religious conflict (1%) are shown least concerning from the survey.

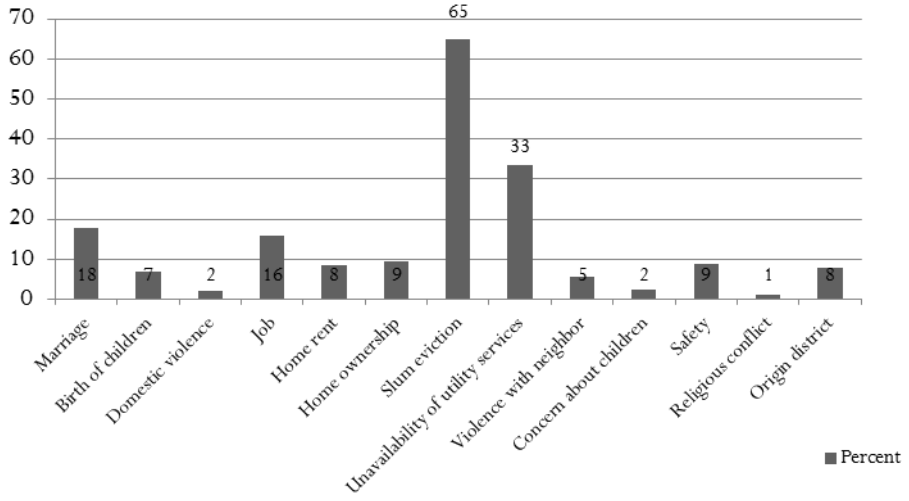

Figure 1 Factors Affecting the Residential Mobility of Slum Dwellers
Source: Research data, 2017

3.4 Nature of Residential Mobility of Slum Dwellers

The nature of residential mobility, whether imposing positive or negative impacts on the slum dwellers is investigated and discussed in this section. The common factors as identified in the earlier parts are examined in detail to evaluate the impacts of residential mobility.

3.4.1 Change in Job of the Movers

According to survey findings, the maximum number of movers (38%) was in the same job while 26%, 22% and 14% of the movers consecutively got better job, worse job and became jobless. Here the option "unchanged" in job does not show the positivity or negativity of the nature of residential mobility. The options worse job and jobless are considered as negative residential mobility and the option, getting better job is considered as a positive impact. Therefore, according to the survey data, change in job of movers that is 36% of mobility is negative in nature and 26% is positive in nature.

3.4.2 Change in Family Income of the Movers

In this research, the increased family income of the households due to residential shift is considered as positive mobility impact while the decreased mobility as the impact of negative mobility. The survey findings revealed that among the 203 movers; 30%, 35% and 35% of the respondents' family income respectively increased, decreased and remained unchanged. The families whose incomes remain unchanged after the residential mobility are not considered for any type of mobility impact. Therefore, according to the change in the family income of the movers, 35% of the mobility is negative and 30% of the mobility is positive in nature.

3.4.3 Change in the Availability of Utility Services

For investigating the nature of the residential mobility, the increase in availability of utility services due to shift in residence is considered as positive mobility while the decrease in availability of utility services is considered as negative mobility. No change in the availability of utility services defines none of

the above. The utility services of 33% of the movers are increased when they changed their residence. Only 6% of the respondents' utility services decreased after changing the residence. The utility service of 61% of the movers remained unchanged. Therefore, according to the change in the availability of utility services, the residential mobility of about 33% of slum dwellers is positive and of 6% of slum dwellers are negative.

3.4.4 Change in the Home Ownership Status

During analysis, the mobility in which the movers became homeowner from renter is considered as positive mobility impact while the mobility in which the movers became renter from owner is considered as negative impact. The survey data revealed that the status of the home ownership of 54% of the movers remained unchanged. Only 9% of the movers became homeowner from renter and 37% of the movers became renter from homeowner. Therefore, 9% of the respondents had positive impact of residential mobility while 37% of them had negative impact.

3.4.5 Change in Safety of the Movers' Family Members

When the safety is increased as the decision of residential mobility, it is considered as the positive impact while the decreased safety is considered as negative impact. According to the survey findings, 26% of the respondents reported that the safety of their family members increased due to residential mobility while 21% of the respondents reported negatively. The safety of 53% of the respondents remained same as before. Thus, it can be opined that 26% of the respondents faced positive impact while 21% of them realized negative impact because of their residential mobility.

3.4.6 Change in Social Clashes

Increase in social clash or clash with neighbors is regarded as the negative impacts of residential mobility while the decrease in such activities as the positive impact. According to the survey data, 36% of the respondents reported that the social clash is increased while 26% respondents reported decreased social clashes after their shift of the residences. Therefore, 36% of the residential mobility of the slum dwellers presents negativity and 26% of the mobility of slum dwellers presents positivity.

3.4.7 Comparison among the Variables of Nature of Residential Mobility

Among the six variables for assessing the nature and impact of residential mobility on slum dwellers (refer 3.4.1 to 3.4.6) only two presents positive impacts while the other four variables present negative impacts. Figure 2 presents that the change in the utility services and the change in the safety feelings of the family members are the two variables which showed positive impact. The change in job, change in family income, change in home ownership status and change in social clashes are the four variables which reported more negative impacts than positive ones. Therefore, the survey findings revealed that due to the residential mobility of slum dwellers the average family income and home ownership status lowered, social clashes increased and the number of people with inferior or without job increased.

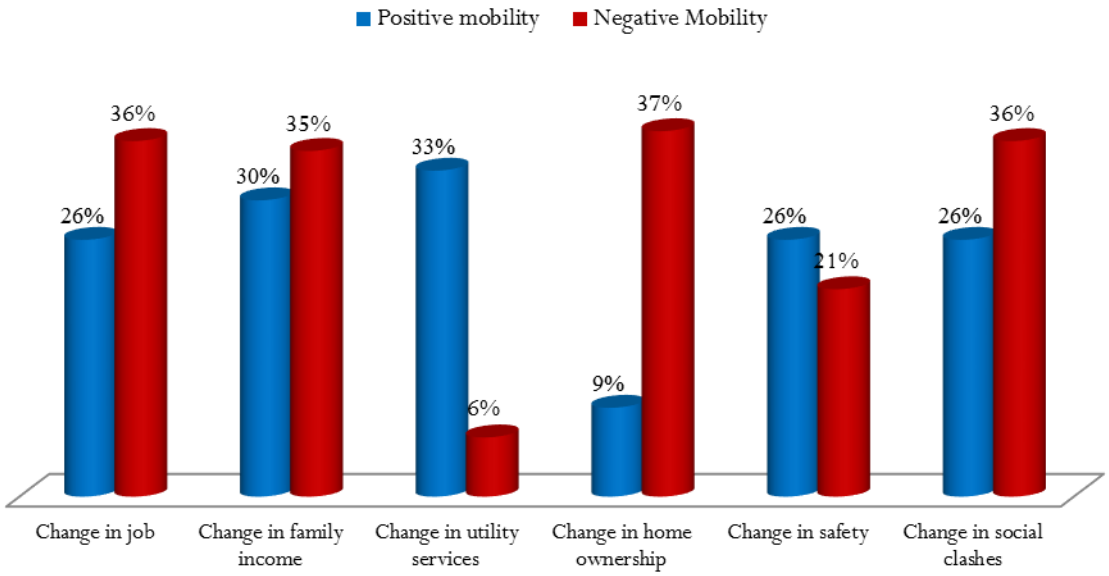

Figure 2 Nature and Impact of Residential Mobility of Slum Dwellers
Source: Research data, 2017

3.4.8 Overall Satisfaction of the Movers with Current Residence

Even after the shifting of the residences for several times, 60% of the respondents reported that they were dissatisfied with their current residence while 40% reported that they were satisfied. However, most of the dissatisfied respondents (71%) answered negatively about their willingness of further shifting of the residences.

3.5 Socio-Economic Impact of Residential Mobility on Slum Dwellers

The socio-economic impact of residential mobility on the slum dwellers has been assessed through investigating these five variables: the living cost, neighborhood involvement, acceptance as community member, education of the children and balance between income and expenditure. Due to residential mobility, the living cost of majority of the movers was increased. According to the survey findings, living cost of 58% of the movers increased, that of 16% movers decreased and for 26% of the movers living cost remained unchanged due to residential mobility. In most of the cases it was difficult for the respondents to get involved with the members at the new slums after their initial shift. More than 90% of the movers admitted that they were hesitant to talk with the new neighbors after their shift to a new slum but gradually the neighborliness developed. To become a member of the new community after the residential mobility is tough and requires more time. This is also the case for the slum dwellers. Most of the movers (91%) responded that it was very difficult for them to become a part of the new slum while 9% of the movers found it easy to become the community member of the new slum. Sometimes the education of the children of the moving families is disturbed and even stopped forever due to the residential mobility. Lack of formal educational institutions for the low-income people is also one of the reasons for that incidence. The survey data revealed that the education of the children of 67% of the family was disturbed due to the residential mobility. It is of utmost importance to justify the residential mobility in terms of income and expenditure to realize its impact on the socio-economic aspects of the slum dwellers. Since most of the slum dwellers are rickshaw pullers, day laborer, housemaids whose income level and savings are small, it requires a big amount of money for them for shifting to a new place. Furthermore, being involved in the informal employment, the residential mobility has both negative and positive impact on getting new income opportunities. About 67% of the movers reported that the expenditure increased for them than the income which made the balance in income and expenditure decreasing. For 33% of the respondents the balance in income and expenditure increased. Overall, enormous impacts on the social-economic aspects of the slum dwellers are observed.

This study investigates the factors of residential mobility of the slum dwellers and reveals that the nature of the residential mobility for the surveyed slum dwellers is mainly negative and it poses significant impact on the socio-economic aspects of life. The findings of the study pave the way to recommend specific measures for the slum dwellers to improve their condition by lessening the negative impacts of residential mobility. To analyze the significance of the factors on residential mobility of the slum dwellers, five types of factors and the related variables are scrutinized. The factors are related to life cycle; employment, income and distress; land tenure and home ownership; neighborhood condition and grouping issues. Among all the studied variables the most five significant factors influencing residential mobility are slum eviction, unavailability of utility services, marriage, changing job and getting home ownership status.

After examining the nature of residential mobility through selected six variables namely change in job, change in income, change in utility services, change in home ownership, change in safety and change in social clashes; it is revealed that because of the residential mobility of slum dwellers the average family income and home ownership status decreased, social clashes increased and number of people with worse job increased. The impact of residential mobility on the socio-economic life of the slum dwellers are assessed through five variables namely living cost of the movers, neighborhood involvement, being the community member, education of the children and balance in income and expenditure of the movers. The study uncovers that due to the residential mobility the living cost is increased imposing decrease in the balance between income and expenditure; creates complicacy in involving the movers with the community which eventually pose barrier for majority of the movers to be community members. Sometimes it also hinders the education of the children. In fact, overall socio-economic life is influenced by residential mobility of the slum dwellers.

4. Recommendations and Conclusion

The study reveals that most of the slum dwellers must move due to slum eviction and this type of mobility influences the homeownership status and convert the slum dwellers from owners to renters. This also poses negative impact on the socio-economic aspects of the dwellers and the education of their children. Therefore, as Ozo's (1986) had suggested, decision makers should consider about the rehabilitation of slum dwellers before any slum eviction takes place. Since unavailability of the utility facilities is another major reason of residential mobility, it should be of utmost importance to provide the basic utility facilities to the slums at minimum cost. As suggested by Zanganeh et. al. (2016), the government should work hand in hand with the non-government organizations (NGO) in this regard. Likewise, Lall et. al. (2006) and Sanga (2015) had opined that NGOs should also take initiatives for the provision of income generating activities and poverty alleviation programs to the poor and unskilled slum dwellers. This vulnerable section of the society should be allocated interest free loans for self-employment. Formal and informal education programs and vocational trainings targeting the children as well as the adult illiterate people should be arranged for person enrichment which is also inline with the suggestion made by Ersing et. al. (2009). There should be free supply of textbooks, uniform, stationery items and various scholarships for attracting the

children and their parents. Further, there should be initiatives for night schools for old people of the slum.

The slum dwellers are mostly migrants who work as day laborers and live very deplorable life. Due to the high cost of city life and higher rentals, they tend to live in slums in congested environments and move to new slums for life cycle events, better employment opportunities, changing home ownership status and better neighborhood condition. However, this residential mobility is not positive always, rather in most of the cases the residential mobility is negative in nature and imposes great toll on socio-economic aspects of their life. The government should take effective initiatives so that the negative impacts of residential mobility are reduced. Further studies can be conducted to investigate in detail the socio-economic impact by such residential mobility on the overall slum neighborhood.

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Probing Phenomenological Experiences Through Electroencephalography Brainwave Signals In Neuroarchitecture Study

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ABSTRACT

Experiences are a part of our daily lives through our interactions with the environment around us. We live life through the realm of experiences, be it playing or working. As we encounter phenomena frequently, it is deduced that most of it comes from within the built environment, considering how most of our time is spent indoors. Hence, it is imperative that we understand the impact of the built environment on human physiology especially within the context of religious spaces which is largely attributed to phenomenological experiences. Despite the importance of understanding the impact of the built environment on human physiology, phenomenological studies that addresses this relationship are still lacking. This presents a gap which necessitates evidence to be provided in the form of phenomenological studies. Hence, this study attempts to address the gap by utilising evidential data with the utilisation of the portable electroencephalography (EEG) device. In doing so, the brainwave readings from four participants at the Tuanku Mizan Zainal Abidin Mosque were observed. Data from the EEG device in the form of brainwave signals was analysed through the performance metrics detection suite which focused on the possibility of analysing brainwave data through three phases of habitation. The findings detected relaxation performance metrics from the participants whilst being within the mosque prayer area, whereas the phases prior to entering and after leaving the mosque appears to have detected higher excitement and engagement levels. Thus, it could be deduced that the interior prayer area of the mosque appears to have had a positive influence on the participant's physiology. This study could contribute to the novel field of neuroarchitecture in Malaysia, an area of study at the threshold of neuroscience and architecture that could be significant in understanding the relationship between the built environment and human physiology.

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1. Introduction

Experiences are a part of our daily lives. We live life through the realm of experiences, be it eating, speaking, playing or working. According to Edmund Husserl, a German philosopher who founded the philosophy of phenomenology; 'to live is to experience' (Bailey, 2013). Experience forms the basis of our conscious understanding of the world through sensory interactions. As stated by Pallasmaa (2009), human beings are connected to the world through their sensory stimuli which are not merely passive receptors but rather conscious modes of

storing and structuring knowledge. Through direct interaction with the world, human beings were able to learn from their environment and study their experiences as a part of the formation of their knowledge. This is further elucidated by Pallasmaa (2014):

"The new sciences of bio-psychology and ecological psychology actually study such evolutionary causalities in human instinctual behaviour and cognition. It is evident that we are genetically and culturally conditioned to seek or avoid certain types of situations or atmospheres. Our shared pleasure in being in the shadow of large trees looking onto a sun-lit open field, for instance, is explained on the basis of such evolutionary programming – this specific type of setting demonstrates the polar notions of 'refuge' and 'prospect', which have been applied to explain the pleasurable pre-reflective feel of Frank Lloyd Wright's houses, for instance" (Juhani Pallasmaa, 2014).

This method of studying experiences is called phenomenology. According to Bailey (2013), phenomenology is understood "as the careful description of experiences in the manner in which they are experienced by the subject, proposes to study, in Husserl' s words, the whole of our 'life of consciousness'. In the Stanford Encyclopedia of Philosophy, phenomenology is defined as the "study of structures of consciousness as experienced from the first-person point of view"(Smith, 2013). As we encounter phenomena frequently, it is deduced that a majority of it comes from our interactions within the built environment, considering how most of our time are spent indoors. According to Seamon (2017) "on average in the Western world, people spend nine-tenths of their lives inside buildings; about two-thirds of that indoor time is spent at home". Bearing in mind the amount of time we spend indoors, it is imperative that we think about the impact that architecture has on our physical health as well as psyche; and the possibilities that could emerge from understanding our patterns of behaviour and the reasoning behind it.

In Holl's (1996) Intertwining book, he states that "architecture can shape a lived and sensed intertwining of space and time; it can change the way we live. Phenomenology concerns the study of essences; architecture has the potential to put essences back into existence. By weaving form, space and light, architecture can elevate the experience of daily life through the various phenomena that emerge from specific sites, programs, and architectures." By inducing various phenomena into architecture, an architect could improve the occupants wellbeing or elevate their sensory perception. Tadao Ando discussed his experience of sound phenomena within architecture, stating that architectural space becomes a phenomenon that we not only take in visually but through our senses and whole bodies as well. Ando discusses his experience in the interior of the Pantheon where a procession came in and sang a hymn. Ando remarked that it was the sound of space that affected him strongly (Shirazi, 2012).

However, despite all the potential of positives that could emerge from the application of phenomenology into architecture, it is still not a strongly observed, analysed or theorized method in the context of architecture (Juhani Pallasmaa, 2014). There is a difficulty in situating phenomenology amongst other schools of thought in architecture, mostly owing to its unique position of subjectivity. Many scholars on the other hand, from both architecture and other disciplines, believes that phenomenology is intersubjective . They believe that the aspect of shared understanding is possible and not wholly subjective as claimed by some theorists (Wang, 2013). Hence, it can be concurred that more architects may consider using phenomenological methods if its results can be substantiated.

This raises the possibility of using cross-disciplinary tools to measure phenomenology as an outcome. There is current research done in architecture in relation to clinical tools such as brainwave (EEG), heart rate (HR) and blood pressure (BP) equipments. The ongoing cross research between medicine, neuroscience and architecture is promising and holds opportunities for architecture as a discipline. As Pallasmaa; et al. (2013) states, "I believe that neuroscience can give support to the mental objectives of design and arts, which are in danger of being disregarded because of their "uselessness" and apparent subjectivity."

Thus, what if the interchange between neuroscience and architecture could help us document and interpret the brain activity of people within a specific location? Would this type of mapping and recording open up the possibilities of documenting and analysing architecture from the perspective of human experience? Within the context of Malaysia, there is a collation of opportunities for the study of phenomena in Malaysian architecture.

