ENHANCING SPACE MULTI-FUNCTIONALITY THROUGH FLEXIBILITY STRATEGIES IN THE DESIGN OF FACULTY OF MEDICINE, YOBE STATE UNIVERSITY

BY

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NIGERIA

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Declaration

I declare that the work in the thesis titled "ENHANCING SPACE MULTI-FUNTIONALITY THROUGH FLEXIBILITY STRATEGIES IN THE DESIGN OF FACULTY OF MEDICINE, YOBE STATE UNIVERSITY." was done by me in the Department of Architecture under the supervision of Dr. A. Abubakar and Dr. J.J Maina. The information derived from the literature has duly been acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

Wakil Midala		18 Sept, 2018
Name of student	Signature	Date

Certification

This thesis titled "Enhancing Space Multi-Functionality through Flexibility Strategies in the Design of Faculty of Medicine, Yobe State University" meets the regulations governing the award of the degree of Master of Science in Architecture of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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Abstract

This study investigated ways of enhancing space multi-functionality through flexibility strategies in the design of Faculty of Medicine. This is because current changes in medical schools due to contemporary technology and curriculum has brought about spatial needs that stand in contrast to the priorities of the earlier system, posing more demands for designing logically reconfigurable spaces. Three case study areas were purposively sampled to carry-out the study. Data were obtained through a visual survey checklist on flexibility attributes of the case study areas as well as an interview for staff/students and stakeholders to identify unique challenges both in the building structural system as well as trends and etiquettes of medical practice; the validity of the results was further tested through space-syntax analysis, using the depth map software. Findings revealed that the global shift in the educational system of schools from teacher-centred to student-centred approach to learning, leading to the shift from a general purpose to problem-based learning approach in medical schools, has affected the character of spaces in medical schools. These new approaches came with the need to reconcile multi-disciplinary basic science learning processes and changes in technology that stand in contrast to the earlier priorities of the educational system. While these factors have architecturally helped to reduce the amount of exclusive single-purpose spaces they place more demands for interactive spaces and logically designing reconfigurable space and fixtures over short and long-term uses. These needs were not adequately reflected in the cases under study as evidence continue to be more pronounced whenever attempts are made for periodic changes and expansion within their spaces due to changes in medical technological advancement and contemporary space needs. The implication of these suggests that the buildings under study did not foresee the

current changes, as further evidence from space syntax analysis indicated a low intelligibility value of 31%, 22% and 17.5% for case study 1, 2 and 3 respectively. However, a proposed design taking into cognisance the basic principles of flexibility in design increased spatial intelligibility to 60%. Therefore, for a design of medical schools to be flexible and adjust to its unforeseen future changes it needs to take cognisance of the basic principles of flexibility in Architecture that ensure Transformation, Interaction, Mobility and Adaptation within its building settings based on both its short and long-term spatial needs. This will proffer a robust strategy for architectural flexibility of medical schools of the future.

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1.0 INTRODUCTION

1.1 Background of the Study

The dynamic nature of human life-style has drastically changed the way inhabited spaces are perceived. Research has shown that most buildings are now unable to function up to their theoretical anticipated lives; this is because their potentials to respond to the rapid and dynamic demands posed by a contemporary spatial needs have not been adequate (Connor, 2004; Acharya, 2013), a research on public schools reveals an average life-span of 45 years with most of them abandoned after 60 years due to their inability to cope with their contemporary spatial needs (Connor, 2004); a greater percentage in Nigeria are either partially used, or become chaotic when forced to adjust to new space requirements (Okereke, 2014; Adebayo, 2015). These problems have called for a change in the approach for the design of most spaces and have necessitated the need for re-orientation in the design of medical schools in Africa which are also massively affected by similar challenges (Mwaikambo, 2009; Baker, 2012; Goswami & Sahai, 2015)

The history of medical schools all over the world has always been acquainted with periodic changes and expansion. This has been shown boldly from statistics all around the continents of the world (Boulet, Bede, Mckinley, & Norcini, 2007).

These changes in medical schools, however, have always been accompanied by a number of challenges of the 21st century schools, which include; the need for new facilities and technology, multi-user spaces with flexible learning plans and a response to the potential growth and increase in the world's population (Guide to sustainable schools, 2014; Levine, 2014). A great number of these challenges, nevertheless, had been inspired by the dynamic nature of medical school curriculum which is subject to changes periodically (Boulet, Bede, Mckinley, & Norcini, 2007; School of Medicine Prospectus, 2015). Howbeit, changes in curriculum itself have been identified as a necessary plan that spells out all that is required in terms of both human and material resources for the successful implementation of a program (Abdullahi, 2011) -these undoubtedly affect the nature of space infrastructure. Medical schools in Africa have been shown to be more commonly affected by these changes (Mwaikambo, 2009), this is because when medical education became established in Africa; many curricula were adopted from the West so as to achieve comparable standards in training. Over the last half a century however, major global pedagogical shifts have occurred in medical education without Africa keeping pace due to a lack in strategy flexible enough to accommodate new changes (Mwaikambo, 2009). The implication of these was shown boldly by a case-by-case analysis of medical schools in sub-Saharan Africa which shows a good performance in their teaching and learning setting within first 10 years of their existence but followed by a general downward spiral as the need for new changes arise. History over 30 years clearly shows this pattern throughout Africa (Mwaikambo, 2009). This clearly indicates the weak attention given to African medical schools to a more sustainable design requirement.

Mullan et al., (2012) on the other hand seem to have a different opinion on the cause of the challenges of space infrastructure in African medical schools; he observed that the economic condition of most developing countries has also put a strain and determine the capacity and capabilities of built spaces in medical schools. The world health organization (WHO) in 2009 reported that, despite the fact that Africa suffers 24% of the world's total burden on disease and has only 3% of the world's health workforce and a physician to population ratio of 18/100,000 (1/5556), the per capita income in middle-income African countries is less than one tenth of that in developed countries. The proportion of income spent on health is correspondingly low (Mwaikambo, 2009; Mullan .etal, 2012). This has affected the budget for built spaces in medical schools and limits the design capabilities of built infrastructure (Mullan .etal, 2012; Medical planning and design, 2012). This clearly indicates that the buildings within the region might require frequent changes in the future.

This is bound to create serious problems if plans are not adequately put in place in future African medical schools to adjust to or accommodate these challenges when they come.

Historically, one of the architectural design strategies used to address unforeseen future challenges has been attributed to flexibility in design (de Bos, 2012). A flexible and pragmatic approach to design has been shown to allow successful development despite a difficult economic climate and dynamic spatial requirement. Haven observed the dynamism of the contemporary society, (Young-Ju, 2013) tries to draw attention to this appropriate architectural solution by highlighting that modern life can no longer be defined within a static order of symbolic buildings and spaces but rather be flexible containers for use by a dynamic society. This approach allows buildings to cope with their existing and unforeseen challenges (Anupa, Christine, Alistair, Andrew, & Mohan, 2013). The emphasis on flexible buildings were obvious because flexibility is seen as a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance, Upton, (1994) cited in (Gosling, Naim, Paola, Losif, & Lark, 2008). It can also be defined as “The exhaustive anticipation of all possible changes. It is the creation of margin-excess capacity that enables different and even opposite interpretation and uses” (Bharatkumar, 2013).

In order to come up with unique strategies, recent studies had begun to view flexibility with some specific problem solving approach: these include, flexibility through Multi-functionality or through polyvalent form in design (Young-Ju, 2013); others had identified approaches such as, the brief or long term flexibility (Ponti, 2005); some suggested over-provision of spaces first and then division later (Saari, 2002; Emamgholi, 2011; Sunday, 2014). Despite these determinations it appears that there is still a conflict between architects perception of flexibility to that of individual users (Young-Ju, 2013); this is because many of buildings designed for flexible use seem to be applying flexibility strategies in the generic sense, meanwhile information from stakeholders varies. Medical schools have problems and contemporary space requirement unique to itself (Olds & Barton, 2015). And since medical schools in sub-Saharan Africa have been shown to encounter problems with compliance to its future trends, this research seeks to know why.

1.2 Problem Statement

Throughout history medical schools have always been associated with periodic changes in the character of its spaces (Trelease, 2006; Boulet, Bede, Mckinley, & Norcini, 2007). These changes have always been made to accommodate the dynamic nature of medical curriculum, pedagogy, learning instructions and the need for contemporary technology which does not fit-in any longer to the priorities for which the educational system was originally based , (Jupp, 2002; Mullan. et al, 2012). Unfortunately medical schools in Africa, like most educational buildings in Africa has failed to provide a sustainable strategy that will adequately cater for its predictable future space challenges due to insufficient building systems and planning, (Mwaikambo, 2009). This is evident from the chaos and continuous decline in the use of spaces when the need arise to accommodate changes a few years after their establishment. Consequently there is no medical school in sub-Saharan Africa that has been able to show a systematic and sustained record in the use of its spaces to accommodate needs unique to the practice for at-least a decade (Mwaikambo, 2009). Since medical schools in Nigeria are part of the larger whole of its counterparts in sub-Saharan Africa, there is, therefore, the need to improve the design strategies employed in the design of medical schools in Nigeria.

1.3 Aim and Objectives

The aim of this study is to enhance space multi-functionality using flexibility strategies with particular emphasis on Faculty of Medicine design for Yobe State University.

The objectives of this work are as follows:

1) To identify the concept and strategies of flexibility required for the design of Faculty of Medicine, for Yobe State University;
2) To identify factors that affects the concepts and strategies of flexibility in the design of Faculty of Medicine in Nigeria;
3) To examine faculties of medicine in Nigeria and identify factors that enhances their spatial flexibility;
4) To develop a framework for the design of Faculty of Medicine Yobe State University with flexibility strategies; and
5) To demonstrate the outcome of the research in the design of Faculty of Medicine, Yobe State University.

1.4 Research Questions

1) What are the concepts and strategies of flexibility required for the design of Faculty of Medicine for Yobe State University?
2) What are the factors that affect the concepts and strategies of flexibility in the design of Faculty of Medicine in Nigeria?
3) What are the factors that enhance spatial flexibility in the design of Faculty of Medicine in Nigeria?
4) How can a framework be developed for the design of Faculty of Medicine with flexibility strategies, for Yobe State University?
5) How can the out-come of the research be demonstrated in the design of Faculty of Medicine for Yobe State University?

1.5 Scope

For the purpose of this research, information only related to concepts and strategies of flexibility in design would be considered. The field work was conducted within selected Medical institutions in Nigeria. However, literatures have been reviewed to study other medical schools outside Nigeria in order to view international perspectives. The research addressed only the challenges of design with the pre-clinical programme of faculties of medicine.

1.6 Justification

Research has shown that a flexible design strategy to cater for contemporary school learning environment, increasing students population and other unpredictable circumstances, has become a matter of urgency in Nigerian schools and the world at large. Medical institutions are faced with these specific problems as well and, therefore, need to be addressed. In 2008 Yobe state had identified the need for medical institutions to curb its health challenges (Yobe state government strategic health development plan, 2010). As at the time of this research, these goals were yet to be adequately achieved; however, as part of the health strategic plans, Yobe state university is proposing to establish a Faculty of Medicine to produce graduates that can cater for its health challenges. This research can be a necessary tool to achieving that goal.

In addition, the findings of this study would help the National University Commission (NUC) in reviewing infrastructure evaluation criteria during accreditation of medical programmes. This by implication will enable effective training in medical institutions; serve contemporary design needs of the building industry and also the nation at large in meeting the challenges of medical schools of the 21st century.

2.0 LITERATURE REVIEW

Preamble

This chapter reviewed literature with the aim of enhancing space multi-functionality through the application of flexibility strategies in the design of Faculty of Medicine. The chapter began by highlighting historical perspectives of authors on flexibility; it then went further to examine key concepts and principles related to the study. It also establishes a background for the new trends of medical schools that prompted the research. The summary of the chapter highlighted key issues taken into account to formulate the research framework.

2.1 Definition of Flexibility in Buildings

Different researchers tried to define flexibility from different perspectives. Gerwin, 1993 saw flexibility in buildings as an adaptive response to environmental uncertainty. More specifically, it is a reflection of the ability of a system to change or react with little penalty in time, effort, cost or performance, (Upton, 1994). While (Naim, Potter, Mason, & Bateman, 2006) sees flexibility as a proactive attribute designed into a system, rather than a reactive behavior that may in fact result in a detriment to time, effort, cost and performance. Ultimately, "Flexibility is not the exhaustive anticipation of all possible changes. It is the creation of margin-excess capacity that enables different and even opposite interpretation and uses," (Bharatkumar, 2013).

2.2 Historical Review of Flexible Spaces

Generally humankind possesses values that allow defining it as dynamic (Kronenburge, 2011). Today, the modern dynamic man finds himself in a dynamic, ever changing environment. Mankind by nature has always been transient, to varying degrees through the history- what has changed with the time, and what we can witness today is the speed and scale at which the increasing restlessness occurs. In order for modern architecture to serve the contemporary society, it must embrace and respond to the state of constant transfer, exchange, relocation and adaptation to new theories and principles (Acharya, 2013).

2.3 Theories of Flexibility in Architecture

The term "flexibility" entered the field of architectural terminology around the early 1950s. Walter Gropius (1954) cited in (Acharya, 2013) stated one of the earliest presumptions of flexibility, he opined that an architect have to conceive buildings not as a monuments, but as a receptacle for the flow of the life which they are to serve, and that his conception should be flexible enough to create a background fit to absorb the dynamic features of our modern life". Therefore, we can assume that social flexibility is in compliance with modernity.

Critical controversies over "flexibility" in 1960s have developed into divisive discussions whether the architect should leave his work unfinished thus to provide with opportunity to develop the final design in the future (flexibility by polyvalence), or whether the design of the building should be finished (flexibility by multi-functionality), but nevertheless flexible. John Weeks, an English architect was the one to defend the "unfinished" solution on the ground that all the big institutions such as airports or hospitals are not able to predict the changes that the building might require in the future. In strong opposition to this statement came another one from a group who warned about "...the glove that fits all hands, and therefore becomes no hand" (Acharya, 2013)

Yona Friedman, one of the leading architects and theorist in the 1950s and 60s, identified flexibility as a key concept in architecture. In 1958 Friedman published his first manifesto called 'Mobile Architecture', which proposed a new kind of mobility, which he called "general theory of mobility". His concept of "mobile architecture" implies mobility not of the building, but for the inhabitants, who are given freedom. Friedman describes mobility in this sense as a kind of "natural law," (Friedman, 2006).

Adrian Forty, professor in architectural history, sees flexibility as a subject that requires long-term thinking in architectural design. He argues that the flexibility becomes part of a wider regime of control when architects are confronted with the predicament that their involvement in a building "ceased at the very moment that occupation began. The incorporation of 'flexibility' into the design allowed architects the illusion of projecting their control over the building into the future, beyond the period of their actual responsibility for it." (Forty, 2000).

A number of the different aspects that drive dynamic ideas of architects and designers observed by (Acharya, 2013) have been discussed to indicate how today the renaissance of flexible structure reflects the increasing dynamics of modern times. These reflect how different architects and designers perceived flexibility within buildings from a modern perspective and its trends overtime.

2.4 Modern Trends of Flexibility

One of the most important motivations of the Modern Movement was the pioneering view on social matter. Social liberals and visionaries believed that the most important agenda of the day was to improve living and working conditions of the nation. The Modern Movement sought to find a simplified, abstract mode of expression, to develop architectural design into a pure concept, with clear form and free from unnecessary ornaments. The artistic movement De Stijl (Dutch for "The Style") had a philosophical vision on the design, which was based on the functionalism and simplicity of forms. Folding and sliding walls could divide or expand the room volume. Furniture elements such as chairs, desks, tables, cupboards etc. were either folded or slid from the walls and other surfaces. Their approach provided flexibility by creating multipurpose space and instant response to personal needs. Shröder House, shown in plate I below, is a famous example of this design idea where free plan liberated the living space and created flexible domestic environment.

Plate I: Shröder House Exterior.
Source: http://vimeo.com, 2016

The Combination of clean lines, simple pure forms, unrestricted by constructional elements plan layouts, ribbon windows, flat usable roofs that defined architecture, became known as International Style. International Modern Style was promoted by and represented among others by *Bauhaus* a group founded by architect Walter Gropius in 1919. Bauhaus' buildings are characterized by a feeling of openness, clean lines, simplicity and flexibility.

