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ARTICLE The Impact of Nature, The Teaching and Learning of Elementary Lessons in Students 9-11 Years Old (Case Study: Shiraz Elementary **Schools**)

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ABSTRACT

In today's world some changes have been occurred in human lifestyle, these changes, along with the advantages, have led to a series of disadvantages including their disconnection with the nature. One of the most important areas to re-establish the relationship is the school. The presence of nature at schools, and holding some classes in nature, in addition to meeting the special needs of children causes their separation from those small and boring classes as well as their interest in courses . This study aimed to investigate the role of nature in children's learning. For this purpose, third, fourth and fifth grade classes of 3 schools were held outside the school environment and in the nature in 5 courses. The study is a combinational research and field, indirect observation and library data collection methods were applied, where in the indirect observation, two types of questionnaires were prepared related to the students and teachers and were randomly distributed among 580 students and 50 elementary school teachers. Test reliability was assessed using Cronbach's alpha and it was obtained to be 0.890. The results of this study indicate that the physical place as one of the factors in children's learning has the maximum impact on teaching and learning of children. At the end of the study and by investigating the existing factors in the environment we understood that the expansion of the nature and natural light of it causes the students' interest in lessons in nature.

1. Introduction

Changes in lifestyle and technological advances in the cities, especially in large cities have changed human life. Nowadays the advances caused humans prefer landscaped and nature built environment^[1-2]. This reflects the separation of the human from the real nature while his strong need to it where the children have less daily experiences among these people^[3]. Studies concentrating on children find that environments predominated by natural features are valued most ^[4]. Furthermore, outdoor public spaces providing trees and vegetation are used more frequently by adults and adolescents than are spaces without those features ^[5]. Findings on humans' general preference for nature and greenery imply that exposure to green environments has beneficial effects on humans' restora-

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tion, well-being, and health [6], given that the potential of environments probably depends on people liking the environment^[7]. With regard to the above materials, we can say that nature has an important role in human life, especially children, who have been disconnected from the nature in today's world and this connection is necessary to be re-established. Schools are one of the important areas where children spend many hours of their daily life at important ages of modelling, educability and learning and one of the places to re-establish this relationship.Based on the results of a Scottish study about the training program, learning is a chaotic matter for children and hardly put a simple issue in the way of a predetermined result. And it seems that they understand the world through linking a part of their information to other parts and comparing them with each other and become dependent on events which are felt through rational, physical, emotional, aesthetic and spiritual ways ^[8]. One of the most important factors affecting children's learning is the environment. Learning environment is a cultural, social and physical context where learning takes place. Understand how a learning environment becomes effective, is necessary to design an architectural environment. Effective learning environment is an environment which along with the other effective factors in children's education such as curriculum, teachers and ... has an important impact on education. Although the physical environment of the school is only one of the factors affecting learning; but we can say that it is considered as the most important component in an active learning environment [8-9].

This study focuses on the importance of the nature on children's learning in schools. The study of educational theories indicates the children's educators' interest in the education out of the classroom environment along with the education inside the classroom and the nature as a learning tool has been focused. The nature has a great deal of potential to improve skills in children and can be a proper substrate to foster various aspects of child development and learning. The existence of natural places also leads to spiritual relief, freshness and the sense of belonging to the school environment. The main hypothesis of this study is the presence of nature and natural places, as one of the major factors influencing the growth of knowledge, and children are learning. The subgroups of this hypothesis include the following items:

1. The natural places have a lot of abilities in educating children and the proper design of natural places at schools can improve a part of children's education.

2. The proper designing of natural places at schools could be effective on children's feelings regarding the school environment and their sense of belonging to the school environment.

1.2 Research Method

The main areas of research include the design of educational spaces, and child psychologist. The design of appropriate learning environments and courses in nature are the main purpose of this study. the method of this research study is not in the usual way as the way children perceive and express is different of the adults' understanding, perception and expression, because personality and age characteristics of children caused the use of practices such as test-image (painting) to express their favourite class and school. The use of this type of test is because the children create well mental picture in their favourite spaces, and it increases their learning. Barraza, in relation to children writing from observations surroundings, states that "Children schemes are a powerful tool in providing useful information for evaluating the observations of the surrounding environment". Research method is that math and science classes have been held outside of the school environment, 580 students (as the toughest courses) in 3 chosen schools and each school individually had 6 classes in 5 courses outside the school and in nature. Children reactions and learning in the natural environment and the typical classroom environment have been observed and recorded. And then the students were asked to draw their interesting and effective learning class they have ever had during their education according to their experiments. All plans and drawings received in time and stretched and obtained in the class under supervision of the teacher. Official approval to participate in this research and to use the images has been issued by the school principal and parents. And no other information than the children school year was collected about their background. Then questionnaires completed by 50 teachers and 580 students (280 boys and 300 girls) according to learn and holding classes in nature and the data analysed by using statistical methods and SPSS 20 software.

1.3 Review of the Literature

The importance of educational environments to improve the quality of learning and teaching is obvious nowadays. Many researchers have investigated the importance of designing the educational environment on children's learning in recent years.Researchers such as Tanner also emphasize the need of outdoor places including green areas and its positive effect on learning ^[10]. Recently, school architects and planners have focused on the importance of involving users (children) in the designing process. Bjorklid writes Piaget believes that: "Children should be able to conduct an experiment and a research themselves and gain experience that these issues will be effective in children's learning" ^[11]. This caused the use of innovative approaches in children's education at times. This issue was first developed by one of the educational activists such as Lawrence Sarmin in America, which was developed through combining Steiner's educational model in many parts of the world. Many educators in America have defended the need to abandon traditional practices not only in education, but also in the design of educational facilities ^[12].

2. Theoretical Fundamentals

2.1 Nature Impact on Children

Many children in urban environments do not have access to nature. Many parents prohibit their children from exploring wild natural areas because parents and children have little familiarity with nature, parents have concerns about children's safety, and children experience academic pressures and other demands on their time^[13]. This reduced contact with nature may influence children's development. Empirical research has demonstrated that experiences with nature have a positive influence on children.Davis, Rea, and Waite (2006) suggested that spending time outdoors may help children develop positive values about nature, whereas Wells (2000) suggested that children whose home environments improved the most with regard to greenness after relocation were more likely to have higher levels of cognitive functioning after relocation. Wells and Evans (2003) indicated that natural environments can increase children's psychological well-being. Children whose homes had more nearby nature coped better with life stress than those whose homes lacked nearby natural areas^[14-15].

3. Examining the Methods Used in the Research

As described above, two methods have been used in this study in order to obtain more favourable results. First Method:

1.Children's illustration from their own desired and favourite class they had during their course of study. Second Method:

2.Distributing a questionnaire among 50 teachers and 580 students, and then analysing it.

3.1 The First Method

3.1.1 Participants

Students at grades 3, 4 and 5 (9-10-11 years) in 3 el-

ementary schools (near the park) in Shiraz were studied. The selected age group was recognized as appropriate for the study, because the studies indicate that the symbolic representation usually occurs during the last period of childhood and is Distinguished from "knowledge, insight and ingenuity". Also at the age of 7-9 years, "Children have a raphical language that contains special symbols and the three-dimensional understanding (threedimension-al organization) and at the age of 9-11 they attempt to be more precise".

3.2 The Analysis of The Data

3.2.2 Analysing the Mental Images of Children

There were wide variations in the participants' artistic abilities, but this was not a concern about children's analysis because by observing their behaviour and talking to them about the content of the image, enough descriptions and information were collected. Each design and the interview along with it was encoded by the content in order to determine the common characteristics among the 100 received samples and obtain a through this process. Keywords explored in these images are: place, the school and the desired class, environmental considerations and any special feature including the green area and gardens.

3.3 Interpreting Students' Designs with Regard to Their Talk

Designing the main instrument for children to express their ideas of the best classes they have had in their entire education; talking with the children, along with their drawings provided important information about what they had drawn, which helped a lot to understand and analyze the figurative data. A problem in the figurative content analysis was the interpretation of the contents on the position of the viewer that his history, social and cultural relationships may vary with the artist (student) that this could cause incorrect assumptions and misperceptions. It has been tried not have such an interpretation ^[16]. Interpreting students' designs reveals that they want studying to be mostly fun and in a place that is environment friendly. Their imaginations are involved in colorful and exciting places; and also insist on where they can learn something and be in contact with real life. For example: I think of a happy and colorful school where students enjoy attending the class (male, grade 5). It would be nice if the class is full of colorful flowers (like rainbow) that cause happiness in everyone (male, grade 3). More than 83 percent of students were considering these features in open and natural places. It is clear that students do not like boring classes. Boringness in their schools would eliminate or reduce the interest for learning. The children also preferred to have schools with trees, grass, water and outdoor garden instead of brown, dark and dusty classrooms. These results are consistent with findings of similar researches [17-20] about children who experience their need to space, light and colour in the open space. The key features of an ideal and effective classroom learning of the children include: Playground with framework for climbing, tree houses for classes in the quiet space with water sound, musical sound of nature instead of bells, colourful place for painting, reading and outdoor games, greenhouses for growing fruit and vegetables for consumption and selling them to make money, creative environment full of colourful flowers and large green spaces, oxygen-rich atmosphere ^[21]. These listed issues are parallel with different climatic conditions of Shiraz. According to the students' experience of the class as well as natural environment, they imagine their favourite learning environment in outdoors which is active and full of trees and relaxing. This reflects the desire for children to learn outside of the boring and frustrating classroom. This has been promoted in other countries by educational fans such as the Experiential Learning Centre of John Dewey in America, Neil summer hill school in England, Ivan Illich's de schooling movement^[22].



Figure 1. Children's illustration of their favourite class during their course of study

Source: The authors 2015

3.4 Analysing Research Topics

A wide range of participants (children) in this study held their favourite class and effective learning outside today's close classroom as well as in environmental in nature with direct and palpable education and portrayed as large, happy, exciting and colourful environments and have stressed holding classes in nature due to having experience in this field as their expectations from their favourite custom class space is limited in nature.

3.5 Procedures 2

3.5.1 Questionnaire data Analysis

In this study, two types of questionnaires prepared and distributed between educators and students in four elementary schools, two girls' and two boys' schools and Factors affecting children's learning are investigated in both the questionnaire and the nature of learning, anxiety, fond of children to school, working children. Among students and educators from four schools, 580 students (280 boys and 300 girls) in the third, fourth and fifth grade and 50 teachers (25 in the girls' schools and 25 in the boys' school) have been randomly selected as the study population. The following table shows the number and percentage of students' gender in the chosen levels.

Table 1. Number and percentage of participants

Source: The authors 2015

Educational level	Gender	Number of classes	Number of students	Percent
	girls	6	120	20.68
grade 3	Boys	6	120	20.68
	Total	12	240	41.36
	girls	3	60	10.34
grade 4	Boys	4	80	13.79
	Total	7	140	24.13
	girls	6	120	20.68
grade 5	Boys	4	80	13.79
-	Total	10	200	34.47

Schools that have been selected as the sample in this study have been allocated a range as nature in their yard (trees and plants). Following table analyses the relationship of children and nature outdoor in their school and information have collected by field observations and interviews with students.

 Table 2. Children connection with nature with open space in the school

The performance of students in nature	Number	Percent
Use nature to study	313	53.96
The nature of the game	267	46.03

The above table indicates that 53.96% of children use their environment within school yard with trees and flowers and plants to study. Table 3 is to review and study better outcomes for children by segregation and we came to the conclusion that most of the boys (53.57%) use the courtyard of their school with more trees and plants for game and most of the girls (61%) use their school yard with more trees and flowers for their study.

Table 3. Children connection with nature in the school open air, differentiated by gender

Source: The authors 2015

Gender	The performance of stu- dents in nature	Number	Percent
Davia	Use nature to study	130	46.42
Boys	The nature of the game	150	53.57
Cirla	Use nature to study	183	61
GIFIS	The nature of the game	117	39

3.6 analyzing the data related to students in Nature

This part of the study demonstrates the average weight (the students use of nature to play and study), Single-sample T-test (a test that the average of a community is distribution based on T and analyses that how much an average of a society is more or less than a fixed amount) shows the relationship of students with outdoor nature, that average amount are 4.1947 and 3.8947 for studying and games, respectively. The results were obtained according to the whole 5-item Likert scale (very high = 5, high = 4, mean = 3, low=2, very low = 1). Number 3 in one-sample T-test was selected as mean for school students' relationship with nature in school open space. The results indicate that the average used of nature by students in the study (4.1947) was higher than this value and this represents a significant impact of the nature on the teaching and learning of students.

Table 4. Quantitative table of children connection with nature in the school open air

Source: The authors 2015

The performance of students in nature	Number	Mean	Standard devia- tion
Use nature to study	313	4.1947	.19876
The nature of the game	267	3.8947	.29876

 Table 5. Single-sample T-test quantitative table of children connection with nature in the school open air

Source: The authors 2015

The perfor- mance of stu- dents in nature	Т	df	SIg	Mean differ- ence	95% confi- dence interval of the difference
-	-	-	-	-	Lower Upper
Use nature to study	313	4.1947	.19876		.7196 .8726
The nature of the game	267	3.8947	.29876		.5083 .7135

The aim of the study is to examine the role of nature in teaching and learning of children. Questionnaire assessed factors affecting children's learning at school by using analytical model of study. The following tables reflect the opinions expressed by teachers in the questionnaire.

Table 6. Factors Influencing Children learning at school

Source: The authors 2015

Row	Factors	Mean	Standard deviation	Total
1	Physical space class	4.1525	.84718	50
2	Children interact and collaborate with each other	4.1356	.81912	50
3	Children's sense of attachment to class	4.0000	.85096	50
4	Anxiety	3.9661	.92785	50
5	Children com- municate with teachers	3.7966	.82587	50

According to the table above, we came into the conclusion that physical space and physical classes have the highest effect than other factors with an average of 4.1525. Then the interaction and cooperation of children with each other, a sense of belonging for children to class, anxiety, relationship between children and the secretary are the other factors that affect student learning.

3.7 Analyzing Questions Related to the Questionnaire, Holding Classes in Nature in 5 Periods

It was concluded by above investigation that physical space of class is effective on children's learning. So keeping in mind the purpose of this study (the role of nature in learning and education), classes in science and mathematics (as the most difficult courses) were held in nature (on 5 second semester of students). We analysed the effect of nature on factors affecting children's learning. According to teachers, an interest in challenging courses among students is more with their presence in nature and outside of the boring and dull classroom. In order to a more favourable result among students, we separated the questionnaire between girls' teachers and boys' teachers and the top result was true among girls and boys, separately.