In Malaysia, the majority of the population are Malay Muslims and the established religion of the state is Islam (Embong, 2002). In accordance to the religious beliefs of a Muslim and their day to day lives, the mosque plays a central part of a Muslim's life. A mosque is seen not only as a place to pray but also to conduct multipurpose activities for the community of Muslims (Baharudin & Ismail, 2014). With so many possibilities of a mosque's function, there has been numerous reports and suggestions that mosques positively impact the feelings and behaviour of its occupants. According to Ardhiati (2013), "when a person enters a mosque he or she would have left the hustle and bustle of the material world and retreated into a calm shelter or sanctuary." The mosque is therefore also seen as an experiential phenomena of calmness wherein the stresses of the world are left behind and one enters a calmer state of mind.

Therefore, this study investigates the possibilities of clinical analysis in relation to phenomenological experiences in Malaysian mosques with the intention of substantiating evidence of phenomenological experiences.

Does an occupant's state of mind truly change when they enter a mosque? How does one know this? Are the experiences positive or negative? Which mosques contributes to a positive experience,

and which ones less so? How does one prove this? The focus of the study is divided into two parts. The first delves into the attributes of phenomenology, its meaning, relationship to architecture, its relationship to human wellbeing. The second looks into the correlation between architectural phenomenology and human physiological, physical and mental responses in the context of the mosques which forms an integral part of the life of a Muslim. Within 1 pre-selected mosque, all EEG recordings are recorded inside the environment in real-time using the participants brain electrical activity readings through a EMOTIV brainwave equipment, as well as qualitative processes within a limited time frame. The relationship between brain activity in relation to the interior of a mosque is analysed and mapped to gain a better understanding of the experiences one encounters within it. Four (4) participants brain activity are analysed. Through a mapping of the data, we will seek to uncover the relationship between interior parameters of a mosque and its connection to their brain activity. The cross intersection between the disciplines of neuroscience and architecture is also reflected upon.

2. Context

"While the brain controls our behaviour and genes control the blueprint for the design and structure of the brain, the environment can modulate the function of genes and, ultimately, the structure of our brain, and therefore they change our behaviour. In planning the environments in which we live, architectural design changes our brain and behaviour". – Fred Gage, Adler Professor in the Laboratory of Genetics at Salk Institute (Pallasmaa; et al., 2013)

As one can summate from the paragraph above, architectural design has the capacity to change one's behaviour thereby modulating our brain reactions. According to Juhani Pallasmaa (2005) "architecture initiates, directs and organises behaviour and movement". Pallasmaa also goes on to state that architecture enforces the existential experience, one's experience of being in the world through not only vision but all the five (5) classical senses. These five (5) senses involve several layers of sensory experience which cohesively comes together and interacts to form a multisensory experience. Though the vision may be seen as the dominant sensory stimuli in our experiences, it is in actual reality a cohesive unit of sensorial experience. However, does architecture really have the ability to influence a person's feelings or behaviour?

In a study done by Shariff and Najafi (2011), five (5) state mosques were chosen as a part of a study looking into factors influencing public attachment to mosques in Malaysia. These five (5) mosques were the National Mosque, Negeri Sembilan Mosque, The Federal Territory Mosque, Putra Mosque as well as the Al-Azim Mosque. In all selected mosques, participants "experienced feelings of peacefulness, safety, refreshing, relaxation, spiritual, tranquillity, comfort, calmness, presence of God, and worship." As such, it can be seen that architecture does have an influence on human behaviour and feelings, with the participants reporting feelings of calmness and tranquillity for all five (5) mosques.

However, as gathered from the mentioned study, a gap of existing literature exists wherein no substantiated evidence was offered. A participant may express their feelings but there is no process in which a validation of qualitative comments could occur. This is seen in most research approaches in relation to phenomenology as elements of biasedness may occur in regards to a participant's feedback. Most research approaches towards the study of phenomena in general employs the qualitative approach such as surveys, interviews, questionnaire which is deemed to be subjective in nature and lacks a definitive evidence to substantiate the claims of its participants.

Furthermore, there still remains criticism against the methodologies of the architects, in part owing to its apparent subjectivity. Without evidence, there is no proof to back up an architect's claims. However, an emerging field of cross disciplinary research between neuroscience and architecture offers hope that criticisms against a lack of evidence could finally be subjugated. At the helm of this cross disciplinary research is ANFA which stands for Academy of Neuroscience for Architecture. In 2003, ANFA was formed by John P. Eberhard, who is the founding president of the Academy of Neuroscience for Architecture and the fellow of the American Institute of Architects and his collaborators to address this growing body of research in relation to human responses within the built environment. ANFA's purpose was anchored to a frustration with a lack of evidence based design (Taylor-Hochberg, 2016).

It was found that many researchers rely on social sciences and economic research that are too subjective in nature, whereas neuroscience was found to offer solid evidence in comparison. Jessica Pykett, a researcher at the University of Birmingham in the School of Geography, Earth and Environmental Sciences, cited in Karandinou and Turner (2017); adds on that neuroarchitecture (fusion of the word neuroscience and architecture) can be seen as a resolution for sceptics who sees flaws in an architect's qualitative as well as intuitive methodologies. Thus, what is neuroscience?

Edelstein and Macagno (2012) explains that "neuroscience encompasses a range of disciplines that study the multiple functions of our brains, and how these functions change from birth to death and are affected by disease. Our brains survey our environments through multiple sensory organs, and generate appropriate behaviors, conscious and unconscious. Neuroscientific research reveals how dynamic and plastic our brains are, and informs us about how different our capacities to respond to our environments are as children and as adults, and how exposure to environmental conditions influence such capacities." Here it is important to emphasize that the brain scans the environment through our senses and generates behaviours accordingly in response to the environmental stimuli. The most appropriate method for examining behaviour would be to understand the neural mechanisms that selectively filters external information, generates and produces behavioural tendencies (Taylor-Hochberg, 2016). Studies has been conducted in this cross disciplinary research field to investigate such possibilities.

In 2017, a study was done by Banaei et al. (2017) through VR simulated interior rooms to understand the impact of interior forms on the human brain. On the overall, it was found that the participants recorded a strong impact on their brain dynamics when they were exposed to rooms with more curvature

geometries. Hence it can be deduced that neuroscience has the potential to uncover the relationship between the built environment and our brain's neural responses.

Thus, the relationship between neuroscience and architecture is a highly promising fusion, as it enables an evidence-based approach towards the design of the built environment. Though the exact features that would be necessary to design a building in relation to neuroscience has not been spelt out, architects can certainly design buildings with features that promotes wellbeing through neuroscience data (Dance, 2017).

Nonetheless there are criticisms of the integration between neuroscience and architecture. Dan Montello, a geographer and environmental psychologist at the University of California, cited in Taylor-Hochberg (2016) claims that his concern is with the overestimation of the benefits of neuroscience which will instead be used to channel the designer's attention from an empathy based process to a quantitative based process instead. It has also been pointed out that neuroscience could be used for the betterment or quite the opposite in relation to the built environment. Rather than the promotion of wellbeing, it could end up merely being used as an excitement ploy by artists (Mehaffy & Salingaros, 2018).

Despite the reservations, as an emerging cross disciplinary field, it is expected that there will be hesitations as to the appropriateness of the medium in relation to the discipline. With more extensive research being done in this area, perhaps more architects will open up to the possibilities that neuroarchitecture offers.

3. Methodology of Neuro-Architecture Research

With the emerging possibilities of cross-disciplinary research, architects and neuroscientists alike has lent their voice to support the integration of these two (2) disciplines. The advocates for this integration claim that the fusion of these two (2) disciplines will help architecture and the field of neuroscience move forward. However, it is important to note that these two (2) bodies of disciplines are quite different from one another especially in the context of research methodology. In architectural research, the architect has relied more on observation and intuition whereas in neuroscience, the focus has been on experimentation and proof (Sternberg & Wilson, 2006). In studying a phenomena, an architect would usually observe the patterns of human behaviour, study physical settings and intuitively synthesize a solution, immersing themselves in a situation or experience to gain an insight into the encounters that the built environment delivers. As defined by the Stanford Encyclopedia of Philosophy, phenomenology is the "study of structures of consciousness as experienced from the first-person point of view" (Smith, 2013). This varies substantially from the methodology employed by neuroscientists which seeks an evidence-based approach.

A neuroscientist would follow a predetermined path of research, gathering quantitative data and then validating it, either proving or disapproving the experiment's hypothesis.

As such, the phenomenological (interpretive science) approach used by architects differs from the method used by neuroscientists due to different schools of scientific thought employed. Neuroscientists follow a logical positivism approach, in which data and facts takes precedence over intuition. According to Amaratunga et al. (2002) "logical positivism uses quantitative and experimental methods to test hypothetical-deductive generalisations". Positivism seeks fundamental laws and causal explanations, and reduces the whole to simplest elements in order to generate analysis. It is also based conceptually on social structure and social facts, with quantitative and hypothesis tests being used. On the other hand, the phenomenological approach uses naturalistic and qualitative approaches to comprehend human experience holistically. It is based on social construction and meaning, with qualitative and hypothesis generation being its cornerstone (Amaratunga et al., 2002).

According to Papale et al. (2016), both schools of scientific approaches are equally needed to validate one another. "Many socially relevant research questions could be explored by neuroscience and architecture in synergy. Whereas currently the outcomes of this dialogue and contamination between architecture and neuroscience are hardly predictable, we believe in the paramount importance of sharing knowledge among disciplines" (Papale et al., 2016). Hence, the triangulation methodology was employed for the purposes of this research. "Triangulation is the combination of methodologies in the study of the same phenomenon" (Amaratunga et al., 2002). The essence of triangulation lies in its effectiveness to counter-balance the weakness of each methodology and is seen as an effectual research approach which combines both qualitative and quantitative methodologies in approaching a phenomena. Thus, an interdisciplinary synergy was deemed most appropriate for this research with a combination of quantitative (neuroscience data) and qualitative (interview) methodology being used to gain further clarity into the phenomena.

As for the building typology, a space of worship was chosen. In a study conducted on places to pause and be introspective, participants identified places of worship (Shah, 2009). Therefore, in Malaysia, as Muslims make up the majority of the population and Islam being the established religion of the state (Embong, 2002), the mosque was chosen as the most appropriate typology of worship spaces. In relation to the historical nuances of Malaysia and feedback of visitors to mosques, the Iron Mosque of Putrajaya was seen as the most appropriate mosque for the experiment to be done as it has recorded numerous feedbacks online about the calmness it exudes to its visitors (Saya, 2018) (Noorashani, 2018).

For this study, only a single case study of the mosque was employed. This is because single case studies are proven to be better models to test new theories (Gaya, 2016). The study is also not comparing sets of mosques but rather looking into a single mosque to understand the specific physiological changes of the participants. This is also corroborated by Yin, cited in Gustafsson (2017) who states that if a researcher is only focused on a single group of people, then the single case study would be the best method as it is not a comparative study.

For this experiment, four (4) participants from the Built Environment discipline were chosen. The students from this discipline was chosen because it has been proven that education can affect the impact of a person's experience. In one fMRI (functional magnetic resonance imaging) study, Wiesmann and

Ishai, cited in Coburn et al. (2017) found that architecture students employed different cortical areas when viewing buildings as compared to students from different disciplines. Architects also seemingly employ activation of the hippocampus region and precuneus when viewing buildings as compared to faces, which demonstrates that their education memories had a contribution to their affective responses.

All chosen participants were Muslims as it was necessary to enter the prayer space to experience the interior context fully. On the duration, the rationale behind the fifteen (15) minutes was to record three (3) separate phases of five (5) minutes each. The three (3) separate phases of habitation were outside of the prayer space, in the prayer space and outside of the prayer space again. This was necessary in order to understand the reaction of the brainwaves before entering a mosque prayer area, whilst being in it, and after departing it.

Through phenomenological literature contexts, the act of sitting has appeared in various phenomenological discussions. According to a study conducted by Shah (2009), "sitting is the activity which most of the participants have described while narrating their contemplative experiences – whether this be sitting on a bench in a park, or church, sitting on the floor while praying, or sitting in a tree for fun. It appears that the activity of sitting provides a ground or basis for moving to another dimension of experiencing." In another two (2) studies, it was found that the assessment of phenomenological experience could be reliably tested through sitting quietly and keeping the eyes open or closed (Pekala et al., 1986). For Elbow (1989), the act of sitting on the floor achieved an altered feeling of phenomena. As Elbow described, "I remember sometimes sitting on the floor-I'm not sure why, but probably as a kind of bodily acting out of my sense of desperation. I could type fast and I learned that I could just let myself flow into words with a kind of intensity." It can be surmised that the act of sitting quietly with the eyes open or closed could bring about a contemplative experience for a person, which in turn leads to experiential phenomenology.

The participants were advised to avoid sudden movements and to abstain from the act of prayer as movements could affect the accuracy of data readings. This is because any activity of any kind would result in biased consciousness which would display inaccurate readings (L Singer et al., 1981). The EEG readings were measured during non-prayer times as it was imperative to avoid any sensory interferences which could result in biased readings as the focus of this study is to understand the relationship between the mosque's-built environment and the participants physiological responses. All participants have not experienced this mosque before and are visiting for the first time.

In deciding the appropriate amount of time for a baseline EEG reading to be stabilized, though the current range to achieve baseline conditioning varies, a figure of four (4) minutes was deduced. According to L Singer et al. (1981), a time period of four (4) minutes is enough for any stable and intransient properties of consciousness to be assessed without disrupting one's stream of consciousness and remembering the experience would not be difficult. In another study, a psygram depicted the pattern of the act of sitting quietly with eyes closed for fifteen (15) minutes (Rock & Kambouropoulos, 2007). However, since this experiment is related to the context of the built environment, a visual stimulus of the built environment is needed to correspond to the brain signals therefore the act of sitting quietly for fifteen (15) minutes in total with the eyes open was deemed the most suitable position as shown in Figure 1.

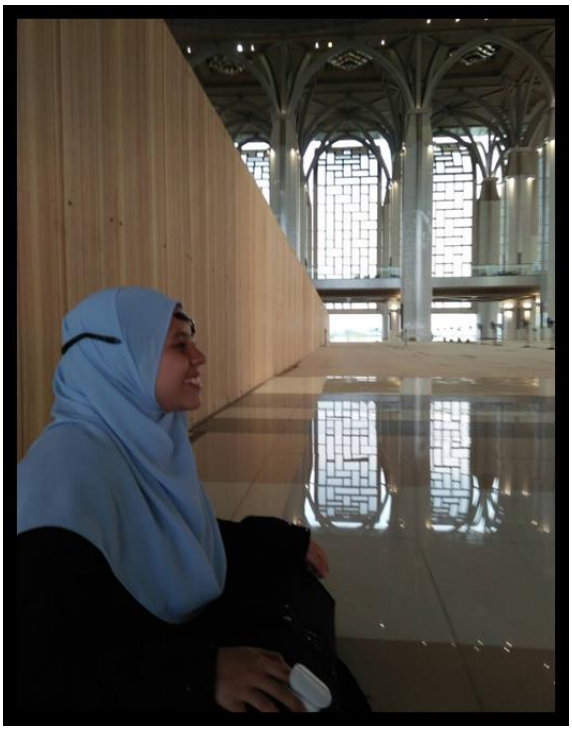

Figure 1 Participant's Sitting Position

The device used to measure the brainwave signals is an Emotiv Insight 5 Channel Mobile EEG Device, as shown in Figure 2. The device has a high accuracy range with an over 85% accuracy range for Excitement and over 70% for Interest. However it must be noted that the accuracy of emotions varies across individuals as not every individual has the same limits for certain emotions, therefore EMOTIV calculates the dominant performance metric of the motion out of a 0-100% range which is divided into excitement, engagement, relaxation, interest, stress and focus on the MyEmotiv application (Emotiv, 2019). Engagement is a mixture of attention and concentration, focus is the measurement of one's fixed attention on a task, interest is the degree of attraction or aversion, relaxation is the ability to rest and recover or 'switch off', excitement is the level of mental arousal, whereas stress is the measurement of the level of comfort one has with a particular task (Emotiv, 2012). This device would enable the justification of the objective of study which is to study physiological differences of a person's brainwave signals in response to the built environment, which in this study is the Iron Mosque in Putrajaya.

Figure 2 EMOTIV Insight 5 Channel Device

Using the MyEmotiv application, the participants will have their device calibrated between 1-2 minutes however this time period will differ according to each participant's sensor contact with the scalp (Emotiv, 2018). After the calibration period, the participants physiological responses will be recorded through screenshots taken at three (3) intervals using the MyEmotiv application which detects their Mental Performance Metrics.

It is postulated that in this study, participants may display higher relaxation metrics whilst being in the mosque prayer area, whereas prior to and after leaving the mosque, it is expected that the participants will record higher engagement or excitement metrics.

The participants were briefly interviewed the day after to garner their qualitative feedback. This was important as the what the participants felt could be cross validated to the data. Through an analysis of the brainwave signals performance metrics, are there any patterns that can be deduced from it? Is there a correlation between the brainwave signals and the participants qualitative feedback? These questions can be seen as stages of a scientific process; as the testing of a new theoretical methodology in relation to neuroarchitecture. The observation and recording of the participants' brain activity may reveal patterns as to their brain wave performance metrics, such as engagement, excitement, stress, focus or relaxation. The findings may potentially lead to observations which will inform the impact of the space on the participants physiology. This study has a limited number of participants but is acceptable in relation to other studies done in the field of neuroscience and architecture. This experiment is exploring the possibility of theoretical cross fertilization between neuroscience and architecture and therefore should not be used as a generalized statistical outcome. It is an exploratory study and it is the aim of this study to test the possibilities of neuroscience within architecture.

4. Principal Experiment Observations

Before delving into the experiment observations, the participants were given an alphabetical and numerical combination label in order to identify each participant. Since there are two (2) males and two (2) females, the males are labelled M1 & M2 and the females F1 & F2. All participants were given an informed consent form and hence agreed to the publishing of specific details such as gender. The following are the key findings observed throughout the experiment for each participant for the EEG performance metrics as well as the brief focus group feedback:

1st Interval

After the participants had achieved a stabilized EEG calibration, the performance metrics were then captured. In the first interval, based on the performance metrics dominant range, participants exhibited either excitement or engagement dominant frequencies as shown in Table 1. M1 recorded 74% on excitement, M2 had 82% on engagement, F1 displayed 92% on engagement and F2 recorded 73% on excitement. As previously mentioned, engagement is a mixture of conscious concentration and attention whereas excitement is the level of mental arousal. It could be deduced that all participants exhibited a conscious level of thinking and engagement with their new surroundings, and this is consequently reflected in their performance metrics. According to Patel (2015), arousal happens when the body issues chemicals into the brain that stimulates emotions and creates physical agitation in readiness for action. The dominant frequencies of the participants appear to support the premise that all participants seem to be either engaged or excited within the context of the compound of the mosque.