Le Corbusier was the most prominent architect that contributed to the Modern movement and his Villa Savoye (1930) can be seen as an icon of this movement with its emphasis of proportion, clear composition and aesthetic impact. Interlocking living areas of the building were created by merging the spaces via a succession of ramps and volumes and can be seen as essential elements of flexible space as shown in plate II.

Plate II: Le Corbusier, Villa Savoye.
Source: http://vimeo.com, 2016

Among many, one of the most influential representatives of the Modern movement that promoted credo of flexibility was the Metabolists. Metabolism was glorious Japanese architectural movement of 20th century that had envisioned a new direction for architecture and urbanism. They manifested their pioneering idea that buildings and cities should develop organically, and grow accordingly to the needs of their inhabitants (Henket & Heynen, 2002) cited in (Acharya, 2013). Their vision for a new direction resulted in the creation of various architectural projects and urban plans with large, flexible and expandable structures. One of the most distinguishing buildings that became an architectural icon of that era is The Nakagin Capsule Tower, shown in Plate III.

Plate III: Kurokawa, Nakagin Capsule Tower, Tokyo.
Source: http://vimeo.com, 2016

The building most precisely represents the Metabolist theory. “The philosophy of metabolic design is based on exchangeability, modular buildings, prefabricated parts and capsules. The units move, change or expand according to the needs of the individual, thereby creating organic growth” Pilar Echavarria (2005) cited in (Acharya, 2013) . The whole design was a prototype of sustainable architecture, with recycle ability, as all capsules were prefabricated and each module could be plugged in to the central core and replaced or exchanged when necessary based on the requirements of the user. This has been demonstrated in figure 2.1 and plate IV.

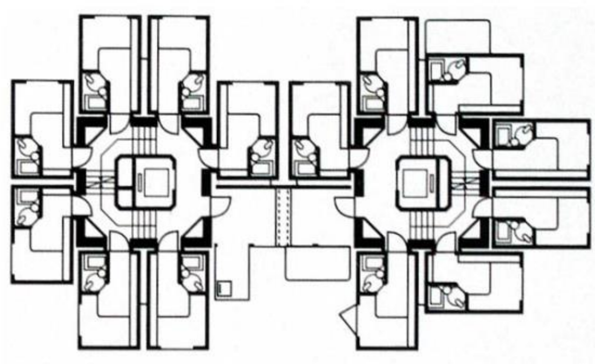
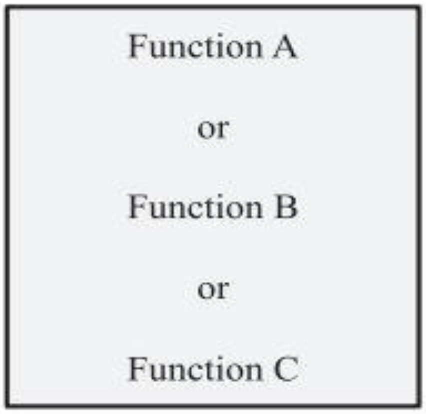


Figure 2.1: Floor Plan of Nakagin Capsule Tower   Plate IV: Interior of the Capsule
Source: http://vimeo.com, 2016

Each unit was about 10m2. Metabolists envisioned the cities of the future as flexible and expandable structures that remind the process of growing organisms.

2.4.1 Types of flexibility in architecture

There are two dominant strategies to achieve architectural flexibility: *multi-functionality and polyvalence*, indicated in figure 2.2 and 2.3. Multi-functionality can afford changeable environments with satisfying spatial conditions, relying on some precedents to achieve flexibility by interchangeable units based on modular planning; however it lacks tolerance to accommodate other uses but intended functions by architects. Meanwhile, flexibility by a polyvalence form relies on the vague anticipation of user's various interpretations (Young-Ju, 2013). It is important to note, however, that beyond its capability the adaptable space is no longer flexible. In adaptable space, the variety of possible activities and satisfaction is significantly limited by the given spatial properties which can be size, material and building systems.



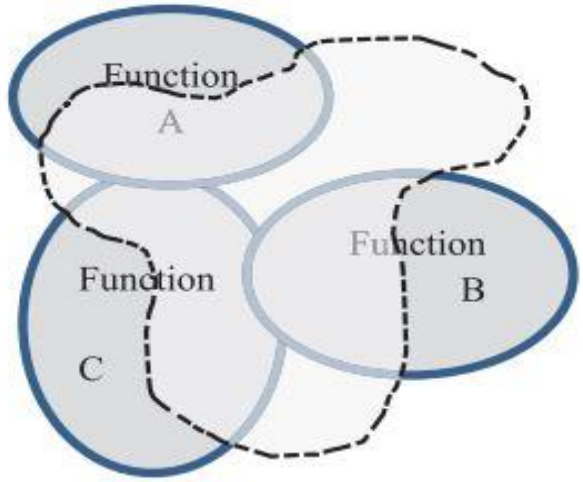


Fig 2.2: Multi-Functionality model Fig 2.3: Polyvalence Model
Source: http://dx.doi.org/, 2016

2.5 Strategies and Principles of Flexibility in Architecture

Flexible architecture requires design which is shaped by attitude to integrate the requirements of the present with the possible changes of the future. Different situations, functions, patterns of use, individual users' requirements for today and for tomorrow - are the main criteria that outline the design of flexible architecture. Kronenburge, 2011 identifies four key factors that characterize flexible architecture: ***Adaptation***, ***Mobility***, ***Transformation*** and ***Interaction***. These factors are further discussed below:

2.5.1 Adaptation

Adaptability in architecture is defined as an ability to recognize that the future is not finite, that change is inevitable, but that a framework is an important element in allowing that change to happen (Kronenburg, 2007). Adaptable buildings are designed to adjust to the different functions, defined by users' activities. Buildings, while having one distinct purpose, can operate for all kind of different others. The process of change is seen as the most momentous attribute to adaptable architecture. The flexibility of the possible layouts gives freedom for users and inhabitants to choose own designer, and freedom for the designer to create the desired space the client needs.

Adaptability in architecture is also recognized as an essential component in creating sustainable architecture. Preserving and adaptive reuse of a building instead of demolishing it and erecting a new one in its place contributes significantly to the environmental sustainability. Adaptable buildings are designed to be changeable, with multi-purpose space, freedom of use. Plate V is a building with an adaptive system.

Plate V: Shipping Container Converted to Guest House.
Source: Poteet Architects, 2016

2.5.2 Mobility

The term used for “Mobility” in the building context refers to components that can relocate from one place to another or the efficiency of movement of the users of the building, (Kronenburge, 2011). The tendency for relocation according to needs, shown in plate VI below is the basic idea behind mobile structures. Mobile architecture presents effort in promoting movement, and flexibility of a place (Codrescu & Siegal, 2002).

Plate VI: Mobile Home for 50 Scientists, Hhalley Antarctic Research Station.
Source: Hugh Broughton Architects, 2015.

2.5.3 Transformation

Transformable buildings are able to change their shape, space, appearance by the physical alteration to their structural components, outer shell or internal surfaces. This is architecture that opens, closes, expands or contracts (Kronenburg, 2007). Introducing transformation characteristics to a stationary building brings something magical about this performance – a building becomes kinetic at a touch of a button. By simple or more complicated operation building changes its form and gives the impression of being alive, as shown in Plate VII.

Plate VII: Idea of Unfolding Transformable Modules.
Source: Michael jantzen, 2015

The important additional aspect of transformable architecture is ability of the building to interact with external environment and respond to climatic situations. Roofs, windows or other parts of the facade can be opened for example for light or closed for any other atmospheric reasons. This kind of control removes the barrier that buildings usually have between inside and outside, and again contributes to environmental sustainability.

2.5.4 Interaction

In an architectural world *interactive architecture* is seen as a type of architecture that performs interaction between the building, people and appliances, as shown in plate VIII. It merges physical interaction of environment with people and interactive design, where the mind moves through abstract spaces. It is architecture that is receptive to people's needs to alter their environment and has mechanisms in place to do so easily.

Plate VIII: Adaptive Facades.
Source: Kas Oosterhuis, 2015

Interactive architecture is still an up-and-coming design arena. It nevertheless absorbs the inspiration from other industries, such as car manufacturing.

2.6 Flexible Spaces in Architecture

Emamgholi, 2011, observed that the objective of flexibility in architecture is to provide spaces with simply changing structures, respect to changes in required performance and application. Though architectural spaces could be identified and restricted through physical elements such as floor, ceiling, and walls and so on, it should be designed in a way that changes flexibly, as shown in the changes in figure 2.4.

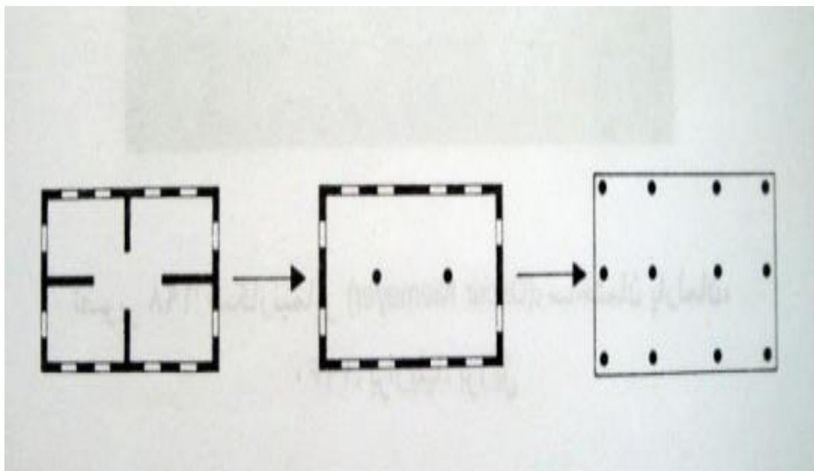


Figure 2.4: Khavaran Higher-Education Institute, Mashhad, Iran.
Source: SASTech, 2016

During the years of modern architecture, Theo Van Doesburg expresses his theories in a paper titled “toward a flexible architecture” as follow; “Modern architecture is an open one. A unique space constitutes the whole house that is partitioned according to required application and performance. Such partitioning takes place through internal divider walls and external supporting ones- the former divide the house space in accordance with performance and application which could be portable, in contrast to traditional dividing walls). Hence each resident could arbitrarily expand or shrink the room. Such effects are created through decomposition of structural elements and recombining them in another way, (Emamgholi, 2011).

Multi-Functional spaces: The above mentioned approaches include adaptation of space restrictive elements against modern space performance. Another approach to this issue is creating a multi-functional space that is the space capable of meeting different requirements. In other words such space is designed for multi-purpose activities and by changing furniture one could utilize the space without any further general modification. Such flexibility could mentally be perceived and there are no physical changes in the space (Emamgholi, 2011). This has been indicated in figure 2.5.

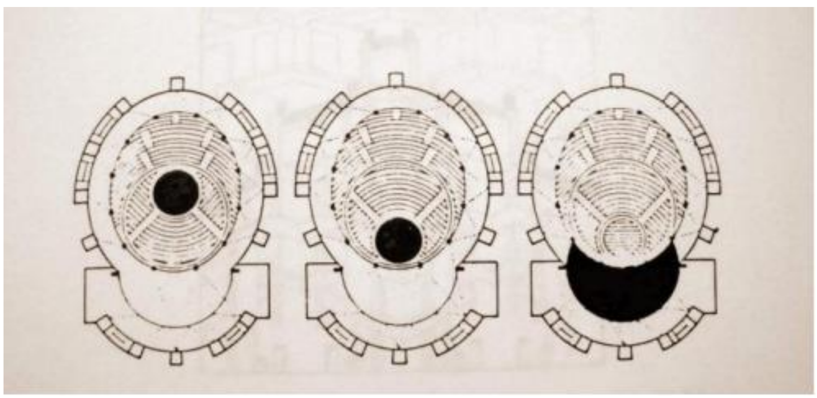


Figure 2.5: Project of the City Theatre of Berlin.
Source: SASTech, 2016

2.7 Setting of Flexibility Targets for a Building

The programming of a building project is done at an early phase before building designs are drawn and work commences. In order to program flexibility into the project, one must establish what kind of spatial flexibility is required of the building. Saari, 2002 observed that flexibility may be needed due to the fact that the users of the building are not known (construction-phase flexibility) or to allow for changes in building over its life cycle (life time flexibility). Users of buildings are primarily interested in the spaces and their features. Thus, one should determine what kinds of spatial features a building must offer immediately on its completion as well as over its life cycle. Therefore, programming starts with setting flexibility requirements (Saari, 2002), as shown in figure 2.6.

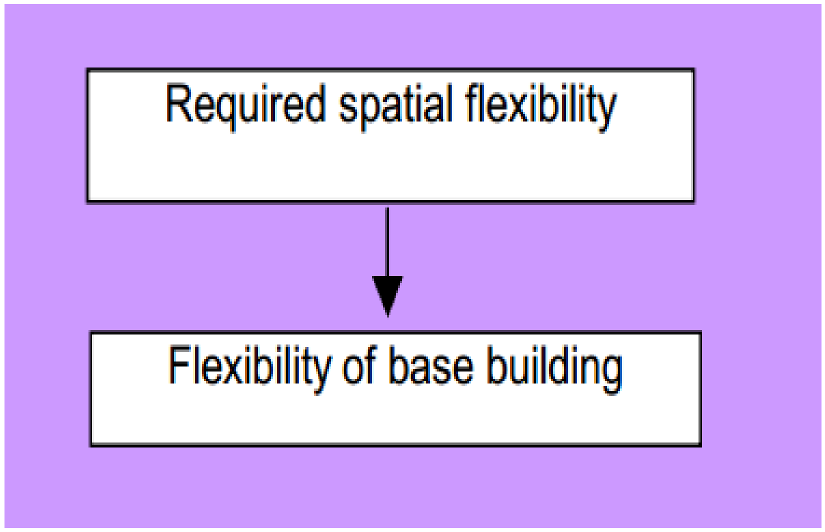


Figure 2.6: Setting of Spatial Flexibility Requirements.
Source: CIB and CABER, 2016

2.8 Upgrading the Flexibility of Buildings

The recommendations for upgrading the flexibility of buildings apply to buildings and went further to distinguish between recommendations for building technology and those concerning installation technology (Upgrading Building Flexibility, 2001).

i) Integrate the design of installation systems into the structural building design. The flexibility of buildings and homes is inextricably linked with the flexibility of their installations which more and more constitute an important component of buildings. The development construction and operate processes must distinguish between two different decision-making levels – the support level and the infill level – to ensure that buildings can be optimally modified to meet changing future needs.

ii) Avoid using penetrating connections between support structures. Accommodation of installation systems in load-bearing walls and in floors leads to a confusion of different systems, as shown in plate IX.

Plate IX: Cables and Pipes Housed in Weight-Bearing Floors (left) and Walls (right).
Source: World Building Congress, 2016

Bearing future adaptability in mind, it is strongly inadvisable to incorporate installation distribution components in walls or floors that form part of architectural construction. If installations are built into structural components because they have to be accessed for future modification, they should not be built into weight-bearing architectural constructions. This will allow for ease of modification and changes in the future.

iii) Keep a support structure disconnected from infill elements.

When a buildings support and infill elements are easily separated, and well-interfaced, this reinforces a building’s flexibility. A flexible system of inner walls also contributes to overall flexibility. Support structures and their various components are designed and implemented to fulfill various long-term functions as well as possible.

iv) Make structural design for construction and installations on maximum partition plan. Base the structural design for building construction and installation systems on a maximum partition plan based on the smallest independent and connectable unit. The repartitioning of a building means that both the spaces and the installations can be split up, depending on changing user requirements, into smaller independent units.

v) Make the support structure partitionable.

A partitionable support structure gives a re-partitionable building that can accommodate various types of functions and units, as the functions change and vary in number and size. The ability to easily compartmentalize a building for various independent users or occupiers increases its flexibility over both a long-term and short-term use.

vi). Set requirements for the connection of construction and installation system. It is important that construction and installation components can be designed to be easily disconnected, removed or repositioned within the building system. This would ensure that all foreseen changes have been properly addressed, as represented in plate X.

Plate X: Modular Radiator and Window ledge System with Dismountable Walls.
Source: CIB World Building Congress, 2016

vii) Use modular coordinated systems.

Choice on size and position of construction and installation components enables exchange and repositioning of components. The applicable position and size systems must facilitate dismantling; repositioning and exchange of construction and installation components, as shown in plate XI.