 Table 7. The role of the nature of the factors influencing children's learning

Source: The authors 2015

Row	Factors	Mean	Standard deviation	Total
1	Anxiety	4.1000	.86944	50
2	Distractions	3.7831	.85066	50
3	Interest in the lessons	4.2186	.89266	50
4	Cooperation children	4.1317	.81493	50

 Table 8. The role of the nature on the factors influencing girls' learning

Source: The authors 2015

Row	Factors	Mean	Standard deviation	Total
1	Anxiety	4.0000	1.05045	25
2	Distractions	3.9831	.88066	25
3	Interest in the lessons	4.1186	.87266	25
4	Cooperation children	4.1017	.86493	25

 Table 9. The role of the nature of the factors influencing boys' learning

Source:	The	authors	2015
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Row	Factors	Mean	Standard deviation	Total
1	Anxiety	3.4068	1.05240	25
2	Distractions	3.4576	1.13445	25
3	Interest in the lessons	3.5862	1.02657	25
4	Cooperation children	3.7797	1.14572	25

The survey indicates that the nature has significant relationship with students' interest in teaching and learning. For further proof, single-sample T-test was used in this context and number 3 is selected as the middle of factors affecting children's learning in nature. Calculations show that each of the factors influencing children's learning in nature was higher than this amount.

Table 10.	One sample T-test Table for the role of nature in	n
the	actors affecting learning in boys and girls	

Source: The authors 2015

				95% confidence
Row	Т	Df	SIg	interval of the difference
Girls	-	-	-	Upper Lower
1	10.450	25	.000	1.3733 .9318
2	8.442	25	.000	1.1226 .6063
3	6.703	25	.000	1.1532 .7112
4	6.367	25	.001	1.0470 .5462
Boys	-	-	-	Upper Lower
1	10.649	25	.000	1.3733 .9310
2	4.392	25	.000	1.1226 .6063
3	3.227	25	.000	.1532 .71121
4	4.205	25	.001	.5462 .8256

3.8 Statistical Analysis, Chi-square Test

To prove the hypothesis by citing the questionnaires, by using the chi-square test, we should find a significant relationship between the role of nature and children learning concepts and emotions and a sense of peace and belonging towards the school environment. The results of the test between two variables of nature and interest to teach the students shows the correlation coefficient as 0.683 and a significance level of .000. as the significance level is less than 0.05 level, we have enough evidence to reject the null hypothesis and conclude a significant positive relationship between nature and the students' interest in learning and in fact the presence of students in nature makes them to find an interest in challenging courses, followed by increased learning and thus the first hypothesis is accepted. Maximum correlations, based on the role of nature on anxiety, distraction, information exchange and cooperation, were 0.676, 0.657 and 0.528, respectively, with significant levels of 0.000, 0.000 and 0.001. It can be said that the significance level is less than 0.05 as sufficient level, therefore the null hypothesis is rejected, and it can be concluded that there is a positive and significant relationship between nature and anxiety, distraction, exchange of information and children cooperation. And the second hypothesis will be accepted as concerning the effects of nature on a sense of peace and belonging to the school among children.

Table 11. Evaluation of the correlation coefficient and
significant level of the impact of the nature on learning
factors

Source:	The	authors	2015
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Row	Factors	Correlation coefficient	Sig
1	Nature impact on anxiety	.676	.000
2	Nature impact on distraction	528.	.000
3	The effect of the nature of the in- terest to lessons	.683	.000
4	Nature impact on cooperation children	.657	.001

The following table generally is using a correlation coefficient of 0.772 and a significance level of 0.000 (significance level less than 0.05 level) which shows the relationship and the role of nature in children's learning.

Table 12. Correlation coefficient and significant of theimpact of nature on learningSource: The authors 2015

Factors	Correlation coefficient	Sig	_
Nature impact on learning	.772	.000	

When the correlation coefficient is between 0.50 and

1.00, in this case, the correlation is strong. So according to the above tables and the amount of solidarity, a strong correlation between the factors affecting learning with nature can be seen. The table below examines the factors in the environment from the perspective of teachers and students and we conclude that the size and extent of nature is one of the most effective factors in nature.

 Table 13. Analysing Factors in the environment and effective on school children learning

Source: The authors 2015

Row	Factors	Mean	Correlation coefficient	Total	
1	Light	3.8644	.99060	50	
2	Color	3.9322	.80653	50	
3	The materials used in class	4.0000	.85096	50	
4	Class size	4.1356	.81912	50	

By separating the questionnaires between girls and boys we concluded that boys' school believe the extent of space, as one of the factors in the nature, has the greatest impact of their learning. Girls' schools believe that light, as one of the factors in the nature, is the most effective factor on their learning.

 Table 14. Analysing the factors in the environment and effective on boy students' learning

Source: The authors 2015

Row	Factors	Mean	Correlation coefficient	Total
1	Light	3.4915	1.04011	280
2	Color	3.5593	1.02168	280
3	The materials used in class	3.6271	1.04878	280
4	Class size	3.7119	1.14547	280

 Table 15. Analysing the factors in the environment and effective on girl students' learning

Source: The authors 2015

Row	Factors	Mean	Correlation coefficient	Total
1	Light	3.6102	1.06701	300
2	Color	3.3559	.96065	300
3	The materials used in class	1.25060	3.5254	300
4	Class size	1.04011	3.5085	300

3.9 Research Reviews and Discussions

According to the obtained results and analysis, it can be concluded that the presence of students in nature increase their interest in studying as one of the factors affecting learning in comparison with other factors (anxiety, distraction, cooperation and information exchange students, student liaison with the players). This can be a very important factor in learning and education. Natural light and space in the class as natural factors will cause students to be interested in challenging courses and their learning, compared to boring and dull and small classes, will increase in nature.

4. Conclusion

Information obtained in this study lead us to conclude that physical space of class has the greatest impact on children education as one of the factors affecting student learning. So by creating an outdoor classroom we can see tremendous impact of nature as a suitable space for classes as well, because the nature is one of the most important factors in generating interest among students and therefore increases the lessons they are learning. Studies have shown that features found in nature, such as the expansion of space, and natural light enhance the students' learning. Holding classes in nature or creating natural spaces in the class and school, in addition to a positive impact on children's learning, will be able to meet the needs of specific groups of children. These needs include: (1) the needs of educational, social and psychological development 2. Emotional needs and physical growth. Meeting the needs, will change physical environment of class into effective environmental for education of children. In the first group, the natural spaces should be suitable to children's cognitive development with the aim of increasing knowledge and learning. In the second group, the space should be natural for social and physical growth of children. Social spaces are designed in natural environments, offers interaction and communication and a platform for students to deal with each other and creates collective and individual children's playgrounds which cause noticeable social and physical growth. In the third group, the natural spaces are designed in combination with artificial spaces and create visual elegance with the aim of creating a beautiful surroundings to create a sense of belonging for children. By analysing the questionnaires, it can be said that two research hypothesis include: 1. natural spaces has many capabilities for the teaching and learning of children, and proper designing of natural spaces in schools can improve part of children training. 2. The proper design of natural spaces in schools could make children feel a sense of peace and belonging to the school environment which has been approved and indicates that the nature has an important role in teaching and learning of children.

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ARTICLE Benefits of Viewing Nature: A Review of Landscape Health Research

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1. Introduction

1.1 Nature and Health

No matter where we come from in this world, viewing natural landscapes seems to make us feel good. Several ways can be used to view nature: the first is viewing nature through a window; we often spontaneously view natural landscapes in this way, and we may not even realize it; the second is on television, in a painting or in a book; the third is being with the presence of nature (e.g., in a forest or in a normally nearby nature). This essay provides a general description of the relationships of viewing natural scenes with mental and physical health and cites certain previous studies to support it.

The belief that viewing vegetation, water, mountain, and other natural elements can reduce stress and be fa-

ABSTRACT

Nowadays, several studies demonstrate that viewing nature has positive effects on human health and well-being. This essay discusses about the essential methods of viewing natural environment and their impacts on human well-being by clarifying four important theoretical models: reducing stress, lowering heart rate, improving outcome of surgery, and increasing attention. In addition, some important research results in this field are taken as examples to introduce research methods. By collecting and organizing existing studies and theories about the relationship between viewing nature and human well-being, the methods of viewing nature can be divided into two parts: viewing nature through specific media (e.g., through a window, a book, a painting or a videotape) and being with the presence of nature. This study aims to clarify the research significance of viewing nature and find deficiency in this field to maximize the role of landscapes in human health and well-being.

vorable to patients in the healthcare environment can be traced back to some earliest large cities, like Persia, China, and Greece. In the Middle Ages, the first hospitals in Europe were infirmaries in monastic communities where a cloistered garden was a fundamental part of the environment used to bring relief to the ill ^[1]. In history, the relationship between nature and healing has been replaced by the increasing number of technical approaches, and the idea that access to natural environments can help recovery has lost its significance ^[1-2].

Whereas, in the last 35 years, these traditional methods of connecting nature to healing have gradually reemerged as an important topic in the field of human health. Relatively rich studies have been conducted to help explain the methods of nature, and other environments have an effect on human health. Several theories and approaches have been proposed for explaining and evaluating the effect of

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natural scenes on human health. Ulrich's stress recovery theory is a relatively convincing theory, which suggests that natural scenes is beneficial to reduce stress, whereas settings in the built environment is favorable to hinder recovery from stress. Another theory states that people have a common innate bond with nature, which implies that certain kinds of contact with the nature may be directly advantageous to health ^[3]. Some studies have shown that health benefits related to experiencing nature is based on the opportunity to notice and observe nature, rather than participating in natural activities ^[4]. On the basis of the discussion about four important theoretical models and the elaboration of research methods by using three concrete studies, this essay categorizes the ways of viewing nature: viewing from the window (without being exposed to natural environment) and viewing in natural environment. The essay also points out the deficiency of the current research in this field.

2. Four Important Theoretical Models

2.1 Viewing Nature Contributes to Reducing Stress

Wells and Evans ^[5] noticed that children aged 8-10 years old, who are exposed to indoor and outdoor vegetation in five upstate New York communities, are relatively less stressed out and more easily to get recovery from stressful events than those who live in homes with little green space ^[5].

Xinxin Wang et al.^[6] revealed that urban parks offer great opportunities for people to enhance their physical health and psychological well-being. After finishing an oral examination as a stressor, participants were randomly assigned to watch one of the seven videotaped scenes during a stress recovery stage, including six urban parks and one urban roadway scene, and data were collected based on the changes in stress and attentional levels. The results suggested that people may increase the stress recovery potential of urban parks when the numbers of nature-based elements and reduced crowds are high ^[6].

2.2 Viewing Nature Contributes to Lowering Heart Rate

A study of the effect of observing natural scenes on the physiological and psychological health of middle-aged hypertensive men has an interesting finding. The restorative effects of exposure on the forest environment were researched. Middle-aged hypertensive men were assigned to sit on chairs and viewed forest scenes for 10 minutes. The results suggest that parasympathetic nervous activity was much higher while viewing forest, whereas heart rate was much lower while viewing forest, implying that forest landscapes can produce the benefits of physiological relaxation on hypertensive men^[7].

Another study of the function of viewing natural scenes on the physiological health of aged women also shows similar results. A quasi-experiment was conducted to measure the physiological characteristics of aged women when they observed different landscapes. Heart rate and blood pressure were monitored when aged women viewed a natural landscape, a built landscape, and a control room with no outside views. The results suggest that observing the natural landscape made for lower systolic and diastolic blood pressures and lower heart rates than those measured in the control room. Observing the built landscape also had the universal effect of lowering blood pressures and heart rates, although the effect was less consistent, and the magnitude was smaller than that induced by viewing the natural landscape ^[8].

2.3 Viewing Nature Contributes to Improving the Outcome of Surgery

Records show that between 1972 and 1981, the recovery of patients from cholecystectomy in a suburban Pennsylvania hospital was tested to find out whether a room with a window view of a natural landscape can have restorative effects. Twenty-three surgical patients were arranged to rooms with windows where they can view the natural landscape. These people commonly had shorter postoperative stay, got less negative evaluative comments on nurses' notes, and used less analgesics than the twenty-three patients who stayed in similar rooms but without windows ^[9].

Diette et al. ^[10] found that pictures and sounds of nature have great benefits to patients. One group of patients was equipped with a landscape picture to view and listened to the sounds of birdsong and a brook before the operation of bronchoscopy. This group showed a 50% higher level of good or excellent pain control than those who were not equipped with pictures and sounds. It implies that more natural features can be equipped in operation rooms to help improve the outcomes of surgeries in the future ^[10].

2.4 Viewing Nature Contributes to Increasing Attention

A theoretical view suggests that the individual's ability to concentrate may become fatigued when the need for attention increases. Once fatigue occurs, attentional restoration must have a response, and it can be promoted by looking at nature. This view was explored in detail in a previous study, which explored whether college students who live in dormitories with more natural scenery outside the window are score taller than students in dormitories with less green views in a directed attention test. According to the views from the dormitory windows,72 students are divided into four groups, ranging from nature to the built. A variety of objective and subjective measures were used to assess direct attention. The result supports the proposed theoretical view, that is, natural views have positive effects on promoting directed attention ^[11].

Another study supports this finding to an extent. It focuses on examining whether observing nature pictures can improve executive attention in adults. The results show that, according to the results of the attention network test, viewing nature rather than urban pictures can greatly increase the executive attention of the young and older adults, and the effects observed in the two control groups are similar. The scores of alerting and orienting attention are unaffected by picture viewing ^[7].

3. Research Methods

3.1 Study 1: Stress Recovery Effects of Viewing Urban Park Scenes

Wang et al. ^[6] discussed the stress recovery effects of viewing different videotaped scenes, including natural and urban scenes. Although several studies have demonstrated that natural landscapes are beneficial to human health and wellbeing, few of them have seriously measured the restorative effect of specific landscape elements in Chinese environments. The urbanization in China brings many hardscape elements in cities; thus, exploring the restorative quality of urban green space is a significant issue. This study mainly covered the stress recovery capacities in different videotaped scenes consisting of six urban parks and one urban roadway scene. In this study, participants were recruited from the Architecture College, Tongji University. A total of 140 students aged 18-24 years old from this university were involved in this experiment. Considering that it is a public university, more than 90% of them coming from the area outside Shanghai. Moreover, these students are from 16 different disciplines, and all of them have been attending the university for more than one year. They (one half of male, one half of female) were randomly assigned to complete the experiment, watching one of the seven videos (20 subjects watched each scene).

A total of 76 urban parks were investigated in preparation for the study, which are located in the high-density districts of Shanghai. Before selecting the six representative parks from the sampling frame, all 76 parks were catalogued. Two types of parks exist: 14 municipal-level urban parks and 62 district-level urban parks. Municipal-level parks serve people in the whole city (average 19.39 ha), whereas district-level urban parks serve people in the adjacent neighborhood (average 2.85 ha). In these potential sites, municipal-level urban parks were found numerous in different kinds of natural environments, and they are better maintained than district-level parks. In addition, the management and whether they have visible water feature were considered.

An urban roadway was selected to make a comparison among the scenes of urban parks, which have a similar openness to the scenes of the park in this research. This road was not served for recreational uses, as shown in urban parks, but it is common in high-density cities, such as Shanghai. This kind of road is generally viewed by highrise buildings residents in China.

This study took a previous videotaped approach as reference ^[12], simultaneously recording video audios and images on sunny days in April and May 2014. The video was taken at several different edges around each site, and some people were recorded in the video. Finally, an eight-minute colored video was made. The decision of making an 8 minutes video was referred to previous studies ^[13-15]. In the pretesting, some participants showed impatience at the 10-minute mark, and few impatient participants were noticed in the eight-minute video.