2nd Interval

During the second interval, another reading was taken after a stabilization of the EEG calibration on the device. It was found that all participants recorded a dominant relaxation frequency, with participant M1 recording 73%, M2 with 82% as shown in Figure 3, F1 with 83% and F2 with 80%. This appears to support the early mentioned postulation that participants may record relaxation frequencies whilst being within the prayer area of the mosque. It could be surmised that participants were feeling relaxed within the prayer area of the mosque and demonstrated physiological changes that were specific to the area of the mosque.

3rd Interval

Upon exiting the prayer area of the mosque and being seated once again at the compound of the mosque, a final reading was taken after the calibration of the device. It was found that participants returned to exhibiting either excitement or engagement frequencies. Participant M1 recorded 72% on excitement, M2 with 78% on engagement, F1 with 82% on engagement and F2 with 69% on excitement. The dominant metric points to the possibility that participants were actively engaged with their thinking processes and the environment around them thereby demonstrating these specific metrics. It appears that participants display a sense of animation upon leaving the vicinity of the mosque prayer area. It must be noted however that the frequency of engagement and excitement is lower than at the first interval, and this could be possibly attributed to the sense of relaxation experienced at the second interval and the gradual engagement with the outside world upon leaving the prayer area.

Table 1 Performance Metrics Dominant Readings at Tuanku Mizan Zainal Abidin Mosque

Participant and Dominant Performance Metrics	Before Dominant Frequency (0-100% Range)	During Dominant Frequency (0-100% Range)	After Dominant Frequency (0-100% Range)
M1	74 (Excitement)	73 (Relaxation)	72 (Excitement)
M2	82 (Engagement)	82 (Relaxation)	78 (Engagement)
F1	92 (Engagement)	83 (Relaxation)	82 (Engagement)
F2	**73 (Excitement)**	**80 (Relaxation)**	**69 (Excitement)**

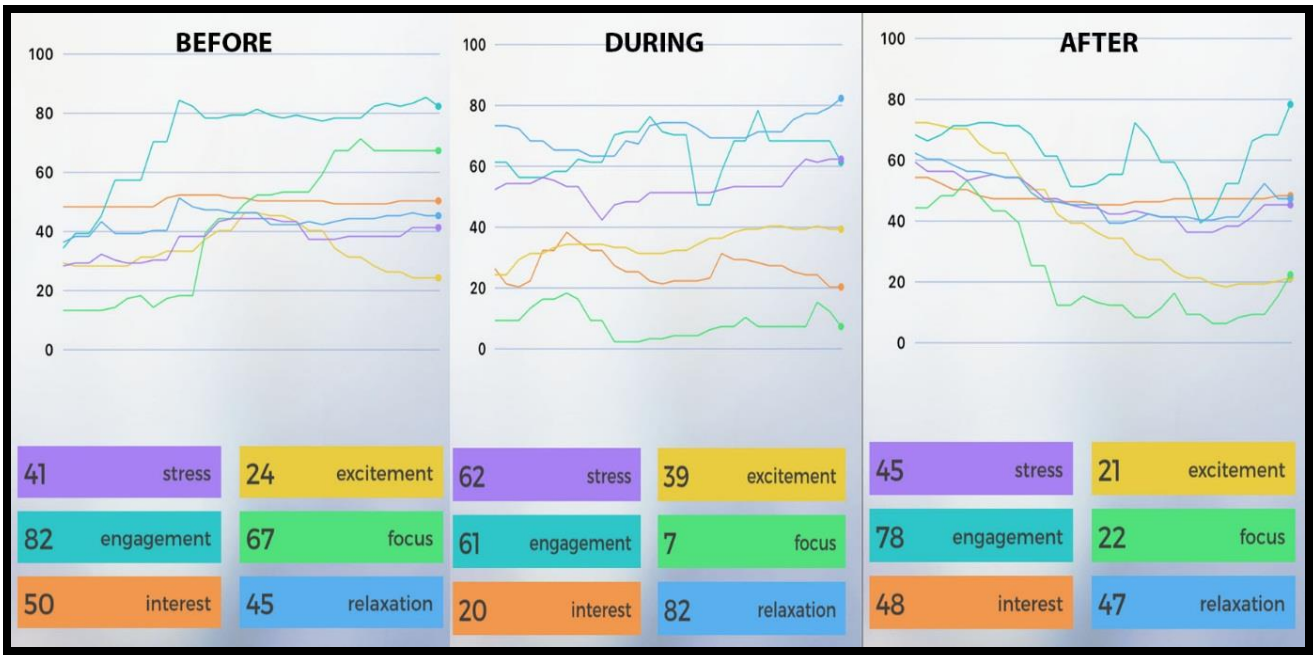

Figure 3 Participant M2's Brainwave Performance Metrics

Experiment Summary & Feedback

We observed some principally similar themes that emerged from this experiment.

Before entering the mosque prayer area and after leaving it, all participants recorded excitement or engagement performance metrics which is associated to active thinking processes and mental arousal. Whilst being in the mosque area, all participants recorded relaxation performance metrics which is related to aspects of rest and recovery. This is corroborated by Aoun (2016) in a study done using a portable EEG headset to measure the impact of architectural elements on emotions. It was found that architectural elements did trigger emotions and provoked feelings of engagement, emotion and relaxation amongst others. Thus, it can be determined that the participants were reacting in relation to the environment around them across all three intervals. It appears that the mosque prayer area was the context that impacted them most positively as it brought about a sense of relaxation.

Mosque Prayer Area (2nd Interval)

All participants expressed their affinity towards the design of the interior of the mosque. They identified words such as joy, serenity, surprise and amazement as the notable feelings they felt within the interior. All participants agreed that scale was an important factor in the feeling. They also observed that the aspect of nature was involved in the design of the mosque and that it had a positive reaction on them.

M1 remarked that the high ceiling of the mosque gave him a feeling that he was small, and God was big. He also remarked that he felt calm. M1 also felt that the multiple smaller entrances which were small revealed a delightful surprise of the sudden disclosure of the heightened scale of the mosque. M2 verbally identified the views from the mosque looking outwards towards the water feature had a calming effect.

He also commented that the materials on the floor felt cool to the touch, and somehow felt a correlative effect on calming himself down. F1 had similar views on the water feature which felt like it had a calming effect on the body and mind however she felt interrupted by the sudden construction noise. F2 observed that the scale of the space was big, and made her feel like her problems were small and insignificant in comparison. She mentioned that 'there were greater things out there.' F2 also pointed out that the volume of the space made her feel 'overwhelmed.'

As such, it could potentially be surmised that the interior of the mosque left a considerable impression on the participants at the 2nd interval. Being within the mosque's prayer area seems to have brought a change to the participants' EEG performance metric readings and could possibly point to the positive effect it has on the wellbeing of a Muslim. There appears to be a relationship between the performance metrics data and the qualitative feedback. Both appear to support one another in relation to the qualitative feedback of calm and the performance metric of relaxation. The possibilities of portable EEG readings in analyzing how a person may feel or respond within the context of a mosque could determine the efficiency of the design of the mosque in relation to the wellbeing of Muslims who congregates there for prayers.

Technical / Equipment Constraints

Despite spending fifteen (15) minutes per participant for the recording, the actual time to adjust the sensors and calibrate the equipment for each participant and the three (3) intervals was much longer. An approximate additional half an hour was spent calibrating each participants' sensors to achieve polymer contact with the scalp. During the recording, there were moments in which the sensors were detached and this produced 'noise' glitches on the readings. The removed noise glitches were left out so as to not influence the bearing of this experiment.

It should also be noted research has demonstrated that though one brainwave state may dominate at a specific time depending on the individual's activity, the remaining brainwave states are present at all times. Thus if a person is exhibiting a dominant brainwave, it does not mean that all other brainwave patterns cease to exist; it would still be present at a trace level whilst demonstrating the dominant frequency (Herrmann, 2019). This must be kept in mind when viewing the performance metrics.

5. Conclusions

This experiment was initiated as a point to further instigate the possibilities of neuroarchitecture and to enhance the possibilities of studying the wellbeing of occupants within the framework of architecture and neuroscience. Throughout this study, several observations were found to be supported by existing literature. This is demonstrated by the recording of engagement and excitement metrics whilst the participants were actively thinking of their surroundings and involved in cognition processes. The other observation found in this experiment relates to the recording of relaxation metrics when the participants were within the prayer area of the mosque, which demonstrated a possible relaxation phase within the interior. The participants also verbally identified words such as joy, serenity, and amazement in relation to the interior of the mosque which correlates to the collated data. Two (2) participants felt that the scale of the mosque positively overwhelmed them into contemplation and reflection. It can be surmised that specific design factors of the mosque such as scale, tactile qualities and the element of water within the mosque seems to have made an impact on the participants' emotions. It was also found that setting up the equipment and calibrating it fit each participant took much longer than expected and was challenging as there were moments during the reading when the sensors would become detached.

On another note, it is important to elucidate that the principal observations are based on a small sampling size, four (4) participants in one (1) mosque, for the purposes of testing the cross disciplinary bridge between neuroscience and architecture. It is imperative to note that this experiment was done as a theoretical study, and must not be used as a generic tool to

reach conclusions on a much larger scale representative of any population. Having said that, this experiment develops new ideas in relation to proving architectural phenomena in mosques in Malaysia and seeks to enhance this discussion on a much larger network.

It seeks to be part of an ongoing discourse on the relevance of neuroscience within architecture and the various possibilities it could propose in the context of architectural phenomenology. As it stands, there has been further excavation of this cross-disciplinary research field with well-known architects involved and therein lies potential for this body of research to be investigated further. Architectural phenomenology, for all the years it has been discussed, lectured on and debated, has not been put through rigorous scientific tests hence this is an opportunity to prove the existence of specific phenomena within the context of architecture especially within Malaysia.

With such exciting collaborations between the field of neuroscience and architecture, architectural phenomenology may yet undergo a paradigm shift of sorts, examining the link between space and brain, logic and intuition, architectural design and human emotions. This is a narrative that will bring together an alchemy of ideas and disciplines, though it may be on opposite ends of the scale, to a new frontier of phenomenological neuroarchitecture.

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Factors Impeding the Integration of Sustainability Elements in Built Environment Academic Curricula

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ABSTRACT

Development within the construction industry shows that higher education is critical in the sector's skills improvement. However, research findings are also explicit about absent and shadow integration of core sustainable construction modules for built environment's curricula. The study aimed to examine issues critical for the integration of sustainability element in the built environment curricula. It outlined two objectives which: (1) to determine the causes for the low integration of sustainability elements in academic curricula and, (2) to identify the principal factors inhibiting the integration of sustainability elements in academic curricula in Nigeria. Data for the study was obtained using a questionnaire survey administered to a random sample of 186 academic stakeholders related to schools of the built environment across Nigeria with factor analysis was subsequently employed to analyze the survey data. The results showed that seven principal factors inhibit and are responsible for the dearth of sustainable construction modules in built environment academic curricula in Nigeria. These are: (1) Skills and knowledge dearth, (2) Lack of empowerment to effect change, (3) Low level of awareness, (4) Lack of green building council, (5) Lack of real-life sustainable projects, (6) Non-prioritization by accreditation bodies and (7) Lack of research and industry collaboration. The findings suggest that strong government policy and viable industry and academic collaboration are imperative to effect curriculum change in support of the integration of sustainability element in the built environment curricula. The findings reported in this paper is significant as a basis to inaugurate the development of academic curricula which integrates the sustainability elements, capable of driving behavioural change to adapt sustainability practices among graduates.

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1. Introduction

The sustainability of the built environment hinged on the mitigation of construction impacts on the environment. Achieving this goal is also predicated on acquiring requisite skills in sustainable construction (Hayles and de la Harpe, 2010). However, sustainable construction skills set remains an area where vast deficit in learning is increasingly reported (Nduka and Ogunsami, 2015; Higham and Thomson, 2015). Despite this awareness, learning of related skills is alarming low (Tramontin and Moodley, 2016; Ekung and Odesola, 2018). Sustainability education, therefore, seeks to embed skills imperative to safe environmental practices. At the centre of this education, higher education curriculum has a pivotal role in advanced complex manpower skills development (Ferrer-Balas et al., 2008; Rieh et al., 2017).

Development of sustainability-based curriculum at higher education level began decades ago in many developed nations (Rieh et al., 2017, Mros, et al., 2018). Advocacies to replicate similar efforts in the African context also exist (Ameh et al., 2010; Tramontin and Trois, 2016), but the level of response in the built environment is low. As a result, efforts to combat climate change impact remain voluntary, and without applied consequences (RICS, 2007). Studies attribute this development to less timetable space for sustainability-related modules in schools' curriculum (Edward, 2004; Ameh et al., 2010).

Review of the literature suggested varying contextual descriptions with the term curriculum. This suggests a lack of consensus in the literature to the term though an outline of expected learning requirements, defined under a set of goal, content, objectives and pedagogy are supporting it's basic understanding (Sahlherg, 2011). The context of academic curriculum is therefore complex, and is constantly changing as a response to the dynamics of practice (Levin, 2007; McKernan, 2008). Curricula for disciplines in the built environment are also subject to changes although, the level of response to sustainability concern is laggard. But despite the slow take-off in this sector, sustainability issues have nevertheless reached deep (Abdul-Wahab et al., 2003; Gelengis and Harris, 2014; and Xia et al., 2016); and is on-going (Cruz et al., 2015). Educational programmes in this sector are also being evaluated for sustainability (Watson, 2013). However, the structure of existing curricula is fragmented along with disciplinary silos. The focus is also mainly on specific organisation/region's learning needs (Thomson and Gleeson, 2012), and selected higher education programmes (Xia et al., 2016; Opoku and Egbu, 2017). As a result, the level of students' dissatisfaction with the delivery of sustainability literacy modules is alarmingly high (Opoku and Egbu, 2017).

In Nigeria, studies that focus on curriculum change for the integration of sustainability elements are still lacking (Ameh et al., 2010; Oluwatayo et al., 2014). The consequences of these lapses include low application of sustainable construction techniques (Ali et al., 2010; Bobbo et al., 2015) and less engagement in climate change preventive practices (Saliu and Achimugu, 2016). Against the background, the study reported in this paper aims to examine issues critical for the integration of sustainability element in the built environment curricula. It outlined two objectives which: (1) to determine the causes for the low integration of sustainability elements in academic curricula and, (2) to identify the principal factors inhibiting the integration of sustainability elements in academic curricula in Nigeria. The findings reported in this paper is significant as a basis to inaugurate the development of academic curricula which integrates the sustainability elements, capable of driving behavioural change to adapt sustainability practices among graduates.

2. Literature Review

There were reports which attempted to explore the constraints to embed sustainability elements in academic curricula (Lozano, 2006; Lozano-Garcia et al. 2008). These studies adopted both linear process and smooth cumulative approach, the result obtained, therefore, focused on a single outcome. The single-outcome result was characterised by variations between undergraduate and postgraduate programmes, and between institutions. This trend is widespread and cut across studies conducted at regional level (Sherren, 2005; Iyer-Raniga and Andamon, 2013). However, the importance to integrate sustainability elements in a curriculum to improve the awareness and perception of students about sustainability issues in construction was equally reported. There were also studies which portrayed a clear lack of attention for sustainability-related issues in the academic curriculum (Amaratunga, et al. 2014). Based on the survey of Russian, Ukrainian and Byelorussian Universities; Amaratunga et al. (2014) noted that sustainability issues were considered non-essential. In a study of one Nigerian university, Allu (2016) revealed that only half of the population of graduate architecture students are knowledgeable in sustainable construction. The fundamental values, concepts, and methodologies of sustainability is therefore not widespread hence, the low level of knowledge currently bedevilling practices in the built environment sector in Nigeria and globally (Nduka and Ogunsami, 2015; Higham and Thomson, 2015). This study proposes there are fundamental constraints critical to the integration of sustainability elements in academic curricula. This baseline study, therefore, seeks to identify possible impediments to low integration with a view to direct relevant mitigation actions that will improve schools' curricula in the higher education sector.

2.1 Critical Issues in the Integration of Sustainability Elements in Built Environment Curricula

Factors influencing sustainability integration have been conceived differently, and various scholars' view is either organisational practice or context-dependent. This varying contextualisation, have led to poor communication between higher institutions and the labour market, including lack of compliance with environmental laws and regulations (Amaratunga, et al., 2014). However, key issues raised in extant literature seems to be a common denominator across all studies impliedly.

2.1.1 Designed Learning

Sterling (2004) pinpointed that designed learning that is, learning by curricula and structured pedagogy inhibits formal and informal learning. Designed learning is counterproductive to attendant learning, that is, learning with an extended community of stakeholders including senior management, academics and industry actors. Designed learning is also learners focus with limited attention to teachers' education (Altomonte, 2012; Iyer-Raniga and Andamon, 2013). Teacher continuous education is necessary because, new attitudes and skills are required to effectively understand and embed sustainability learning (Sterling and Thomas, 2006). Issues related to the inability to develop learning and lack of adaptation towards practice as focal curriculum development barriers are also common-place (Finlow, 2008). This is driven by the academic doctrine, which tends to advance research over teaching. Although teaching in higher institution underlines both responsibilities, Harvey and Kamvounias (2008) however maintained that the problem

portends a strong conflict that must be clearly resolved to improve teacher's performance.

2.1.2 Multi-disciplinary Structure of Sustainability Learning

Sustainability skills and knowledge are generic and multidisciplinary. This philosophy contradicts the disciplinary-based focus of existing built environment curricula (Jones, 2009; Badcock et al., 2010). The present disciplinary curriculum lacks innovation, and the persistent alignment to a rigid curriculum structure poses a severe challenge to sustainability-based curriculum development in higher education (Tilbury, 2004). Tilbury (2004) contested the increasing emphasis on integration and suggested that curriculum change for sustainability actually requires innovation and not integration. MacDonald (2013) is concerned about the isolated training within disciplines in the built environment. MacDonald's study noted that the level of update and capacity of educators, and the problems of interdisciplinary rivalry remains imminent threats to integration targeted in sustainability education (MacDonald, 2013).