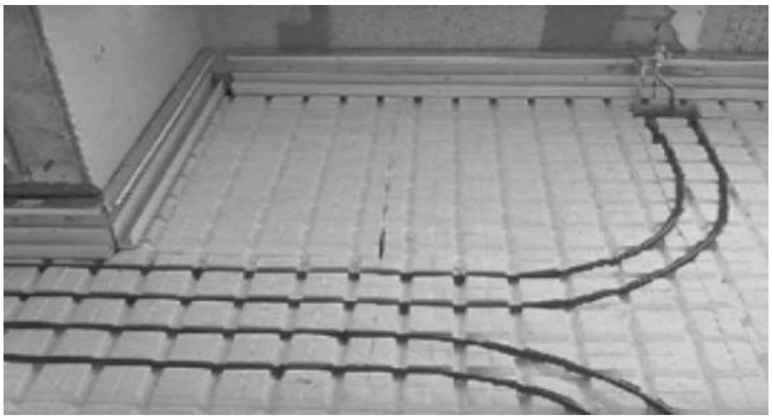


Plate XI: Position and Measuring Agreement with Respect to Modular Coordination.
Source: CIB World Building Congress, 2016

These standards constitute a means to coordinate the process lifecycle *from its global phase to its specification phase* with no obligation to adopt a specific process.

viii) Make construction and installation components readily accessible.

Access is improved considerably when elevated floors, suspended ceilings or skirting are used to duct installation systems. Installation components that are easy to access are closely linked to their level: infill level or support level. Construction and installation components at infill level are easy to access and, as a rule, have a short technical, functional and economic lifespan. This is shown in plate XII.

Plate XII: Distribution Ducts and Control Facilities in an Easy-to-Dismantle Ceiling.
Source: CIB World Building Congress, 2015.

ix) Provide local (individual) and central measurement and control facilities. To maximize flexibility at local and central levels, it is necessary, as with local and central transfers of installation functions, to measure consumption. The most flexible way of doing this is to measure consumption per user component.

x) Ensure that there is surplus capacity

The term surplus installation capacity refers to the installation ability to easily and quickly adapt to new situations. This should exist for both horizontal and vertical expansion of the building, to allow floor surface areas to be usefully deployed and at the construction level in weight-bearing walls and floors, and finally at the installation level.

2.9 Incorporating the Principles of Flexibility in the Design of Educational Spaces.

The following explains some laid down principles incorporated in the design of educational spaces, observed by (Ponti, 2005)**.**

2.9.1 The brief flexibility

This is the possibility of daily or hourly changing of the space components preferably guaranteed by the easy closing and opening of the common or sliding doors and by the quick re-programming of the plant systems components. This may be carried out, for example, contextually using modular spaces, from the amalgamation of spaces. Brief flexibility also takes into cognisance convenience of movement within spaces and also spatial interaction for both users and the facilities, based on regular bases.

2.9.2 The long flexibility

This is the modification adaptability with longer timings (weekly, monthly, quarterly / every four months and annually), which will act on the sides (especially on the internal dividers) and on the plant systems. This will lead to the inevitable use of industrialized assembling / disassembling elements and plant tricks projected for ‘modular’ use, with programmable functioning and calibration. Long-term flexibility also takes into cognizance the building ability to adapt to changes and be able to transform because of the changes happening overtime. This also considers the structural system used and the building materials used for construction that will adapt to its periodic changes. In any case, the materials and structural system to be used is based on the requirements of the use of spaces. Figure 2.7 shows an example of a modular learning space unit.

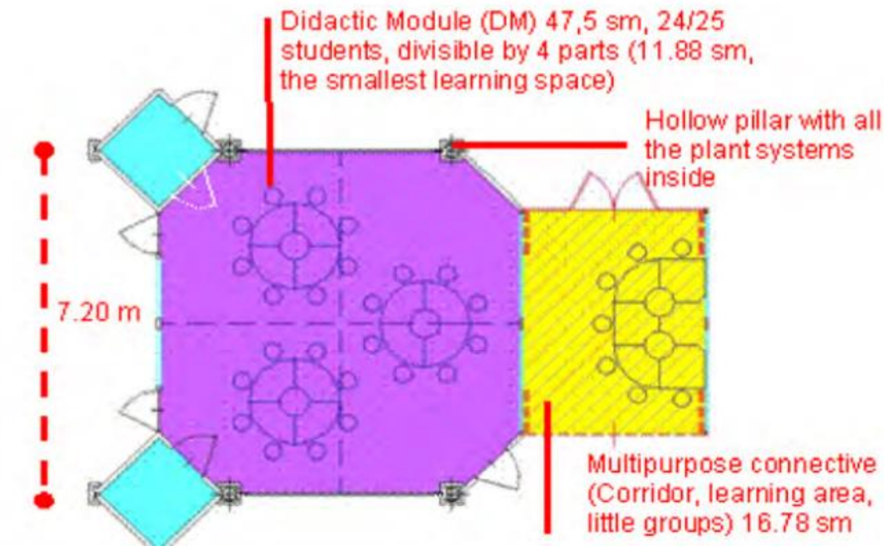


Figure 2.7: Flexible Learning Space.
Source: OECD/PEB, 2015

Above is a modular learning space suitable for holding 24/25 students/pupils (small / medium groups, classes, etc.) with a piece of connective / corridor, and with a basic module of 7.2 X 7.2m.

2.10 An Approach to School Design

2.10.1 Preamble

Contemporary education design strongly emphasizes stimulating, adaptable learning environments with spaces able to support various styles of teaching and learning. Delivering successful school buildings requires a close collaborative relationship between the architect and all key stake holders from initial briefing through to project hand over. Below considers an approach to school design proposed by (Robinson & Robinson, 2009), the brief identified the opportunities and challenges to create an exciting architectural solution which is functional, aspirational and contextually responsible. The design should demonstrate adaptability and flexibility, maintainability, attention to siting, a culture of community, and sustainability. The building program and budget also require special attention. Plate XIII shows the building interior and the flexibility attributes.

Plate XIII: Gilmore College learning Community – Flexible Spaces.
Source: OECD, 2016

2.10.2 The brief

Firstly, exploring and developing a comprehensive brief includes both functional requirements and aspirational goals. Functional and technical expectations can be clearly briefed; however the aspirational and inspirational aspects of the brief require a commitment from all stakeholders. Secondly, every aspect of the project – the facilities, the planning, the building form and structure, finishes, embedded technology, adaptability and flexibility, siting, and sustainability – needs to contribute to the effectiveness of the buildings in supporting, enhancing and contributing to the whole school environment.

2.10.3 The design

Adaptability and flexibility

These are essential requirements for school design that is needed at the design phase.

Building requirements are constantly evolving and if a building is to meet the aspirations set down, it must be adaptable and flexible and allow for changes both to technology and to the demands and requirements of its users, as demonstrated in plate XIV.

Plate XIV: Scotch College Upper Primary Boarding House Recycled.
Source: OECD, 2016.

Maintainability

School facilities must withstand a high level of "wear and tear". Therefore materials and finishes need to be carefully selected to provide a low maintenance and robust physical environment.

Siting

It is important to obtain a clear understanding of the context in which the new facility will exist amongst current buildings in the vicinity, since key aspects of the site have an impact on the facility's design. The design should be contextually responsive in relation to the immediately adjacent buildings; it should not copy existing architecture but take design queues where appropriate. While maintaining that relationship to the adjacent built environs, the facility should provide a contemporary design embracing cutting edge forms, materials and finishes.

A culture of community

When a new school building is designed, a community is also being formed. Learning occurs socially within a physical space and the design of that space is pivotal in encouraging a culture of participation in the learning process. In essence, the students interact as a community. The size of this community is important and experience suggests that creating smaller learner groups within a building (and a school generally) is more conducive to fostering this sense of community, as shown in plate XV.

Plate XV: Scotch College Building.
Source: OECD, 2016

Sustainability

A major consideration in today's energy conscious world is the design of a facility which is environmentally responsible. The facility should demonstrate a commitment to innovation and use passive design elements and active systems, materials, finishes and selections with the ultimate goal of eliminating any footprint on the environment. The refurbishment of existing buildings after they are no longer able to meet the needs of a modern curriculum is often a commercially and environmentally viable option for school decision makers.

Program

It is necessary to establish and maintain a programme for the procurement of any new facility, beginning immediately with milestones agreed with the school and key stakeholders.

In existing schools, it is important to determine the impact of a major building programme on the school's operation during the construction phase. Construction is disruptive and places stresses on staff and students. These questions should be considered: Will additional teaching spaces be required as an interim solution? Will external breakout spaces be compromised during the construction phase?

Budget

One of the most significant factors in the successful delivery of any project is the building budget. Regular review is essential to ensure that the brief and the design match the budget. A process to prioritize "must" happen early in the design phase and be costed accordingly.

2.11 An Overview of the World's Medical Schools

Providing training that will ensure an adequate global healthcare workforce is essential. Based on The International Medical Education Directory (IMED) listings, there is a fairly wide dispersion of medical schools throughout the world. (Boulet, Bede, Mckinley, & Norcini, 2007). First, the population (or population health)–medical school relationship is certainly dependent on medical school class size, curriculum focus (e.g. public health), and clinical experiences of the graduates. While the variability in class sizes would tend to average out over large regions, this is unlikely to be the case at the country level, especially for nations with relatively few medical schools. Although physicians are extremely important in any healthcare delivery model, the role of other practitioners (e.g. nurses) and advanced technology will certainly have some impact on resource needs (Boulet, Bede, Mckinley, & Norcini, 2007). The more detailed analysis, by continent and region, of medical schools by population and physician density clearly shows that medical schools and physician resources are not dispersed uniformly. For example, over 11% of the world's medical schools are located in South America yet less than 6% of the world's population resides there. In contrast, nearly 14% of the world's population resides in Africa, an area serviced by only 127 medical schools. From a regional perspective, the Caribbean clearly has a disproportionate number of medical schools. Historically, of the 25 Caribbean nations, 24 had an operating medical school at one time or another. Currently, there are 54 operating Caribbean medical schools, located in 16 different countries (Mc Avinue, 2005). In addition, physician density in this region is comparable to that for North America, suggesting that the medical education programs do, at some level, provide for local needs. However, more important than the excess of 'offshore' schools, there are some populated countries (e.g. Somalia), including 15 other nations in Africa, with no medical schools. While the physician workforce needs of these nations could potentially be met by other countries, there is no guarantee that other nations, especially those in Africa, could afford to lose their local doctors. Although efforts to redistribute, or create new, medical schools may alleviate some of the local supply problems, at least temporarily, a more pressing concern is physician migration, Cooper, 2005 and Hagopian ,2004 cited in (Boulet, Bede, Mckinley, & Norcini, 2007). In essence, while the location of the medical school is fixed, the practice locations of medical school graduates are not. While physician migration certainly plays a role in the worldwide distribution of physicians, there remains a strong relationship, at least regionally, between medical school density and physician density.

2.12 Medical Education Expansion; Case of Memorial Faculty of Medicine Canada.

In 2007, Memorial graduates made up 478 of 873 (54.8% of fully licensed Newfoundland and Labrador MDs. From 2002 to 2006, 144 MUN MD graduates established practice in Newfoundland. This represented an average of 29 per year (72.5% of the approximately 40 medical students from Newfoundland and Labrador who graduate each year), (Medical Education Expansion, 2008).

All other faculties of medicine in Canada have expanded or are about to expand to meet their provincial needs. Canada's total medical school enrolment has increased from a low of 1563 in 1997 to 2458 in year 2006 to a projected 3000 in 2010. Memorial's medical school current enrolment of 60 has not really increased from the 58 admitted in 1976. There is a clear need to increase enrolment to meet the current and future provincial needs. While recognizing that there will always be the need and benefit of having physician graduates from other Canadian and International medical schools to practice in Newfoundland and Labrador, the goal is to work towards a stable physician supply with an emphasis on self-sufficiency. Considerable work and calculations were done to attempt to establish the optimal size and makeup of the medical school enrollment expansion to best meet the Province's needs while also considering medical education capacity factors. The following factors contributed largely to the overall expansion.

(a) MD Programme – Medical Student Enrolment Increase

(b) MD Programme - Curriculum Renewal

(g) Medical Education Facility Expansion

(h) Information Technology

2.13 Learning Spaces for Health Care Education.

Context maps, shown in figure 2.8, help individuals create a snapshot of their environment. The map included here was developed at a panel discussion on learning spaces held at the November 2008 Annual Meeting of the Association of American Medical Colleges in San Antonio, Texas (Souza, 2008). It provides a framework for learning space stakeholders.

• Educational Trends versus Health Science Education Trends • Economic Climate

• Political Factors • Technology Factors • Customer Needs • Uncertainties or Unknowns

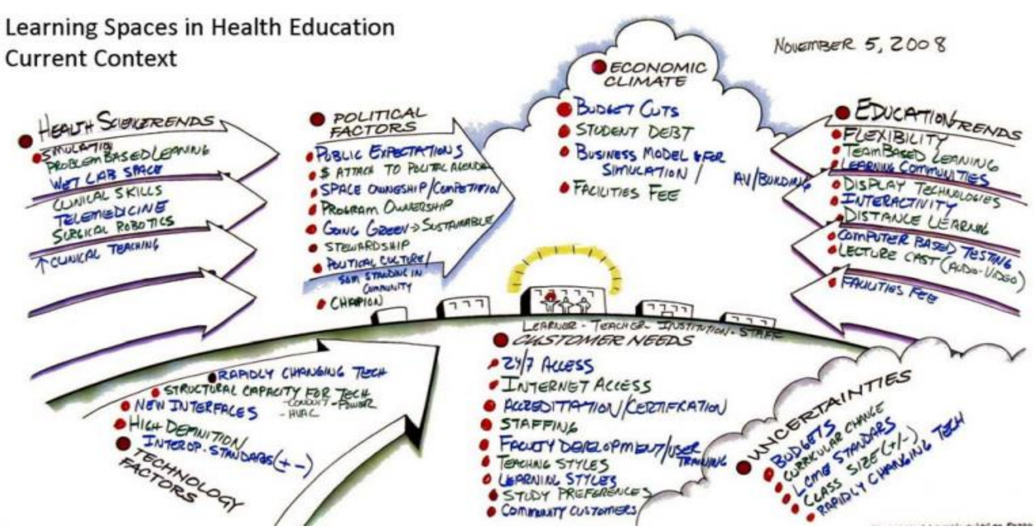


Figure 2.8: Learning Spaces in Health Sciences Education Current Context Map.
Source: EdTech, 2016.

The role of education

For educators, facilities are the physical space in which learning and/or assessment of competency-based performance occurs congruent with specific educational goals. For example, a primary educational goal for simulation centers is to serve as a safe setting for deliberate practice, a setting where learners can obtain feedback relative to a set of defined benchmarks in situations that capture clinical variations and difficulty (http://services.org) cited in (Souza, 2008) The educator, as the end-user for the learning space, must be an integral member of the learning space design team to ensure that the physical environment aligned with current and future learning and/or assessment needs. Various suggestions by (Souza, 2008) were indicated as follows:

2.13.1 The role of educational technology

Advances in health science education require medical schools to install and support more diverse and complex technology in learning spaces than ever before. Medical education has moved beyond planning for lecture halls and small group spaces with tables, chairs, and whiteboards. New demands now exist for multiple computers and high-resolution displays for virtual microscopy and diagnostic imaging, as well as full-scale simulation centers, part-task trainers, and video capture and annotation systems. All of this means that the educational technologists are now a key part of the planning team for any learning space, and their role in designing learning spaces is becoming larger and more complex. Before a space is designed and built, the educational technologist can do a number of things to ensure that the space is designed well and that the technology supports the teaching and learning process.

• ***Observations and Interviews*** – Educational technologists should go into current spaces and watch how technology is being used, misused, or not used at all. Although the design team often has a faculty member involved in the process, interviewing a variety of faculty members and students can provide a bigger picture. Interviewing support staff is also helpful, because they can identify the technology that is difficult to support currently and they often have key insights into technology placement and interfaces.

• ***Photo Documentation*** – In designing spaces, a picture is worth a thousand words. Photos give architects and furniture designers, key insights to help design better spaces. This is demonstrated on the outdoor learning space shown in plate XVI.

Plate XVI: An illustration of outdoor lectures in medical schools.
Source: EdTech, 2016

This photograph documents the need for informal spaces placed outside of classrooms so that teaching can continue beyond class rooms. This is a new trend for learning in higher institutions and especially in medical education. Classroom approach to learning has also been indicated in plate XVII.

Plate XVII: An Illustration of Indoor lectures in Medical Schools.
Source: EdTech, 2016

Plate XVII shows a lecturer using a chalkboard, meanwhile plate XVIII shows a lecturer using tablet monitor and annotation software to teach anatomy, this will inform lectern design, screen size, white board placement, etc.