This study conducted an 8 minutes timed English speaking examination as stress induction. All of the participants speak English as a foreign language. Karmanov and Hamel ^[12] used examinations as stress induction. Meanwhile, Salehi and Marefat ^[14] and von Wörde ^[17] found that students feel stressed when speaking in English or other foreign languages. The examination in the study was administered by a computer during the whole process, and the participants were required to obey the instructions of an examiner who speaks English only.

Stress level has two major measures: physiological and psychological indexes. Physiological indexes include skin conductance response (SCR) and R-R interval. Skin conductance is a common measure of stress. Higher conductance indicates higher stress levels. In this study, a wireless device (Biopac MP150) was used. Participants were asked to wear a special shirt, which is equipped with a transmitter, allowing them to freely move their bodies during the experiment. Electrocardiography was also used to produce electrocardiogram (ECG), a graphic that traces the electrical activity of the heart. The longer the R-R intervals, the slower the heart rate, and vice versa, suggesting increased stimulation or stress. Psychological indexes consist of health status, state anxiety, attention, restorativeness, and experience. Health status data were taken from the questionnaire, which used a five-point Likert-type response set. Participants were asked to rate their health condition and their frequency of suffering from physical illness. Some questions about emotional problems and whether such problems influence their social activities were also involved. State anxiety data were collected using the State Trait Anxiety Inventory (STAI-S) ^[18-19]. Considering that data from ECR and SCR can only measure the emotional changes of participants, such data cannot be used to distinguish subtle emotions, such as anxiety, anger or excitement, all of which can influence heart rates. Attention data were collected using the Digit Span Backwards (DSB) test ^[20], which can evaluate the attentional level of participants by asking them to recall a set of numbers accurately. Although the effects of stress reduction and attention restoration have some common characteristics and can be regarded as synthesized outcomes, they belong to different theories: stress reduction theory and attention restoration theory. The data of restorative effect and experience were collected using the perceived restorativeness scale (PRS). It has been extensively used as a tool for measuring the restorative quality of physical environments [21-22].

Upon entering the laboratory, the participants were given a printed sheet, which introduced the goals and measures of the experiment. When filling out the sheet with their information (including health status), the researchers attached the sensors to the participants. The participants were seated on a chair at that time and were given 2 minutes to adjust the device on their bodies before conducting the ECG and SCR tests. They were also asked to sit for three minutes for recoding baselines. During the stress and recovery stages, all intervention stimuli were delivered on a 19-inch computer monitor. The stressor "mock English speaking examination" lasted for eight minutes on the monitor. Subsequently, the video directed participants to conduct the DSB test, which took about 3 minutes.

During the recovery stage, each participant watched one of the videos for eight minutes.

ECG and SCR measures were monitored throughout the stress and recovery stages. When the recovery stage was completed, the second round of the DSB task started. The participants also performed PRS test and STAI-S tests to show their emotional changes before and after watching the video.

The reason why this article was selected is because it has a well-designed experiment and introduced many common measures for researching about viewing nature. Both factors are beneficial for the further research on this topic.

This study has good points. First, the sample size, that is, 140 is large. Second, the Pretest-Posttest Control Group was used. The sample was randomly selected, which makes the findings convincing. Third, the procedure was described in sufficient detail, which is beneficial for another researcher to repeat the investigation for further advancement.

However, the limitation of this study is that a selection problem exists. Only one semi-enclosed scene, walkway, was included. Therefore, fully exploring the differences in the restorative effects between open and semi-enclosed space is difficult. Further research can be organized to include a systematically varied range of scenes with different degrees of openness ^[6]. In addition, given that the sample included all university students who have the same age range and same educational background, the research findings cannot represent the people from all walks of life. Future studies are supposed to include people of different ages, especially elders with reduced functional abilities who are greatly different from the age group tested here ^[23]. A wide range of educational backgrounds can also be included in future research as Yu^[24] pointed that there are remarkable differences in landscape preference among different educational levels in his study.

3.2 Study 2: Physiological and Psychological Effects of Viewing Urban Forest Landscapes

Tsunetsugu^[25] measured the physiological and psychological influences of viewing urban forest landscapes in Japan using multiple methods.

Abundant studies have demonstrated the connection between contact with nature and good health to a considerable extent ^[26]. Nevertheless, green space's health benefits are still not fully accepted in urban planning and decision-making ^[27].

To raise the awareness of such an issue in urban planning, to evaluate the health benefits with credible measurements and providing sufficient evidence are necessary. Some reviews have indicated that quantitative data and controlled studies are lacking, although green areas and relevant interactive activities are recognized as sanative settings. Therefore, scientific research is essential to enhance the position of health benefits brought by nature in the governmental decision-making process ^[28]. Several studies have gotten down to this requirement. Some previous studies have reported that visiting forests has more significant positive effects on low blood pressure and pulse rate than urban settings. However, these studies have only treated with a small group of subjects or only targeted psychological responses. Therefore, this research explored the physiological and psychological responses to natural and urban settings in a larger group than previous studies. This study aims to find evidence for incorporating green space in urban design and planning by clarifying the influence of the two different settings. This research also focuses on two questions: (1) are there differences in the influences of environment between forested and urban environments? And (2) are there differences between shortterm visits in accessible forests and long-period visits in the same settings?

The studies were implemented in four areas in central and western Japan (e.g., Kamiichi Town, Yoshino Town, Akiota Town, and Oita City). In each area, participants needed to visit two experimental sites: a forest site and an urban site. The forested area is among the important recreation areas in the local municipalities with 800-34,225 ha. The downtown area is located close to the commercial center of each town and city. Conifer species mainly populated two of the forest views. For the two other forest views, one was dominated by deciduous tree species, whereas the other had a view of a small lake combined with a forested landscape. No buildings or roads were found in the forested areas, except the spot facing a trail in Akiota. Every urban view consisted a road where traffic passed at a rate of 10-45 cars per minute. The studies took two days in different areas and were taken in August or September in 2011. 12 male university students (21.1 \pm 1.1 years old) took part in each experimental area, hence a total of 48 subjects. They were assigned in the morning of the first experimental day and signed an informed consent. Half of them were assigned to the experiment in a forested setting, whereas the rest was tested in an urban setting on the first day. The participants took a bus to each site; the ride took approximately an hour to an hour and a half. In the experimental sites, each participant waited in turn to take part in an individual viewing session. When the time came, each participant was asked to fill in the Profile of Mood States (POMS) questionnaire, which evaluates the following six mood states: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Fatigue, Confusion, and Vigor. After riding a car to a viewing spot to view a landscape for five minutes, each participant took a five-minute rest and underwent a camping chair's physiological measurements. Subsequently, they were asked to sit to view the landscape for 15 minutes. The physiological measurements consist of the continuous measurement of the periods between two consecutive heartbeats (AC-301A, GMS Corporation) and the measurement of systolic blood pressure and diastolic blood pressure (HEM1000, Omron). After the 15-minute viewing, each participant experienced another blood pressure measurement. Three different questionnaires followed the physiological measurements: a subjective rating of the levels of comfort, sedation, and naturalness; the state of being refreshed; and the POMS. On the second day, the participants visited the opposite area to exlude the effect of order.

This study has good points. First, its purpose was clearly defined, and some common concepts were used. Second, the research design was suitable to answer the research questions. Third, methods to control relevant confounding variables were applied. For example, in the experimental design, participants were designed to visit the opposite area to eliminate the influence of order.

However, this study has certain limitations. First, each participant visited forest and urban areas only once for a short time, which induces the influence of repeated visits, and long-term effects remain unclear. Second, the participants purely comprised healthy young males. Therefore, whether the results can be generalized to different groups of people, such as children, seniors, females, and patients, is unknown. According to the authors' statement, the most direct solution to this problem is to conduct further research to ascertain diverse groups' effects. We can also speculate from previous studies, such as Ulrich ^[9] who focused on hospitalized patients and Matsunaga, Park, Kobayashi, and Miyazaki ^[29] who targeted on seniors.

3.3 Study 3: Psychological Benefits of Indoor Plants in Workplaces

Bringslimark ^[30] attempted to discuss the potential benefits of indoor plants in a broad workplace context. Several studies have examined the positive effects of indoor plants on outcomes such as psychophysiological stress and ill health's task performance. However, these studies mainly focus on the value of indoor plants in work settings, and other reviews about how the effectiveness of plants may compare with those of other workplace characteristics must be conducted.

This study performed hierarchical regression analyses to evaluate the relationships that plants and several often-studied workplace factors have with perceived stress, sick leave, and productivity. Other variables, such as gender, age, physical workplace factors (air quality, temperature, lighting, noise), and psychosocial workplace factors (demands, social support) are also included in the study models. Relevant data were obtained from a questionnaire survey in which 385 Norwegian office workers participated.

An anonymous email questionnaire was sent to 605 office employees at three different workplaces in Norway for recruiting participants. In one place, a large private company in Oslo, the questionnaire was sent to 500 employees, randomly selected from departments, and filled during working time. The second place is a smaller private company in Oslo, the questionnaire was sent to 70 employees. In the third company, a governmental agency in Stavanger in which the questionnaire was also sent to 70 employees. In the latter two workplaces, all of the participants were from one department and were selected by the management based on cost. A total of 385 participants filled out the questionnaires during working hours, resulting in an overall response rate of 63.6%. The age range of the participants was 24-66 years (mean = 43.1 years). Moreover, 63% of the sample were male, and it predominantly consisted of longterm employees (range from few weeks up to 39 years, mean = 7.1 years). The three workplaces were selected since they are all office workplaces and located in large cities. Besides, the managers of these companies were willing to let their employees participate in the survey. Moreover, each of the workplace had a plant firm that is responsible for installing and maintaining plants. All employees can decorate their own workstation or office freely. The plants installed in these workplaces included "Epipremnum aureum", "Ficus benjamina", "Spathiphyllum wallisii", "Dracaena fragrans", "Dracaena concinna", "Beaucarnea recurvata", and "Schefflera arboricola". These plants were placed on shelves, on top of cabinets or on the floor with varied sizes (up to 1.5 m height). In the email sent to the employees, the survey's purpose was explained, and they were messaged that the responses would be totally anonymous. Meanwhile, two reminders were sent to non-respondents: the first one was sent after one week and the second after two weeks. To encourage participation, the employees were informed that their name would be entered into a drawing for an a1000 NOK (US\$160) gift card from a large shopping chain. The questionnaire used closed-ended questions; thus, participants only had two alternatives for responding: they could use one of the valid response options for any item (one- to five-point scale) or they could choose not to answer the question. A small percentage of respondents chose not to answer the given question. The questionnaires' responses were directly exported into an SPSS system file (SPSS14.0, 2006) by using Questback (a program for electronic surveys).

The 10-item version of the perceived stress scale (PSS)^[31-32] was used to measure the stress degree in the questionnaire. For instance, "How often did you feel nervous

and stressed during the last four weeks?" Sick leave was measured with a single question: "How many days last year have you been absent due to your own illness?" ^[30]. Productivity level was measured by four questions. For example, "Are you satisfied with the quality of work you are doing?", "Are you satisfied with the amount of work you are doing?" This measurement referred to a previous study ^[33].

This study has good points. First, the sample is representative and adequate, which is greatly helpful to provide trustworthy conclusions. Second, the study has managed to lower mortality. For example, they sent an email to non-respondents twice as a reminder and offered an award as an incentive to participate.

However, the limitations in this study are obvious. First, the sample was disproportionately male (63%). Second, part of the measurements used in the study was not specific to work-related circumstances. For example, the 10-item version of PSS ^[31-32] was a global measure and not specific to the work environment. The authors believe that this limitation can be overcome by judging the scale appropriately because most adults spend a large proportion of their time at their work environment.

4. Different Ways of Viewing Nature

4.1 Viewing from the Window

The evidence for the benefits of viewing landscape comes from the home and workplace. Windows in the workplace can alleviate the stress of labor, and people who work with windows over a long period have fewer illnesses, are more patient, complain less, and show more enthusiasm at work than those who work without windows. People can think better with green views, including university students, than those without green views ^[34]. People in offices without windows usually place pictures of landscapes or indoor plants ^[34] to compensate for the missing views and may become stressed or aggressive. One research involving Alzheimer patients in five houses suggests that people in the three houses with gardens exhibit low aggression and violence levels than those in the two houses without gardens ^[35].

Green view is also important at home. Kuo et al. ^[36] found that even a small piece of green space in Chicago's barren urban environment makes a huge difference in people's lives ^[36-37]. Green views from home and nearby nature have a beneficial effect on children's cognitive functioning. Residents in the two of the 10 poorest neighborhoods in the US positively evaluated the trees and grass near their blocks and said that the greener, the better. Moreover, buildings with more vegetation had 52% lower property and violent crimes than those without green space; the residents also reported lower levels of fear and aggressive behavior in the local neighborhood. Besides, the difference between nongreen and moderately green buildings was more significant than between moderately green and highly green buildings, suggesting that a positive effect can accrue from a light-greening of all urban spaces, rather than a dark-greening of just a few ^[37].

Certain studies about green views in hospitals also exist. Ulrich ^[35] reported that patients in a Swedish psychiatric hospital had always complained and damaged paintings on the wall over a 15-year period. An interesting finding is that only abstract painting was reported to be damaged, and no record showed that any pictures of nature and landscapes were damaged. Diette et al. ^[10] demonstrated that pictures and sounds of nature have great benefits to patients. One group of patients was equipped with a landscape picture to look at and listened to birdsong sounds and a brook before the operation of bronchoscopy. This group had a 50% higher level of good or great pain control than those who were not equipped with pictures and sounds. It implies that less money is needed to be cost on painkilling drugs for patients ^[10].

4.2. Viewing in Natural Environment

Abundant studies show that viewing green in natural environment has significantly positive effects on human beings. A study that examined the restorative effects of viewing forest landscape has an interesting finding. Twelve 20-year-old Japanese male as subjects took part in a three-day field experiment. They were transferred to view forest and urban landscapes randomly during these days. Meanwhile, the physiological and psychological data of each subject were gathered. The results indicate that people who viewed forest landscape has lower values of salivary cortisol concentration (an index of stress response), diastolic blood pressure, and pulse rate than those who viewed urban landscape. This observation suggests that viewing real forest landscape may moderate stress, aid relaxation, and create positive emotion ^[38].

Tsunetsugu et al. ^[25] supported this finding. They used a control group to compare the difference between viewing natural landscape and urban forest landscape and found that participants who were allocated to view forest landscape for 15 minutes have greatly lower diastolic blood pressure and heart rate, and greatly higher parasympathetic nervous activity, implying that forest landscape can induce a positive mood. A short-term viewing of forests has physiological relaxing effects, such as lowered diastolic blood pressure and heart rate ^[25].

Another novel study compared the restorative effects of the four types of landscape environment (i.e., urban, mountain, forest, and water) through questionnaires and by investigating the association between different environments and brain region activities by means of functional magnetic resonance imaging technology. The results reveal that the participants perceived more restorative effects when viewing natural landscapes than when viewing urban landscapes. People show decreased ability to recover from fatigue when viewing urban landscapes. In addition, among the four types of landscapes, water, and mountain scenes have the best restorative abilities, followed by forest and urban landscapes [^{39]}.