2.1.3 Awareness, Funding, Limited Resources and Lack of Empowerment to Effect Change

Factors such as inadequate funding, poor planning, limited expertise in sustainability issues, inadequate human resources, lack of case studies, low level of awareness, and lack of technical courses that support sustainability were prominent issues to the integration of sustainability elements (Adegbile, 2012). Although Adegbile (2012) discuss obstacles to sustainable architectural education, emergent factors are can issue critical to the overall integration of sustainability in the built environment's curricula. Sinnott and Thomas (2012) also found that limited resources, low enrollment rate, and academic diversity are peculiar to curriculum changes in the built environment. Low awareness about sustainable construction issues among stakeholders in the built environment is equally a significant barrier to integration (Higham and Thomson, 2015; Nduka and Ogunsami, 2015).

2.1.4 Non-Prioritisation of Sustainability Education

Absent of motivation and non-prioritisation of sustainability content by programmes accrediting bodies also significantly inhibit sustainability integration into the academic curriculum (Altomonte et al., 2014).

2.1.5 The Barrier To Change

Lozano (2006) explored barriers to incorporation and institutionalisation of sustainability in universities. According to Lozano (2006), barriers to change exist at three levels namely: 'resistance to the notion of sustainability itself'; 'resistance involving deeper issues'; and 'deeply embedded resistance to change'. Lozano's study was not curricula focused, but the curriculum was recognised as part of the five universities' systems aligned to sustainability by the study (Lozano, 2006).

Shari and Jaafar (n.d) on the other hand surveyed educators in Malaysia and identified 109 barriers to sustainability integration grouped into eight categories. The grouping variables include educators; resource, government, students, public, subject, curriculum and monetary factors. Table 1 provides an overview of critical issues extracted from the literature. The factors are collectively and individually organised and filtered based on the sources under discussion of result as a general practice, regulatory, academic, and industry.

Table 1 Summary of Factors Influencing Sustainability Integration in Built Environment Curricula

Authors	Challenges
Shari and Jaafar (nd)	Low knowledge and exposure; non-prioritization by policy bodies; lack of practical skills at the right level; poor dialogue and coordination; lack of training & education in sustainability; restrictive structure towards innovating; crowded curriculum; lack of agencies to promote sustainability issue; lack of resources (books and the likes); lack of exemplar projects; and ignorance and negative attitude towards sustainability.
Yang and Giard (2001) & Metropolis (2002)	Complex and added skill requirements; and lack of adequate trained academic staff
Shaffi and Othman (2005)	Lack of awareness; lack of research and professional network, and skills and knowledge dearth.
Bobbo, Garba, Ali and Salisu (2015)	Incompatible teaching methods; and lack of training and theory-based curriculum
Majumdar (2009)	Inability to define sustainability skills and knowledge; inability to integrate sustainability in subject domain; and inability to define learning and teaching methodology
Lozano (2006)	Lack of information, disagreement with the idea, individual and organizational resistant to change, lack of facilities, lack of empowerment, rigid curricula, lack of interdisciplinary training in learning

The study, therefore, proposed that factors influencing sustainability integration in the built environment curricula are regulatory, industry, and academia related. The rationale is to contest whether the task of curriculum change could be more effective using 'community' of efforts. This is important to interpret learning into practice using the essentials of active engagement across organisations (Treleaven et al., 2012; Southwell et al., 2005). Lack of active engagement of stakeholders in curriculum development provides imperative to advance knowledge beyond mere information transmission towards ensuring curriculum changes.

3. Research Methodology

The study employed a cross sectional design using survey as the instrument to collect data. The study covered the six geo-political zones of Nigeria and Abuja. The study area was extended to Abuja based on the need to sample academic stakeholders in professional bodies, and universities' regulatory organisations. The sample frame comprised lecturers in twelve schools of built environment (two universities were selected from each zone), and stakeholders from the respective profession's regulatory bodies, and universities' commission.

The population of the study covers six disciplines namely: Architecture, Building Technology, Estate Management, Geo-informatics, Quantity Surveying and Urban and Regional Planning. A preliminary investigation conducted revealed the total population of 346. The population was subjected to sample size determination using Taro Yamane formula, where the sample size of 186 was obtained. However, 250 questionnaires were administered to curb non-response bias. The administration of the questionnaire involved largely face-to-face administration and email. The data from the survey was developed into a database management system using Statistical Package for Social Science (SPSS) and analysed using the relative important index, and factor analysis. The reliability of the measurement constructs (factors), was also determined using Cronbach Alpha. The value (0.86) was obtained for the 28 factors generated from the literature. This value indicates a high level of consistency and is within the acceptable threshold of 'good' reliability (Meyers et al., 2006).
Factor analysis (FA) has been recognised as a successful tool for dimensional reduction and classification by detecting relationships among variables, and can also integrate a large number of observed variables into a few common latent factors (Babatunde and Perera, 2017). The use of FA in this study is consistently based on the spread of these factors across literature, and the need to compress them into principal components. The spread of the adopted measurement variables (factors) in the literature was captured in Table 1.

4. Data Analysis and Findings

4.1 Response Rate and Profile

The study retrieved 206 questionnaires but only 106 valid responses were analysed, and this is equivalent to a 43% response rate. The Sample consists of Senior Lecturers (45%), Readers and Professors (15%) and Lecturers (40%). The quantity surveying profession constitutes about 22% of the study population, estate management (20%), Architecture (15%), Geo-informatics (10%), Building (15%) and Urban and Regional Planning (18%). The average years of experience of respondents are twelve years. Thirty-six percent have participated in curriculum review and programme accreditation in the last five years. Ninety percent of the respective programmes of the respondent disciplines have been reviewed in the last five years. However, the focus of the review was not on sustainability, but mainly to integrate disciplinary modules based on professional/universities' commission requirements, industry demand/changing dynamics of practice, and for general courses. The distribution of respondents shows a fair representation of programmes in the School of Built Environment.

4.2 Descriptive Importance of Factors Critical to Sustainability Integration

Figure 2 presents the descriptive perception of the respondents about the Twenty-Eight factors explored in the survey. Based on the disconnect between respondents' perception and actual practice (Leireiger, 2015); the study further validated the dimension of the actual implication of each factors using group survey. The overall Relative Important Index (RII) weaned towards zero and none of the factors was rated above average. The only factor that achieved an approximated average rating (0.50) is non-prioritisation of sustainability by accreditation bodies. Based on the developing characteristics, the study explores using data reduction tool, the principal components.

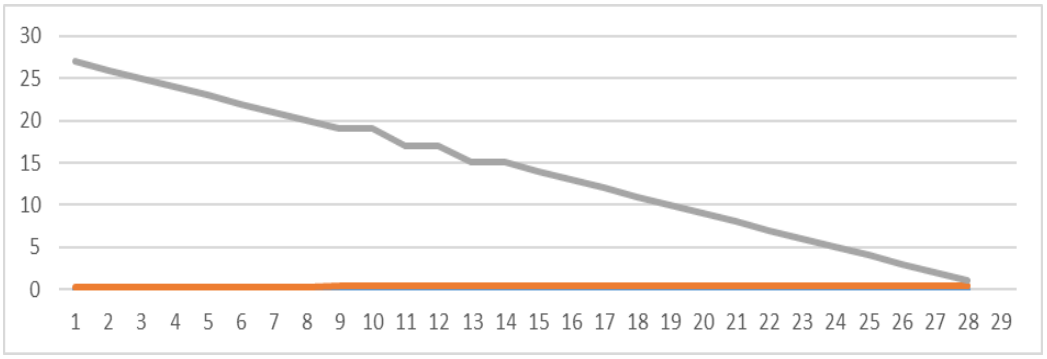
4.3 Internal Validity and Significance of Correlation

The preliminary factor analysis evaluated the extent and pattern of relationships. To achieve this, Field (2005) significance of the correlation matrix for values greater than 0.05, and the correlation coefficient for values greater than 0.9 was used. However, due to the complexity of the correlation matrix, the determinant of the matrix was used (Field, 2005; Ledesma and Valero-Mora, 2007; Hayes & Lamb, 2012). The Determinant is 1.441E-016 (0.0001441). This value is significantly greater than the necessary value of 0.00001 (Field, 2005). The result, therefore, means absent of multicollinearity in the data set. Multicollinearity explains the presence of a highly correlated factor ($R > 0.8$) (Field, 2005); and data without this threat reflects that data collection instrument was appropriate. This analysis further provides the second reliability to Cronbach tests earlier presented above. The relevant factors influencing sustainability integration are related and correlates fairly well.

The study also evaluated sampling adequacy using Kaiser-Mayer-Olkin (KMO) and Bartlett's test of sphericity. The appropriate sample has KMO value greater than 0.5 (Field, 2005), but the study yielded KMO value ($0.791 > 0.50$) and this is close to One. KMO value close to One indicates that the order of correlations is relatively compact, and dimension reduction will generate reliable factors. Field (2005) considered KMO values between 0.7 and

0.8, fairly good. Bartlett's test, on the other hand, indicates that the samples are related.

Kaiser-Mayer-Olkin (KMO) was conducted to determine whether the correlation matrix is not an identity matrix. Based on data in Table 2, the null hypothesis (that is, the correlation matrix is not an identity matrix) is rejected ($0.000 < p = 0.05$); and the inference is that the correlation matrix (R-matrix) is not an identity matrix but have some relationship between variables. The Bartlett test is therefore highly significant.



Designed learning (learning by rigid curricula and pedagogy)	14	Skills and knowledge dearth.	28
Lack of adequately trained capacity academic staff	13	Inadequate resources and planning	27
Lack of adaptation towards practice	12	Limited expertise in sustainability issues	26
Emphasis on research over teaching	11	Lack of case studies and exemplar projects	25
Isolated training among discipline	10	Low level of awareness	24
Inadequate skilled human resources	9	Poor dialogue and coordination	23
Academic diversity (culture, economic; language)	8	Lack of training & education in sustainability	22
Crowded and theory-based curriculum	7	Lack of agencies to promote sustainability issue	21
Incompatible teaching methods	6	Lack of innovation	20
Inability to integrate sustainability in subject domain	5	Lack of information lack of facilities	19
Inability to define learning and teaching methodology	4	Individual and organizational resistant to change,	18
Lack of empowerment	3	Lack of compliance to environmental laws and regulations	17
Inability to developed learning	2	lack of research and professional network,	16
Non-prioritization of sustainability by accreditation bodies	1	Bridge in communication between higher institutions and labour market	15

Figure 1 Relative Important Index of Factors

Table 2 KMO and Bartlett's Test of Identity Matrix

Tests		**Values**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.791
Bartlett's Test of Sphericity	Approx. Chi-Square	1562.381
	Df	378
	Sig.	0.000

4.4 Exploratory Factor Analysis

The exploratory factor analysis generated seven principal components. The initial exploratory extraction created 28 factors with Eigen values greater than 1, but with significant variance explained by only seven factors. Only seven factors, therefore, yielded Eigen value greater than 1.00 benchmark used in the analysis (12.702; 3.131, 1.885; 1.507; 1.314; 1.189; and 1.060 – see Table 3). Twenty-One (75%) extracted factors, therefore, explained only an insignificant proportion of the issues critical to the integration of sustainability in built environment curricula. The 21 factors are also responsible for an insignificant 18.62% variation in the sample, while 7 (25%) factors account for 81.38% of the variation in the entire sample.

Table 3 Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	12.702	45.363	45.363
2	3.131	11.181	56.544
3	1.885	6.732	63.276
4	1.507	5.381	68.657
5	1.314	4.694	73.350
6	1.189	4.247	77.597
7	1.06	3.787	81.384

Extraction Method: Principal Component Analysis

The study further analysed the commonality test. Communality was carried-out to measure commonness in the spread of the factors. This result is important to direct the number of factors to be extracted and in this case seven (7). The seven factors are valid since the number of variables are less than 30, and the averaged of the commonalities total significance – column two Table 3 (22.788/28 = 0.81) is greater than 0.70 (Field, 2005). Related to the result in Table 3 is the scree plot shown in Figure 2. The plot actually tailed significantly after the eighth factor before attaining relative plateau. It is safe to retain 8 factors against 7 suggested by SPSS. Since the factors are less than 30, and commonalities after extraction are greater than 0.70 (0.81), the seven factors (Table 3) are accordingly retained. Seven principal factors can be grouped from 28 factors identified from the literature as issues critical to the integration of sustainability in the academic curriculum.

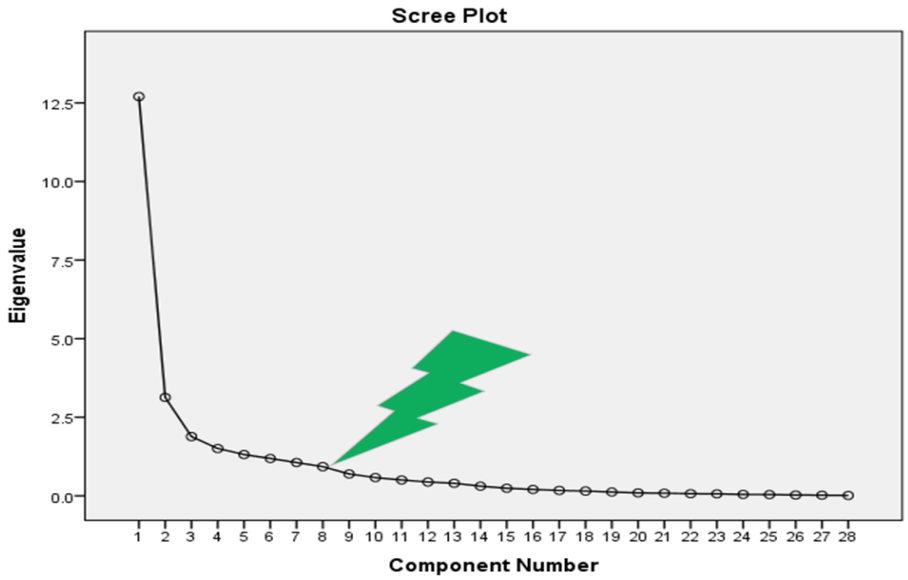


Figure 2 Screen Plot of Principal Factors

4.5 Principal Factor Analysis

Factor rotation was further conducted to suppress loading less than 0.40 to make interpretation easier. Using oblique rotation, seven factors are therefore loaded unto component matrix, and a scan through the various factors loading indicates the most significant loading in factor one has the score 0.804, this component relates to lack of agencies to promote sustainability (Table 4). The study, therefore, selected the framing 'lack of green building council' for this factor. Under the second factor, the most significant loading has the value 0.815, this component relates to a low level of awareness, the frame 'lack of awareness' is selected for factor 2. The most critical issue under the third factor relates to lack of empowerment (0.883), the framing 'lack of empowerment to effect change' is adopted. The fourth factor relates to the 'non-prioritisation of sustainability by accreditation bodies (0.730). The frame non-prioritisation by accreditation bodies' is retained for the fourth component. Under the fifth component, lack of case studies and exemplar project is most significant (0.856), the frame 'lack of real-life sustainable projects' is adequate. The sixth factor relates to the lack of research and professional network (0.723), the frame for this component is 'lack of research and industry collaboration'. The most significant challenge under the seventh factor relates to skills and knowledge dearth problem (0.938). The seventh issue is, however, the most critical, and the frame 'skills and knowledge dearth' is appropriate.

Table 4 Rotated Principal Component Matrix

	Component						
Challenges	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Skills and knowledge dearth							0.938
Low level of awareness		0.815					
Lack of green building council	0.804						
Lack of empowerment to effect change			0.883				
Lack of real-life sustainable projects					0.777		
Non-prioritization by accreditation bodies				0.730			
Lack of research and industry collaboration						0.723	

5. Discussion Of Findings

The findings are discussed in the context of policy issues, academic institution's neglect, and industry's inactions. However, issues related to collaboration and lack of regulatory agencies which is central to the overall groupings are discussed separately. The contexts which the findings are discussed are fitted with the result in Table 4 to obtain the representation of the findings which is depicted in Figure 3. The figure shows that each sector's actions and inactions collectively contribute to the interface problems inherently responsible for foot-dragging in integrating sustainability in the built environment curricula. The critical issues in the general domain, therefore, affect all spheres of the industry, academia and regulatory bodies and will be discussed in the following sections.

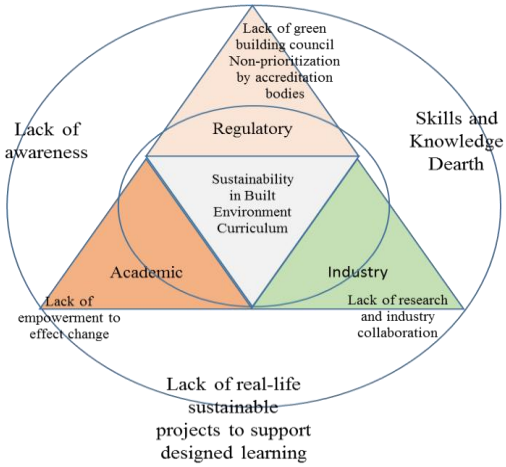


Figure 3 Principal Constraints Influencing Sustainability Integration in Curricula

5.1 Lack of Collaboration among Stakeholders

The results of the study reinforce the role of critical stakeholders' involvement/collaboration to effect curriculum change to benefit sustainability. Moreover, a greater proportion of validated factors in Figure 1 could be resolved through stakeholders' collaboration. Therefore, critical issues to sustainability integration are seen as the failure of relevant stakeholders' to take appropriate actions toward addressing extant gaps. This means that factors responsible for the current state of affairs are mirrored to relevant stakeholders' institutional roles and responsibilities. Three factors are directly linked with this collaborative actions namely: isolated training among disciplines, lack of research and professional network, and poor dialogue and coordination.

The importance of collaboration in curriculum change to benefit sustainability elements is not however new. A study by Tramontin and Trois (2016) showed that sustainability issues have multiple linkages. The result also conforms to the findings of De Coninck (2008) which indicated that effective curriculum development is a duty of the entire society. Moreover, the nexus between human, society and sustainability discourse is not also in doubt, hence respondents' view about the interrelatedness of stakeholder's collaboration for effective curriculum change towards sustainability is consistent with the literature (Barr and Tagg, 1995; Tramontin and Trois, 2016; and El-Feki and Kenawy, 2018). Tramontin and Trois (2016) obtained that blended interdisciplinary competencies are required to implement sustainable construction strategies in project delivery. Also, El-Feki and Kenawy (2018) found that multi-sectorial nesting of sustainability issues will enhance international experience sharing between industry and academia. Similarly, Barr and Tagg (1995) also found that sustainability integration requires an integrative framework and not isolated 'nesting' as currently obtained in the built environment curricula. Lack of stakeholders' collaboration is therefore imperative issues critical to the integration of sustainability in schools' curriculum in the built environment.