Plate XVIII: Use of learning Instructional Facilities in a Medical School.
Source: EdTech, 2016

• ***Site Visits*** – Visits to other institutions that have similar types of spaces and talking with faculty members, support staff, and students is also helpful.

• ***Support and sustainability*** – It is important to have both support and sustainability models agreed before making final technology purchasing decisions. This includes, appropriate increases in the general supplies budget, as well as budget for equipment. For example, in a five-year cycle, the simple act of adding dual high resolution projection to classrooms doubles the number of replacement lamps and project replacement costs.

2.14 Laboratories Design for New Anatomist

As curricula have continued to evolve in individual medical schools, anatomy teaching laboratories have been redesigned to accommodate new methods, technologies, and practices. In that context, we will consider the anatomist's perspectives on the most important features for designing new facilities for anatomy laboratories, outlined by Drake, Lowrie, & Prewitt, 2002. Table 2.1 lists a range of these essential structural concerns.

Table 2.1: Essential Features and Issues for Modern Anatomy Laboratory Design.

Features/Aspects	Variable Details and Issues
curricula supported	single or multiple disciplines (medical, allied health sciences, undergraduate), continuing medical education; student dissection emphasized or prosections and other instructional methods
class session sizes	whole large classes or subgroups; simultaneous different classes
specimen tank layout	single large lab, sub-divisions, or multiple smaller labs; number of students per tank; working space between stations; capacity for growth or reconfiguration for different uses
ventilation	closed return downdraft tanks vs. whole room systems; climate control
room subdivisions	none; subdividing walls and doors; transparency; small group rooms
entry doors	traffic patterns; security provisions; relation to other facilities (e.g., willed body area)
lighting	general room lighting and spotlights; fixture types and mounting locations; windows, daylight and view controls (window treatments, etc.)
computers/network	"tank-side" workstations and position; display types desired; network support related to content intended (e.g., high-speed for video); wireless capabilities (speed reductions, limits < 25 connections/router)
audiovisual support	public announcement (audio system) with wireless microphone; speaker locations; room video displays, type, analog and computer capabilities; wiring patterns related to room use (e.g., splittable system for sub-rooms); AV system location; whiteboards, display boards, posters
student locker rooms	separate male/female facilities; wash facilities; showers; seating
plumbing/fixtures	Number of sinks and hand washing station capacity related to class sizes; hands-free operation; self-draining countertops; soap dispenser types; safety stations (eye wash etc.); vacuum lines, electrical outlets
trash and sharps	space for receptacles and locations; types of containment
storage space	plentiful in-lab, out-of-lab; display space for models, specimens, supplies
willed body area	proximity to lab; accessibility and security; educational support resources
esthetics	colors; wall and window treatments; wall protection; glass; metal work

Source: Anat. Record, 2016

In many “classical” late-20th-century laboratory designs, dissection exercises for an entire medical school class (e.g.100 students) have been accommodated in a single large room, with regularly spaced student dissection tables. With individual institutions’ prior preferences and in newer curricula, classes may be broken into multiple smaller groups for laboratory sessions and problem-based learning, permitting anatomy laboratory spaces to be subdivided or to be distributed among several smaller rooms. Furthermore, in many institutions, student dissection may have been drastically reduced or eliminated, with the substitution of prosected specimen observation, regional model displays, and computer workstation-based exercises. While these factors may further reduce the amount of floor space needed for cadaver dissection tanks, they place more emphasis on logically designing reconfigurable space and fixtures for student exercises using models and PC workstations (Trelease, 2006).

Historically, adequate laboratory ventilation has been one of the principal design concerns with the use of formaldehyde-embalmed cadavers. At present, two major approaches are favored: individual downdraft and high rate ceiling-floor systems.

With individual downdraft ventilation systems, air is drawn through special dissection tanks by flexible return ducts (large hoses) connected to the laboratory’s air withdrawal system. This approach assumes that formaldehyde (and other embalming chemical) vapors are heavier than air. Ideal as it may sound to some users, it does provide some practical constraints for per-unit space, tank positioning, and re-configurability.

With high-rate ceiling-to-floor ventilation systems, incoming air is distributed by ceiling ducts centered over clusters of tanks, and outgoing air is removed by high-rate floor-level exhaust ducts located within peripheral walls. A high rate of room air exchange keeps individual formaldehyde exposures well below the parts per-million regulatory thresholds dictated by Occupational Safety and Health Administration (OSHA) and other safety standards. Other necessary features of dissection laboratories include a combination of diffuse room and individual spot lighting, multiple sinks for hand washing and instrument cleaning, counter tops for specimen displays, models, and computer workstations. Structural provisions can further included creating a more restricted area convenient for sterile cleaning and blood borne pathogen (universal) procedures compliance. This entailed partially subdividing a larger laboratory, with the special procedures located proximal to the willed body facility.

Large-scale modern anatomy laboratories have relied on built-in audiovisual systems for addressing the entire class and showing videos. Custom audio systems, including wireless microphones, distribution amplifiers, and feedback suppressors, remain essential for daily use during relatively noisy laboratory sessions, whether dissections, pro-sections, models, or computer media are in use. To some degree, however, computer use may reduce the need for large-scale video displays for playing VCR or DVD media. Although planning computer layouts and networking seems straightforward, they present nontrivial implementation challenges. A laboratory could be designed to allow several different computer location and network implementation schemes, depending on the desired laboratory instruction methods. For example, if anatomists propose to use computers as an integrated instructional resource/medium around a dissection tank, the laboratory design might have compact personal computers (PCs) and monitors or screens suspended from the ceiling, together with the lighting. This may constrain other potential uses above

above-tank view space (e.g., room video monitors). Alternatively, for a more mobile configuration, small computer carts or laptop pedestals could be parked next to dissection tanks, consuming more floor space. If desired, PC workstations can also be sited in a separate small group room, facilitating activities such as guided virtual anatomy exercises.

Ultimately, local faculty anatomists should come to the planning table with a comprehensive vision of what they want their new laboratory to include meeting current, anticipated, and innovative teaching needs at their institution. The following provide three scenarios by (Trelease, 2006) suggesting methods of planning for new laboratories.

2.14.1 Renovation, long-term planning, and final design for new medical schools.

This section examines some practical scenarios in which anatomists can work with architects to help design new facilities. These share the previously discussed common needs for supporting ongoing laboratory instruction while introducing technical innovations and anticipating changes in curriculum. They differ in terms of scope of work planned, overall design constraints, and increasing project complexity.

In simple renovation, relatively short-term planning is undertaken to arrive at new design specifications for renovating or replacing existing aging facilities within an institution. Extensive technical improvements may be desired, but the constraints of the available existing space and building layout place limits on the scope of changes in the facility’s structure. In early planning for new laboratories for a new school at an existing institution, the preliminary scope of project planning can be much broader than in a simple renovation. Designs are not limited to making the best use of existing space, and there may be greater latitude in generating novel facilities. Architects work with anatomists to specify general laboratory needs and initial floor plans that can be used as starting designs that integrate with those for the other major rooms and overall mechanical layout of new buildings.

Figure 2.9: Floor Plans for First Phase Renovation at Washington School of Medicine.
Source: Co Architects, 2016

Left: initial proposed plan for the entire fourth floor of the medical education building, showing a single large gross anatomy laboratory, willed body facility, and "virtual anatomy" computer laboratory, along with faculty office (bottom) and "generic" basic sciences computer laboratories (left). Right: rough sketch of a redesigned floor plan, following initial planning meetings between the project architect and consulting anatomist and between the architect and client faculty. Note the repositioning of the virtual anatomy laboratory to adjoin the basic sciences computer laboratory (left), the subdivision of the laboratory by glass walls and doors, and reconfiguration of the willed body area for access privacy.

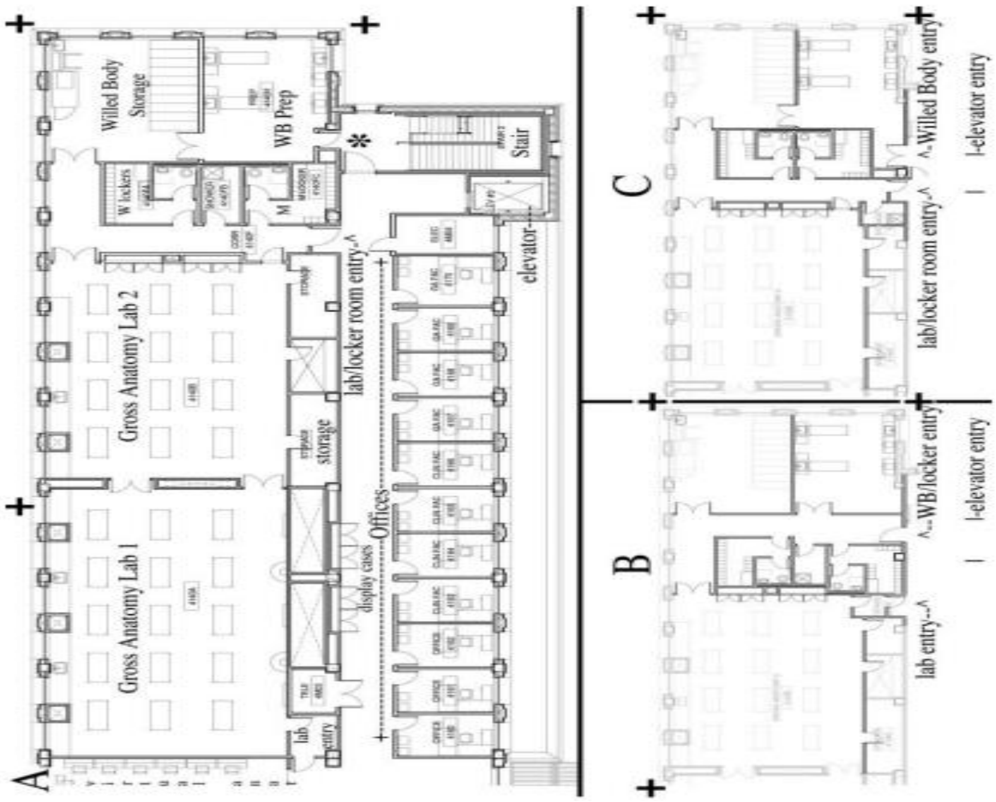


Figure 2.10: Updated Partial Floor Plans for the Project Shown in Figure 2.9 . Source: Co Architects, 2016.

Figure 2.10 above shows some partial changes from the one represented on fig. 2.9; note the variations in configuration for student locker rooms and shower locations, and alternative locations for willed body programme doors and access hall. A: Separate student locker room and willed body (WB) area doors and entryways, with the WB entry door located at the top of a major stairwell (asterisk). B: Common door and shared entryway for student locker rooms and WB area. C: Separate student locker room and WB area doors and entryways, with the WB entry door located outside of the stairwell, directly opposite the elevator.

Plate XIX is a picture of a modern Anatomy laboratory, equip with contemporary laboratory facilities, showing the placement of dissection tanks for student's practical. The headroom was designed at a considerable height for installation of equipment.

Plate XIX: A View of a Modern Gross Anatomy laboratory.
Source: Medicine.uconn.edu, 2016.

Plate XX is an Anatomy simulation laboratory equip with audio-visual display system for student practical. It shows the integration between the Anatomy laboratory and the simulation room, as opposed to earlier designs of the laboratories.

Plate XX: A view of Anatomy simulation laboratory**.**
Source: Medicine.uconn.edu,2016

Plate XXI shows a view of University of Toronto Medical School. The framed structural system used is obvious from the design, allowing the design to be adaptable to different changes. This is also obvious from the floor plan on figure 2.11.

Plate XXI: A view of University of Toronto Medical School.
Source: Medicine.uconn.edu, 2016

Figure 2.11 shows the third floor plan of the University of Toronto Medical School. The floor plan shows a framed structural system for construction. Rectangular and modular

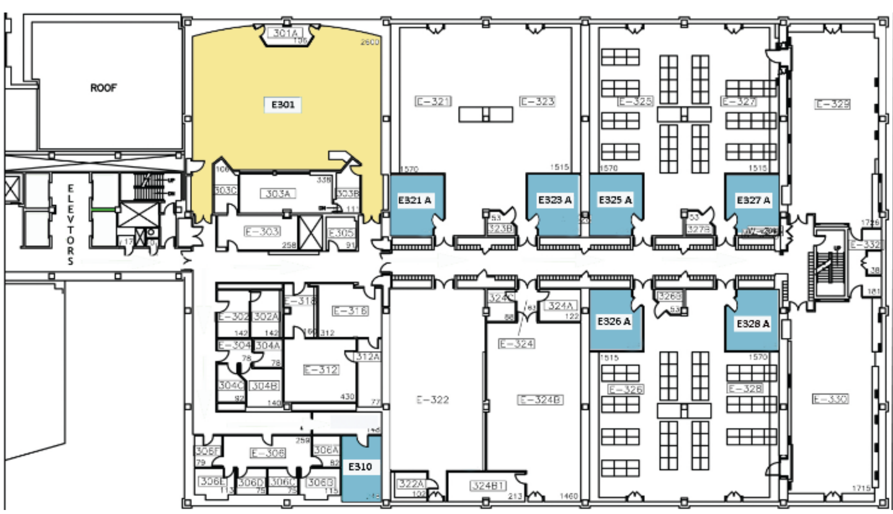


Figure 2.11: Third Floor Plan of University of Toronto Medical School.
Source: Medicine.uconn.edu, 2016

sized spaces were used to define the spaces and the building form. However, the deep-planning concept used in some spaces can make expansion and replacement of partitions difficult and thus reduce the flexibility potential of the building system.

2.15 Standard Requirements for Medical Colleges

2.15.1 General introduction

These regulations provides the "Minimum Requirements for 100 M.B.B.S. Admissions annually, approved by the medical council of India (www.mciindia.org).

Medical college or medical institution shall be housed in a unitary campus near its teaching hospital having room for future expansion. However the existing medical colleges shall make efforts to have their teaching hospital within a radius of five kilometer of the campus. The medical institution shall be designed with consideration to the following facilities:

i). Administrative block.

Accommodation shall be provided for – Principal/Deans office (36 Sq.m.), staff room (54 sq.m.), college council room (80 Sq.m.) office superintendent's room (10 Sq.m.), Office (150 Sq.m.), record room (100 Sq.m.), separate common room for Male and Female students with attached toilets (100 Sq.m.each), cafeteria (200 Sq.m.)."

ii). Central library.

There shall be an air-conditioned Central Library (1600 Sq.m) with seating arrangement for at least 200 students for reading and having good lighting and ventilation and space for stocking and display of books and journals. There shall be one room for 100 students inside and one room for 100 students outside.

iii). Lecture theatre:

There shall be a minimum of three lecture theatres preferably air conditioned, of gallery type in the Institution out of which two will be of seating capacity for 120 students and one will be of capacity for 250 students each. Lecture theatre shall be provided with necessary independent audio-visual aids including overhead projector, slide projector, and a microphone. Lecture halls must have facilities for conversion into E-class/Virtual class for teaching.

iv). Auditorium and Examination Hall:

Auditorium/Examination Hall (Multi-purpose): There shall be an auditorium/examination hall of 800 sq.m. area.

v). Central Photographic Section:

Central photographic and audiovisual sections with accommodation for studio, dark room, enlarging and Photostat work shall be provided.

vi). Central Workshop:

There shall be central workshop having facilities for repair of mechanical, electrical and Refrigeration equipment of the institution.

vii). Animal House:

Department animal house may be maintained by the department of Pharmacology. In addition to the animal house, experimental work on animals can be demonstrated by Computer Aided Education.

viii). Laboratories:

There shall be 6 laboratories (150 Sq.m. area each) which will be provided with continuous working tables. Every seat shall be provided with stainless steel wash basin. Every working table shall have drawer or steam proof top, and individual lighting. One preparation room each of 15 Sq.m. area shall be provided with all the laboratories. All of these laboratories may be used in common with various departments.