5. Conclusion

Natural landscapes influence human beings in diverse ways, including health and well-being and aesthetic appreciation. This essay mainly discusses the benefits of viewing natural landscapes to the physical and mental state of people. The restorative effects of viewing landscapes are the focus of this article, and other physiological and psychological benefits are mentioned. In general, viewing natural landscapes includes viewing natural vegetations, mountains, soils, lakes, and so on. The cases discussed in this article mainly focus on natural vegetations. Further research about other components of natural landscapes can be conducted to obtain additional generalized results.

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ARTICLE Thermal Indices Influence on Occupants' Window Opening Behaviours: A Case of Ibadan and Ogbomoso, Oyo State, Nigeria

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ABSTRACT

Window opening operations are considered as one of the significant way of regulating indoor climate and maintaining thermal comfort in buildings, even when alternative active devices such as fans and air conditioners are available. This study investigates responses of occupants of the traditional core areas of Ibadan and Ogbomoso to thermal comfort conditions (thermal stress) through window opening behaviours. Climatic data of the two cities were subjected to Evans scale to predict their day and night thermal stress and questionnaires were administered to know how occupants respond to changing thermal conditions through window opening behaviours. Descriptive and inferential statistics were used in analysing the data. The study found the morning periods to be the most comfortable, the afternoon periods offer the most hot discomfort condition and cold discomfort is mostly experienced in the evening periods in both cities. Findings revealed that majority of occupants in both cities prefer to keep their windows opened in the morning and afternoon periods and an increase was observed in the numbers of occupants who prefer to keep their windows closed in the evening periods. This is an indication that building occupants in both cities actively respond to thermal stress using window opening operations. Results obtained from chi square analysis concluded that there is a significant relationship between occupants' window opening behaviour and thermal conditions at different periods of the day in both cities. Recommendations were given on how to improve on window opening systems in the future.

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1. Introduction

The concept of comfort in buildings represents the state of building occupants' satisfaction with the indoor environment^[1]. Various scholars have studied the concept of Indoor comfort (IC) in buildings using different approaches and parameters. Among these are sound and acoustic comfort in buildings, light and visual comfort in buildings, ventilation and thermal comfort in buildings, moisture and humidity, odour, colour, ergonomics etc. While all these parameters as they affect human IC are all important, Authors [1-5] all established in their various studies that thermal comfort is of top priority to man. This is because it has a direct effect on occupants' psychological wellbeing, health and welfare. Thermal comfort is said to be the state with which occupants' expresses satisfaction with the indoor thermal condition (indoor temperature) of the environment^[6].

Buildings must protect occupants against extreme temperatures because they have a direct consequence on occupants' health and general wellbeing. Factors affecting indoor temperature include Outdoor temperature, Solar radiation, outdoor humidity level, wind velocity, mean radiant temperature-generated from bulbs and other equipments and appliances (mostly cooking appliances) in buildings etc. ^[7].

The outdoor thermal temperature can be best described in terms of Thermal (heat) Index (TI). According to National weather service ^[7], TI is a measure of perceived temperature derived from Ambient Outdoor temperature (AOT) and Outdoor Relative Humidity (ORH) used in calculating Thermal Stress (TS). Similarly, Author ^[4] submitted that TI is a measure of perceived TS imposed by external conditions which is derived from AOT and ORH; it is used to predict the optimal thermal environment needed for comfort in buildings. Simply put, TI is a measure of perceived range of outdoor temperature causing perceived hot and cold discomforts in buildings resulting from AOT and ORH.

Indoor thermal environment varies according to season, just as Indoor thermal comfort is relative to occupants i.e., it is a measure of the subjective feeling of occupants; meaning that a thermal condition that is said to be comfortable for an occupant may not be comfortable for the other. Author ^[6] put the comfortable limits for occupants condition at about 74-83°F (23-28°C) in the summer and 67-79°F (19-26°C) in the winter seasons.

Considering the climatic condition of Nigeria and other tropical regions which according to Author^[8] is characterised by high temperature, high rainfall, high humidity and intense solar radiation, the effect of AOT is heat

build-up in indoor spaces and the constant challenges are how to avoid heat from getting into the building and how to swiftly remove such once they get in ^[9-10]. High TS is hence a general threat to people in Nigeria and other tropical regions and a greater threat to those whose health, economic situation or social circumstances makes them vulnerable to exposure to high temperatures ^[7]. This has however caused occupants to adopt different measures of regulating their various spaces to suit their IC conditions. Among these is the use of active driven devices such as fans, air conditioners, humidifiers, ventilators, heaters etc. to dissipate heat and regulate Indoor environment mostly used by the rich and affluent ^[10].

However, these devices are heavily dependent on electricity and the fact that electricity supply in Nigeria is erratic and with very high costs implications makes them uneconomical and unaffordable for the poor who are mostly found in the traditional core areas of cities in Nigeria^[9]. Occupants hence resolved to maintain IC by opening windows as a way of responding to high TS^[1]. This can also be inferred from the studies of Author^[11] who posited that the most common and economical way to control thermal comfort is through window openings and Author ^[12] who found window opening behaviour of occupants as the most economical and effective way of responding to TS and maintaining good IC. Understanding TI and TS of cities and how occupants respond to them through window opening operations would further assist architects and engineers in delivering buildings devoid of active driven mechanical devices while maintaining indoor comfort of occupants.

This study attempts to establish the thermal indices of Ibadan and Ogbomoso, both in Oyo state, Nigeria and to study the response and attitude of their building occupants to TS through window opening behaviours. The study specifically focuses on residents of the traditional core areas of the two cities that are adjudged by several scholars as being poor and vulnerable and hence cannot afford the cost and maintenance of active driven mechanical devices [13-14].

2. Study Areas

Ibadan lies on latitude 7 degrees, 23 minutes North and Longitude 3 degrees, 55 minutes East of the Greenwich Meridian and falls within the forest region of Nigeria while Ogbomoso is situated on latitude 8 degrees, 10 minutes North and longitude 4 degrees, 10 minutes East of the Greenwich Meridian and falls within the derived savannah region of Nigeria. Both cities are in Oyo state, South west Nigeria. Ibadan is the largest city in the state and Ogbomoso is the second largest^[1].

Both cities fall within the warm humid climate like every other towns and cities in the South western part of the country. Hence, their climates are characterised by high temperature, high humidity, high rainfall and a relatively low wind velocity with their maximum temperature rising above 33 degrees and their humidity rising above 89 percent in some months ^[15]. However, both cities have variations in their microclimatic conditions because of their geographical uniqueness and their level of urbanization ^[1].



Figure 1. Showing the traditional core area of Ibadan.

Source: Google maps, 2020



Figure 2. Showing the traditional core area of Ogbomoso *Source:* Google maps, 2020

3. Research Method

The data presented in this study were drawn from a larger research project designed to assess the indoor environmental quality of houses in selected cities in Oyo state, Nigeria. The study subjected 5 years climatic data of Ibadan and Ogbomoso to the Evans heat index scale to determine the day and night thermal stress of the two cities. The climatic data were between the periods of 2011 and 2015. In a study conducted by Authors ^[4] in 2003, the Evans heat index scale and the Mahoney tables were adjudged to be the best method of calculating TI of any city, owing to their accuracy, low error of prediction and their ability to predict the day and night comfort conditions.

Questionnaire was used to collect data on the so-

cial-economic characteristics of occupants, their tenure status, length of stay in their various houses, their subjective feelings of thermal stress in their various houses at different times of the day (morning, afternoon and evening) and to determine their response and attitudes to TS through window opening operations and behaviours at those periods of the day.

Respondents are expected to express their subjective feeling to indoor temperature on a likert 5 point scale ranging from cold, cool, neutral, warm and hot at those periods of the day and were simply asked to indicate whether they prefer to open their windows or keep them closed anytime they are in their various spaces at those periods as a way of moderating the indoor climate.

Data obtained from the National bureau of statistics (NBS)^[16] indicated that a total number of 5,310 and 5,240 buildings are in the traditional core areas of Ibadan and Ogbomoso respectively. This data was a subset extracted from the broader research project earlier mentioned. 2.5% of buildings were studied in each of the cities and hence, 133 and 131 houses were sampled in Ibadan and Ogbomoso respectively. Summarily, a total of 249 buildings were sampled out of a population of 10,550 buildings. However, 131 questionnaires representing 98.5% were retrieved in Ibadan and 118 (90.1%) questionnaires were retrieved in Ogbomoso. A total of 249 (94.3%) questionnaires were retrieved and analysed. See table 1.

 Table 1. Building population and sampling in the two study areas

Study areas	No of buildings in the study areas (Population)	No of build- ings studied (Sample)	No of question- naires retrieved	Percentage of questionnaires retrieved
Ibadan	5,310	133	131	98.5
Ogbomo- so	5,240	131	118	90.1
Total	10,550	264	249	94.3

Simple random sampling technique was adopted to select houses studied in each of the city. This was done after the areas had been divided into segments and houses in each segment have been numbered. An adult respondent of above 18 years was simply selected in a building to be studied.

Descriptive and inferential methods of analysis were employed to analyse the data. Chi-square was used to determine the relationship between respondents' attitude to windows openings and periods of the day. Findings are discussed below.

4. Findings and Discussions

4.1 Evans Scale

As earlier mentioned, Author^[4] in 2003 posited that the Evans heat index scale and the Mahoney tables were adjudged to be the best method of calculating TI of any city in Nigeria, owing to their accuracy, low error of prediction and their ability to predict the day and night comfort conditions. The Evans scale employs air temperature and relative humidity to predict the thermal stress^[10]. See Table 2:

Relative humidity (%)	Day comfort limits (°C)	Night comfort limits (°C)
0-30	29.5-32.5	27.5-29.5
30-50	28.5-30.5	26.5-29
50-70	27.5-29.5	26-28.5
70-100	26-29	25.5-28

Source: Author [10]

Table 3. Categories of thermal stress

Category of thermal stress	Conditions	Symbol
Very cold	Temperature less than 5 de- grees below the lower comfort limit	
Cold	Temperature below the lower comfort limit but more than 5 degrees below the lower comfort limit	-
Comfortable	Temperature within the com- fort limits	0
Hot	Temperature above the upper comfort limit but less than 5 degrees above the upper comfort limit	+
Very Hot	Temperature more than 5 degrees above the upper comfort limit	++

Source: Author [10]

* Monthly mean maximum temperature (°C) and monthly mean minimum humidity (%) are used to determine day comforts.

*Monthly mean minimum temperature (°C) and monthly mean maximum humidity (%) are used to determine night comforts of each month.

4.2 The Comfort Condition (Thermal stress) in Ibadan and Ogbomoso

Table 4. Climatic data of Ibadan

Town: IBADAN latitude7°, 231 longitude 3°, 551 Year: 2011-2015

Month	Temp. °C (Max.)	Temp. °C (Min.)	Temp. °C Mean monthly	RH(AM) %	RH(PM) %	Rainfall (mm)	Radiation MJ/m ² /day	Wind Speed(m/s)
Jan	33.6	19.7	26.7	78.8	28.0	1.3	14.2	0.98
Feb	35.0	21.8	28.4	93.7	30.2	12.8	15	1.16
March	34.6	23.1	28.9	96.4	38.0	66.9	17.3	1.28
April	33.1	23.2	27.0	98.1	59.5	174.3	16.2	0.99
May	31.6	22.3	27.0	98.1	59.5	174.3	16.2	0.99
June	30.0	21.8	25.9	98.8	63.8	233.6	13.9	0.96
July	28.1	21.5	24.8	99.0	67.7	195.7	11.7	0.92
August	27.6	21.3	24.5	99.6	72.4	109.7	12.8	0.87
September	29.2	21.5	25.4	98.2	68.2	197.7	12.8	0.87
October	29.1	21.7	26.0	98.1	60.8	187.9	13.3	0.83
November	31.9	22.6	27.3	98.2	49.6	28.9	15.2	0.81
December	32.5	20.9	26.7	95.6	35.4	1.2	13.5	0.78
Average	31.4	21.8	26.6	96.0	52		14.2	0.98

Source: Author^[1]

Table 5. Human Comfort condition (Thermal stress for Ibadan)

Ibadan 2011-2015	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max Temperature (°c)	33.6	35.0	34.6	33.1	31.6	30.0	28.1	27.6	29.2	29.1	31.9	32.5
Monthly Mean Min. Relative Humid- ity (%)	28.0	30.2	38.0	51.1	59.5	63.8	67.7	72.4	68.2	60.8	49.6	35.4
Day Thermal Stress	+	++	+	+	+	+	0	0	0	0	+	+
Monthly Mean Min Temperature (°c)	19.7	21.8	23.1	23.2	22.3	21.8	21.5	21.3	21.5	21.7	22.6	20.9
Monthly Mean Max. Relative Hu- midity (%)	78.8	93.7	96.4	97.2	98.1	98.8	99.0	99.6	98.2	98.1	98.2	95.6
Night Thermal Stress		-	-	-	-	-	-	-	-	-	-	-

Source: Authors' Analysis, 2020.

e		0						
Month	Temp. °C (Max.)	Temp. °C (Min.)	Temp. °C Mean monthly	RH(AM) %	RH(PM) %	Rainfall (mm)	Radiation MJ/m²/day	Wind Speed(m/s)
Jan	35.5	19.6	26.6	66.3	41.3	0.3	12.1	1.47
Feb	34.8	20.5	27.7	68.2	35.9	10.8	12.8	1.45
March	34.6	22.6	28.6	62.6	46	47.7	13.6	1.44
April	33.1	22.2	27.7	77.2	61	103.2	13.1	1.42
May	32.0	22.2	27.1	80.8	65.6	149.5	12.3	1.51
June	30.9	21.8	26.4	84.7	69.1	180.1	10.9	1.51
July	29.3	21.5	25.4	89.1	71.6	181.6	9.7	1.49
August	28.9	20.8	24.9	84.8	73.6	141.3	8.9	1.47
September	29.4	20.8	25.1	87.3	71.6	222.6	9.5	1.5
October	31.3	19.6	25.5	85.3	66.3	185.2	10.6	1.47
November	33.0	20.5	26.8	83.5	54.9	79.7	11.9	1.47
December	33.2	18.7	26.0	73.9	44.5	12.2	11.8	1.43
Average	31.9	20.9	26.4	78.6	58.5		11.4	1.47

Table 6. Climatic data of Ogbomoso.

Source: Author [1]

Table 7. Human Comfort condition (Thermal stress for Ogbomoso)

Ogbomoso 2011-2015	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max Tem- perature (°c)	35.5	34.8	34.6	33.1	32.0	30.9	29.3	28.9	29.4	31.3	33.0	33.2
Monthly Mean Min. Rela- tive Humidity (%)	41.3	35.9	46	61	65.6	69.1	71.6	73.6	71.6	66.3	54.9	44.5
Day Thermal Stress	++	+	+	+	+	+	+	0	+	+	+	+
Monthly Mean Min Tem- perature (°c)	19.6	20.5	22.6	22.2	22.2	21.8	21.5	20.8	20.8	19.6	20.5	18.7
Monthly Mean Max. Rela- tive Humidity (%)	66.3	68.2	62.6	77.2	80.8	84.7	89.1	84.8	87.3	85.3	83.5	73.9
Night Thermal Stress			-	-	-	-	-					

Source: Authors' Analysis, 2020.