5.2 General Factors

Thirty-eight (38) percent of the principal issues in the integration of sustainability in academic curricula are generic to all sectors. Factors in this category include lack of awareness; skills and knowledge dearth, and lack of real-life exemplar projects to support designed learning. The term designed learning was earlier defined to mean curriculum-based teaching. Two of these factors (skills and knowledge dearth and low awareness) are first and second most critical issue in sustainability integration, while the third-factor lack of real-life (exemplar) sustainable project is the fourth most critical issue in sustainability integration. These set of factors form the base of the sustainability integration interface (Figure 3). Sustainability skills and knowledge dearth in the construction industry is seminal in the local and global perspectives (UKCES, 2013; Nduka and Ogunsami, 2015). Therefore, factors relating knowledge gap and lack of awareness are also imperative issues critical to the integration of sustainability in schools' curriculum in the built environment

5.3 Regulatory/Governmental Factors

At the top of the integration, interface is factors associated with actions and inactions of regulatory/government bodies. Twenty-five percent of the principal components validated in Table 4 are in this domain. Factors in this category include lack of established green building council and non-prioritisation of sustainability by accreditation bodies. Lack of green building council was rated the third most significant constraint, while non-prioritisation of sustainability by accreditation bodies was rated sixth. The Green Building Council is responsible for setting a framework for sustainable construction practices learning across sectors. This result differs from the finding in the Egyptian survey undertaken by El-Feki and Kenawy (2018), which study showed that discharge of the isolated roles of Green Building Council, was not enough to address the dearth of sustainability integration in architecture's curriculum. This paper attributes the deviant view to the lack of an established Green Building Council in Nigeria, a position which also influences stakeholders' conception of their roles in sustainability curriculum development.

On the other hand, although, sustainability issues are not limited to the building sector, the role of Green Building Council is central to achieving sustainable construction in the built environment sector. The impact of Green Building Councils in countries where they are established is undisputable. This result is consistent with the findings of Shari and Jaafar (n.d) which study also found this factor critical to sustainability integration.

Accreditation bodies are agencies of government saddled with the responsibility of maintaining standards of academic programmes in higher institutions. The criticality of the issue related to non-prioritisation of sustainability by accreditation bodies shows that the government retains the most important role in integrating sustainability in academic curricula. This viewpoint is consistent with the position reported in El-Feki and Kenawy (2018). El-Feki and Kenawy (2018) recommended that when the government mandates sustainability integration through enabling legislation, and the provision of requisite resources, uptake will flourish. The position of the government and its regulatory bodies to the overall integration of sustainability is significant not just in the built environment but also in other fields. These bodies are

largely responsible for the review of the curriculum, and schools are sometimes restricted to remove from the basic requirements of each regulatory body. Based on this reason, schools' curriculum is therefore christened rigid. Altomonte et al. (2014) in the study of sustainability integration in European countries universities obtained that sustainability is fused between legislative issues, professional regulatory criteria and accreditation structures. The role of coordination bodies, exemplary projects and access to funding are therefore significant to achieving progress in integration (Ferrer-Balas, 2008).

5.4 Academic Factor

The left side of the sustainability integration interface has academic related factors. The principal component underlying this frame from Table 4 is lack of empowerment to effect curriculum change. Lozano (2006) linked empowerment to effect curriculum change to self-actualisation needs. According to Lozano (2006), empowerment at this level refers to motivation to transform accumulated self and system's beneficial actions into reality. The built environment system is stiffened by the curriculum, research, campus operations, community outreach, and assessment and reporting (Cortese, 2003). The curriculum is also fixed and rigid, inclined to research than teaching, and campus teaching methods are regulated. There is limited empowerment for the individual professional staff to influence and add or modify existing modules. The case for overcrowded modules is seminal in the relevant literature (Arsat et al., 2011).

5.5 Industry Factor

The right side of the sustainability integration interface has academic related factors. The principal component underlying this frame from Table 4 is lack of research and industry collaboration. The role of industry/academia collaboration is critical to the integration of sustainability in structured learning, the principal framing relating to industry factor is therefore consistent with extant literature. Du Plessis (2007) found that dearth of research collaborations between industry and academic in the African context stiffens progress toward diffused learning of sustainable construction. Lack of research collaboration inhibits transformative action and experiential learning needed to adapt sustainability skills and learning. Characteristically, sustainability learning requires interdisciplinary and trans-disciplinary learning approach, (Ekung and Odesola, 2017). This view agrees to the integrated project delivery practised as a life-long learning mechanism in developed countries.

It is important for stakeholders to moderate the respective sectorial problems towards effective sustainability integration in the curriculum. RICS (2007) responded to this problem and advanced the responsibility of its related professions in the sustainability agenda. But current and on-going efforts seem to generate additional challenges. For instance, insistent on integrated project practice seeks to compel respective professions to learn generic skills external to individual discipline knowledge and skill areas. There is also limited content for sustainable thinking, and the problem of where to fit the sustainability modules in an already crowded curriculum is yet unresolved. Effective curriculum design must be positioned to address these emerging concerns to benefit the graduate professionals, since learning at the industry level is itself bedevilled with challenges.

6. Conclusion

Years after the 'Decade for Sustainability Education', low awareness, low skills and knowledge gap in requisite sustainability issues applied to construction poses critical problems to the industry. The developed countries may have achieved significant progress with sustainability integration, as many degree and post-graduate programmes are now available with designed modules for sustainable construction. Developing countries are however, laggard in their response including Nigeria. This study explored issues critical to the integration of sustainability element in built environment curricula using data reduction tool (Factor Analysis).

The study showed that seven principal factors categorised into five groups namely: collaborative issues, general factors, academic, regulatory, and industry factors inhibits the integration of sustainability element in academic curricula in Nigeria. The distribution of these factors shows that effective curriculum design for sustainability requires relevant stakeholders' collaboration at various levels. This includes prescription of appropriate modules and pedagogies and facilitation of implementation. Therefore, knowledge dearth, low awareness, lack of green building council, lack of empowerment to effect change, and lack of real-life sustainable projects are issues critical to the integration of sustainability element into built environment curriculum. Sustainability integration could be facilitated by directing inferred stakeholders' actions towards moderating the effects of the principal factors headlined in this paper. These results portray vast benefits to sustainable built environment curricula development in Nigeria in verifying that the bane of curriculum change to suit sustainability elements lies with Government (accreditation/regulatory) bodies. This means that upscaling sustainability integration in academic curriculum could be best achieved through the effects of regulatory

arms such as accreditation bodies; and sustainability promoting council such as the Green Building Council.

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Field Investigation of Indoor Thermal Performance in Malaysia Air-Welled Terraced House

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ABSTRACT

This paper aims to determine the performance of the air well system in a hot and humid tropical climate with existing full-scale air well of single-storey terraced house. The application of air well in residential building widely applied in a traditional building, especially in the Middle East and Europe countries. However, resulted from the development, the application of passive cooling strategies such as air well is gradually replaced by a mechanical cooling system. The aim of the study is to investigate the cooling system role in tropics, where hot and humid climate the overheating of building interior are a critical dilemma due to solar penetration through building fenestration. A field measurement has been carried out in a single storey terraced house with built-in air well in Kuching, Sarawak for 5 days. The field measurement investigates the thermal performance of the single-storey terrace house air well under tropical context. The investigation was measured with U-12 HOBO data logger for temperature and humidity while the air velocity was measured with HD32.3 DeltaOhm measurement logger. Both types of the instrument placed in the air well in a vertical position while another U12 HOBO datalogger placed in a test room with window connected to air well. The outdoor weather data set were measured with HOBO U30. Findings show that the under Malaysia tropical climate, the mean air velocity induced by the air well throughout the measurement days marked as 0.91m/s while during the hottest hour of the measurement days, the air velocity induced in the upper air well could reach 1.09m/s with an outdoor air temperature of 33.6°C and solar radiation of 198 Wh/m². The findings of the study have explained the effectiveness of the air well in providing the thermal performance in the indoor environment and further study on modification of the air well configuration could enhance the airflow and air temperature.

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1. Introduction

The advantages of air well are widely recognized and practice backdated to 900AD. The employment of natural ventilation developed since the existence of vernacular architecture. The principle of the air well effect is functioning assisted by the solar energy and wind-driven ventilation. By creating the temperature gradient between the top of the air well and the room environment, air movement could be induced from the external via inlet (room's window) to outlet (the roof-top opening of air well). Other than air well, the principle of the stack ventilation applied widely in passive cooling strategies such as solar chimney, Trombe wall, solar roof and so forth (Agung Murti & Mohd Hamdan, 2006; Gan, 1998; Sacht, Bragana, & Almeida, 2013; Zhai, Dai, & Wang, 2005). Those passive cooling strategies functioning based on the indoor-outdoor ambient air temperature gradient could be found mainly in the vernacular and traditional domestic buildings, which have already withstood time. The research developed based on the traditionally-existent natural cooling techniques are basically reliable and potentially to be developed since it were growing based on the ancestors experience by generations as responses to the climatic environment. (Paul, 2006) However, the application of air well was slowly diminishing with the introduction of air conditioning system in the industrialized 19th and 20th centuries. The global awareness of the importance of sustainable issues and fossil fuel crisis have leading the building industry into a worldwide view with the application of passive cooling strategies as the effective and efficient strategies to induce natural cooling into the indoor habitable environment. (Wong, Tan, Ang, Mok, & Goh, 2012). Thus, this paper intended to investigate the effectiveness of air well in tropical climate terraced houses of Malaysia which could be the potential passive cooling strategy that benefiting the occupants of domestic building.

2. Literature Review

Literature reviews have studied the advantages, the workability, the mechanism and parameters of solar assisted stack ventilation shaft such as solar chimney, courtyard, air well and so forth (Agung Murti & Mohd Hamdan, 2006; Gan, 1998; Chen, 2009 ; Zhai, Dai, & Wang, 2005) . The solar assisted stack ventilation could be studied with several methods; namely empirical models, analytical models, zonal models, multizone models, Computational Fluid Dynamic (CFD) models and experimental models. (Chen, 2009).

In Malaysia, Nugroho and Ahmad (Agung Murti & Mohd Hamdan, 2006) has studied on the possibilities of the solar chimney to induce stack ventilation by using a small scaled model with PVC pipe (0.15 Ø x 3.5m). He found that the air temperature gradient between the upper and lower levels of the PVC pipe could reach differences of 5°C under Malaysia tropical climate. (Hirunlabh, Kongduang, Namprakai, & Khedari, 1999) has studied on the use of metallic on solar wall as solar updraft natural ventilation tool. The findings show that the temperature within the metallic solar wall increasing with wall height and decreasing with air gap. Tareq and Ossen has (Tareq G. Farea & Ossen, 2013) found that the lightwell can be functioning as the heat removal building component as the lightwell adjacency room has lower air temperature compared to the street adjacency room. The highest air temperature gradient between the upper and lower part of the light well in a five storey high apartment during the daytime under clear sky condition was about 2°C. Air temperature gradient between the upper and lower part of ventilation shaft during the hot day shows that the hot air is updrafted by solar energy.

Wong et al. (Wong et al., 2012) has investigated the performances of full scale solar chimney system under tropical climate in Singapore. The findings show that the solar chimney can induce average air velocity of 1.5m/s within the solar chimney and 0.4m/s in the classroom during the low solar irradiance day. Bassiouny and Koura (Bassiouny & Koura, 2008) studied on the parameters of solar chimney. He found that the chimney width has a more significant effect on air change rate compared to chimney inlet size. The increase of inlet size three times only improved the air change rate by 11% while increasing the chimney width by three times could increase the air change rate to 25%.

N.K. Bansal et al. (N.K.Bansal, Rajesh Mathur, & M.S.Bhandari, 1993) has developed a steady state numerical model for solar chimney which is designed to enhance the solar induced ventilation in building. Different sizes of solar chimney inlet openings with varying discharge coefficients were tested. The mathematical calculations shows that the solar collector with area of 2.25m² could induce 140m³/hr to 330m³/hr of air flow for solar radiation of 200 W/m² and 1000 W/m². Mathur et al. (Mathur, Bansal, Mathur, Jain, & Anupma, 2006) has investigated on a small scale solar chimney and the findings show that the air flow rate increases with the ratio between absorber height and air gap. There is a potential to induce 55 to 150m³/h air flow rate for 300 to 700 W/m² solar radiation incidents on the vertical surface for a typical room with size.27m³.

Ren et al. (Ren et al.,2019) has studied the fluid flow and heat transfer mechanism in solar chimney which regulated by thermal buoyancy via numerical studies and experiment investigations. The findings show that the temperature on the heated wall is not distributed evenly which is useful for the solar energy utilization in building energy conservation.

Frutos Dordelly at al has studied the impact of integrating Phase Change Material (PCM) into the solar chimney. The studies show that the solar chimney prototype integrated with PCM could enhance the ventilation rate and the storage of energy for 6 hours. This shows that the effect of heat gain and storage ensured the solar chimney function accordingly (Frutos Dordelly et al., 2019).

Asadi et al has studied on the (Asadi et al, 2016) the effect of orientation on the performqance of solar chimney layout with EnergyPlus software. The findings show that east-southern part of the building position suitable for solar chimney orientation.

Rattanongphisat, Imkong and Khunkong have experimenting the used of square steel on solar chimney for building ventilation application in order to enhance the temperature differences in the horizontal plane on chimney. The air temperature differences in horizontal plance across solar chimney width could up to 7°C while the gradient air temperature on vertical direction could up

to 1.4°C . The highest air flow near the black durface is up to 0.26m/s. The finding contributes to low height type of chimney (Rattanongphisat, Imkong and Khunkong, 2017).

Khosravi, Fazelpour and Rosen have studied on the enhanced application of solar chimney on two-story building via mathematical model approach. The results show that the application of inclined solar chimney would increase the ventilation rate by 24% compared to conventional solar chimney design (Khosravi, Fazelpour and Rosen, 2019).

The selected literatures stated above have previewed the effectiveness of the ventilation shaft, such as solar chimney and light well. The literature reviews stated above scientifically presented that ventilation shaft is a useful passive ventilation tool which provide thermal comfort for occupants, especially in tropical climate. The significant variables contributed to the effectiveness of solar chimney includes the geometry and configurations of solar chimney, the innovation and integration of solar chimney with absorber materials, the inclination of solar chimney angle as well as the gradient temperature of solar chimney. In this study, the thermal performance of the selected case study single storey terraced house with air well under Malaysia tropical climate was investigated. The studies focusing on the investigation of thermal performance of existing bulding prior to the modification steps of air well to solar chimney in order to examine the vertical temperature and thermal performance of the passive ventilation tool

3. Research Method

A single storey terraced house with air well, which located at Kuching, Sarawak, East Malaysia was studied from 18 November 2013 to 22 November 2013. The case studied house has been selected based on its building layout and size as well as the numbers of room provided in the house is falls within the range of the typical size according to Toe, D. H. C terraced house classification studies (Toe, D. H. C, 2013). The main purpose of the study is to investigate the thermal performance of the air well in a single storey terraced house and its effect to the adjacency room. Air movement could reduce the thermal discomfort of the indoor environment, especially in the tropics with high air temperature and high air humidity. However, in Malaysia, the low value of indoor air velocity, which range from 0.04 – 0.47m/s (Hui, 1998) could not satisfied the thermal comfort of the occupants. This is due to the inappropriate design layout of the modern terraced house, where the factors of space optimization for marketing demand and value are being prioritized. Most of developers and designers solving the ventilation problem of the bedroom by providing single sided opening for ventilation. The solution, however, still failed to fulfill the needs of daylighting and ventilation of the occupants which eventually ended up with installing the mechanical ventilation system. The terraced house layout with air well attached to the bedroom believed to be effective in providing bedroom with natural ventilation and daylighting.

In this study, the case model focuses on the air well (2m in depth x 1m in length x 5m in height) and adjacency room (3m in length x 3m in width x 3m in height). The case model is in a 3m ceiling height single storey house measuring 14.1m in length and 6m in width as shown in Figure 1.