2.15.2 Departments

Department of Anatomy

i). Lecture theatre – As per item c.

ii). Demonstration Room – there shall be two demonstration rooms (45 sq.mt.each) fitted with strip chairs, Over Head Projector, Slide Projector, Television, Video and other audiovisual aids, so as to accommodate at least 50 to 60 students.

iii). Dissection Hall – There shall be a dissection hall (250 sq.mt.) to accommodate at least 100 students at a time. It shall be well lit, well-ventilated with exhaust fans and preferably centrally air-conditioned. There shall be an ante-room for students with lockers and ten wash basins. There shall be adequate teaching aids in the hall. In addition, there shall be an embalming room (12 sq.m.area), space for 3 storage tanks (one of 3 sq. m. & two of 1.5 sq.m. each) and cold storage room with space for 10-12 dead bodies (18 sq.m.area) or cooling cabinets.

iv). Histology- There shall be Histology Laboratory (150sq.m.) with accommodation for work benches fitted with water taps, sinks, and cupboards for microscope storage and electric points for 60 students. There shall be a preparation room (18 sq. m.) for technicians and storage of equipment.

v). Research - There shall be one research laboratory (50sq.m.area) for research purposes.

vi). Museum-There shall be a museum (150sq.m.)-provided with racks and shelves for storing and proper display of wet and dry specimen and embryological sections, models, revolving stands for ski grams, CT scan, MRI and trolly tables, X-ray view boxes shall be multi-stand type to take 4 plates standard size 3 boxes (3view boxes for 100 students). Adequate seating accommodation for 25 students to study in the museum shall be provided. There shall be two attached rooms (15 sq.mt. each) for the preparation of models/specimens and for artists and modelers.

vii). Departmental Library

Department of physiology

(i) Lecture Theatre

(ii) Demonstration Room-There shall be one demonstration room (45 sq.mt.) fitted with strip chairs, Overhead Projector, Slide Projector, Television, Video and other audiovisual aids, so as to accommodate at least 50-60 students.

(iii) Practical rooms- The following laboratories with adequate accommodation shall be provided to accommodate 60 students.

(iv) Amphibian laboratory (one)-(150 sq.m.area) shall be provided with continuous working tables. Every seat shall be provided preferably with stainless steel washbasin. Every workings table shall have one drawer and one cupboard, an electric point and with fire and steam proof top. One preparation room (14 Sq.m. area) shall be provided with the amphibian laboratory.

(v) Mammalian laboratory (one)-(60 Sq.m.area) shall be provided with four tables (2mx0.6,) with stainless steel top and operating light. The laboratory shall have attached instrument rack, two large size wash-basins (stainless steel) and cupboards for storing equipment. On preparation room (14 sq.m. area) shall be provided with the Mammalian laboratory.

(vi) Human Laboratories: a) Haematology Lab. (150 Sq.m.area) provided with continuous working tables. Every seat shall be provided preferably with stainless steel wash basin. Every working table shall have one drawer and one cupboard, an electric point and with fire/steam proof top including provisions of light sources on each table. On preparation room (14 Sq.m.area) shall be provided with this laboratory.

vii) There shall be a Clinical Physiology Laboratory (60Sq.m.area) provided with 8 tables (height 0.8 m.) with mattresses and adjustable hand-end.

(viii) Departmental Library

There shall be a Departmental library-cum-seminar room (30Sq.m.area) with at least 80-100 books. However, not more than two copies of anyone book shall be counted towards computation of the total number of books.

(ix) Research - There shall be one research laboratory (50 Sq.m.area) for research purposes.

(x) Accommodation shall be provided for the staff as under:-

1. Professor & Head of the Department- (18 Sq.m.area);

2. Associate Professor/Reader-Two rooms (15 Sq.m.area);

3. Ass. Professor/Lecturers (Three)-One room (20 Sq.m.area);

4. Tutor/Demonstrators-One room (15 Sq.m.area)

5. Department office cum Clerical room - one room (12Sq.m.area); and 6. Working accommodation for non-teaching staff (12sq.m. area)

Department of Community Medicine

(i). Lecture theatre

(ii). Demonstration room-There shall be one demonstration room (45 sq.m.) fitted with strip chairs, Over Head Projector, Slide projector, Television Video and other audio-visual aids, to accommodate at least 50-60 students.

(iii) There shall be a laboratory (150 Sq.m.area) with facilities for purposes of demonstration of various laboratory practicals.

(iv). Museum-There shall be a museum (100 Sq.m. area) for the display of models, charts, specimens and other material concerning communicable diseases, Community Health, Family Welfare planning, Biostatics, Sociology, National Health Programmes, environmental Sanitation etc.

(v). Departmental Library

There shall be a Departmental library-cum-seminar room (30 Sq.m.area) with at least 80-100 books. However, not more than two copies of anyone book shall be counted towards computation of the total number of books.

(vi). Research- There shall be one research laboratory (50 S1.m.area) for research purposes.

(vii). Accommodation shall be provided for the staff as under, namely:-

Professor & Head of the Department- (18 Sq.m.area); Associate Professor/Reader-Two rooms (15 Sq.m.area); Asstt. Professor/Lecturers (Three)-One room (15 Sq.m.area); Statistician cum Lecturer-One room (12 Sq.m.a) Epidemiologist cum Lecturer-One room (12 Sq.m.area) Tutor/Demonstrators-One room (15 Sq.m.area) Department office cum

Clerical room - one room (12 Sq.m.area); and Working accommodation for non-teaching staff (15 sq.m. area).

Beside the above-said departments the Medical colleges and Medical institution running Postgraduate degree/diploma courses in various specialties may have other departments to meet teaching needs of the college or Medical Institution and healthcare needs of the public.

2.16 Benchmark Minimum Academic Standards for Undergraduate Programs in Nigerian Universities

The information provided below relates to the benchmark established for basic medical and health sciences program in Nigerian Universities (April, 2007).

Decree (Act) No. 16 of 1985 as contained in the National Universities Commission amended Decree (Act) No. 48 of 1988 empowers the Commission to lay down minimum standards for all programs taught in Nigerian universities. This section, however, looks at specific requirement that relates to medical and health science programme.

Resource Requirements

i). Personnel – Academic Staff

Teacher/Students ratios for the basic courses would be 1:15. The staff mix is as follows: Professional/Readership - 30%, Senior Lectureship - 40%, Lectures 1 and below - 30%

ii). Non-Academic Staff

The Non-Academic staff to support the teaching of students will be as follows: Senior Non-Teaching Staff - 1:30 Students, Administrative Staff - 50% of Academic Staff.

Physical Facilities

Each university must provide adequate facilities for teaching the programmes within its institutions. These facilities include:

i). Space: Adequate space such as class rooms, lecture theatres, seminar rooms, laboratories, clinical/practical rooms must be provided for teaching and lecturing according to NUC guidelines. Also adequate office accommodation must be provided for all academic and non-academic staff according to NUC guidelines.

ii) Equipment: Teaching and learning resources must be provided in the right quality and quantity. These should include audio visual materials, phantoms, mufti-media and modern information and communication technology networks, adequately equipped laboratories, clinical equipment and instruments.

2.17 Conclusion from Literature Review

From the literature reviewed the researcher was able to have a thorough understanding of the right tools, technique and hypothesis to enhance the flexibility of buildings. The literature also established facts that affect buildings potentials to achieve effective flexibility in medical schools and buildings in general. There is, however, a strong link between the factors for determining flexibility to the activities of the users and facilities used, simultaneously. One of the most pronounced factors realized is the conflict that exists between spaces when interchanged for different activities with multiple facilities. The author synthesized the literature review in figure 2.12:

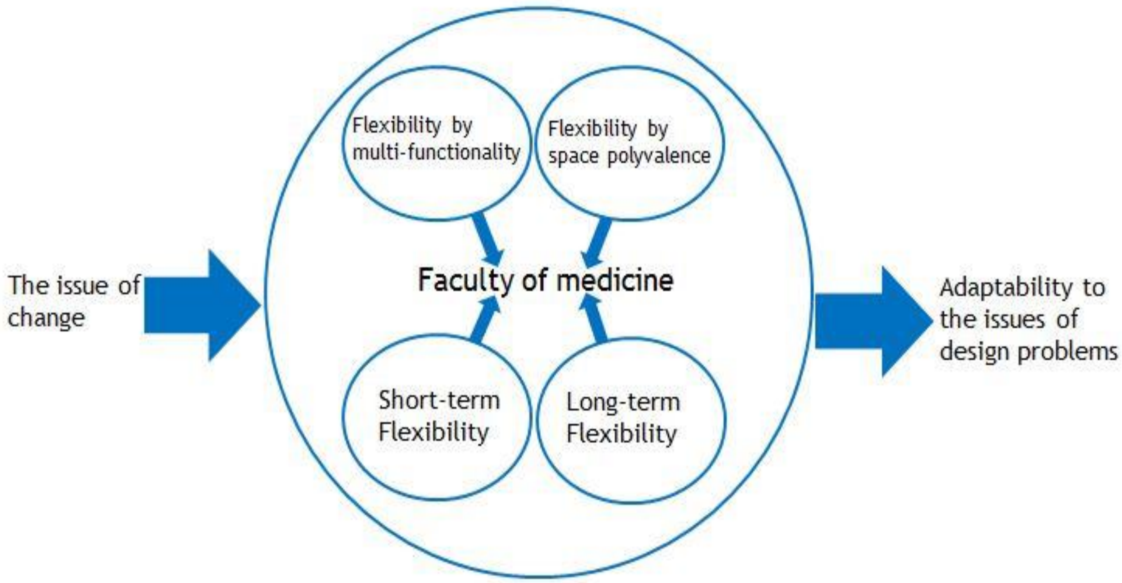


Figure 2.12: Synthesis of Literature Review of Flexibility in Faculty of Medicine.
Source: Authors fieldwork, 2016

Based on the description that was analyzed on the composition of the above literature it can be drawn to a conclusion that a Faculty of Medicine is a dynamic building. Change can occur therein. The diversity of its need for change is necessary both over a long and short-term. In other to ensure a detailed and replicable research the methodological approach to be used seeks to focus on qualitative approaches of deriving data.

3.0 METHODOLOGY

3.1 Preamble

The aim of this chapter is to describe the method to be employed in carrying-out this research. Research methodology is the plan, mode or conceptual structure of the research and type of approach adopted in the study (Olaofe, 2010). The approach was designed to seek an answer to possible ways of enhancing space multi-functionality through flexibility strategies, and apply research findings in the design of a Faculty of Medicine. The chapter ,therefore, discusses the research method selected and used in conducting the study and is arranged under the following headings: Introduction; Research methods; Population of the study; Sample and Sampling Techniques; Case Study Selection Criteria; Research variables ;Instrument of data collection ;Procedure for Data collection; data presentation and analysis; and Conclusion.

3.2 Research Methods

This research is qualitative in its approach. It establishes a framework that guides investigations, data collection and analysis. A field work has been conducted to investigate data on existing spaces in some sampled medical institutions in Nigeria. However, cases are identified for study due to their inherent qualities which are in consonance with the phenomenon under investigation (Oluigbo, 2011); this is geared towards obtaining first-hand information that will be used for comparative analysis between the selected facilities and their standard for flexibility. Data collection involved collecting information from stakeholders to obtain views and opinions of people. The analysis of the research has been conducted based on principles, elements, features and adequacy of flexibility strategies employed in the spaces examined. This has further been verified by obtaining values on connectivity, visibility and spatial integration from *space syntax* analysis using the *depthmap* software. Data obtained from the methods used for the research were analyzed, comparatively, which draws a conclusion on its findings and implications. These, ultimately, aims to propose a hypothesis on how to enhance space multi-functionality through flexibility strategies based on contemporary space challenges in the faculties of medicine in Nigeria.

3.3 Population of the Study

Medical schools in the Nigerian universities made up the primary population for this study. According to the Medical and Dental Council of Nigeria (MDCN, 2015), there are thirty one (31) medical institutions in Nigerian universities that made-up both fully and partially accredited schools approved by the commission. Out of this population only twenty seven schools met the requirements of fully accredited schools. The research targeted twelve (12) medical schools from first and second generation universities established from 1948-1985, out of which three medical schools were purposively selected.

3.4 Sample and Sampling Techniques

According to Mugenda, (2003) researchers select a sample due to various limitations that may not allow researching the whole population. In this research, sampling of study population targets three selected schools out of the thirty one universities that offer Medicine as a course in Nigeria. Here a survey was carried out in order to identify cases that meet up with the requirements of the study. (Veal, 2006) postulates that case study selections are comparative to sampling in a research and that such cases were usually purposively selected. It must possess some intrinsic features or qualities which are in relation with the phenomenon under investigation (Oluigbo, 2011). This may be because they were information-rich, critical, revelatory, unique, representative or extremely atypical (Osuala, 2005).This method of sampling according to Burgess et al (2007) yields a very accurate result if the study population is homogeneous. The population of this study is homogeneous in the sense that they engage in the same type of activity irrespective of their location. Hence the adopted sampling technique carried out in this research has been based on purposive sampling which have related peculiarities.

3.5 Case Study Selection Criteria

Assessment of cases was based on the purposive sampling method earlier mentioned. The underlying factors for these options are as a result of the information they provide which border on some of the issues that revealed the contemporary challenges of African medical schools. The following factors were considered for purposively selecting the cases;

i). Time: this considered cases based on their year of establishment, recognizing the first Faculty of Medicine in the country and also Faculties of Medicine with minimum of 30 years working experience.

ii). Infrastructure: this considered cases based on alternative methods of construction used from either the single floor or multiple floor system, or the courtyard and pavilion concept used, or the use or lack of framed structural system and their implication on flexibility.

3.5.1 Selected cases to be studied

i). Faculty of Medicine, University of Ibadan.

ii). Faculty of Medicine, Ahmadu Bello University Zaria, Kaduna State.

iii). Faculty of Medical Sciences University of Jos, Plateau State.

3.6 Research Variables

i). Adaptation (Building form): this has to do with convenience of the building form to do the following: 1. to be versatile and convertible to new changes in space and functions. 2. And to be re-scalable due to change in size.

ii). Transformation (Method of construction): building transformation is based on convenience for two operations, a. Elimination of the building element, b. Addition of the building element.

iii). Interaction (Spatial organization): spatial interaction has been assessed based on a. Zoning of activities, b. Spatial sequencing, c. Connectivity and compartmentalization d. spatial integration.

These variables were further tested on the case study areas using the V.G.A to obtain resultant values from 'connectivity and spatial integration' to obtain intelligibility values. Intelligibility values of 0.31 (31%), 0.22 (22%) and 0.175 (17.5%) were obtained for case study 1, 2 and 3 respectively. While intelligibility value of 0.6 (60%) was obtained for the proposed design.

iv). Mobility: mobility within the building setting entails a. accessibility b. relocation and c. ease of movement of the building components.

3.7 Instrument of Data Collection

Research instruments are tools used in a research to collect necessary data. For the purpose of this research, data was collected as primary and secondary data. The primary data has been collected through primary sources using *interviews* and *visual survey*. Data from secondary sources were obtained through literature review and appraisal of official documents relevant to the area of this study. Other instrument used was the space-syntax software, the *depthmap* used to analyze and obtain relevant data on the floor plans of the case study areas.

3.7.1 Visual survey checklist

Visual survey involved a site visit by the researcher to the school buildings selected and ensured a careful visual appraisal of various factors and elements of a flexible design. This has been represented by descriptive sketches, write-ups and photographs. The information gathered has been used for space syntax analysis on building floor plans in order to ascertain the relationship between spaces.

3.7.2 Oral interview

This was done through verbal questions to the general users which include student, lecturers and facility managers in order to get detailed and precise information. The oral interview, as far as this research is concerned, explored an up-to-date history of space challenges of the study areas and other relevant information within reach.

3.8 Data Collection Procedure

The procedure for data collection involved visits to the three local case study areas earlier mentioned and making an analysis of their architectural features. These buildings were evaluated based on flexibility criteria through the use of interview and visual survey checklist. Images and sketches were also obtained to support research findings.

Additional data has been collected through space syntax analysis obtained from the *depthmap* software.

Space syntax is an analytical method that emerged within architecture in response for the need to develop a strong theoretical base within the discipline. It has been employed to analyze space and hidden patterns in the built environment (Maina, 2014). It is a theory and set of methods about space built on two ideas: that of space being an intrinsic aspect of human activity and its relationship to other spaces which make up the layout of a building or city as a whole (Hillier, 2005).

There are three basic geometric elements in space syntax analysis. These include the axial line, convex space and isovist field. The theory being that human beings move in lines interact in convex spaces and view vistas in changing panoptical views when moving around the built environment (Hillier, 2005, Van Nes, 2011). As far as this research is concern the advantages of key attributes of space syntax from analysis of axial lines and interaction within spaces were taken into consideration. This was done by comparing values for spatial integration and connectivity which were used to analyse applications of flexibility strategies. Together the connectivity and integration values of a layout can be calculated to establish how intelligible a layout is. This shows the degree of how far the configuration of a layout can be inferred globally as a whole system by observing its local connection from its internal structure. Usually intelligibility values ranges from 0- 1 and an average value of 0.5 for a good design, which can be expressed as 50%. Any value less than this is said to be not intelligible in Space Syntax analysis (Hillier, 2008).