Analysis from the Evans heat index scale reveals that Ibadan witnesses a comfortable thermal condition during the day for four months which are: July, August, September and October. The city experiences hot discomfort throughout the rest of the months except February which presents a very hot discomfort condition. Cold discomfort is experienced at night throughout the year except January which presents a very cold discomfort condition.

Town: Ogbomoso latitude 8^0 , 10^1 longitude 4^0 , 10^1 Year: 2011-2015

The thermal condition of Ogbomoso is very different from that of Ibadan. Comfortable condition is experienced during the day in just one month which is August; the city experiences hot discomfort during the day throughout the rest of the months and even experiences a very hot discomfort condition in January. Cold discomfort is experienced at night for 5 months; these months are March, April, May, June and July. Very cold discomfort condition is experienced at night throughout the rest of the months.

4.3 Residents' Social-economic Characteristics

Data obtained from field work revealed that 49.6%

respondents in Ibadan are male while 50.4% are female. Similarly, 39.0 % respondents in Ogbomoso are male while 60.2% are female (see table 8). Respondents' age distribution in the study areas indicated that majority of the respondents in the two cities falls between the age ranges of 31- 45 years. This age structure makes up 74.0% of the respondents in Ibadan and 45.8% of the respondents in Ogbomoso. Second to this are those that fall between the ages of 18-30 years with Ibadan having 15.3% and Ogbomoso having 26.3%.

Data also revealed that 90.1% respondents in Ibadan are married while only 9.9% are single. Also, 84.7% respondents in Ogbomoso are married while only 14.4% are single. Obtained data revealed that 71.8% of respondents in the traditional core of Ibadan either have no formal education or does not complete primary school, 15.3% completed primary school, 9.2% completed secondary school and only 3.8% have a tertiary education. Similarly, 91.5% respondents in Ogbomoso have either an incomplete primary education or no formal education at all, only 6.8% completed primary education and 1.7% has a secondary

Cities	Socio-economic characteristics	Attributes	Frequency (%)	Percentage (%)
		Male	65	49.6
Ibadan		Female	66	50.4
Ibauan		T-t-1	121	100
	C	Total	131	100
	Sex	Male	46	39.0
Oghomoso		Female	71	60.2
Ogboliloso		No Response	01	0.8
		Total	118	100
		18 30 years	20	15.3
		18 - 30 years	20	13.5
		51 - 45 years	37	74.0
		46 - 60 years	04	3.1
Ibadan		61 - 70 years	00	00
		71 and above	00	00
		No Response	10	7.6
	Age	Total	131	100
	90	18 - 30 years	31	26.3
		21 45 years	54	45.9
		51 - 45 years	19	43.6
Ogbomoso		40 - 60 years	18	15.5
- g		61 - 70 years	02	1./
		71 and above	13	11.0
		Total	118	100
		No formal education	47	35.9
		Prv Sch Incomplete	47	35.9
		Pry Sch Complete	20	15.3
Ibadan		Completed Secondary	12	15.5
			12	9.2
		Completed Tertiary	05	3.8
	Educational	Total	131	100
	Status	No formal education	67	56.8
		Prv. Sch Incomplete	41	34.7
		Pry Sch Complete	08	68
Ogbomoso		Completed Secondary	02	17
		Completed Tertiary	02	00
		Completed Tertiary	00	00
		Total	118	100
		Below ₩18,000:00	97	74.0
		№18,000 - №25,000 №25,100 -	27	20.6
		₩40,000	07	5.3
Ibadan		₩40.100 - ₩60.000	00	00
Ibauan		₩60 100 - ₩80 000	00	00
		Above 1100,000	00	00
		Above A 80,000	00	00
	Monthly Income	Total	131	100
	Monthly Income	Below ¥18,000:00	86	72.9
		₩18,000 - ₩25,000 ₩25,100 -	25	21.2
		N 40,000	02	1.7
Ogbomoso		№40,100 - №60,000	00	00
- S		₩60,100 - ₩80,000	02	1.7
		Above ₩80 000	03	2.5
		Total	119	100
		Total	118	100
		Student/Apprentice	05	3.8
		Farmer	10	7.6
		Artisan	44	33.6
Ibedan		Trading	44	33.6
ibadan		Civil Servant	27	20.6
		Pensioners	00	00
		Clergy	01	0.8
		Total	131	100
	Occupation		151	100
		Student/Apprentice	06	5.1
		Farmer	06	5.1
		Artisan	35	29.7
Oghamaga		Trading	62	52.5
Ognomoso		Civil Servant	06	5.1
		Pensioners	00	00
		Clergy	03	2.5
		Total	118	100
			110	100
		Singled	13	9.9
Ibadan		Married	118	90.1
ibadali		Divorced	00	00
		Total	131	100
	Marital Status	Singled	17	14.4
		Morried	1/	14.4
Ogbomoso		Diversed	100	04./
0		Divorced	01	0.8
		Total	118	100

Table 8. Residents socio-economic characteristic

Source: Authors' fieldwork.

school certificate and none of the respondents have a tertiary education.

Occupation distribution in the study areas revealed that majority of respondents in the two cities are either artisans or traders i.e., 33.6% and 33.6% respondents in Ibadan are artisans and traders respectively and 29.7% and 59.2% respondents in Ogbomoso are artisans and traders respectively. 20.6% respondents in Ibadan are civil servants, 7.6% are farmers and 3.8% are either students or an apprentice. 5.1% respondents in Ogbomoso are civil servants, another 5.1% are farmers and 5.1% are either students or serving as an apprentice.

Data gathered on the monthly income distribution of respondents in the two study areas indicated that 74.0% and 72.9% respondents in Ibadan and Ogbomoso respectively earn below 18,000 naira per month, this implies that they earn less than the minimum wage in Nigeria and hence lives in abject poverty ^[17]. This further justifies their inability to afford the cost of procurement, operating and maintenance of active driven mechanical devices used in achieving comfort in indoor spaces. 20.6% and 21.2 % respondents in Ibadan and Ogbomoso respectively earn between 18,000 and 25,000 naira per month. 5.3% respondents in Ibadan earn between 25,100 and 40,000 naira per month and no respondent earns above that in a month. However, in Ogbomoso, 1.7% respondents earn between 25,100 and 40,000 naira per month, 1.7% earns between 60,100 and 80,000 naira per month and 2.5% earn above 80,000 naira per month.

4.4 Respondents Tenure Status and Length of Stay

Data on the tenure status of respondents revealed that 21.4% of respondents in Ibadan are owners of their various houses, 38.2% lives in rented apartments and 39.7% houses freely. Similarly, 28.8% respondents in Ogbomoso are owners of their houses, 31.4% lives in rented apartments and 33.9% houses freely.

Data also revealed that 42.7 % respondents in Ibadan have lived in their various houses for between 2- 5 years, 33.6% have lived for between 6-10 years and 19.1 have stayed in their various houses for over 10 years. Similarly, 16.9% respondents in Ogbomoso have lived in their various houses for between 2- 5 years, 17.8% have lived for between 6-10 years and 56.8% have stayed in their various houses for over 10 years. This implies that 95.4% and 91.5% of respondents in Ibadan and Ogbomoso respectively have lived in their various houses for over two (2) years which makes them suitable for the study.

Table 9.	Residents	tenure	status	and	length	of	stay	chara	IC-
		te	eristic	s					

Cities	Socio-econom- ic characteris- tics	Attributes	Frequency (%)	Percentage (%)
Ibadan		Owner Occu- pier Renter Free Houser Others	28 50 52 1	21.4 38.2 39.7 0.8
Ogbomoso	Tenure Sta- tus	Total Owner Occu- pier Renter Free Houser Others	131 34 37 40 7	100 28.8 31.4 33.9 5.9
Ibadan	Length of Stay in the	Total Less than 2 years 2 years - 5 years 6 years - 10 years Over 10 years No Response Total	118 05 56 44 25 01 131	100 3.8 42.7 33.6 19.1 0.8 100
Ogbomoso	House	Less than 2 years 2 years - 5 years 6 years - 10 years Over 10 years Total	10 20 21 67 118	8.5 16.9 17.8 56.8

Source: Authors field work.

4.5 Respondents' subjective Feelings of Thermal Stress in the Study Areas (Thermal Comfort Sensations)

The subjective feelings of respondents towards thermal stress in the two study areas at different times of the day (morning, afternoon and evening) were assessed on a likert 5 point scale ranging from cold, cool, Neutral, warm and hot. Data obtained in Ibadan indicated that 21.4% respondents feel cold in the morning, 11.5% feel cool, 64.1% feel comfortable, 2.3% feel warm and 0.8% feels hot. However, 2.3% feel cool in the afternoon, 9.2% feel comfortable, 44.3% feel warm and 44.3% feel hot while 37.4% feel cool in the evening, 45% feel comfortable, 16.8% feel warm and 0.8% feels hot.

Data obtained from Ogbomoso on the other hand indicated that no respondent feels cold discomfort in the morning, 15.3% feel cool, 38.1% feel comfortable, 25.4% feel warm and 21.2% feel hot discomfort. 2.5% respondent indicated that they feel cold discomfort in the afternoon, 0.8% feels cool, 1.7% feels comfortable, 0.8%

feels warm and 94.1% feel hot discomfort. 4.2% respondents also indicated that they feel cold discomfort in the evening, 40.7% feel cool, 18.6% feel comfortable, 19.5% feel warm and 16.9% feel cold discomfort.

It can be inferred from this result that while 64.1% respondents in Ibadan feel comfortable in the morning period, only 38.1% respondents feel comfortable in Ogbomoso.

Whereas only 3.1% respondents feel either warm or hot in Ibadan in the morning, 46.6% respondents in Ogbomoso either feels warm or hot discomfort.

Data obtained also revealed that while 9.2% respondents feel comfortable in Ibadan in the afternoon period, only 1.7% respondents feel comfortable in Ogbomoso. Also, 88.6% respondents feel either warm or hot discomfort in Ibadan in the afternoon period as against 94.9% who feel either warm or cold discomfort in Ogbomoso. This period of the day however offers the greatest hot discomfort conditions in the two cities.

45% respondent indicated that they feel comfortable in Ibadan during the evening periods while only 18.6% feel comfortable in Ogbomoso. Similarly, while 17.6% respondents feel either warm or hot discomfort in Ibadan in the evening period, 36.4% feels either warm or hot discomfort in Ogbomoso.

This result has however shown that the climate of Ibadan is more comfortable than that of Ogbomoso and this is in line with the objective findings presented by the Evans scale.

4.6 Residents' Response to Thermal Stress through Window Openings

Data obtained from the respondents attitudinal response to thermal stress at these periods of the day shows that 98.5% respondents in Ibadan prefer to leave their windows opened in the morning while 1.5% prefers to leave them closed. Similarly, 94.7% prefer to leave their windows opened in the afternoon as against the 5.3% that prefer leaving them closed and 74% prefer leaving them opened in the evening as against 26% who prefer leaving them closed.

However, 94.1% respondents in Ogbomoso prefer to leave their windows opened both in the morning and afternoon periods as against 5.9% who prefer closing their windows at both periods of the day. However, 66.9% respondents prefer leaving their windows opened in the evening as against 33.1% who prefer leaving them closed.

Chi-square analysis was used to determine whether there is a significant relationship between residents' response to thermal stress through window openings and periods of the day or not. Result obtained indicated that their relationship is significant at 0.05 significant level in the two cities (x^2 = 46.43, df = 2 and p value = 0.000 in Ibadan and x^2 = 45.45, df = 2 and p value = 0.000 in Ogbomoso).

City	Deviade of the Day	Indoor Temperature Feeling							
City	renous of the Day –	Cold	Cool	comfortable	Warm	Hot	Total		
	Morning	28 (21.4)	15 (11.5)	84 (64.1)	03 (2.3)	01 (0.8)	131 (100)		
Ibadan	Afternoon	00 (00)	03 (2.3)	12 (9.2)	58 (44.3)	58 (44.3)	131 (100)		
	Evening	00 (00)	49 (37.4)	59 (45.0)	22 (16.8)	01 (0.8)	131 (100)		
	Morning	00 (00)	18 (15.3)	45 (38.1)	30 (25.4)	25 (21.2)	118 (100)		
Ogbomoso	Afternoon	03 (2.5)	01 (0.8)	02 (1.7)	01 (0.8)	111 (94.1)	118 (100)		
	Evening	05 (4.2)	48 (40.7)	22 (18.6)	23 (19.5)	20 (16.9)	118 (100)		

Table 10. Residents subjective feelings of thermal stress in the study area at different periods of the day

Note: Figures outside brackets represents frequencies; Figures in brackets represents percentages. *Source:* Authors fieldwork.

Table 11. Residents' response and attitude to thermal stress through window openings for indoor comfort in the study areas

			Periods of the Day	
Cities	Window Opening conditions	Morning	Afternoon	Evening
		Freq. (%)	Freq. (%)	Freq. (%)
	Opened	129 (98.5)	124 (94.7)	97 (74.0)
Ibadan	Closed	02 (1.5)	07 (5.3)	34 (26.0)
	Total	131 (100)	131 (100)	131 (100)
	Opened	111 (94.1)	111 (94.1)	79 (66.9)
Ogbomoso	Closed	07 (5.9)	07 (5.9)	39 (33.1)
	Total	118(100)	118(100)	118(100)

Note: Figures outside brackets represents frequencies; Figures in brackets represents percentages. *Source:* Authors fieldwork.

Cities	Variables	Chi-square X ²	Degree of Freedom (df)	P value	Signifi- cance
Ibadan	Window open- ing condition	46.43	2	0.0000	Sig.
Ogbomoso	the day	45.45	2	0.0000	Sig.

Table 12. Chi-square result

Note: ($\alpha = 0.05$) Source: Authors analysis.

4. Conclusion

The results from the Evans scale revealed that hot or very hot discomfort is experienced in most of the months in the two cities (8 months in Ibadan and 11 months in Ogbomoso) and cold or very cold nights is experienced in the two cities throughout the year. Through the subjective assessment, the study found that occupants' experiences a more comfortable condition in the morning periods in the two cities (64.1% and 38.1% in Ibadan and Ogbomoso respectively), the afternoon periods presents the highest hot discomfort condition in the two cities (88.3% and 94.9% in Ibadan and Ogbomoso respectively) and cold discomfort is mostly felt in the evening periods in the two cities (37.4% and 44.9% in Ibadan and Ogbomoso respectively). This result however aligns with the results of the Evans scale.

The study however realised that over 90% of occupants in the two cities prefer to keep their windows opened in the morning and afternoon periods when comfortable and hot discomfort conditions are mostly experienced and only less than 10% prefers keeping their windows closed during those periods. Findings also revealed that there is a rise in the number of occupants who prefer to keep their windows closed in the evening periods (26.0% and 33.1% in Ibadan and Ogbomoso respectively) this is owing to the fact that the evening periods present the highest cold discomfort condition.