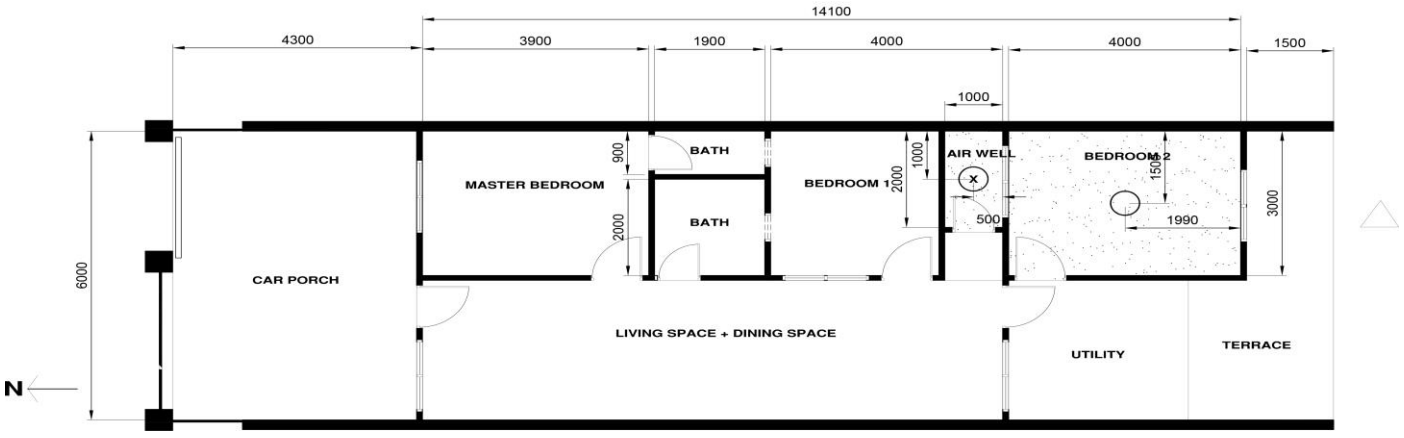
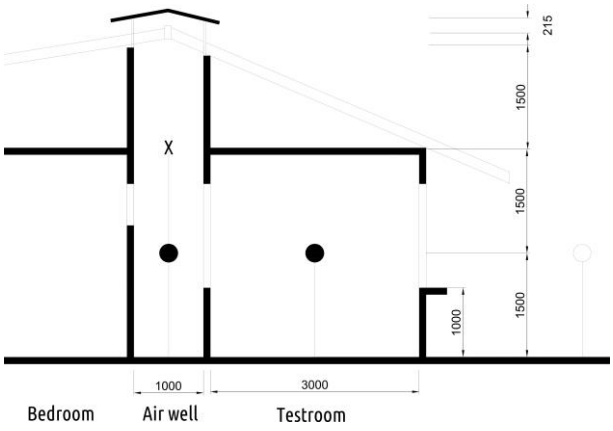


Figure 1 Location of measuring tools with symbol (O), (x) and (Δ) are marked above. The (O) represents HOBO U12 air temperature and relative humidity data logger, (x) represents HD32.3 Delta Ohm measurement logger while (Δ) represents the HOBO U30 outdoor weather station. *The hatced zone with scattered dots represents the study focus area (Source: Author)



2(a)

2(b)

Figure 2 (a) and (b). The section drawing of the air well and test room in case study house. The (●) represents the position of the measuring point of HOBO U12 air temperature and relative humidity data logger, which is 1.5m from floor level while (x) represents the HD32.3 Delta Ohm measurement logger placed 4.5m from floor. The photograph shows the location of C (Source: Author

As seen in Figure 1, the study area only focuses on the air well and test room (hatched with scattered dots). The air well is located bedroom 1 and bedroom 2(test room). It is functioning as the ventilation and daylighting shaft for bedroom 1 and airflow passageway for bedroom 2. The inlet (window at test room) is placed 1.0m above floor level with an opening of 1.2m by 1.5m in width and height. The air well is made up of 100mm thick brick wall with both side plastered, having a width and depth measuring 2.0m by 1.0m respectively. The outlet measures 4.5m in total height from floor level and air escapes from the internal window to the roof top of air well with 100% opening, which shaded with the polycarbonate roofing material to prevent the penetration of rain water. Under the solar radiation, the hot air in the air well expands and the pulling effect of air is generated. The ambient air is forced into the interior through the inlet opening. With the Malaysia tropics climate conditions, the air well system hopes to provide air flow in the test room from the stack effect which induced along the air well shaft.

Table 1 Field experiment setup for measuring tools

Space	Data Type	Equipment	Time Intervals	Measuring Point (center point of the room)
Outdoor	• Air temperature • Relative humidity • Solar radiation • Wind speed	• HOBO U30 weather station	• 15 minutes interval	1.5m from floor level
Air Well	• Air temperature • Relative Humidity	• HOBO U12 air temperature and relative humidity data logger	• 15 minutes interval	1.5m from floor level
	• Air speed	• HD32.2 Delta Ohm measurement data logger	• 15 minutes interval	3.0m from floor level
Test Room	• Air temperature • Relative humidity	• HOBO U12 air temperature and relative humidity data logger	• 15 minutes interval	1.5m from floor level

The HOBO U12 air temperature and relative humidity data logger and HD32.2 Delta Ohm measurement data logger were placed at the center of the air well at 1.5m (point B) and 3.0m (point C) height from the floor level respectively (As shown in Figure 2(a) and 2(b). Another HOBO U12 air temperature and relative humidity data logger placed at 1.5m level (point A) in order to investigate the thermal performance of the test room. The HOBO U30 weather station was set up on site to obtain the

outdoor weather climate condition as reference. The height of 1.5m considered as human sensory height, whereas the air speed data logger placed at 3.0m in order to investigate the ventilation performance of the air well. The data set from outdoor weather station is important, as the reference set for the thermal performance of the air well and test room. All readings were recorded at a logging interval of fifteen minutes, and further averaged over every 4 readings per hour. The sampling period was measured from 12:00am of 18 November 2013 to 11:45pm of 22 November 2013. All measurement data were recorded simultaneously from 12:00am of 18 November 2013. Summary of the investigation points of measuring instrument has been listed in Table 1 above. The significance of the investigation study enabled researchers to identify the thermal performance of existing air well in terraced house in Malaysia. Due to the limitation of the exposed outdoor envelope of terraced housing, interior layout of habitable room only allowed single sided ventilation which is not efficient in providing thermal comfort to the occupants. This study has been carried out for one week under the climatic condition with average range of air temperature and relative humidity for past 10 years, hence the outcome of the studies still valid for the future references (Malaysia, 2018)

4. Results and Findings

Malaysia's weather is generally characterized by high temperature and humidity whole year round, and accompanied by two significant Monsoon seasons and long period of solar radiation. (Malaysia, 2018) According to the field measurement as shown in Figure 3 and Figure 4, generally Malaysia possesses high temperature and high humidity, which ranged from 23.07°C to 37.08°C and 48.81% to 98.03% respectively , with daily average air temperature of 27.21°C and humidity of 83.40%. The average measurement result is fulfilled the range of the average air temperature and humidity recorded by Department of Meteorological Malaysia, which stated 23°C to 32°C, and 85% respectively. In general, Malaysia's wind speed is light and variable. However the two significant Monsoon seasons, which happened in May to September and November to March, would determine the prevailing wind flow.

The wind speed in Malaysia throughout the year ranged from 5.14m/s to 15.43m/s above 10m level. However, the gradient velocity profile at the suburban area slows down wind velocity from upper atmosphere. This is caused by the turbulence due to the uneven landform and obstacles. Thus, according to Figure 4, the highest outdoor wind velocity recorded 1.5m above floor recorded as 5.52 m/s while the lowest air velocity recorded between 0 to 0.22m/s. The insignificant mean outdoor air velocity with value 1.29m/s that could not enhance the ventilation for indoor room has caused the thermal discomfort to the occupants in terraced house. (Malaysia, 2018)

Located close to the equator, Malaysia is gifted with abundant of sunshine. In average, Malaysia receives 5 to 7 hours of sunshine per day, or more than 2200 hours per year. The average annual daily solar irradiations for Malaysia ranged from 4.21 to 5.56 kWhm^{-2}. (Muzathik, 2013) The long hour sunshine and high solar irradiations in Malaysia benefit the performance of solar induced ventilation shaft. Figure 4 indicated that the highest solar radiation recorded as 581 Wh/m² at 13:00 of 19 November 2013 while the average solar radiation for the field measurement day marked as 290.40 Wh/m². Solar irradiation is one of the factors influenced the thermal comfort of the buildings. In general, higher solar irradiation would increase the air temperature under the condition air velocity is near zero or static. Hence, in order to stimulate air movement under no wind condition, air temperature differences within a zone could induce stack ventilation to achieve indoor natural ventilation.

The air well plays the role to induce the ventilation via the stack effect. In this field measurement, two set of measuring data logger were placed at 1.5m (lower air well) and 3.0m (upper air well) to investigate the existence of temperature gradient. According to Figure 5, the temperature differences between air well (upper and lower) and outdoor is significant. The fluctuation range between air well and outdoor air temperature throughout field measurement days registered with total mean air temperature differences of 2.07°C, which is 4.71%.

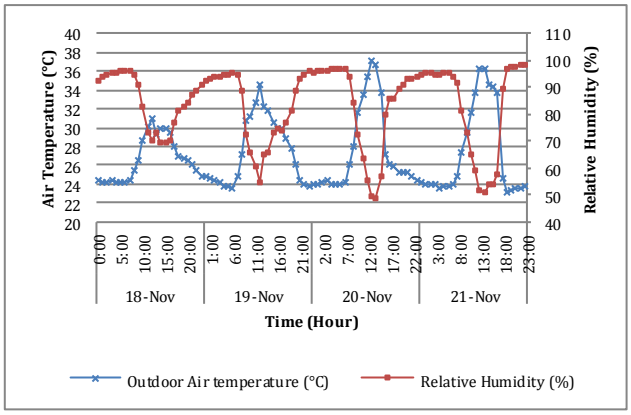


Figure 3 Measured outdoor air temperature and relative humidity from 18 November to 21 November 2013
(Source: Author)

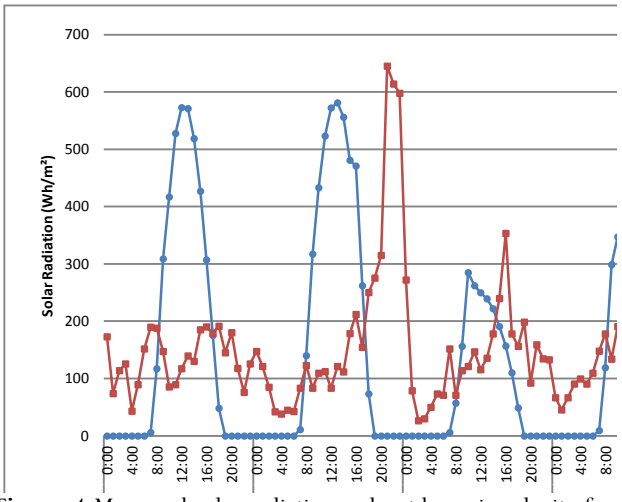


Figure 4 Measured solar radiation and outdoor air velocity from 18 November to 21 November 2013
(Source: Author)

Although both differences is relative small, which is not compatible with the fluctuated graph pattern in Figure 5, the stability of the air well air temperature fluctuation is higher compared to outdoor air temperature. The air well air temperature fluctuated between 27.97°C to 30.92°C, with differences of 9.54% while the outdoor air temperature fluctuated between 24.07°C to 37.08°C, with differences of 35.09%. This shows that the air well manage to stabilize and balance the air temperature of the indoor environment, and functioning as ventilation outlet and daylighting provider medium for the room. Similar to air temperature, the air humidity for the air well and test room is also fluctuated within the balance and acceptable range compared to the outdoor air humidity as in Figure 6. The mean air humidity for the overall measurement days recorded as 83.40% while the test room and air well marked 77.53% and 76.24% respectively. The differences between both indoor and outdoor air humidity is 6.52% (Figure 6). This shows that the air well manages to retain the air humidity and air temperature in relative similar range between day and night time, via the use of sensible heat stored in the air well brick material in the day time and release in the night time, where the surrounded environment is being cooled down.

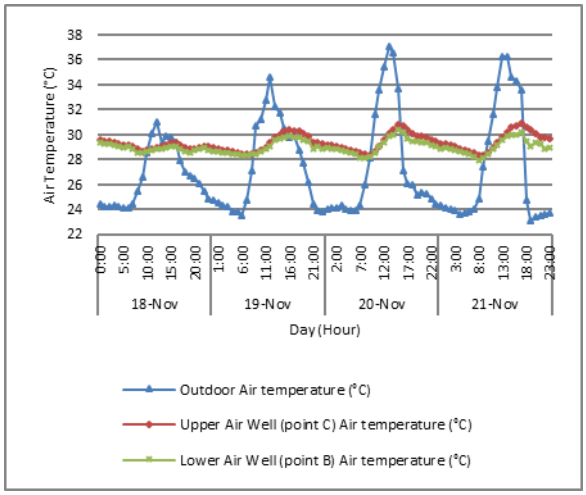


Figure 5 Measured outdoor air temperature, upper air well air temperature and lower air well air temperature from 18 November to 21 November 2013
(Source: Author)

In Figure 7, the wind velocity in the air well is noticeable, which has followed the air temperature pattern of the air well. The average air velocity induced by the air well marked as 0.91m/s throughout the field measurement period. Meanwhile, when the outdoor air temperature marked as 33.6°C with solar radiation 198 Wh/m², the air velocity induced in the upper air well on 20 November of 15:00hr registered value of 1.09m/s. Another example shown in 20 November 15:00hr, the air flow registered as 0.65m/s with the increase of mean air well air temperature from 29.61°C to 30.49°C. According to Wong et al. (Wong et al., 2012) the solar ventilation shaft able to induce average air velocity of 1.5m/s with air temperature differences of 4°C. The phenomenon result of this case is similar, which stated the possibility to induce stack ventilation with temperature differences.

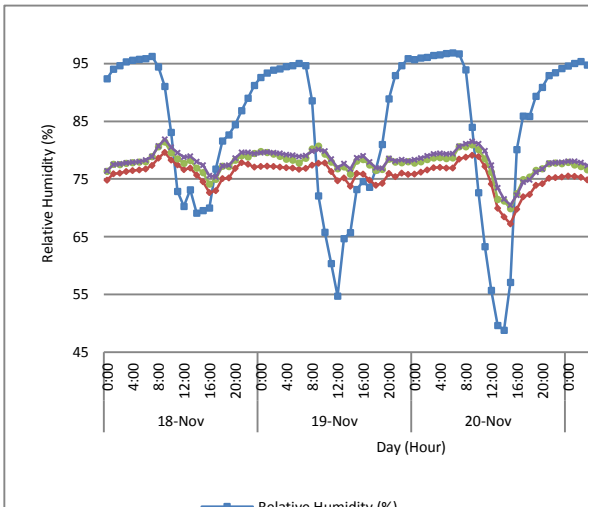


Figure 6 Measured relative humidity of outdoor, upper and lower air well as well as testroom from 18 November to 21 November 2013
(Source: Author)

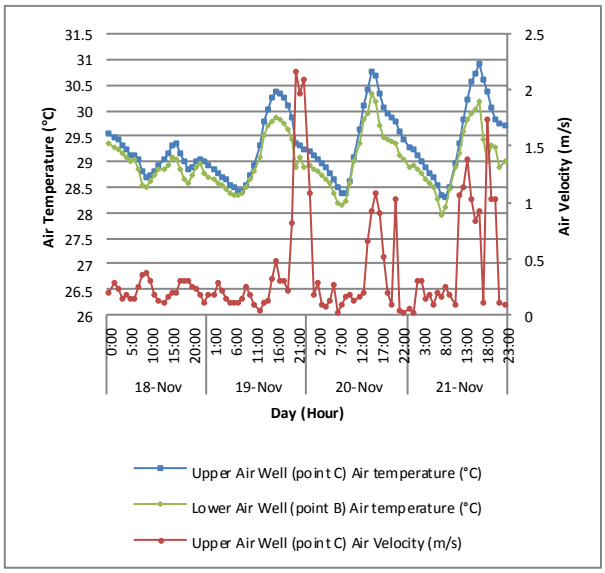


Figure 7 Measured lower and upper air well air temperature as well as upper air well air velocity from 18 November to 21 November 2013
(Source: Author)

For Figure 8, the solar radiation in general has a great influenced on the air temperature patterns. Significantly, the outdoor air temperature flows accordingly to the solar radiation while the upper air well fluctuated based on the outdoor air temperature. The time range of the peak for air temperature and solar radiation recorded as 10:00hr to 16:00hr. The highest value of solar radiation within four days recorded as 581 Wh/m², while the outdoor air temperature at that time recorded as 32.24°C.

However, air temperature for both air well and test room at that time ranged from 29.52°C to 29.79°C, which is 2.64°C lower than outdoor air temperature. Air well stabilizes the thermal performance (air temperature) of the indoor environment.

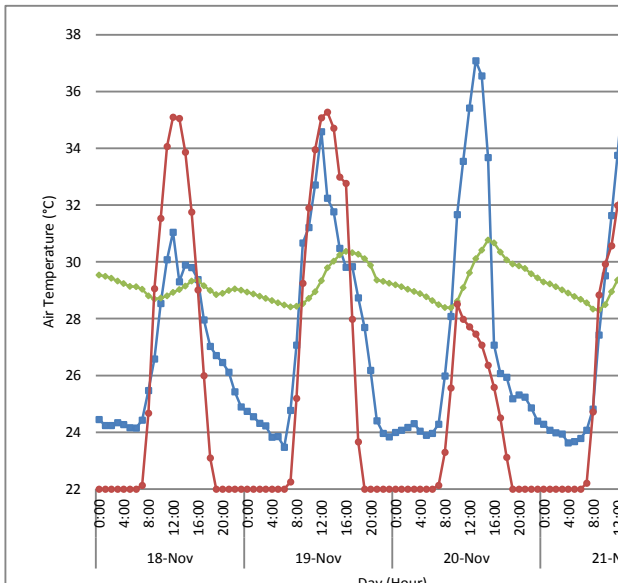


Figure 8 Measured outdoor and upper air well air temperature as well as solar radiation from 18 November to 21 November 2013 (Source: Author)

In Figure 9, the comparison between air temperatures of air well and test room was made. The maximum differences between upper and lower air well diurnal air temperature (07:00hr to 18:00hr) marked as 1.35°C while the minimum differences is 0.034°C. For the outdoor and upper air well air temperature, the maximum differences marked as 7.29°C while minimum as 0.031°C. From the results, the significant maximum and minimum air temperature between the upper air well and outdoor air temperature has revealed that air well plays the role of thermal performance regulator for indoor room. When the maximum mean test room result compared to the air well result, the differences of both areas marked as 2.8°C.

By managing the field measurement data into the psychometric chart according to ASHRAE Standard 55-2010, the field measurement data of the test room has fulfilled 62.8% of the adaptive comfort ventilation. Climate consultant 5.5 is free software that helps designer to translate the weather data into graphically display graphs and charts including the psychometric chart. The parameters used for the thermal comfort model is Adaptive Comfort Model in ASHRAE Standard 55-2010. The ASHRAE Standard 55-2010 has been widely applied to measure the thermal comfort of indoor environment in the tropical climate. This could be used to benchmarking the position of thermal comfort of existing terrace house in Malaysia. In general the model is suitable to be applied for the naturally ventilated spaces where fenestration and openings allowed to be opened and closed freely. The model assumes occupants adapt their clothing (1.0 to 1.3 met) to the thermal environment with sedentary job and no mechanical cooling system used in the measuring room. (Robin Liggett & Milne, 2008) The adaptive comfort ranged is set between 23.3°C to 29.8°C with the humidity ratio of 0.012 to 0.025. The adaptive ventilation comfort could be further improved via the modification of air well into solar chimney to induce stack ventilation for terrace house room.