As part of the methods of collecting data on space syntax all three types of syntactic maps can be converted or transformed into graph, often in the form of Justified Permeability Graph (JPG). The graph is a figure representing the relationship of movement and permeability between spaces in a layout. The following explains the underlying factors investigated within the JPG for the analysis in this research.

Integration Value IV: this is a numerical figure calculated for each space in a complex as a reflection of the extent to which spaces integrates or organizes access and movement, and by implication of social network and activity within the complex (Maina, 2014).

Connectivity: connectivity measures the number of immediate neibours that are directly connected to a space (Klarquist, 1993). Integration is however a global static measure as it describes the average depth of a space to all other spaces in the floor plan or layout.

Intelligibility Value (r^2): a combination of connectivity and integration values of a layout gives a resultant value called intelligibility. This shows the degree of how far the configuration of a layout can be inferred globally as a whole system by observing its local connection from its internal structure. This is usually established as (r^2) value.

In using VGA, a varied grid of points is overlaid on the plan. A graph was made of the points, where each point is connected to every other point that it can see. The visual integration of a point is based on the number of visual steps it takes to get from that point to any other point within the system (Turner, 2004). The grid properties were set at 500mm spacing for analyzing the Visibility graph.

For the Space-Syntax Data on Visibility Graph Analysis (V.G.A) map, a numbering indication of 1,2,3,4 and 5 represent areas with staircases, walkways, lobbies, major entrances and parking lots respectively. These areas were studied and strategically located on the V.G.A map (for the proposed design) in areas with high connectivity and integration values, so that not only spatial integration and connectivity is enhanced but also ensures that users and visitors can conveniently find their way around the building.

3.9 Data Presentation and Analysis

Data obtained from each case study were analyzed and represented in different forms which include, the description of various buildings showing the elements and features as well as the experiences of users; documentation and presentation of information based on tables of predetermined headings and sub-headings; use of figure and plates to represent maps, plans, graphs and charts.

3.10 Reliability and Validity of the Instruments

Validity was ensured through judgment of experts on the instrument of research and research techniques. The space syntax software used is multi-platform software that performs a set of spatial network analysis, widely used to understand social process. It explains network representations of space for the purpose of architectural and urban research and design, (Al Sayed. et al, 2014).

4.0 DATA PRESENTATION AND ANALYSIS

The use of case study areas as an aid to research has been proven to be a necessary tool to solving problems that have been encountered in existing facilities and research areas that have hitherto not been explored. Architectural case studies take into cognizance features such as the nature of structures, function, site and economy with a view to identifying the intricacies inherent in them. This helps in providing relevant information and ideas to reject or incorporate within the pursued work scope, such that the new ideas to be developed shall give directions to a new design.

Case study report

4.1. Case Study one Findings: Faculty of Medicine, Ahmadu Bello University, Zaria

Plate XXII: Entrance View of the Faculty of Medicine, Ahmadu Bello University, Zaria.
Source: Author's fieldwork, 2016

Location: Samaru Campus, Ahmadu Bello University, Zaria.

Architect: Joint design partnership: Greycoat place Westminster, London.

Client: Ahmadu Bello University.

Contractor: Alistair Mc Cowan & Associates.

Plate XXII indicates the approach view of the Faculty of Medicine, Ahmadu Bello University Zaria established in 1967. It was established to cater for 150 medical students and 50 dental students- with an intake of direct entry students basically. Over time new programmes were introduced in to include, nursing, anatomy and physiology. The number of intake went faster than facility and structural development within the faculty. This has prompted the need to increase the capacity and transform the structures available. While the structural system used has helped to achieved these, within the interior spaces, the same factor also limits the convenience of use within laboratories because of the span between the structural systems. Expansion has also been quite challenging within the exterior spaces of the faculty due to space constraint. The factors observed have been discussed below:

General Site Planning

The site planning of the Faculty of Medicine, Ahmadu Bello University, Zaria, shows good understanding of the typical climate of the region; this can be seen from the nature of the arrangement of various departments and facilities and the orientation of individual buildings. Although ample spaces were provided between individual facilities, integration has not been properly achieved due to inadequate access and design of the courtyard system, see Plate XXIII.

Plate XXIII: Aerial view of the college of Medicine, A.B.U Zaria.
Source: Google Earth, 2016

4.1.1 Adaptation (building form)

The building and its spaces were basically formed from framed structural system as shown in XXIV. The use of the same form concept through-out the faculty building, and the extension of the *form-to-follow-function*, makes it easier for spaces to expand and be altered uniformly. The building was appropriately detailed along various joints with adequate room for expansion. This has been proven true along the columns and beams which showed great stability and resilience to changes over time.

Plate XXIV: A view of the faculty building showing the court-yard and building form. Source: Author’s fieldwork, 2016

4.1.2 Transformation

Easily replaceable building materials were used for construction. The trabeated style used for construction allows for transformation within the interior and exterior spaces either by addition or elimination of partition and elements of the building structure. This was clearly demonstrated in the exterior in plate XXV, showing possibility for extension of columns.

Plate XXV: Faculty Building Showing Extension of Columns for Future Expansion. Source: Author’s fieldwork 2016

Figure 4.1 below shows flexibility for periodic transformation within interior spaces which was made possible at the first floor plan due to the method used for construction. The system, however, brings limitations to spaces in need of a large span.

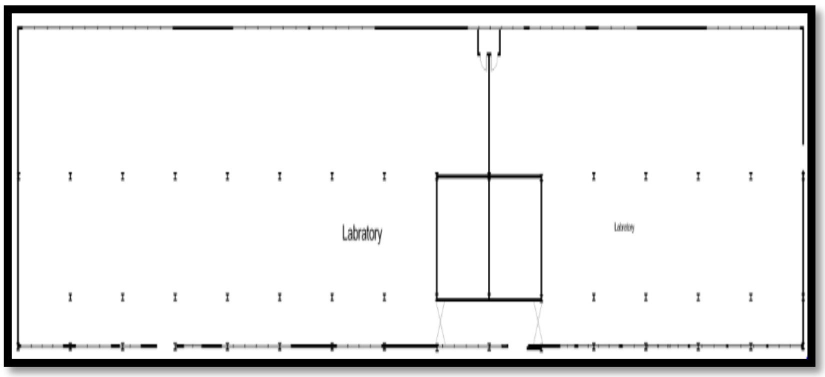


Figure 4.1: First Floor Plan, Physiology Department.
Source: Author's sketch, 2016

Figure 4.2 shows the flexibility potentials indicated on figure 4.1 and how it has been translated on the ground floor plan. This shows flexibility at all floor levels in design.

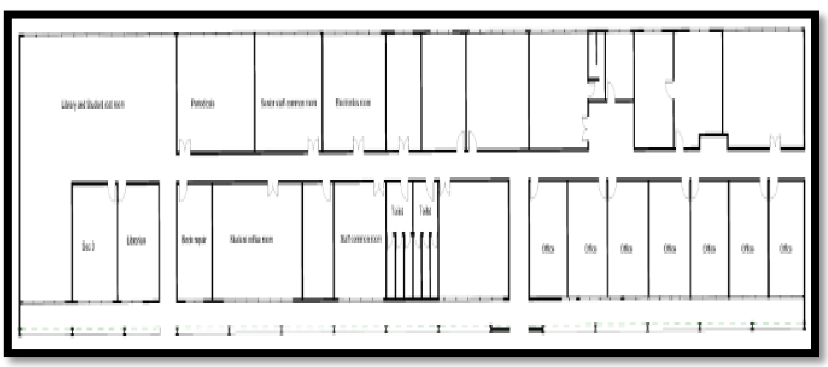


Figure 4.2: Ground Floor Plan Nursing Department.
Source: Author's sketch, 2016

4.1.3 Mobility

Materials and installation are mostly permanently fixed and difficult to be dismantled or movable for interchangeable uses. The placement of these installation components on the maximum partition allows for flexibility in the use of spaces and also allow for circulation in the event of the need for long and short-term changes as shown in plate XXVI.

Plate XXVI**:** View of Histology Laboratory. Plate XXVII: View of Anatomy Laboratory. Source: Author’s fieldwork, 2016

4.1.4 Interaction (spatial organization)

The *zoning* of the buildings established a flow in relationship to site location as well as between the buildings. This is evident in the pattern in which the buildings are arranged around a central courtyard of green spaces; however, transition between the interior and the exterior courtyard has not been well utilized due to lack of proper integration of spaces.

Spatial sequencing: a design emphasizing order, sequence and routine is most appropriate for a flexible approach to design. The faculty buildings did not show good transition between the interior and exterior spaces within the faculty; this is visible from the access point within departments, however, the only central access linking the departments is through the admin block, causing a breakage in the link between labs, classrooms and other facilities within the faculty. This has diminished flexibility potentials in terms of usage.

The lack of connection at the first and second floor level of the building has also limited circulation and interaction between spaces as shown in figure 4.3 below:

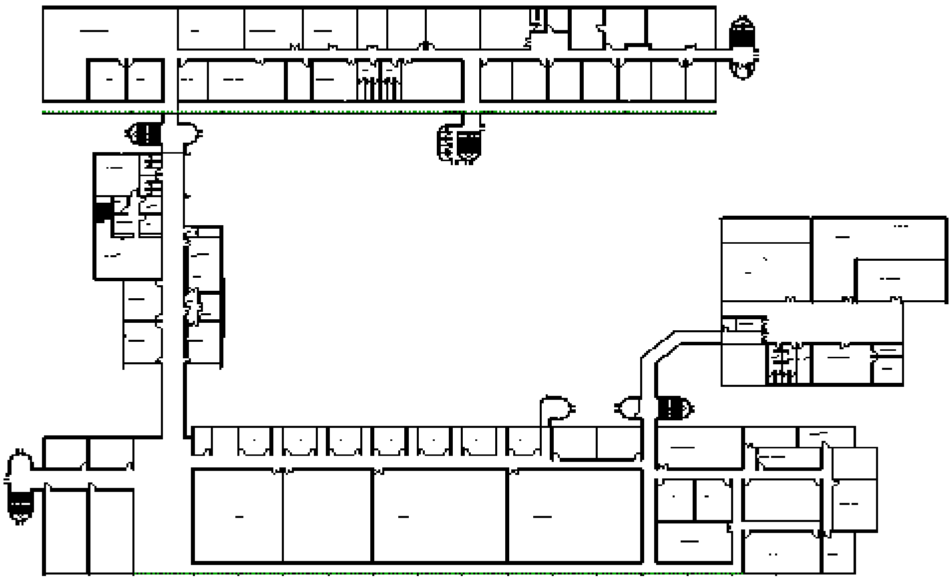


Figure 4.3: The First Floor Plan of the Faculty of Medicine, A.B.U
Source: Author's sketch, 2016

Plate XXVIII below shows a proposed building provided to curb the effect of insufficient spaces within the faculty. This is already defacing the space available and has no major access integrating it with the other facilities within the faculty.

Plate XXVIII**:** Perspective View of the Faculty, Showing New Construction.
Source: Author's fieldwork, 2016

This is bound to create future spatial challenges for both the existing building and the proposed design, as the initial planning has not foreseen current changes. This also means that flexibility in terms of the usage of space will be greatly diminished over time.

Compartmentalization within spaces helps to enhance easy flow of functions and also reduces visual distractions especially where focus is a priority. Physical and visual compartments provide a positive influence and help to minimize outside distractions. Plate XXIX shows careful arrangement and compartmentalization to achieve a variety of usable spaces within a single floor level.

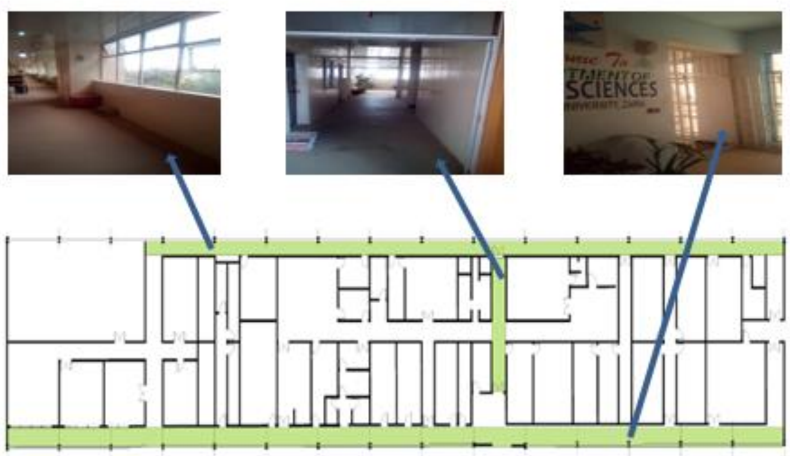


Plate XXIX: Floor Plan of Nursing Department, Showing Compartmentalization of Spaces.
Source: Author fieldwork, 2016

Visual survey was further represented in a tabular form for a closer examination of the survey variables and their level of application. These were supported also by numerical values that show the mean score and it**s** implications on the survey checklist as represented in table 4.2. Meanwhile a Linkert score rating has been shown in table 4.1

Ratings of the case studies: Linkert scale was utilized in table 4.1 to represent the findings obtained from the case study areas using a checklist developed from variables of flexibility strategies. The attribute of the variables were graded on a five point scale system, giving preference to the reflection of each attribute under study. The checklist used for this research is a 5-point likert scale (rated from 1-5, where 1= poor, 5=excellent.

Table 4.1: Description of Likert Scale Ratings. Source: Author, 2016.

Rating	DESCRIPTION
1	Describes a very low reflection of the attribute of the variable under study. Quantifiable below 40%
2	This is a scenario in which the quality of an attribute is fairly noticed. Such could be rated at 40-49%.
3	Describes the state of perceptible presence that satisfies an average pass mark. Such could be rated at 50-59%.
4	Describes an obvious presence of a given attribute. Here it is likened to 70% obviousness of a given criterion. This satisfies any degree to which an attribute is required.
5	Describes the full presence of a given attribute. A scenario in which the presence of an attribute is at its maximum. At this point the quality of the attribute is at its maximum.

Source: Author's fieldwork, 2016

Mean score = (TCUE/Number of variables accessed).

(TCUE) =Total credit unit earned.

Table 4.2: Visual Survey Checklist. (Case study one).

S/N	VARIABLES	CHECKLIST	LEVEL OF REFLECTION 1	2	3	4	5	MEAN SCORE	REMARKS
1.	**Adaptation** (Building form)	Suitability of the building form to periodic extension.				☑		Four **4** represents the mean score. This shows good potentials for adaptation.	The building form and frame structural system used for construction encourages adaptation to future changes.
		Design of structural system for future alterations and expansion.					☑		
		Convenience for change of functions within interior spaces.			☑				
2.	**Transformation**	Ease of replacement of the building materials.			☑			Four **4** represents the mean score. This shows good potentials for transformation	The structural system allows for transformation within the exterior and interior spaces either by change of materials, addition or elimination of partition.
		Convenience of spatial lay-out to addition or elimination of partition elements.					☑		
		Ease of structural system to addition or elimination of forms.				☑			
3.	**Interaction** (Spatial organization)	Zoning of individual facilities to related functions.			☑			For interaction **2.6** represents the mean score. This shows that design for interaction within the building was fairly considered.	Zoning of space has been averagely taken into consideration in the design. Lack of proper circulation within spaces has limited space interaction.
		Spatial sequencing.		☑					
		Compartmentalization of interior spaces.			☑				
		Design of Circulation within and outside the building.		☑					
		Existing spaces performing multiple functions.			☑				
4.	**Mobility** (Use of Facility)	Accessibility of installation components.				☑		In terms of mobility **2.75** represents the mean score. This shows that design for mobility within the building was fairly considered.	The structural system and the inconvenient use of fixed furniture have greatly limited circulation within laboratories.
		Presence of easily replaceable and dismantling furniture.		☑					
		Placement of structural design for construction and installations on a maximum partition.		☑					
		Design provision and convenience of spaces to the movement of facilities.			☑				

Source: Author's fieldwork, 2016

4.1.5 Summary of visual survey findings, (case study one).

The design for the faculty of medicine, A.B.U adopted the court-yard system, providing a large space for this purpose; however, there is no proper integration between transition spaces and the court-yard spaces. Conscious design effort was made to provide a separate vehicular access into the cadaver storage unit. This complies with the design requirement for the faculty of medicine, as observed from literature and interview findings.