The outcome of the study has clearly shown that occupants in the two study areas respond actively to thermal stress in their various buildings by keeping their windows either opened or closed depending on the thermal condition of the environment and periods of the day. This is also in line with the results obtained from the chi-square analysis which found a significant relationship between residents' response to thermal stress through window openings and periods of the day in the two cities.

The study has further proven that building occupants effectively use window openings to moderate indoor climates in achieving balanced thermal conditions and hence, the study is in line with the findings of Authors^[11] and ^[12] who both found window opening behaviours of occupants as the most effective, efficient and economical

way of achieving comfort in buildings. Architects should hence come to the awareness that window opening is one of the most effective ways IC can be maintained with or without active driven devices and should:

(1) Concentrate more on window opening systems and designs vis-a-vis Type, number and sizes which would be capable of achieving comfort in their proposed design.

(2) Ensure good window positions and orientations in order to maximize their effectiveness.

(3) Take decisions on window designs right from design inception with special attention to construction and operation, details and specifications.

If possible, future researches should look further into the effect of privacy, persisting cultural practices, the organization of buildings in relation to density and use of thermal indices and window openings behaviours or operations in various places.

Abbreviations

The following is the list of abbreviations used in the study

IC - Indoor comfort TI - Thermal (heat) Index AOT - Ambient Outdoor temperature (°c) ORH - Outdoor Relative Humidity (%) TS - Thermal Stress

Conflict of Interest

The authors have not declared any conflict of interest.

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ARTICLE Theoretical Issues and Conceptual Framework for Physical Facilities Design in Hospital Buildings

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ARTICLE INFO	ABSTRACT				
Article history Received: 29 July 2020 Accepted: 30 October 2020 Published Online: 31 January 2021	This study reviewed the theoretical issues relating to morphological and psychological design issues in hospital building design evaluation. The study of morphological configurations design issues, concentrates on the el- ements of building, shape/form, the structure of the environment, the struc- tural efficiency and the architectural appearance of the hospital building				
Kevwords:	forms. The psychological design issues focused on the essential issues re lating to Proximity. Privacy and Wayfindings. Through the literature review				
Theories	of previous models such as, Khan (2012) Operational Efficiency Model,				
Framework	Haron, Hamid and Talib Usability Framework, (2012), Zhao, Mourshed & Wright (2009) Model Alalouch Aspinall & Smith Model (2016) and Hill				
Physical facilities	& Kitchen (2009). A conceptual framework for physical facilities design				
Hospital building	evaluation and satisfaction in hospital buildings was developed. The study, however, provides useful information for the development of a design				

1. Introduction

1.1 Background to the Study

In an ideal situation, the healthcare physical facilities in Nigerian hospitals are expected to deliver the highest quality of healthcare services to clients^[1]. But this ideal is never met due to the initial design consideration of the existing facilities in terms of number of patients per ward, spaces, sizes and availability, organization, location, accessibility, privacy, and proximity among other variables, which could no longer meet up with the current demand for healthcare services. Since this has seriously affected the patients well-being and reduced the staff performances^[2-5], research is needed to develop policy strategies for renovation and construction of new hospital buildings and environmental facilities to improve the current healthcare situation.

framework that can inform policy on hospital buildings.

The key drivers that result in the study of hospital physical facilities design include aging facilities (built in the 1950s and 1970s) that no longer support efficient and safe care delivery; advances in treating complicated diseases; rapidly emerging technologies that fundamentally change care delivery processes; and the growing importance of patient and family-centred care ^[6]. This underscored the need to create optimal design of the hospital physical environments which could reduce medical errors, rates of infection, injuries from falls and staff stress, among others. It is, therefore, important to ad-

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dress some of these problems. Researchers and designers working in this field should put more effort in enhancing users' experience in the hospital environment. Hospitals are important components of the healthcare system; the attention on their architectural and spatial designs from user's perspectives needs more qualitative and quantitative researches^[7].

Measures from many researchers in both the developed and developing nations have been identified through the literature to examine the various aspects of healthcare physical facilities addressing design issues and satisfaction from both the patients, caregivers and healthcare professionals' perspectives. For example, the study conducted by ^[2] focused on the performance of hospital inpatient ward spatial configuration in relation to visibility. The findings show the importance of visibility as experienced by the users in hospital ward; and ^[8] focused on design such as layout typologies, space connection to another building, shape and arrangement of spaces as factors that determined overall hospital satisfaction. While ^[9] measured the design issues relating to exterior space quality, orientation, green spaces, building aesthetics, interior space quality, spatial physical comfort, quietness, views and lighting, cleanliness, good signs/information points, adequate seating, overcrowding, and privacy for conversations. These studies failed to critically develop conceptual framework that examine the relationship between the special configurations, the psychological design issues underlying the user's satisfaction in hospital buildings. Hence, this study becomes necessary.

2. The Literature Review

2.1 The Morphological Design Configuration

The study of morphology focuses mainly on the use of space syntax which contains a set of techniques and theories and is applied to the study of spatial configuration ^[10]. The study concentrates on the elements of building, shape/form, the structure of the environment, the structural efficiency and the architectural appearance of building forms ^[11-12]. The movement flows in the building environment are mainly determined by the spatial configuration of the physical facilities which places more emphasis on physical form and human behaviour ^[13] and influence users' sensory perceptions, and affect staff efficiency and productivity ^[14].

Also, the morphological spatial configuration approach from hospital perspectives and architectural configuration of a space is more than just the geometric organization. According to ^[7], hospital buildings are im-

portant components of the healthcare system; therefore, proper attention must be paid to their architectural and spatial designs. However, the morphology of hospital spatial facilities focused on different specializations of physical flow in the hospital environment which is considered as the interplay between spatial, organizational and the configuration of work processes and routines within the hospital environment^[15]. The workplaces are more centred on specific hospital physical facilities locations and the activities around them, whereas the landscape of the hospital environment is more defined by movement between interior and exterior spaces. According to ^[16], interior spaces within buildings are defined by the architectural elements of structure and enclosures which include doors, ceilings, walls, windows, doorways, and stairways. Interior elements are fit for visual and functional purposes that incorporate aspects of materials, construction, and technology.

Many studies have examined the different aspects of hospital workplace environment using the concept of space syntax. Only few of these studies have empirically studied the morphological design of hospital physical facilities. For example, ^[15] analysed hospital workplace environments from architectural configuration and timespace properties perspectives. The authors offered a limited range of variation of spatial configuration and workflow. An interview method of data collection was conducted using different hospital physical facilities such as nurses' stations, the medicine room, emergency ward (both internal, external, and technical conditions) and spatial conditions and workflow practice for each unit was evaluated The finding showed that users of the facilities were satisfied with overall spatial condition and workflow pattern of the facilities and the result highlights the interrelationship between occupational patterns, spatial configuration, and the users.^[2] Addresses the spatial configuration of a hospital inpatient ward in relation to the degree of visibility as an important aspect of patient care in the ward. The findings of the study have some implications for improving the performance of spatial organization of hospital inpatient wards in terms of visibility.

Similarly, ^[17] conducted a study to understand the contribution of space syntax to the improvement of operational efficiency and analysis of patient flow in healthcare settings. The model suggests that physical and visual accessibility of spatial layout, through their effects on patient movement, service delivery, and way-finding, may help reduce travel time, waiting time, service delivery time and, by increasing patient satisfaction, improve operational efficiency in healthcare settings ^[17]. In a

similar tone, ^[18] focused on a new approach to the flows system analysis in the Careggi University Teaching Hospital in Florence. The study showed the potentiality of an evidence-based approach combining both the social and spatial aspects concerning the people's movement compared to the traditional functional approach. The architectural use of these forms alongside their influence on our man-made environment is of general importance. They defined the overall shape of the building structure and its internal configuration^[19] which can be interpreted as building sizes, shape building densities, spatial forms, frontage patterns, physical connections, and arrangement of interior furniture, location, accessibility, and connection to the neighbourhood and landscape facilities, among others ^[19]. The morphological configuration of spaces can be further classified as external and internal configuration of the physical facilities.

2.2 The Psychological Design Features

Studies have shown that psychological design issues are vital and require more attention when planning the hospital environment especially when planning for psychiatric and children hospitals ^[20-21]. The psychological design attributes identified from the literature are privacy, proximity and way-finding. These issues are discussed below;

2.2.1 Design for Privacy

^[22] described architectural privacy as a visual and acoustic isolation supplied by an environment. The focus here is on visual privacy as a function of the arrangement of spaces. Patients' privacy in hospital settings is widely recognized as important factors for patients' well-being and satisfaction. ^[20] defines privacy preference as the biased interpersonal boundary by which people regulate interaction with others.

On a psychological level, the importance of privacy for system-maintenance and system-development has been acknowledged by both theory and research ^[23-24]. Fulfilling people's needs for privacy is linked to their well-being and the evolution of recent trends ^[24-26] has further emphasized the concept of patients' privacy and its importance for patients' well-being. A survey by ^[27] of 140,000 hospital patients also showed privacy to be of primary concern to patients. Healthcare providers have a duty to treat patients with respect to protect their personal data. Single-sex accommodation being with other patients of the same gender is an important component of privacy and dignity. This type of accommodation can take a number of different forms, for instance, the single-sex wards, single-sex bedded bays and single rooms. The hospital should provide a combination of these different types of accommodation.

In addition to segregation based on gender, the patients prefer to have the ability to make their personal space private when necessary ^[24]. Empirical study conducted by ^[9] reported that overcrowding, and privacy for conversation determines the environmental physical quality of a healthcare environment. Similarly, ^[28] conducted a survey in a maternity health centre and found that, despite being treated politely, lack of auditory and visual privacy led women to not using a maternity facility. Hence, provisions to ensure privacy in health facilities are warranted.

2.2.2 Design for Proximity

The study of proximity in hospital physical facilities seems to be a very scarce area of study ^[24]. The proximity of patients and staff is considered as the absolute traveling distance to their nearest hospital and the distance travelled between the hospital's physical facilities^[17]. Also, studies have shown that visiting rates are strongly correlated with travelling distance from the hospital and utilization of inpatient and outpatient hospital care areas ^{[24]. [21]} regarded proximity as an important concept that determines the attributes of the physical setting of a healthcare layout environment. Similarly, ^[29] interrogated the relationship between hospital services, physical facilities and level of satisfaction with services and facilities which showed there was significant relationship between the treatment rooms and lobby areas, which supports the argument that it is important for patients to have the two areas in close proximity. In addition, the study of ^[30] pointed out young children's need to experience proximity environment. However, design for proximity should be done in accordance with the principle of proximity of perceptual organization which stated that stimuli or objects that are in close proximity to each other can be clearly perceived when being grouped together [30; 24]

2.2.3 Design for Way-finding

The problems in way-finding for patients and visitors are common in hospitals^[24]. These difficulties can result in feelings of agitation, disorientation and a loss of control ^[31]. Way finding may help reduce travel time, waiting time, service delivery time and increasing patient satisfaction, thereby improving operational efficiency in healthcare settings ^[17;24]. Although colour coding is often used to assist in way-finding, one group of authors warns that it is often misunderstood by patients and visitors

to the hospital ^[32]. However, the studies of way-finding have been examined in various aspects of hospital physical facilities studies. ^[33] explored the impact of these architectural hospital design factors on patient satisfaction in psychiatric facilities. The findings showed that design assessment regarding wayfinding is a valuable input to support evidence-based design in the hospital environment.

^[21] found out that wayfinding is an important concept that determines the attributes of the physical setting of a healthcare layout environment. ^[34] pointed out that way-finding is a crucial physical design element of an elder-friendly hospital. Further studies by ^[35] showed that wayfinding is an interior physical design component of outpatient healthcare facilities. Similarly, ^[36] included way-finding as hospital design factor in an attempt to assess the impact of architectural design on psychosocial well-being among patients and staff in the context of a new complex continuing care and rehabilitation facility. In addition, ^[37] considered way-finding around the hospital as a factor that enhanced the physical facilities of the patient and care environment which also improved patients' overall satisfaction.

2.3 Theoretical Framework for Hospital Facilities Design

The models and theories adopted in this study documented the relevant design issues relating to the hospital physical facilities design evaluation and satisfaction. Most of the theories stressed recognizable cues that are understood by potential users of the building. The models and theories identified from the literature include the ^[17] Operational Efficiency Model, ^[38] Usability Framework the ^[39] Model, ^[40] Model and ^[41] Model (2009).

2.3.1 The Khan, (2012) Model

^[17] model used the constructs of space syntax to analyse patient flow in healthcare settings and suggested that physical and visual accessibility of spatial layout affect patient movement and service delivery. An easily accessible and visible spatial layout may have direct or indirect positive effects on patient's movement, frequency of trip, visibility and way-finding. These may increase operational efficiency in the hospital settings. The model will be applied to give clear evaluation of the morphological design configuration in the proposed model, such as shape, form, arrangement of interior furniture, location, accessibility, connection to the neighbourhood, attached facilities and amenities, design components facilities and landscape facilities (Figure 1.0)





2.3.2 Haron, Hamid and Talib (2012)

^[38] developed a model to understand the improvement in spatial layout of hospital which led to more efficient, effective, user-friendly work-facilitating environment that improved the comfort level of outpatient's facilities. The findings indicated a positive users' experience of quality of care, usability of physical environment design that fulfils their needs and strong relationship between the usability physical environment criteria and overall patient satisfaction. The model will be applied in this study, to evaluate the design features relating to morphological configuration of spatial usability in terms of organization, layout location and movement pattern among others which is one of the objectives of this study (Figure 2.0).



Figure 1. Haron, Hamid and Talib Usability Concept in Healthcare Design

2.3.3 Zhao, Mourshed & Wright, (2009)

The third model, developed by ^[39], focused on patient-centred design of healthcare facilities and indicated that the physical environment of a hospital is influenced by how various activities are laid out and linked with the indicators, such as safety and wellbeing, organizational, spatial configuration, energy and environment which determine the user satisfaction. Findings from their study suggest that the developments in health care delivery and in allied fields have implications for the design of space layouts and resulting buildings, in ways crucial for efficiency and productivity. The model will be applied in this study, to evaluate the design features relating to user's satisfaction (Figure 3.0)



Figure 2. Zhao, Mourshed & Wright Model of patient-centred design of healthcare facilities, (2009)

2.3.4 Alalouch, Aspinall & Smith Model

^[40] developed model for hospital design criteria at three levels such as; ward deign, ward spatial arrangement; patient's privacy and patient's visual privacy. The aim is to assess how policies and guidance documents in the UK have dealt with architectural privacy in hospitals. However, the model provides a unique source for the minimum hospital ward design criteria that are related to patient's privacy and also provides a design aid to further enable architects and healthcare building providers to make better informed decision regarding design proposal of hospital wards ^[40].

(AEDET) has a clear structure to categorize all design criteria which were distilled from the four NHS toolkits. The (AEDET) is based on the design quality indicator (DQI). The DQI has been developed to evaluate design quality of buildings in the four key stages of building development. The model was applied in this study to evaluate the design criteria for privacy within the internal spaces provided in the inpatient wards of the physical facilities design of the hospital buildings in the developing nations. The model is represented in the figure 4.0.