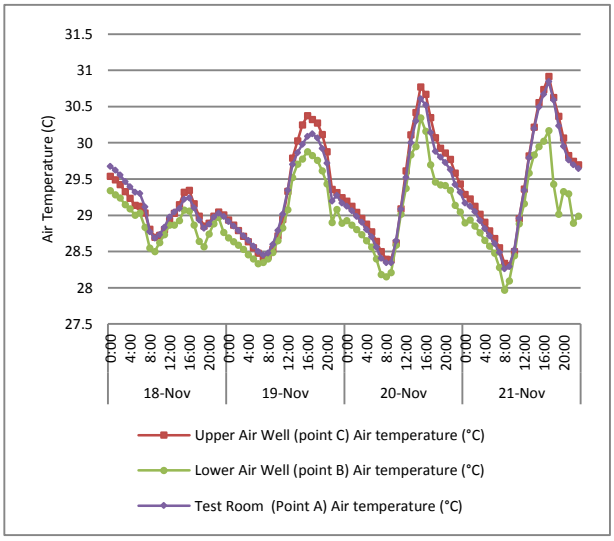


Figure 9 Measured upper and lower air well as well as test room air temperature from 18 November to 21 November 2013

The major concern of the studies are focusing on the potential of the air well in terraced houses, which is mostly exists in terrace house of Malaysia proposed by designer in order to fulfill the compliances of Uniform Building By Law (UBBL) 1984, in Clause 39 (1) under Part III (Space, Light and Ventilation), stated that the requirement by means of one or more windows is required in a total area of not less than 10% of the clear floor area in a room, and it shall have operable openings not less than 5% of total floor area (Malaysia. and MDC Legal Advisers., 2000). Designer creates minimum size air well in order to allow natural ventilation and daylighting for the intermediate room.

Since the single sided ventilation strategy is not performing and giving significant impact for the occupants in providing thermal comfort, modification of air well into solar chimney is one of the alternative to promote stack ventilation and increase thermal performance of terraced house habitable room without utilizing the mechanical ventilation system. Malaysia falls within equator zone of the globe and gifted more than 5 hours of solar radiation per day enabled the principle of solar updraft principle works by utilizing the temperature gradient of the solar chimney.

Hence, by conducting this based case study, the extension research could be proceeded by carrying out the modification on air well configurations for better thermal and ventilation performance of the solar chimney.

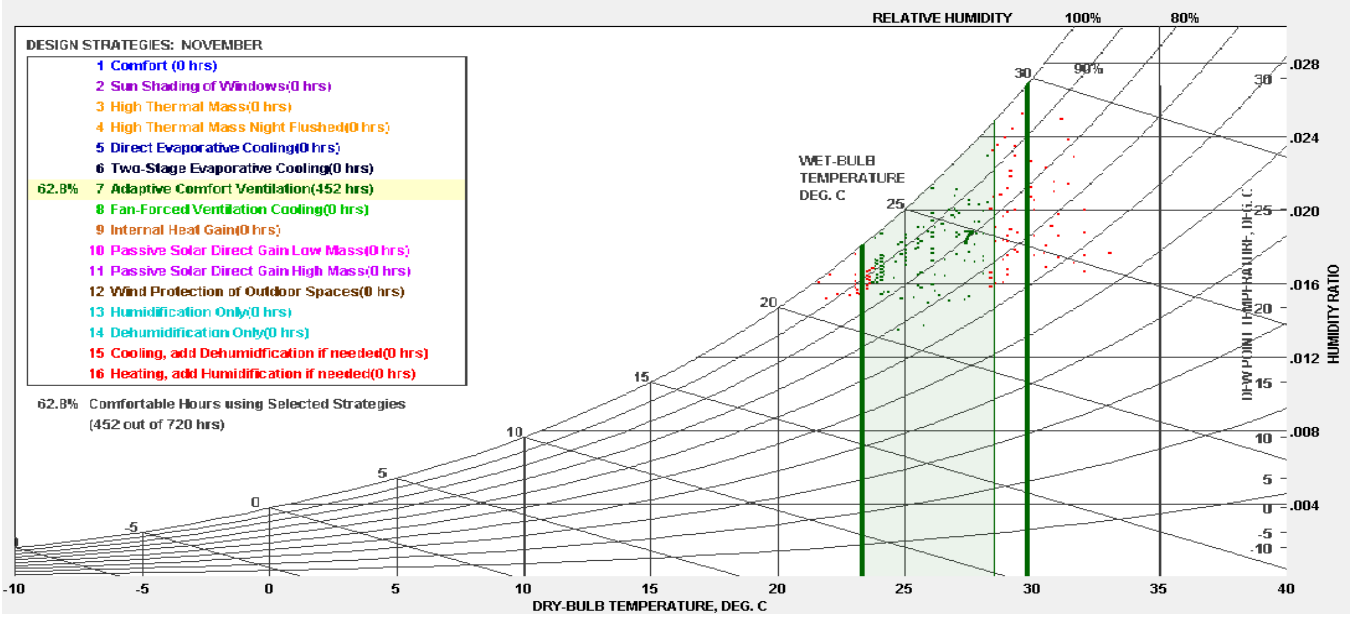


Figure 10 The psychometric chart generated by Climatic Consultant 5.5 shows the overall measuring points obtained in the test room fulfilling 62.8% of the adaptive comfort ventilation based on Adaptive Comfort Model in ASHRAE Standard 55-2010
(Source: Climatic Consultant 5.5)

5. Conclusion

The single storey case study house located in Kuching, Sarawak with air well was studied from 18 November to 21 November 2013. The field measurement carried out in order to investigate the thermal performance of the air well to the test room. Results showed that under Malaysia tropical climate, the mean air velocity induced by the air well throughout the measurement days marked as 0.91m/s while during the hottest hour of the measurement days, the air velocity induced in the upper air well could reach 1.09m/s with outdoor air temperature of 33.6°C and solar radiation of 198 Wh/m². The mean differences of air well and test room of 2.8°C has shown that air well as the thermal regulating medium in order to stabilize the air temperature of indoor environment from being fluctuated dramatically as outdoor environment, and providing ventilation passageway and daylighting medium for the indoor room. The existing air well (2m in depth x 1m in length x 5m in height) and adjacency room (3m in length x 3m in width x 3m in height) has fulfilled 62.8% of adaptive comfort ventilation (As shown in Figure 10). Further research is required to determine the enhanced configuration of air well in order to promote stack ventilation in the terraced house.

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Socialisation Mediates The Relationship Between Learning Environments and Architecture Students' Academic Performance

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ABSTRACT

Good learning environments are often directly linked with academic success though controlling for other factors such as socioeconomic status and entry qualifications are constantly required. This study, re-examines the above premise using qualitative open-ended responses from 29 students majoring in architecture from Ahmadu Bello University as studies investigating this category of respondents are sparsely undertaken. Results from qualitative content analyses of 81 phrases reveal that although learning environment influences academic performance, a number of respondents, particularly males, categorically stated that it has no influence on their academic performance. The findings thus assert that providing conducive learning environments may not always translate into good grades to students. Socialisation and interactions between staff and students as well as student-to-student interactions emerged as mediators in the learning environment-academic performance relationship. The need for socialisation and support was pertinent for lower levels, while inadequacy of facilities notably classrooms and studio space influenced postgraduate students more. IEQ variables such as noise and thermal comfort, security as well as assessment modalities also influence academic performance.

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1. Introduction

Learning environments (LE) have gained research attention in recent years, in part due to perceived links to academic performance of students especially in Higher Education (HE). LE comprises diverse physical locations, contexts and cultures within which learning occurs (Ibem, Alagbe & Owoseni, 2017). Prayoonwong and Nimnuan (2010) assert focusing on LE is one way researchers understand how students learn. In fact, subjective perceptions of the LE, rather than objective aspects are said to facilitate learning (Saghafi, Franz & Crowther, 2012). According to Ellis and Goodyear (2016), "connections between place and learning can be subtle and powerful" (p. 150). McRobbie, Roth and Lucus (1997) explain that students' perception of their classroom environments as well as psychosocial interactions, which occur within them affect academic achievement. In support of these claims, a recent study established air quality in classrooms, good views, space allocation, sound, quality of furniture and lighting affect academic performance (Abdulkadir, 2018).

Academic performance, on its part, enjoys tremendous research appeal due to its established association to socioeconomic development and advancement (Alshammari, Saguban, Passay-an, Altheban & Al-Shammari, 2018; Olufemi, Adeniran & Oyediran, 2018; Opoko, Alagbe, Aderonmu, Ezema & Oluwatayo, 2014; Mustaq & Khan, 2012; Hanushek, Jamison, Jamison & Woessmann, 2008). Academic performance is also linked to employability of graduates and prospects of a better life (AlMurtadha, Elfaki & Abdalla, 2016; Masrek & Zainol, 2015; Ghaemi & Yazdanpanah, 2014; McCowan, 2014). Often referred to in literature as academic achievement (Alos, Caranto & David, 2015) or academic success (Aluko, Adenuga, Kukoyi, Soyingbe & Oyedeji, 2016), academic performance denotes attainment of learning objectives, acquisition of desired skills and competencies, satisfaction of completing academic activities and overall post college performance (ibid). It is usually measured using grade point average (GPA) or its cumulative equivalent (CGPA). Dixson, Keltner, Worell and Mello (2017) summarise benefits associated with high academic achievement as increased probabilities of gaining employment, attending graduate school and increased income after college. Better self-discipline, decision-making skills and higher IQ scores comprise other notable advantages. Overall, academic achievement is a good indicator of key aspects of a person's life.

Due to the aforementioned association between LE and academic performance, the assumption is that a linear relationship exists between the two constructs, with one directly influencing the other. Indeed, it is presumed that students will produce better grades within good LE, after controlling socioeconomic factors and entry qualifications. Ibem et al. (2017) affirm this observation by asserting that students in good LE undoubtedly attain higher achievement as a good LE frees students from the problems of stress, making concentration easier for schoolwork and logical thinking. Ellis and Goodyear (2016) also allude to this observation, noting that university spaces ought to support learning. This study investigates students' perspective of their learning environment at the department of Architecture, Ahmadu Bello University being the pioneer school of architecture in Nigeria. The paper specifically re-examines the premise that LE and academic performance are directly related. It tests the hypothesis that other factors may mediate between LE and academic performance using student responses from a public school of architecture in northern Nigeria as studies investigating the perception of this category of students about their LE are very rare (Oluwatayo, Aderonmu & Aduwo, 2015). Architecture is a discipline combining arts and science and is heavily dependent on architectural design studio (ADS), which is at the core of the architectural curriculum (Bashier, 2014; Megahed, 2018).

Maina, Marafa and Daful (2018) report several factors which influence academic performance in the study area. These are cost of equipment, relationship with other students, quality of natural light in studios, quality of lecturers' experience, parents'/guardians' income, collaboration with other colleagues as well as air quality in studios. These variables record mean importance values equal to or above 3.5 out of 5. Overall, the study found that architecture students in the study area were affected more by school based variables than socioeconomic variables, in constrast to their counterparts at the University of Jos. Consequently, this study also assesses the extent to which LE as a component of school based variables influences academic performance and behaviour.

2. Review Of Related Literature

2.1 Learning Environments And Academic Performance

Learning connotes all activities students engage in purposefully in an educational setting (Ellis & Goodyear, 2016). The result of successful learning usually means understanding a phenomenon, process, principle, mechanism or event. Learning could also result in acquiring a skill or the ability to successfully complete a task (ibid). LE denotes myriad settings and activities that facilitate learning. It encompasses the culture of a school or class, including policies, rules, ethos and organisation. This includes the manner students interact with each other as well as ways teachers organise an educational setting to enable learning (Ibem et al., 2017). LE in literature relating to academic performance are commonly discussed under facilities (or infrastructure, including equipment and utilities), teacher and students' characteristics. This is because these three categories of LE are located within school environments and are the major variables that influence academic performance after controlling socioeconomic status (SES) and entry qualifications. These last two variables are traditionally outside the scope of school/institutional jurisdiction within which LE are located.

Facilities refer to the physical setting and environmental features of spaces and places that facilitate learning. These maybe formal and structured, such as classrooms, lecture halls, laboratories, offices, seminar rooms, libraries, hostels, cafeteria and other support spaces as well as utilities such as electricity and water supply, internet services, security etcetera. Typically, these have been the focus of the vast majority of studies in learning spaces literature largely due to two reasons. First, huge sums are spent on design, planning, construction and management of physical spaces and university facilities (Ellis & Goodyear, 2016). Rising student enrolment rates have necessitated an infusion of funds into the global education sector in recent years, with the wisdom of further investment into physical spaces in question (ibid). Secondly, the emergence of virtual online learning challenges traditional ways of learning. Issues of whether physical learning spaces offer advantages over virtual learning remain under-researched. Facilities such as open spaces are also employed informally for discussions, collaborative work and relaxation (Adedayo, Oyetola, Anunobi & Adebayo, 2017). These have gained research interest in recent times as learning is now becoming experiential, with students employing available spaces on campuses for learning (Maina, 2017; Ellis & Goodyear, 2016; Gebhardt, 2014).

Studies on facilities are generally context specific and establish several physical features as influences on academic performance on university campuses. These are commonly proximity to hostel accommodation (Adama, Aghimien & Fabunmi, 2018; Maina &

Aji, 2017; Owolabi, 2015), adequacy of utilities (Frimpong, Agyeman & Ofosu, 2016), indoor environmental variables such as noise, lighting, ventilation (Abdulkadir, 2018; Davies & Lee, 2007; Higgins, Hall, Wall, Woolner & McCaughey, 2005), quality and adequacy of classrooms/lecture halls as well as other formal educational settings (Abdulkadir, 2018; Akhihiero, 2011) as well design spatial configuration (Fouad & Sailer, 2017). There is also strong evidence in literature to suggest teaching quality critically influences academic performance (Simoes & Alarcao, 2014; Fong-Yee & Normore, 2013). Alos, Caranto and David (2015) assert quality of teaching is the most important school-related factor influencing academic achievement. Although a few studies report high self-esteem is associated with low student-teacher relationships (Nyadanu, Garglo, Adampah & Garglo, 2015), some affirm that subject knowledge, teaching skills, lecturer attendance and attitude have significant positive influence on academic performance (Mustafidah, 2014; Muzenda, 2013). Elegbe (2018) reports quality of lecturer's interpersonal communication with students will positively or negatively influence their academic performance. This is more pertinent for younger students. Student characteristics influencing academic performance in literature usually relate to SES factors such as gender (Borde, 2017), motivation (Fernando, 2017; Sugahara & Boland, 2014), entry qualifications, social background (Dixson et al., 2017), parental and individual characteristics of students (Usman, Mukhtar & Auwal, 2016; Wu, 2014).

2.2 Learning Environments And Academic Performance Of Architecture Students

Several studies establish the influence of features of the learning environment, especially facilities and SES on the academic performance of architecture students. Opoko, Oluwatayo and Ezema (2016) established nine factors that influence academic performance of architecture students at private universities in southwest Nigeria. LE, comprising campus environs, relationship with staff, cafeteria, shopping facilities/buttery, relationship with other students, quality of classrooms, studios, workshops and hostels accounted for the highest number of variables. Library use dwindled largely due to easy access to the internet. This finding echoes results from Rugutt and Chemosit (2005) where internet, campus technology and student achievement were significantly and negatively related to academic performance. Opoko et al. (2016) also report the unique place studio traditionally holds at the core of the architecture curriculum has been lost. In a qualitative research similar to the present study, Ibem et al. (2017) report 45.5% of respondents emphasised variables related to physical conditions within facilities as major components influencing LE. These are lighting, ventilations/air quality, noise levels, colour and decoration. A student notes, *"My opinion is that the right structure is required in learning for good results or outcome, just like an athlete requires good training facilities for better results so is environmental facilities (including architectural structures) important for learning*" (p. 6280). Furniture arrangement and physical conditions were also considered key components of LE by 54.5% of respondents, with a student noting, "*A conducive environment propels learning. Space and design of the class room, seating arrangements for proper engagement"* (p. 6282).

Quality of student accommodation also affects academic performance of architecture students in northwest Nigeria, with students accommodated on campus likely to graduate with an average grade equivalent to second class lower division against students living off campus, who on average would graduate with third class degrees (Maina & Aji, 2017). Ibem et al. (2017) established that LE influences self-awareness, focus, synergy, comfort, concentration and psychological balance of architecture students. This translates to higher productivity in terms of creativity in design. The emergence of perceived support as an additional dimension however suggests that tutor and peer connection is important (Oluwatayo et al., 2015). Although good teaching was not perceived as a significant predictor of academic grades, results from the study suggests that LE in architecture education relates to space and effectiveness of the teaching process as well as involvement of students in creating knowledge (ibid). The complex nature of architecture training comprising theoritical and studio based modules (Hasan, Baser, Razzaq, Puteh & Ibrahim, 2017) may be responsible for this incongruent result.

SES likwise influence academic performance of architecture students. Level of study and age were important as older students indicated the lowest positive assessment but higher ratings for conduciveness of the LE (Oluwatayo et al. 2015), collaborating findings from Elegbe (2018). Gender also matters, as males record higher perceptions of the LE than females (Oluwatayo et al. 2015). This trend is echoed by findings from Opoko et al., (2015) which report students' age, gender, access to counselling and occupation of mothers significantly predict academic performance. Entry qualifications, specifically grades in Maths, Physics, Chemistry and the local language (Yoruba) signifcantly predict academic success for architecture undergraduates in Southwest Nigeria (Aluko et al., 2016).

3. Methodology

In order to explore students' perception of LE in the study area, we adopted a qualitative case study approach with elements of grounded theory to explore emerging ideas from the student perspective. The study specifically employed open-ended questionnaires in lieu of interviews because students in previous studies were ill at ease during interviews, often modifying responses to fit what they thought researchers want to know (Maina, 2018). Questionnaires are anonymous. Interviews are not. Modifying responses may be rooted in social practices prevalent in the study area. It is expected that a younger person defers to the wishes of an elder as a sign of respect especially for those in authority. A notable disadvantage of employing open-ended questionnaires in place of interviews however is opportunites to further probe emerging ideas are lost as respondents may only provide answers to stated questions. To mitigate this limitation, respondents were requested to take the questionnaires home, fill them at leisure and submit same to their class representatives within two weeks.