The form concept adopted for construction shows good tendency for efficient expansion and future alterations. This tendency is further emphasized by the framed structural system used as the method for construction. The design efforts made for the integration of spaces has not been very successful, this is because the only access provided for connection to all departments has only been utilized at the ground floor and meant to be accessed through the administrative unit and faculty boardrooms. This brings about a feel of temporary breakage by the users in the link between individual classroom and laboratories. Current standards lacking in the faculty included a non-up-to-date laboratory design and the need for a medical education unit to upgrade the standard and check the quality of learning respectively. Furthermore, a conscious design effort is required to begin consideration of contemporary technology with new design requirement for the use of manikins as simulation and teaching aids; as this is now part of the goals for future medical schools.

The checklist used to examine the application of the basic principles of flexibility indicated that there are high potentials for adaptation and transformation within case-study area one, with the mean score values of 4 for both. Meanwhile least values were indicated in terms of spatial interaction with 2.6 as the mean score.

4.1.6 Space syntax data, (case study one).

The Space Syntax provides analytical techniques and numerical values that will help mark out features to be used to further investigate on spatial integration and connectivity, and how it enhances space multi-functionality.

Visibility Graph Analysis

The various spaces within the floor plans of the case studies were analyzed using visibility graph analysis (VGA) and the data obtained were documented based on their spatial relationship and how it affects the users of the facility.

Relationship between user spaces and space integration values

Integration values distinguish spaces, level of visibility and connectivity with respect to other spaces within the building. This is indicated from the colour scheme used; Red colour indicates the most integrated areas within the building, while Blue color represents the least integrated areas, as shown in the graph in plate XXX.

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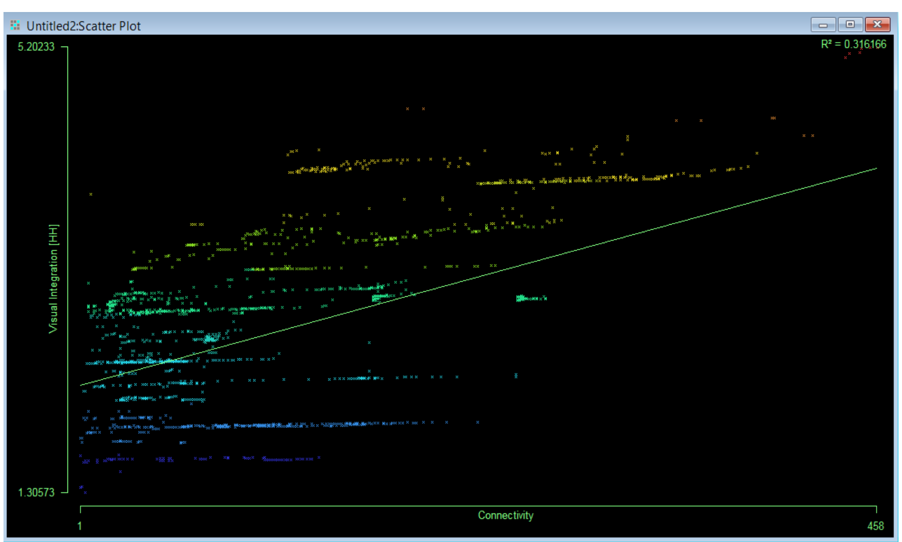

Plate XXX: V.G.A Graph of Visual Integration, Connectivity and R2 Values.
Source: Author’s fieldwork, 2016

The graph above shows values for visual integration from 1.30573 to 5.20233. The straight line shows the path for progressive integration all-round the building. R^2 records 0.316166 as the intelligibility value of the building, expressed as a percentile value of (31%). This value for case-study 1(one) shows that it is below the average for a good design.

Integration [HH] of floor plan

Plate XXXI shows the VGA map indicating the relationship between the class rooms, laboratories, cadaver storage units, offices and walkways. High level of integration can be observed mostly in the walkways and links to the various departments. Meanwhile, staircases which should help vertical integration of the building mostly stands in isolation; and although they are visible from the exterior of the building, this potential has been weakened in the interior due to lengthy corridors that lowers access and visibility to other critical areas. Sequel to this, the main staircases linking all floors, in individual departments, are not visible from the main ground floor entrance, and hence their impact has been weakened on the space-syntax analysis.

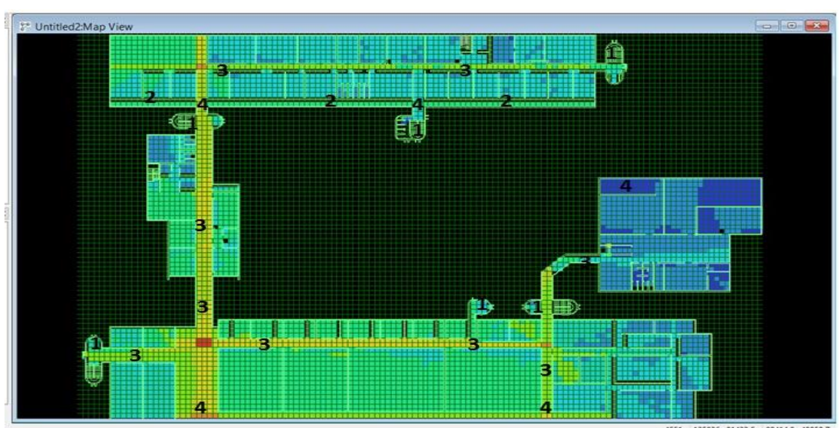

Plate XXXI**:** Integration [HH] for Faculty of Medicine, A.B.U
Source: Author’s fieldwork, 2016

4.1.7 Summary of findings for V.G.A (Case study one).

The visibility graph analysis has analyzed different spaces with their connectivity and integration values. Location of key elements such as the entrance, placement of staircases, design of walkways and accesses are necessary for integration of different spaces. From the analysis conducted, the main entrance indicated the highest connectivity and integration values because of its accessibility to many other spaces. Due to the same reason high integration values were also indicated along walkways around the building. Where connectivity is minimal, integration values were further enhanced by providing staircases at strategic points to aid circulation, access and connectivity to upper floors. The space syntax analysis has shown the need for a conscious design effort to maintain relationship between the walkways, staircases and waiting areas and other physical features that aids navigation and circulation between spaces.

4.2 Case Study Two Findings: Faculty of Medical Sciences, University of Jos

Plate XXXII: A View of the College of Medical Sciences, University of Jos.
Source: Author's fieldwork, 2016

Location: Main Campus, University of Jos.

Architect: Directorate of physical facilities, University of Jos.

Client: University of Jos.

Contractor: Banny ventures limited.

Preamble

Plate XXXII shows the approach view of The Faculty of Medicine U.J. The curriculum for the Faculty of Medicine U.J was planned to integrate the traditional pre-clinical training with clinical training; these are designed into a system which is expected to remain changeable in the light of the evolution of new ideas and objectives. In the light of this, the faculty, in the future, intends to further rely on the Medical Illustration and Technology Unit (MITU), intensify e-learning and also increase the standard of awareness for inter-relationship between various departments and specialties. However, current challenges largely results from inadequate lecture spaces, lack of integration between the departmental unit facilities, lack of proper access within the department and limitations due to lack of close proximity between the faculty and the teaching hospital. The factors considered in the visual survey are discussed below:

General Site Planning

The site planning of the Faculty of Medicine, University of Jos shows minimal proper orientation as shown in plate XXXIII; this can be seen from the nature of different arrangement of various departments and facilities between buildings. Although spaces were provided between individual departments, integration has become a major concern because of the harp-hazard orientation of the buildings and difficulty of accessibility.

Plate XXXIII: Aerial view of the Faculty of Medicine, University of Jos
Source: Google Earth, 2016

4.2.1. Adaptation (building form).

Framed structural system was used selectively as the method of construction. The building spaces are basically rectangular forms- with the functions following the form. The design for individual departments varies from single to two-story floor plan concept through-out the faculty building, lacking uniformity in the method of construction. This serves as constraints in for expansion and need for future alterations, as shown in plate XXXIV.


Plate XXXIV: A View of the Faculty of Medicine U.J, Showing the Court-Yard
Source: Author’s fieldwork, 2016

4.2.2 Transformation

Easily replaceable building materials were used for construction. The structural system varies for different buildings. There were no details shown to suggest intensions for future expansion. However, large spans without intermediary supports were achieved within laboratories due to the method used for construction, as shown in plate XXXV.

Plate XXXV: Department of Nursing Sciences, Showing the Method of Construction.
Source: Author's fieldwork, 2016

Interior spaces within the buildings appear to be rigid and inconvenient for transformation, either by addition or elimination of partition and elements of the building structure because of the concrete material and solid block work used for partition, as shown in figure 4.4.

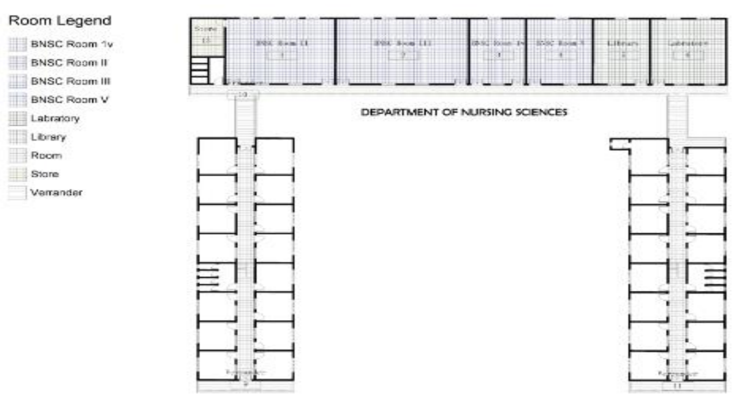

Figure 4.4: The floor plan, Nursing Department, Faculty of Medicine U.J.
Source: Author's fieldwork, 2016.

4.2.3 Mobility

Installation components, as shown in plate XXXVI are readily accessible in the histology laboratory for periodic maintenance and replacement. This is due to the fact that encasements of facilities were not rigid. Placement of these installation components on the maximum partition could have been more appropriate to allow for flexibility in the use of spaces and minimize obstruction in the event of the need for future changes.

Plate XXXVI: A view of the histology laboratory.
Source: Author's fieldwork, 2016

4.2.4 Interaction (spatial organization).

The *zoning* of the facilities did not show good relationship between the buildings. This is evident in the pattern in which the buildings are arranged in relation to each other. The poor zoning of the buildings had an effect on the nature of *spatial sequencing* within the faculty**.** *Transition*s between unit spaces are also not well defined, as shown in figure 4.5.

This arrangement leads to continuous complication of spaces, either from the use of the spaces or addition of new buildings overtime.

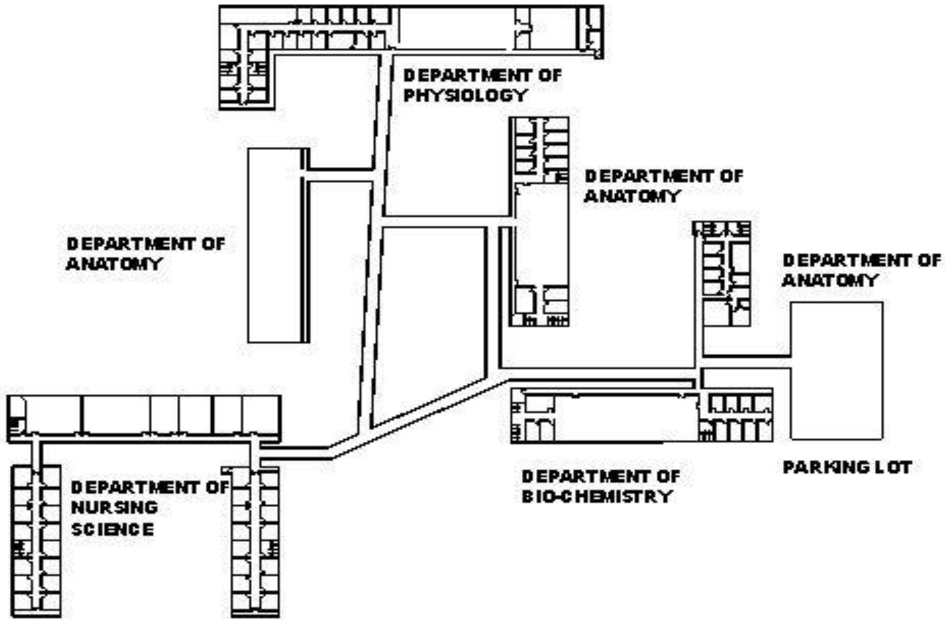

Figure 4.5: Typical first floor plans of the Faculty of Medicine U.J
Source: Author's fieldwork, 2016.

The interior space show good *compartmentalization* with easy flow of functions and reduces visual distractions. Plate XXXVII shows careful arrangement and compartmentalization to achieve a variety of usable spaces within a single floor level.

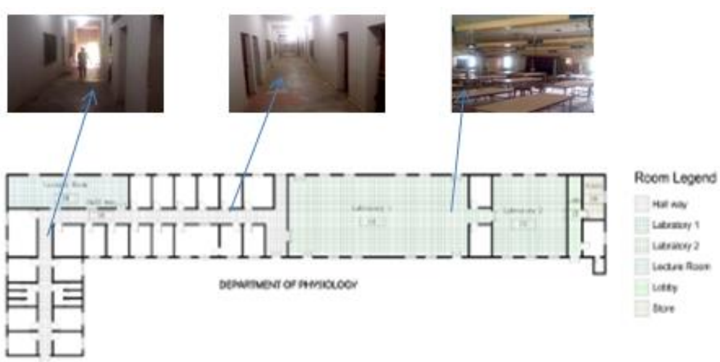

Plate XXXVII: Typical floor plan of Nursing Department, showing spatial arrangement.
Source: Author, sketch, 2016

Table 4.3: Visual Survey Checklist (Case Study Two).

S/N	VARIABLES	CHECKLIST	LEVEL OF REFLECTION 1	2	3	4	5	MEAN SCORE	REMARKS
1.	**Adaptation** (Building form)	Suitability of the building geometry to periodic extension.		☑				**2.3** represent the mean score. This shows a fair score on the potentials for building adaptation.	The haphazard nature of the building form and structural system used limits building adaptation to uniform changes.
		Design of structural system for future alterations and expansion.		☑					
		Convenience for change of functions within interior spaces.			☑				
2.	**Transformation**	Ease of replacement of the building materials.			☑			**2.6** represent the mean score. This shows a fair score on the potentials for building transformation	The mode of construction did not take special consideration to possibilities of addition or elimination of structural elements.
		Convenience of spatial lay-out to addition or elimination of partition elements.		☑					
		Ease of structural system to addition or elimination of forms.			☑				
3.	**Interaction** (Spatial organization)	Zoning of the facilities.	☑					**2.2** represent the mean score. This shows a fair score on the potentials for building interaction.	Improper zoning and circulation within and between individual buildings has limited interaction in the entire faculty building.
		Spatial sequencing.			☑				
		Compartmentalization.			☑				
		Design of Circulation within and outside the building.	☑						
		Existing spaces performing multiple functions.			☑				
4.	**Mobility** (Use of Facility**)**	Accessibility of installation components.				☑		**3.25** represent the mean score for mobility.	The free span within laboratories and the ease in replacement of furniture has helped in achieving good circulation within the laboratories.
		Presence of easily replaceable and dismantling materials.			☑				
		Placement of structural design for construction and installations on a maximum partition.			☑				
		Design provision and convenience of spaces to the movement of facilities.				☑			

Source: Author's fieldwork, 2016

Table 4.3 has indicated the visual survey findings for cased study two based on the flexibility attributes that has been used as a checklist, including their mean score rating.

4.2.5 Summary of visual survey findings, (case study two).

Findings from the design of the Faculty of Medicine, U.J shows little consideration to good orientation and planning; this problem is further compounded by the pavilion concept of arrangement of spaces adopted, as some buildings appeared to be isolated and independent of each other. This has made students and visitors to find it difficult locating various units and departments; it has also made vehicular access inconvenient into the cadaver storage unit. The building forms adopted are rectangular. Their levels vary from single to two story plan concept. Some of the buildings shows poor tendency for expansion, as no conscious design effort and detailing was provided for them. Structural systems and method of landscaping also varies for different departments. Transition between individual buildings and their surrounding buildings are not well defined and this has made integration between them to be difficult. Various departments seem to be acting independent of each other. Over time, new efforts made towards expansion includes the construction of the department of nursing, however, this has not been able to be properly integrated into the existing building due to lack of a clear strategy for expansion. This has made learning processes and routine difficult for students over time.