Figure 3. AEDET Structure Based on Design Quality Indicator developed by Alalouch, Aspinall & Smith, (2016)

2.3.5 Hill & Kitchen (2009)

^[41] developed a theory to underpin the concept of sat-

isfaction with the healthcare in patient facilities such as physiotherapy. The theory of patient satisfaction with physiotherapy was developed by exploring the concepts of need and expectations that are proposed as being important determinants of the construct in relation to the physiotherapeutic approach to care. Such a theory is important in physiotherapy because it can inform current practice and its evaluation and have implications for future patient care.

^[41] also developed a model to describe patient satisfaction with outpatient physiotherapy. The model identifies possible factors leading to satisfaction and provides an explanation for the relationship between expectations and satisfaction as a basis for patients' evaluation of their physiotherapy care.

From the theoretical framework, the first three theories reviewed can be applied to the present study because they can be useful to assess the user's perception of hospital physical facilities design with a view to developing framework that can inform design decisions on the hospital buildings.

Finally, the studies of theories in this research call for the need to integrate individual opinion on the interaction between people and the physical environment. There is no doubt that these theories will guide the issues to address the assessment of the user's perception of the

3. Methodology

The research is based on a critical review of the current state-of-the art of the healthcare building design. Advanced literature review was done to look at various design issues relating to the study of the morphological configuration of physical facilities such as (space layout design) among others and the psychological design issues such as (Privacy, proximity and wayfindings) underlying the study of spaces in the hospital buildings and its environment. Several strategies were employed to identify potential studies/articles for the review. An information portal has been used to identify relevant catalogs, reference databases, citation databases, journals and conferences. Relevant journals, magazines and newspapers in the topics of healthcare design, patient safety and patient recovery were identified through Google search as well. Detailed review was conducted on the 41 of the 65 literatures. The objective was to understand how these identified design factors affect the healthcare physical facilities satisfaction.

4. The Conceptual Framework For The Study

The framework for this study is derived from the literature review and theories discussed in the previous sections of this study. This study developed a framework that can be used to examine the relationship among user's characteristics, design of the physical facilities and the level of user's satisfaction with the hospital physical facilities in the study area. The pictorial presentation of the model is shown in Figure 5.0. Two design characteristics are involved here; the morphological design configuration and the psychological design characteristics of the physical facilities.

This present study defines the morphological design configuration of the physical facilities as external and internal configuration. The external configuration refers to the physical plan layout of the building and spaces, quality standard of materials for exterior façade, accessibility of building, frontage patterns, building impression and aesthetic, size of window, building shape, spatial forms, exterior space quality and landscape, among others. The internal configuration is defined by features such as shape/ form, organization of interior furniture, spatial visibility within the ward spaces, decoration & artwork of spaces, space sizes and proportion, interior movement flow within the ward spaces, flexibility of spaces, attached facilities and amenities, materials of interior architectural elements, which include doors, ceilings, walls, windows, doorways and stairways, among others.

However, a comprehensive model that examine the relationship between the user's perception of the physical facilities design, users' socio economic status and the effect on individual satisfaction is still missing in the literature. This research is an attempt to propose a model that could describe the relationships.



Figure 4. Author's Conceptual Framework Derived from Haron, Hamid and Talib, 2012, Zhao, Mourshed&Wright Model, 2009 and Khan, (2012) For Constructs of Space Syntax

5. Conclusion

This study have succeeded in reviewing the theoretical issues relating to morphological and psychological design issues in hospital building design evaluation. Through the literature review of previous models such as, ^[17] Operational Efficiency Model, ^[38] Usability Framework, ^[39] Model, ^{[40] and Hill & Kitchen (2009) [41]. A} conceptual framework for physical facilities design evaluation and satisfaction in hospital buildings was developed.

In conclusion, the relationship between the designs of the physical facilities such as the morphological configuration, the psychological design characteristics of the physical facilities and satisfaction with the hospital physical facilities have been displayed with respect to individual socio-economic characteristics. It shows that the design of the physical facilities determines the hospital's satisfaction which could inform Hospital buildings design decision.

This study did not only develop a framework that will inform design decision on hospital buildings but also share the information relating to crucial design issues of the health care physical facilities. The study also helps in the transformation of design procedure needed in providing safe care environment for patients and good working condition for its staff; thereby increase the user's satisfaction of hospital buildings. It can also serve as reference document that will support the needs of the health care professionals and workforce in the future.

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ARTICLE **Impact of Procurement Methods and Procurement Requirements on Cost Over-run of Public Building Projects in Uganda**

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ARTICLE INFO	ABSTRACT
Article history Received: 10 January 2021 Accepted: 27 February 2021 Published Online: 30 March 2021	Cost over-run in building projects is endemic and routinely increases construction cost to as high as 52% of contract sums in Uganda. The consequence of this is underachievement of investment objectives due to additional costs to complete projects. This research investigated how pro- curement requirements and procurement methods combine to determine out our run of building projects.
Keywords: Bidding time Performance bond Insurance Workload Contractor experience	cost over-run biodining projects. Procurement requirements of bid time, performance bond, insurance, workload and experience of contractors were investigated within contexts of procurement methods of open domestic bidding, restricted domestic bidding, open international bidding, restricted international bidding and requests for quotations. Purposive and snow-ball sampling were used in identifying construction professionals, consultants and contractors of building projects with cost over-runs. Correlation and independence of procurement requirements on 37 cost over-run datasets were analysed by Spearman's bivariate correlation co-efficient at 5% level of significance and variable inflationary factor of less than 5 respectively. Bid time and performance bond were found to reduce cost over-run of building projects most followed by workload and experience. Insurance increased cost over-run marginally. The novel contribution of this research is a model that explains 63% of cost over-run with 9% margin of error. The variants of the model for each procurement method are presented.

1 Introduction

Procurement and project execution were for the first time in 2020 included in the annual World Bank funded local government performance and service delivery assessment and quality assurance in Uganda. Procurement and project execution have cross-cutting functions in service delivery through construction of education, health, water, environment and micro-scale irrigation infrastructure facilities ^[1]. Cost over-runs are endemic in the construction industry in spite of the considerable research on the subject. The construction industry should therefore not relent on continued research to respond to this seemingly unending challenge. Most previous research on cost over-run has concentrated on their causes compared to prediction. Even among prediction studies, the very public procurement requirements and public procurement methods used for eliciting services of contractors have not been used to determine their impact on

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cost over-run of public building projects. A related paper to this article by Kwio-Tamale et al. (2020) developed a generalized model that predicts cost over-run in public building projects. However, the different procurement methods used to elicit public building contracts impact differently on cost over-runs. This paper addresses and demonstrates the impact and importance of the different public procurement methods with interplay on procurement requirements on cost over-run of public building projects. This is done by presenting specific variants of cost over-run model for the five public procurement methods of (i) open domestic bidding, (ii) restricted domestic bidding, (iii) open international bidding, (iv) restricted international bidding and (v) requests for quotations as used in Uganda.

^[2] disclosed that construction contributes significantly to national economies. According to ^[3], construction accounts for 6-9% of Gross Domestic Product (GDP) in many countries. In Uganda, construction contributes over 12% of GDP and was the second largest employer after agriculture according to ^[4]. However, construction industry is faced with the global challenge of cost overruns that affects over 90% of construction projects ^[2]. The report of ^[5] corroborated this global challenge by observing that adversarial pricing models for construction were still persisting in the United Kingdom (UK). This was in contrast to reduction of cost over-run by at least 10% as one of the key performance indicators that had been set by ^[6] to reform the construction industry in the UK.

Governments regulate public procurement change orders through spending limits which is 25% in United States of America (USA)^[7] compared to Uganda's that was initially 20% under the Public Procurement and Disposal Authority (PPDA) Act (2003) and subsequently revised to 25% (PPDA, 2014). However, Uganda's 25% public procurement change order spending limit is inadequate to mitigate the up to 52% cost over-run as reported by ^[8]. If unresolved, the situation will undermine national development strategies like Uganda Vision 2040 and National Development Programme III (2020-2025) that have construction as one of their key development pillars.

^[9] observed that construction cost over-runs were almost unavoidable due to the fragmented nature of the construction industry. Subsequent to the ^[6] report on reforming the construction industry with a 10% target in reducing cost over-runs, ^[10] reported in the UK that 48% (almost half) of construction industry professionals had acknowledged that cost over-run was still rampant. The unending problem of construction cost over-run was re-affirmed by ^[2] in observing that 90% of global construction was faced by cost over-run. Subsequently, ^[11] regretted the inaction on construction cost over-run because it causes disputes among construction project stakeholders. In Croatia, ^[12] recommended research on quantification of cost over-run of building projects.

Several researchers like ^[13-18] and ^[19] have reported extensively on the factors for construction cost over-run. A study by ^[8] on cost over-run in 30 public-sector projects in Uganda found that cost over-runs ranged from 11% to 52%. However, this study did not develop a model that predicts cost over-run. In contrast, ^[20] in Egypt developed a prediction model for cost over-run based on nominal variables from 30 water and sanitation projects. Although this study had high co-efficient of determination (83%), it had high double-digit standard error (34.8%) probably because of the dichotomous variables used. No previous studies have used public procurement requirements of bid time, performance bond, insurance amount, workload and experience to predict cost over-run. In view of this, this study sought to develop models for predicting cost overrun of building projects based on these public procurement requirements and specific to each of the five public procurement method used in Uganda and in other jurisdictions.

The main and novel contribution of this paper is the specific variants of models for each public procurement method for predicting cost over-run of public building projects based on public procurement requirements of bid time, performance bond, insurance, workload and experience of building contractors. The main users of the model would be government procurement entities in ministries, departments and agencies. The specific variants of cost over-run models informs and guides estimators and managers at planning stage about the likely impact of each procurement method on expected cost over-run during project implementation. This enables determination of appropriate cost contingencies in building project budgets to offset cost over-runs that arise during project execution. This strategy ultimately minimizes projects stalling before planned completion due to budget under-costing.

1.1 Theoretical Framework for Predicting Cost Over-run

This study was guided by construction change management model (also known as the Change Process Model) (CPM) advanced by ^[9]. The Construction Industry Institute (1984) in Austin-Texas (USA) postulated this theory for evaluation of construction changes as a component of project management. The theory forecasts construction changes like cost changes represented in this research by cost over-run. The CPM model uses historical causal factors to forecast construction changes.

According to ^[21], linear regression model is good for the prediction of scalar (i.e. quantitative) continuous dependent variables that use one or more independent variables. For good modeling, ^[21] argued that data for modeling should be discrete or continuous, relevant and numeric. The predictive importance of linear regression model was also shared by ^[22]. However, ^[21] warned that large number of independent variables should be avoided to minimize errors from interaction effects. Similarly, the principle of parsimony of ^[23] prefers regression with the least number of predictors among models of the same predictive power.

In this research, construction change was cost overrun while the historical factors to predict it were public procurement requirements of bid time, performance bond, insurance amount, workload and experience. These procurement requirements are set and enforced by public procurement entities. They are robust, easy to measure with high accuracy, easy to control and therefore relevant for predicting cost over-run. These procurement requirements operate within different public procurement methods of open domestic bidding, restricted domestic bidding, open international bidding, restricted international bidding and requests for quotations. Cost over-run is a quantitative continuous variable hence its prediction by linear regression complies with the rationale of ^[21]. Similarly, the use of five relevant predictors (i.e. bid time, performance bond, insurance amount, workload and experience) conforms to the principle of parsimony of ^[23].

The principles and sequential stages of change process theory include identification of potential changes (in this case cost changes in form of cost over-runs), evaluation (by measurement), approval, implementation and review. Evaluation phase of change process model theory for cost over-run would be the respective specified quantities of bid time, performance bond, insurance amount, workload and experience set to mitigate cost over-run. The output of evaluation phase provides input for approval phase in terms of government policy in setting public spending order limits in building project budgets equal to or above contingency costs to mitigate cost over-runs. Policy outputs of approval phase provide inputs for implementation phase in enforcing public order spending limits in terms of realistic contingencies for managing cost over-runs. Review phase of the theory emphasizes the need and importance to periodically adjust contingencies through revision of public order spending limits and contingencies to contain cost over-runs that change overtime. In the absence of longitudinal surveys on cost over-runs, the review process is informed by cross-sectional surveys on cost over-run as was the case in this research.

The evaluation phase of CPM conforms to the work breakdown structure for project costs of ^[24] as in Figure 1.



Figure 1. Workbreakdown Structure of Typical Project Costs

Source: Project Management Institute 2013

<u>Legend</u>

1. ABE=Activity Budget Estimate, 2. ACR= Activity Contingency Reserve, 3. WPE = Work Package Estimate, 4. WPC = Work Package Contingency, 5. PBE = Project Budget Estimate, 6. PBC = Project Budget Contingency, 7. PDB=Project Design Budget.

Progression of Costs

ABE + ACR= WPE, WPE + WPC= PBE, PBE + PBC = PDE

Figure 1 shows that every work section is susceptible to cost over-run hence the need to disaggregate contingency cost in constituent work sections. It demonstrates that individual work section contingencies cascade to add up to overall project contingency that constitutes contingency reserve for offsetting cost over-run.

Both ^[25] and ^[26] advanced the use of cost reserve structure. This model was supported by ^[27] who argued that cost variations can be quantified by price and time. Pricing of cost over-runs as percentage of original works is shown in the works of ^[28].

1.2 Conceptual Framework for Prediction of Cost Over-run in Building Projects

Using micro-economic theory, ^[29] identified time as a risk factor for price escalation because of increase in production inputs. The influence of time on costs was also recognized by ^{[20], [30]} and ^[2]. In their studies, ^{[13], [30]} and ^[2] included inexperience as risks in setting inadequate contingencies for mitigating uncertainties that cause cost over-runs. Workload was also evaluated by [8] and [30] as a risk factor for cost over-runs. These three factors, namely bid time, experience and workload are among the key factors set by public procurement entities for enforcement in procurement of contracts for construction works. These procurement requirements or factors are quantitative and easy to measure to high accuracy. Therefore, bid time, experience and workload together with other cost over-run risk factors like performance bond and insurance amount combine to determine cost over-run. The quantitative

effect of these procurement requirements as independent variables of cost over-run in multi-linear regression model is as in Figure 2.



Figure 2. Conceptual model for predicting cost over-run in buildings

2 Methods

2.1 Sampling Strategy

Purposive sampling was used to target past building projects with cost over-run as units of analysis. To complement this approach, snowballing technique was used to identify and reach out to network of data sources in survey of past building projects with cost over-run as study population. Primary cost over-run data were obtained from project engineers, architects, quantity surveyors, design and supervision consultants and contractors who participated in the supervision and management of building projects that had cost over-run.

2.2 Sample Size

The sample size was determined from the statistical formula of $n \ge (Z. \sigma / \varepsilon)^2$

where:

n = Sample size,

Z = Standardized 95% confidence interval variate,

 σ = Standard deviation,

 ε = Required error (precision).

The 95% confidence interval standardized variate, Z=1.97 is the minimum standard used in practical engineering and construction industry practice to comply with requirement for minimum "two-sigma" rule. Using the standard deviation obtained from ^[8] that was the most recent study on causes of cost over-runs in Uganda's public sector construction projects before this research, $\sigma = 29.7$ %. The required error (precision) adopted was, $\varepsilon = \pm 10\%$ (again from practical industry practice and professional experience).