Cresswell (2014) suggests employing 20-30 people for case studies and grounded theory. Questionnaires were randomly distributed to 40 respondents, an average of 8 per class across five

levels in the department just prior to the second semester examinations late in October 2018. This is when students are most likely in school preparing for examinations. The slightly large number for a qualitative approach was choosen to make up for the possibility of low retrieval rates, considering respondents had been instructed to return questionnaires within two weeks. The 300 level class was away on mandatory Student Industrial Work Experience Scheme (SIWES) and did not form part of the survey. This is another limitation of the study. A total of 31 (76%) questionnaires were returned.

We designed the questionnaire in two sections. The first elicits demographic information regarding level and gender, two significant variables recurring in literature reviewed on the relationship between LE and academic performance for students of architecture (Oluwatayo et al., 2015; Opoko et al., 2015). The second section requested a description of how LE in the department influences academic performance and behaviour (Ibem et al., 2017). The procedure employed to content analyse responses, based on Lune and Berg (2017), is presented below.

1. Responses were collated verbatim into a word document with relevant demographic data. These usually comprise several sentences stating opinions about LE, academic perfomance and behaviour/actions. Corrections to obvious spelling errors were effected by the second author and verified by the first to improve readability of responses. Such corrections are denoted by [sic].
2. We then grouped the sentences into phrases containing a single idea or expressing a thought, in line with Lune and Burg's (2017) definintion of content analyses being 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). We employed phrases as units of analysis because multiple phrases within a single sentence often relate to different ideas (see example in Table 1). This was the first stage of coding.
3. We colour coded responses based on themes for easy identification (Table 1)
4. We subjected the entire document to this process three times to ensure agreement and congruency of classification. Responses from two female respondents were taken out of the analyses as these focused on ideal LEs and not what it currently is in the department. We identified a total of 81 phrases in the document. These form the basis of all analyses in the study.
5. Sub-themes were inductively derived from the three major themes based on similarity of ideas, thought and synonyms in the second stage of data coding (see Table 1 for example). Some sub-themes were subsequently merged, for example Socialisation, Interaction and support as many responses contained related words and ideas.
6. Frequencies of occurrence of sub-themes are presented as numbers of phrases, with percentages expressed within brackets (%).
7. Findings from these processes are discussed within results and discussion sections in suceeding paragraphs.

Table 1 Coding employed for content analyses

Level	Gender	Response	Theme	Sub-theme
100	Female	• The learning environment in the department has influenced me to be getting along with others	• LE	• Socialisation
		• Especially by sharing ideas, helping me get through difficult home and class works.	• LE	• Interaction/support
		• I think academic performance is based on one's personal effort,	• Academic performance	• Academic Performance based on self effort
		• Behaviourally [sic], the learning environment has made me to be more flexible and cheerful.	• Behaviour, actions	• Positive behaviour
		Legend: LE Academic Performance Behaviour		

4. Results and Discussion

4.1 Results

Results from the demographic section of the questionnaire illustrate students from 200 level returned all questionnaires distributed within the class (N 8, 26%). The fact that one of the authors takes a course for that level likely influenced retrieval rates, supporting our earlier assertion that authority influences completion of tasks and modifies responses in the study area. Retrieval rates were also high for 400 level and MSc II and lowest for 100 level and MSc I (Figure 1). Students in higher levels are familiar with the importance and implications of research, unlike their 100 level counterparts who have barely spent a year within higher education institutions (HEIs). This result supports Oluwatayo et al.'s (2015) finding that level of study (and by implication age) is an important variable for assessing LE in architecture education.

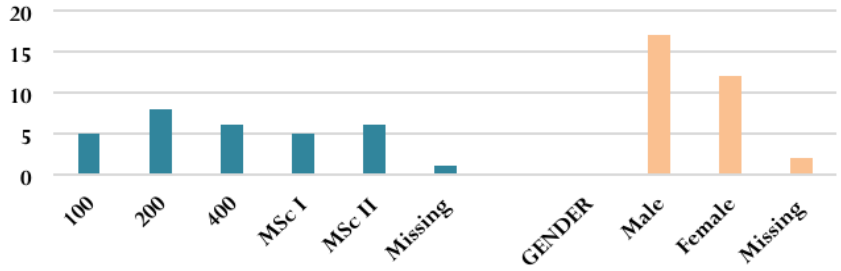

Figure 1 Data in percentage for level and gender of respondent
s

The first stage of coding revealed that students described the influence of LE on academic performance and behaviour into these three categories. LE elicited the highest number of phrases (39). Comments on academic performance (33) closely follow. Behaviour and actions, with nine (9) phrases, recorded the lowest frequencies (Figure 2).

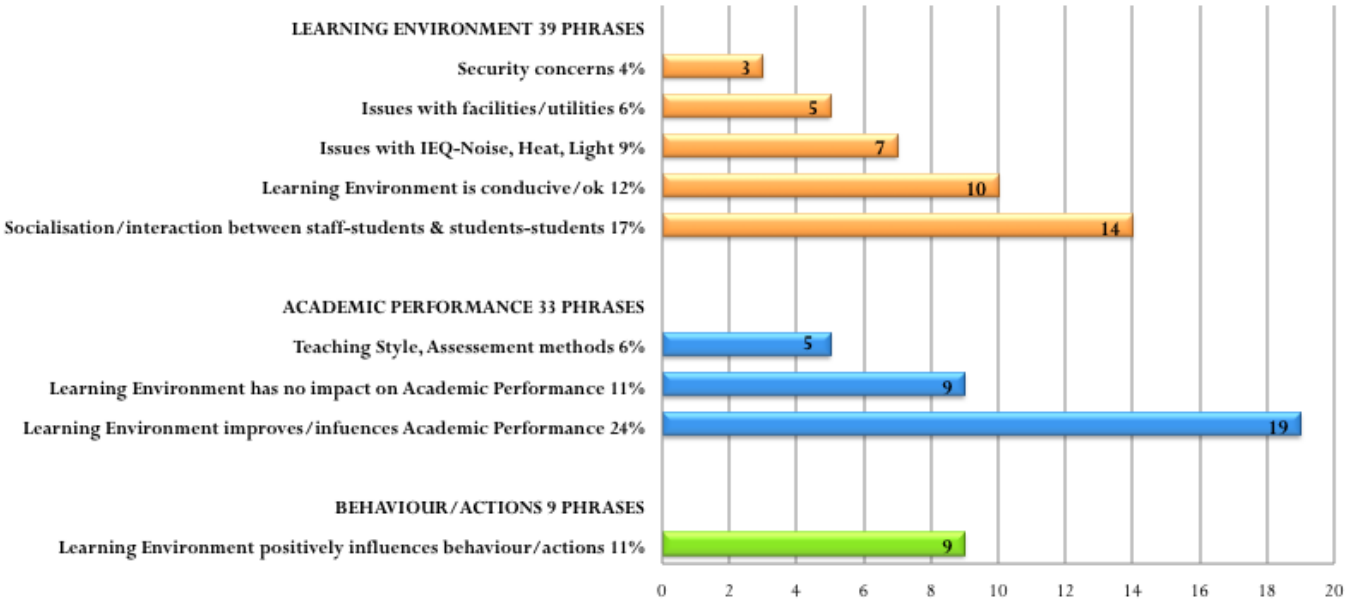

Figure 2 Frequencies of themes and sub-themes derived from phrases regarding influence of LE on academic performance and behavior

Results from the second stage of detailed coding indicate comments regarding positive influence of LE on academic performance record the highest frequencies (N 19, 24%). These account for almost a quarter of all responses (Figure 2). Comments on relationships, notably socialisation between students and staff as well as student-to-student interactions (N 14, 17%) follow these. Conduciveness of the LE (N 10, 12%), LE having no impact on academic performance as well as positive influence of LE on behaviour both record frequencies of 9 (11%). Comments out of these categories, which record lower frequencies focus on negative aspects of the LE in need of improvement, notably facilities and utilities, teaching style and assessment methods as well as security concerns (Figure 2). Overall, responses about socialisation and interaction occurred more in lower level undergraduate levels in contrast to

inadequacy of facilities notably classrooms and library frequently stated by masters students.

4.2 Discussion

4.2.1 LE Influences Academic Performance

Students generally associate academic performance to LE as this category of sub themes recorded the highest frequency from our data. This finding lends credence to studies ascribing a direct relationship between LE and academic performance such as Ibem et al., (2017) as well as Ellis and Goodyear (2016). Several respondents note

> *"The learning environment is very conducive and for that it helps the students to do well in their academics"*
> *"The environment is very conducive for a good learning environment it really helps [sic] us to understand the real concept of architecture in our life"*
> *"The department of architecture has a well-structured living [sic] pattern for the studio, with reasonable times and hours attached to it"*
> *"The learning environment is 70% conducive for learning"*
> *". . . the departments learning environment is encouraging"*

Despite such statements, nine students indicate that LE has no impact on their academic performance. This accounts for 11% of total phrases employed for the analyses. These respondents often ascribe academic performance to personal effort. With the exception of one female, this category of comments all came from male respondents.

> *"The environment has little impact on my academic performance as personal feeling and motivation plays a greater role in academic performance"*
> *"My performance [sic] is based on my hard work not on the learning environment"*
> *"The learning environment is good but not at its best state, it doesn't affect or influence my performance"*
> *"The learning environment in the department is okay. It has nothing to do with my academic performance"*
> *"I think academic performance is based on one's personal effort"*

Results from this sub-theme suggest that while LE is perceived to directly influence academic performance, other variables likely mediate this relationship. In other words, the fact that LE is conducive on average may not always translate to better academic performance per se, controlling for other variables.
Several authors have investigated the role personal motivation plays in academic performance. Geiger and Cooper (1995) found students who take personal responsibility for their performance perform at higher levels than those who attribute success or failure to other individuals and circumstances. Similarly, Fernando's 2017 study established self motivation as the most determinant factor of academic performance among undergraduates of Management and Commerce at a university in Sri Lanka. Self motivation, according to the study accounted for 46.4% of the variance. This trend was also echoed by Sugahara and Boland (2014), who report self effort, not lecturer qualities or lecture attributes constitute key drivers of academic success among 183 postgraduate students in Accounting Schools in Japan. Salmi and Thuneberg's 2019 investigation of sixth graders in Finland revealed that motivation in learning science was related to how autonomous students feel. Authors note, "the most important enhancer of situational motivation was liking science learning in school but this was true only among boys" (p. 43). In our study, all but one of such emphatic statements on self-effort comes from males. This observation suggests that independence and autonomy related to the male gender may be responsible for academic success and not necessarily LE.

4.2.2 Social Interactions Mediate LE And Academic Performance

In support of the hypothesis put forward at the beginning of the paper, results from the second highest frequently occurring sub-theme suggest that socialisation and interactions mediate the relationship between LE and academic performance, at least for architecture students. This is may be related to the nature of the architecture curriculum organised around design studio characterised by interactions and critique by both peers and mentors (Oh, Ishizaki, Gross & Do, 2013; Bashier, 2014; Megahed, 2018). Social interactions and relationships can not be divorced from studio based programmes. Respondents note:

> *"The learning environment influences academic performance by allowing students of lower classes interact with others of higher classes thereby acquiring much more knowledge better than the one taught"*
> *"The diverse nature of people help us the students to learn a wide variety of things whether consciously or not ideas are just passed"*
> *"Behaviour [sic] being [sic] the department collected all together in one building for both staff and students have made it possible to have easy interaction and moderation"*
> *"The learning environment encourages student networking and this is important for me because I am influenced by the work and progress of my colleagues"*
> *"The learning environment is 70% conducive for learning as there is good lecturer-student relationship and also good student-student relationship. This encourages team work and hard work and broadens the students' horizon"*

Influences of mediating variables are not uncommon in literature related to academic performance and learning. Dixson et al. (2017) report personal attitude of a student mediates academic performance and SES and that high hope and motivation of an individual is capable of overcoming disadvantages of low SES. Thomas, Pavlechko and Cassady (2018) likewise report relataionship between instructor effectiveness and academic engagement was partially mediated by influences interactive learning spaces exerted on activities implemented in class. In our study, we find socialisation and interaction capable of boosting morale towards better performance. This is especially true for undergraduate students.

With increasing focus on interactions and collaborations globally, it is worthy to note that LE in HEIs can be maximised with the right atmosphere and environments that foster interactions and social relationships. Several authors allude to the fact that the non-tangible aspects of LE, notably socialisation and interaction are critical to knowledge diffusion (Matthews, Andrews & Adams, 2011; Gebhardt, 2014) as well as knowledge sharing behaviour (Appel-Meulenbroek, de Vrie & Weggeman, 2016). This is especially pertinent in our study context where informal social interactions are part of the cultural set up in northern Nigeria (Maina & Dauda, 2017). Perhaps due to its prominence in everyday informal activities, the role socialisation plays seems muted and under researched within formal and academic environments. Precise mechanisms and pathways socialisation and interaction mediate LE and academic performance begs further investigation as it is out of the scope of the present study.

4.2.3 State/Availability Of Facilities, Utilities And Teaching Style Also Influence Academic Performance And Student Behaviour

Respondents note other variables likewise influence academic performance from the viewpoint of LE. These include inadequacy of facilities notably classrooms and studio space, IEQ variables, teaching style especially assessment methods as well as security concerns (Figure 2). Results regarding physical conditions of facilities support findings of Ibem et al. (2017) as a respondent noted, *"Physical conditions like temperature, air quality, noise and acoustics do affect learning"* (p. 6282). Despite a number of responses stating adequacy and conduciveness of the LE, students decried inadequacy of classroom spaces, high noise levels, uncomfortable studios in terms of thermal comfort, lecturer assessment methods such as giving tests at the end of the semester when students are already overwhelmed. The finding on physical aspects of LE and influence of IEQ variables on academic performance reinforces earlier findings in the study area by Maina et al., (2018), where quality of natural light in studios, quality of lecturer experiences as well as quality of air in studios were ranked third, fourth and sixth respectively out of a total of 44 variables. Security concerns also pose some challenges.

> *"The classes and studio especially for masters' students should be enhanced to encourage their progress"*
> *"More classes should be provided for MSc students specifically to encourage discussions [sic] within the students"*
> *"Because of inadequate classrooms and unavailability of libraries for studying, students are not in class during study time. This has made me adapt to combining all activities in just one available academic facility (studio)"*
> *"The facilities on the other hand do not encourage me much due to large amount of distraction around"*
> *"The learning environment is quite disturbing"*
> *"So I advise studios to be locked and keys given to responsible person to reduce the nuisance that usually occur"*
> *"But studios can be hot during the day and we don't have much security"*
> *"Am not comfortable with the idea of having test close to the end of the semester. It should be made have way through so that students won't be crashing so many things at the end of the semester"*

These present areas in need of attention by the department. Growing population of students admitted into Nigerian public institutions with an inadequate attendant expansion of facilities (Akhihiero, 2011) means that many facilities and resources, including quality of teaching staff are overstretched. The latter emerged as a problem in a recent study of the department (Maina, 2018). Results also present other intervening variables likely to influence the direct relationship between LE and academic performance.

4.2.4 Need For Socialisation Is Higher At Lower Levels, PG Students Decry Inadequate Facilities

Issues regarding the need and usefulness of socialisation and interaction between students and sometimes staff came from lower level students, while the issue of inadequate classrooms and library facilities were from MSc students in the sample. This finding collaborates reports from Oluwatayo et al., (2015) where perceived support emerged as a possible important facet in LE for architecture students. A similar conclusion was drawn at the University of Ibadan (Elegbe, 2018) where results of interviews wiith students revealed that interpersonal communication was a key variable in student success, particulary for younger students. Lecturers are responsible in creating an environment where students can express themselves beyond discussions and lectures. The need for more interaction in early years is understandable as students are adjusting to a new system they are unaccustomed to away from familiar territory and family. Older students and staff form part of the new LE and thus psychologically, new entrants need adequate support in school. Older students have already acclimatised to the local environment and are more grounded, thus likely to exhibit higher levels of independence and autonomy. The focus of older students in our study on facilities is likely related to research requirements at the end of the program. MSc students specifically need such facilities to complete their dissertations and are more likely to notice inadequacy of learning spaces and facilities.

5. Conclusions

We investigated the relationship between LE and academic performance from the perspective of students of architecture as such studies are rare. We specifically explored evidence from qualitative responses to test the premise that the relationship between LE and academic performance is linear, after controlling for SES and entry qualification variables. Results from content analyses of open-ended questions reveal several key findings.

First, while LE was generally conducive it also influenced academic performance, recording the highest frequency (24%) within sub-themes. This supports proponents of a direct relationship between LE and academic performance. It indicates

that providing a conducive LE influences academic performance positively. This finding justifies efforts by government and other agencies including individuals in realising improved facilities and utilities in Nigerian HEIs.

Secondly, 11% of respondents categorically state that LE does not influence their academic performance, eliciting the presence of other factors notably the role of self or personal effort in academic success and achievement. Evaluating the role self-effort plays in academic performance is beyond the scope of this paper. It presents an area for further investigation, bearing gender as a variable in this discourse as all but one of such responses were supplied by male respondents.

The third finding is socialisation and interaction influences academic performance, accounting for 17% of responses. It suggests relationships with staff and students mediate LE and academic performance, as least for architecture students. This may also be true for other disciplines based on design studio and collaborative programs. Future studies are required to test the accuracy of this finding using a larger and more varied sample. Additionally, university authorities and administrators in HEIs need to strike a balance between providing facilities and the intangible but salient aspect of human support, interaction and socialisation that drive collaboration and innovation. This point cannot be overemphasised especially in public institutions in Nigeria and Sub-Saharan Africa where enrolment rates into HEIs are on the increase (McCowan, 2014). The tendency to focus on providing tangible facilities is high, often at the expense of intangible resources such a staff support for students. This is especially true for architecture schools in public universities.

Fourthly, the need for socialisation was found to be delineated along classes, with lower level students commenting more on its influence on their academic performance than postgraduates. Attention should be paid by administrators of architecture departments to lower classes in this regard to enable them adjust and reduce probabilities of attrition and low academic performance. Importance of student-to-student interaction likewise emerged from our data. Further studies how best to optimise an available, often untapped resource in the form of peer mentoring among students are required to bridge the gap in the need for socialisation and interaction. Teaching staff alone are unlikely to provide adequate support in this regard (Zamberlan & Wilson, 2015). Consequently, consideration for peer assessment rubrics to aid student-to-student interaction and relationships in design-based programs such as architecture are timely. This recommendation echoes calls by Eshun (2016) for future research to establish modalities on peer assessment to provide rubrics for use in studio based programs.

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