Substituting, $n \ge (1.97 \ge 29.7\% / 10\%)^2 \ge 34.23$.

The minimum sample size, n = 35. However, sample size used was n = 37 which (1) exceeds 35; (2) exceeds 20 (the required minimum number for regression analysis) and (3) exceeds the lower limit (30) for statistically large sample in accordance with the central limit theorem.

2.3 Questionnaire Design

The dependent variable was cost over-run measured as the positive (incremental) deviation from the original contract sum and expressed as percentage of original contract sum consistent with the definitions of cost over-run of ^{[24], [27]} and ^[2]. The independent variables were bid time, performance bond, insurance amount, workload and contractor' experience. To conform to quantitative study approach, the questionnaire was structured with close-ended questions for each data type. The key questions were: (i) what was the original contract sum?, (ii) what was the final contract amount?, (iii) what was the contingency percentage?, (iv) what was the site possession date?, (v) how much was pre-contract bid time?, (vi) did the contract have a performance bond?, (vii) was the project insured and if so by what amount?, (viii) were there concurrent projects and if so how many were they? and (ix) what was contractor's post-incorporation experience up to date of site possession?

2.4 Data Collection

The change process model theory uses historical data to forecast construction changes. In this research, cost change in form of cost over-run was construction change. Cost over-run was assessed as the difference between higher final contract sum and lower initial contract sum on every typical past building project. The historical data used to forecast cost over-run were public procurement requirements of bid times, performance bonds, insurance amounts, workloads and experience of contractors which were used on past building projects with cost over-runs. These were the five relevant prediction variables consistent with the principle of parsimony ^[23]. Difference between dates of bid invitation and submission provided bid times. Responses to questions on performance bonds and insurance amounts provided data on these particular variables. Information on the number of concurrent projects in the questionnaire provided workloads of contractors at the start of building construction works. The difference between the contractor's year of registration and date of site possession provided contractor's year of experience. Contractor's year of registration was verified by crosschecking their dates of incorporation on the register of providers for works that was available on the website of Public Procurement and Disposal Authority of Uganda. The questionnaires were delivered and received through e-mails and personal deliveries and collections.

2.5 Data Analysis

The conceptual framework that arose from the change process model theory requires cost over-run measured as percentage of original contract sum. To assess their predictive capacity, the correlation of procurement requirements of bid time, performance bond, insurance amount, workload and experience of contractors with cost over-run was assessed by Spearman's bivariate correlation co-efficient at 5% level of significance. The independence of these procurement requirements from one another as effective predictors of cost over-run to limit modelling error was assessed by collinearity statistics of variable inflationary factor of less than 5 (which is the same as tolerance of greater than 0.2). Analyses for descriptive statistics, inferential statistics and multi-variate regression modelling were performed by IBM SPSS V25.

2.6 Respondents

Questionnaires were distributed to 23 industry professionals with request for each to provide as many responses on cost over-run from past building projects. Of these, 12 respondents provided cost over-run data giving a 52% response rate which is acceptable as per the standards of Ritson et al. (2012). Overall, 37 datasets were obtained that exceeded the minimum 34 sample size as in section 2.2.

3. Results

3.1 Cost Contingencies and Cost Over-run of Building Projects

Table 1 presents the descriptive statistics of design cost contingencies and cost over-run in public building projects.

Table	1. Frequency	Statistics of	of Cost (Contingencies a	and
	Cost Over	-runs of B	uilding	Projects	

Item	Cost Contingency (%)	Cost Over-run (%)
Sample Size, N	25	26
Mean	4.92	14.19
Standard Deviation	3.16	10.16
Skewness	-0.047	2.11
Range	10	51.60
Minimum	0	3.94
Maximum	10	51.60

Table 1 demonstrates that deterministic cost contingencies that ranged from 0% to 10% were inadequate to mitigate cost over-run that ranged from 3.94% to 51.6%. This result emphasizes the need for a prediction model for cost over-run. The high positive skewness of 2.11 of cost overrun further demonstrates that project cost contingencies behave far away from normality. This contrasts sharply with project design cost contingencies that practically behave normally with almost negligible skewness of -0.047.

3.2 Correlation of Procurement Requirements with Cost Over-run of Building Projects

Table 2 presents how each public procurement requirement relates to cost over-run.

Table 2.	Correlation	Matrix of	of Public	Procurem	ent Re-
quirem	ents with C	ost Over-	-run of B	uilding Pr	ojects

		CO	BT	PB	IA	WL	EX
				10			
CO	r	1					
0	p-value						
DT	r	-0.445	1				
DI	p-value	0.033					
DD	r	-0.578	0.424	1			
гD	p-value	0.004	0.034				
ТА	r	-0.119	0.163	0.169	1		
IA	p-value	0.648	0.504	0.490			
WI	r	0.187	0.628	-0.129	-0.311	1	
WL	p-value	0.472	0.004	0.599	0.209		
	r	-0.296	0.275	0.261	0.393	-0.272	1
EA	p-value	0.170	0.183	0.208	0.096	0.260	

<u>Legend</u>

1. CO = Cost Over-run, 2. BT= Bid Time, 3. PB = Performance Bond, 4. IA = Insurance Amount, 5. WL=Workload, 6. EX=Experience, 7. r = Pearson's Bivariate Correlation Co-efficient.

Table 2 shows that bid time and performance bond were the most significant predictors with p- values of 0.033 and 0.004 respectively. Insurance amount, work load and experience correlated insignificantly with cost over-run

with correlation co-efficients of -0.119, 0.187 and -0.296 respectively. The high positive skewness of 2.11 of cost over-run further demonstrates that project contingencies behave far away from assumed normality.

3.3 Effect of Public Procurement Requirements on Cost Over-run of Public Building Projects

The multi-variate linear regression model for cost over-run based on procurement requirements of bid time, performance bond, insurance, workload and experience of building contractors was found to be as shown in equation (1) below:

Cost over-run (%)=51.11% -0.47 Bid Time (Days) +1.49E-9 Insurance (Uganda Shillings)-3.24 Performance Bond Status - 1.73 Workload (Number of Concurrent Projects)-1.18 Contractor' Experience (Years) (1)

Performance bond was a dimensionless binary independent variable with values of 1 (when provided) or 0 (when not provided) respectively. It is about the status (presence or absence) of performance bond in a contract for a building project. Therefore, the contribution of performance bond on cost over-run would be - 3.42 % (when provided) or 0 % (when not provided). Currency exchange rate at time of this study was 3,650 Uganda Shillings = 1 United States Dollar.

3.4 Effect of Procurement Methods on Variants of Cost Over-run of Public Building Projects

The five variants of procurement methods specified by the Public Procurement and Disposal Authority of Uganda are (1) open domestic bidding, (2) restricted domestic bidding, (3) open international bidding, (4) restricted international bidding and (5) request for quotation (RFQ). In conventional public contract management, two of the five procurement requirements mentioned in section 5.3, bid time and performance bond (based on project reserve estimate) are known at pre-contract stage during tendering. The other three public procurement requirements namely insurance amount, workload and experience are not known during pre-contract period until after contract award. The minimum bidding periods prescribed by the Public Procurement and Disposal Authority (PPDA) of Uganda for the different procurement methods are 30 days (for open international bidding), 20 days (for restricted international bidding), 21 days (for open domestic bidding), 12 days (for restricted domestic bidding) and 5 days (for request for quotation). Bid time and performance bond that are afore-known during tendering combined to reduce cost over-run of public building projects as shown in Table 3.

 Table 3. Effect of Bid Time and Performance Bond on

 Cost Over-run of Public Building Projects for Different

 Procurement Methods

S. N	Procurement Method	Minimum Bid Time (Days)	Cost Over-run Reduction due to Bid Time and Performance Bond (%)
1	Open International Bid- ding	30	17.52
2	Restricted International Bidding	20	12.82
3	Open Domestic Bidding	21	13.29
4	Restricted Domestic Bidding	12	9.06
5	Request for Quotations	5	5.77

The variants of the generalized cost over-run model in equation (1) for the different procurement methods shown in Table 3 based on the Public Procurement and Disposal Authority's prescribed *minimum* bid times are as follows:

3.4.1 Cost Over-run for Open Domestic Bidding

Cost Over-Run (%) = 37.82 + 1.498E-9 Insurance Amount - 1.73 Workload - 1.18 Experience (2)

3.4.2 Cost Over-run for Restricted Domestic Bidding

Cost Over-Run (%) = 42.05 + 1.498E-9 Insurance Amount - 1.73 Workload - 1.18 Experience (3)

3.4.3 Cost Over-run for Open International Bidding

Cost Over-Run (%) = 33.59 + 1.498E-9 Insurance Amount - 1.73 Workload - 1.18 Experience (4)

3.4.4 Cost Over-run for Restricted International Bidding

Cost Over-Run (%) = 38.29 + 1.498E-9 Insurance Amount - 1.73 Workload - 1.18 Experience (5)

3.4.5 Cost Over-run for Request for Quotation

Cost Over-Run (%) = 45.34 + 1.498E-9 Insurance Amount - 1.73 Workload - 1.18 Experience (6)

Table 3 shows that the range of cost over-run reduction is 5.77% to 17.52% for the different bidding periods and

procurement methods. These cost reductions are less than the additive (positive) cost over-run model constant of 51.11% in equation (1). Clearly, the statutory minimum bidding periods of the Public Procurement and Disposal Authority of Uganda are therefore inadequate to contain cost over-run in public building projects. This is demonstrated in equations (2) to (6) that shows that the variants of equation (1) remain with high additive (positive) cost over-run model constants of 37.82% to 45.34%.

4. Discussions

4.1 Control of Cost Over-run in Public Building Projects

In view of the structure of cost over-run of public building projects in section 3.3, strategies to minimize cost over-run would be to increase bid time, experience of contractor and have a high workload. International procurement methods that offer longer bid times than domestic bidding would therefore benefit from lower cost over-runs. Building contractors with long experience would pose less risk of cost over-run probably due to the immense knowledge they have acquired overtime in managing risk escalation. Insurance amount that increases cost over-run marginally can be overcome by the combined effect of bid time and experience of building contractors.

4.2. Financing of Public Building Projects

Construction is a capital intensive industry that in developing countries is often funded wholly or partially through foreign direct investments. One of the outcomes of globalization is foreign direct capital flows across international borders. The study of ^[31] showed that the ratio/ share of funding of public building projects between government and development partners was 46% to 54%. Projects through especially international bidding attract bilateral and multilateral financing protocols. Large building projects procured through international bidding at times include funding conditionalities like contingency funding. The general structure of cost over-run shown in section 3.3 and the specific variants for cost over-run based on procurement methods shown in section 3.4 can be used to determine the cost contingency to include pre-determined additions to project reserve estimates to ensure that cost over-run incidences do not disrupt planned construction and completion schedules.

4.3 Effect of Structure of Prediction Model of Cost Over-run on Building Projects

Bid time reduces cost over-runs by almost half (47%)

of bid time. This property is important for reducing the large additive model constant of 51%. Building contracts procured through long regulatory bid times would perform better in reducing cost over-run in contrast to building works with short regulatory bid times. Sensitivity analysis of building contracts with bid times of 30, 60, 90 and 120 days would accord to the developed prediction model reduce cost over-run by 14%, 28%, 42% and 56% respectively. Therefore, on account of bid time alone, building contracts with bid times of 120 and above reduce cost over-run by over 56% that completely neutralizes the high additive model constant of 51%.

The reduction of cost over-run by a constant amount of 3.42% due to performance bond is realized significantly on building projects with high contract sums. Regarding experience, sensitivity analysis of building contractor' experience of over 10 years reduces cost over-run by over 12% which is very significant in view of the endemic cost over-runs experienced between 0% - 52%. Increase of cost over-run by insurance is marginal because the Public Procurement and Disposal Authority of Uganda, African Development Bank, International Federation of Consulting Engineers, World Bank and other multi-lateral financing institutions specify insurance amounts that rarely result in high increment of cost over-run as per the structure of the general and specific variant prediction models. Given that four (bid time, performance bond, workload and experience) out of the five public procurement requirements all reduce cost over-run, the increase in cost over-run by insurance amount that is marginal can be reduced to near zero or completely.

4.4 Reforms in Procurement of Public Building Projects

The Public Financial Management Act (2015) of Uganda requires that by 30th June of every year, budgets of government ministries, departments and agencies must have been approved by parliament before start of financial year on 1st July of every year. This requirement affects lead times of procurement of public works. According to the models developed in sections 3.3 (generalized model) and 3.4 (specific variants of generalized model), it is prudent to extend bid times of smaller works more compared to those of larger works to reduce the large additive model constant of 51% on cost over-run. Using this model, the combined effect of bid time and performance bond on reducing the high model constant of 51% is pre-determinable at pre-contract bid invitation (tender) stage. The minimum bidding periods for the different procurement methods do not reduce cost over-run substantially enough. Policy and legal reforms are therefore necessary

to increase minimum bid times. The revised procurement guidelines of ^[32] that relaxed bid security as opposed to revisions on bid times, performance bond and experience of building contractors was good but inadequate. Regulatory reforms should consider the various effects of the different procurement methods on cost over-run.

Administrative review is the process of handling complaints on procurement-related matters. One of such complaints often arise from prospective contractors on disputes of adequacy of bid time to submit responsive bids within submission deadlines. Longer bid time allows contractors to prepare adequately and thus reduce incidences of administrative reviews related to adequacy of time to bid. In so doing, the longer bid times neutralize the high model additive constant of 51% as shown in section 3.3.

4.5 Application of Concept to Other Construction Works

There are similarities in different construction sectors such as building works, road works, water and sanitation works. Elements such as foundation works, equipment and even human resource is common to all these construction sectors. Indeed, some construction companies engage in all these sectors without specializing in any. This case study was specific to building projects. Before similar research is done on other types of construction projects, the findings of this study should be applied with caution in general construction planning and management.

5. Conclusions

This research investigated the impact of procurement requirements and procurement methods on cost over-run of public building projects. The procurement requirements studied were bid time, performance bond, insurance, workload and experience of building contractors. Procurement methods of open domestic bidding, restricted domestic bidding, open international bidding and restricted international bidding and request for quotation provided the different contexts within which the impact of procurement requirements on cost over-run of public building projects was studied. The increasing order in which procurement requirements decrease cost over-run in public building projects was bid time, performance bond and experience of contractors. Insurance was found to increase cost overrun in public building projects marginally.

The study recommends policy and legal regulatory reforms to enhance and strengthen the provision of sufficient minimum bid times and post-registration experience of building contractors to ensure substantial reduction of cost over-run. This is especially urgent for projects procured domestically, by restricted bidding and also through requests for quotation that typically have short bid times and at times their performance bonds are waived-off. The marginal incremental effect of insurance on cost over-run in public building projects can be minimized by phasing large projects into smaller lots.

Future research is needed to determine the quantitative effect of project phasing and project lotting on cost overruns. Similar research should be extended to investigate the effect of procurement requirements and procurement methods on other built environment infrastructure projects in the road and water and sanitation sectors.

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