Current requirement to upgrade the standard of the school includes the need to intensify e-learning, provide needs for Medical Illustration and Technology Unit (MITU) and also increase the standard of awareness for inter-relationship between various departments and specialties. These needs, however, could hardly be achieved within the same spaces provided within the faculty, as there is now a need for relocation of the department to a new site due to space constrain. This has shown that, although ample spaces were provided within the faculty, achieving periodic expansion and convenience of flexibility for use has not been successful due to a lack in a clear strategy that should guide the process. The values obtained from the variables for the application of flexibility strategies was generally low. The least value records 2.2 as the mean score for spatial interaction.

4.2.6 Space syntax data, (case study two).

Visibility graph analysis.

Relationship between user spaces and space integration values

Plate XXXVIII is a visibility graph analysis showing how individual space units of the Faculty of Medicine, University of Jos, was integrated at all levels. Highest integration values correspond with 6.21866 on the graph- this indicates the most integrated areas within the building, while the least values corresponds with the value 1.54659. These values were represented on the y-axis of the graph; while values for connectivity of spaces, ranges from 2 to 3491, were represented on the x-axis. The intelligibility factor records 0.222231, which can be expressed as a percentage value of (22%). This value falls below the average value for the intelligibility of a good design.

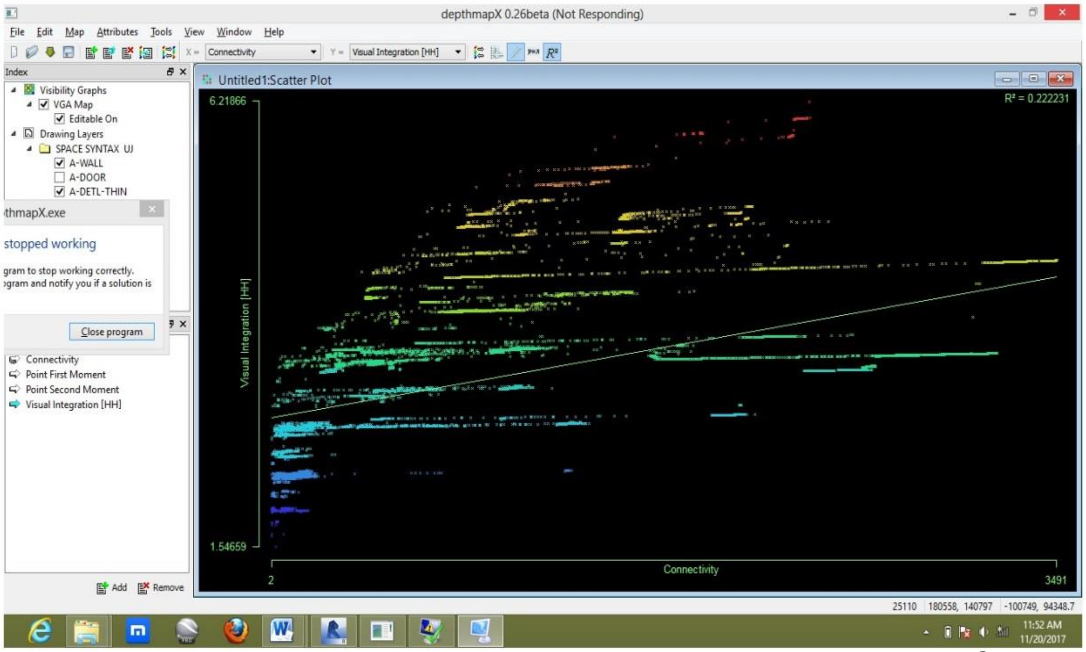

Plate XXXVIII: V.G.A graph showing visual integration, connectivity and R^2 values.
Source: Author's fieldwork, 2016.

Integration [HH] of the floor plan

Figure 4.6 shows the V.G.A map indicating the relationship between the class rooms, administrative units, parking lots, laboratories, cadaver storage units, offices and walkways. The highest level of integration can be observed along the walkways. The main entrance shows a little level of integration because of a lack of conscious design effort to connect the space with other building elements. Utility areas show the least integration, as these are areas that require privacy and convenience. Integration values in offices vary based on levels of compartmentalization and spatial sequencing within each department. Although staircases where not used as means of access between departments due to the single-level floor concept mostly adopted, vertical means of access, however, could have been enhanced by a provision of well-defined corridors within a more integrated design.

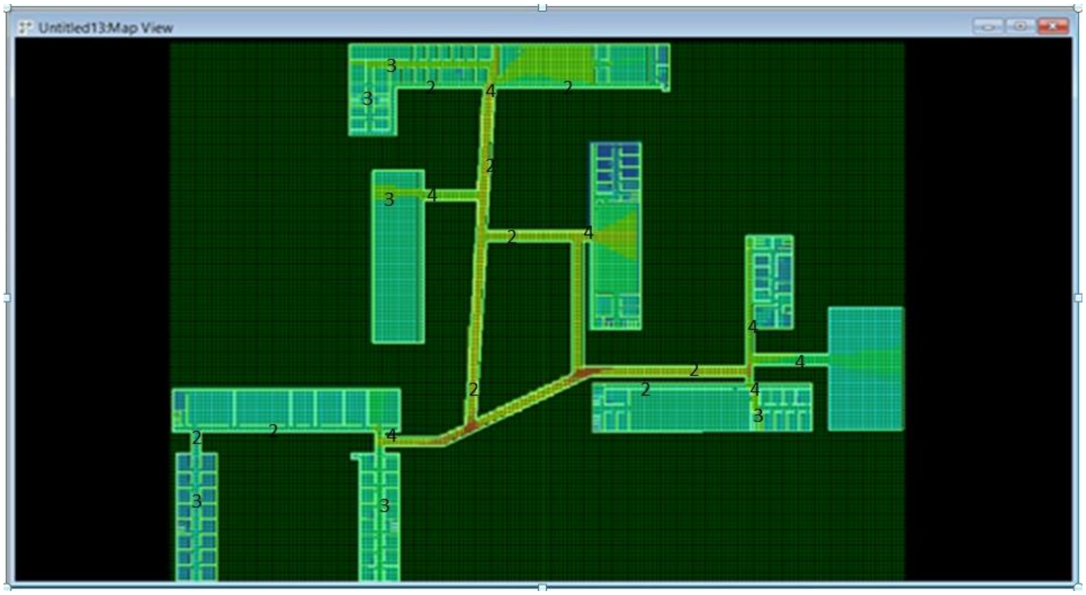

Figure 4.6: Integration [HH] for Faculty of Medicine, U.J
Source: Author's fieldwork, 2016.

4.2.7 Discussion of findings for V.G.A (Case study two).

From the V.G.A it has shown that location of key physical features of access in design enhances the integration between spaces. However, only a little value could be obtained from the parking area which equally serves as the major entrance to the faculty because of poor orientation of individual buildings. The overall effect of this was indicated from an R^2 value of 0.222231, expressed as a percentile value of (22%) which does not meet the requirement for a good design. The space-syntax analysis has shown the need to maintain relationship between the departments by providing proper orientation and integration.

4.3 Case Study Three Findings: Faculty of Medicine, University of Ibadan.

Plate XXXIX: View of the Faculty of Medicine, U. I.
Source: Author's fieldwork, 2016

Location: Main Campus, University of Ibadan.

Architect: Dept. of Works and Maintenance, University of Ibadan.

Client: University of Ibadan.

Contractor: NA

Preamble

Plate XXXIX shows the court-yard for The Faculty of Medicine, University of Ibadan, established in 1948. It started as the Department of Medicine and since then it has grown over time. Currently, the goals of the faculty are to restructure for E-learning technology, provide a more conducive atmosphere for student learning and reposition it for 21st century expectations. The factors considered in the visual survey have been discussed below:

The site planning of the faculty building shows partial connectivity between one another; this is because the buildings do not show any definite orientation from the nature of the site. This can be observed from the arrangement of individual building unit in plate XL.

Plate XL: Aerial View of the Faculty of Medicine U.I, with Major Access and Landscape.
Source: Google Earth, 2016

4.3.1 Adaptation (building form)

Framed structural system was used as method of construction. The same concept was adapted through-out the faculty building which makes it easier for spaces to expand uniformly. The building was appropriately detailed along various grids with adequate room for expansions of the structure as shown in plate XLI.

Plate XLI: A View of the Faculty of Medicine U.I, Showing the Building Form Adapted.
Source: Author’s fieldwork, 2016

4.3.2 Transformation

Easily replaceable building materials were used for construction. The framed structural system used made the spaces convenient for deconstruction or addition of walls and partition, and at the same time ensure maintenance and stability in case of the need for future alterations. Plate XLII shows arrangement of spaces from the interior to exterior.

Plate XLII: The Faculty of Medicine U.I, Having Interconnection between Spaces.
Source: Author’s fieldwork, 2016

4.3.3 Mobility (use of facility)

The provision of large spaces without any structural obstruction makes accessibility to installation components and periodic maintenance easy. This has also made easy the efficient arrangement of furniture and installation component and also provides room for easy adaptation to changes either on a long or short-term basis. This has been demonstrated in plate XLIII.

Plate XLIII: Laboratory, Faculty of Medicine U.I.
Source: Author’s fieldwork, 2016

4.3.4 Interaction (spatial organization)

The *zoning* of the facilities shows partial consideration for good relationship between the buildings; this has greatly reduced interaction between buildings as shown in figure 4.7. Some of the buildings did not show appropriate zoning and orientation in accordance to the nature of the site, however, proximity to individual buildings was kept at a minimal range. The nature of spatial organization has made *transition* between spaces easier.

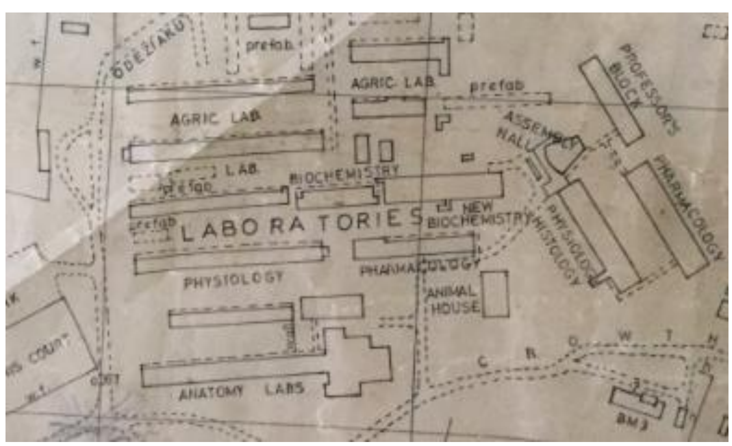

Figure 4.7: A layout of the Faculty of Medicine, U.I.
Source: Dept. of Works and Maintenance, University of Ibadan.

Plate XLIV shows a pictorial view of the Faculty of Medicine U.I. It indicates the nature of spatial arrangement and zoning as shown in figure 4.7. The faculty buildings have expanded over time to meet contemporary requirement.

Plate XLIV: The Faculty of Medicine U.I, Showing the Parking Space.
Source: Author's fieldwork, 2016

Compartmentalization within spaces was easily achieved because of the nature of spatial sequencing as shown in figure 4.8. This has been made possible through an easy flow of functions with minimal visual distractions in spaces where focus is a priority. This careful arrangement also helped to achieve a variety of usable spaces within a single floor levels.

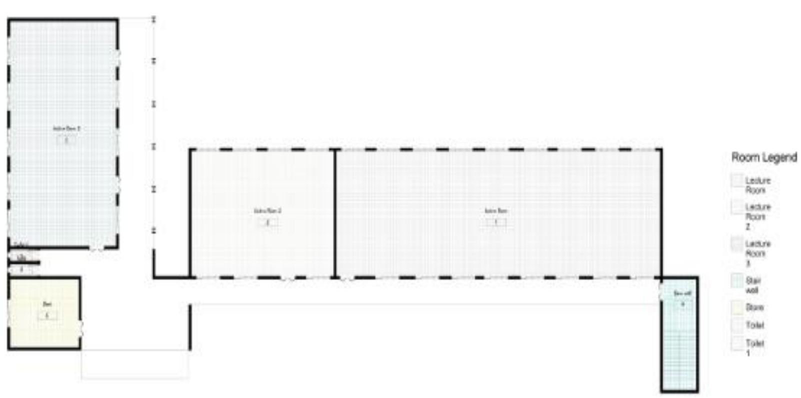

Figure 4.8: Floor Plan Showing Arrangement and Transition between Spaces, U.I.
Source: Author's fieldwork, 2016

Table 4.4: Visual Survey Checklist (Case Study three).

S/N	VARIABLES	CHECKLIST	LEVEL OF REFLECTION 1	2	3	4	5	MEAN SCORE	REMARKS
1.	**Adaptation** (Building form)	Suitability of the building geometry to periodic extension.				☑		**4.3** represent the mean score for the potentials of building adaptation. This shows a good score.	The building form and frame structural system used allows for functions to adapt to changes over time.
		Design of structural system for future alterations and expansion.					☑		
		Convenience for change of functions within interior spaces.				☑			
2.	**Transformation**	Ease of replacement of the building materials.				☑		**4** represent the mean score for the potentials of building transformation. This shows a good score.	Locally available and easily replaceable building materials allows for ease of the building transformation either by the addition or elimination of the building elements.
		Convenience of spatial lay-out to addition or elimination of partition elements.				☑			
		Ease of structural system to addition or elimination of forms				☑			
3.	**Interaction** (Spatial organization)	Zoning of the facilities.		☑				**3.4** represent the mean score for building interaction.	Fair zoning of facilities has limited interaction within the faculty. However, circulation and compartmentalization within interior spaces was well defined
		Spatial sequencing.				☑			
		Compartmentalization.				☑			
		Design of Circulation within and outside the building.				☑			
		Existing spaces performing multiple functions.			☑				
4.	**Mobility** (Use of Facility)	Accessibility of installation components.				☑		**3.5** represent the mean score. Fixed furniture, however serves as limitation for mobility.	The free span within laboratories has helped in achieving good circulation within the laboratories.
		Presence of easily replaceable and dismantling materials.		☑					
		Placement of structural design for construction and installations on a maximum partition.				☑			
		Design provision and convenience of spaces to the movement of facilities.				☑			

Source: Author's fieldwork, 2016

Table 4.4 shows the survey checklist for case study area three with flexibility attributes.

4.3.5 Summary of visual survey findings (case study three).

Findings from the design of the Faculty of Medicine, U.I show, partially, an understanding of proper architectural orientation of the buildings. Although ample spaces were provided between individual buildings, conscious design effort for integration and accessibility was minimal; this challenge is further compounded by the pavilion concept of arrangement of spaces. However, proximity between individual buildings is kept at a minimal range.

The building and its spaces are basically rectangular forms. This concept is adopted in all the buildings. The nature of spatial organization has made easier transition between the buildings. The method of construction shows good tendency for efficient expansion and future alterations because of the structural systems used. The design took advantage of the method of construction and structural system to compartmentalize each department and its facilities as a unit. This system has made required activities within each unit to be very efficient. Compartmentalization within the departments has taken cognizance of convenient transition to the outside environment; this has, carefully, been done through an easy floor of functions with minimal visual distraction in areas where focus is a priority; this has also helped in achieving a variety of usable spaces. The extent for the level of compartmentalization and transition, however, is limited by the distance between departments. This careful arrangement has helped in achieving a variety of usable spaces. Current requirement of the faculty include the need for a more contemporary technology as teaching aids for class rooms and laboratories. Despite the fact that the strategy used for multi-functionality of spaces has not been very successful, the need for expansion has been kept at minimal, as no major form of expansion has been witnessed within the faculty.

Although all variables of flexibility seem to have done well, spatial interaction records the least value in its application of principles of flexibility based on survey finding.

4.3.6 Space syntax data, (case study three).

Relationship between user spaces and space integration values

Plate XLV is a Visibility Graph Analysis showing individual space integration of the Faculty of Medicine, University of Ibadan. Different levels of integration were indicated by a straight line going along a path. The most integrated areas within the building correspond with a value of 9.2997, while the least integrated areas corresponds with the value 3.11924 on V.G.A. The intelligibility value, records 0.175978; this value, as earlier indicated, falls below the value for the minimum standard requirement of a good design.

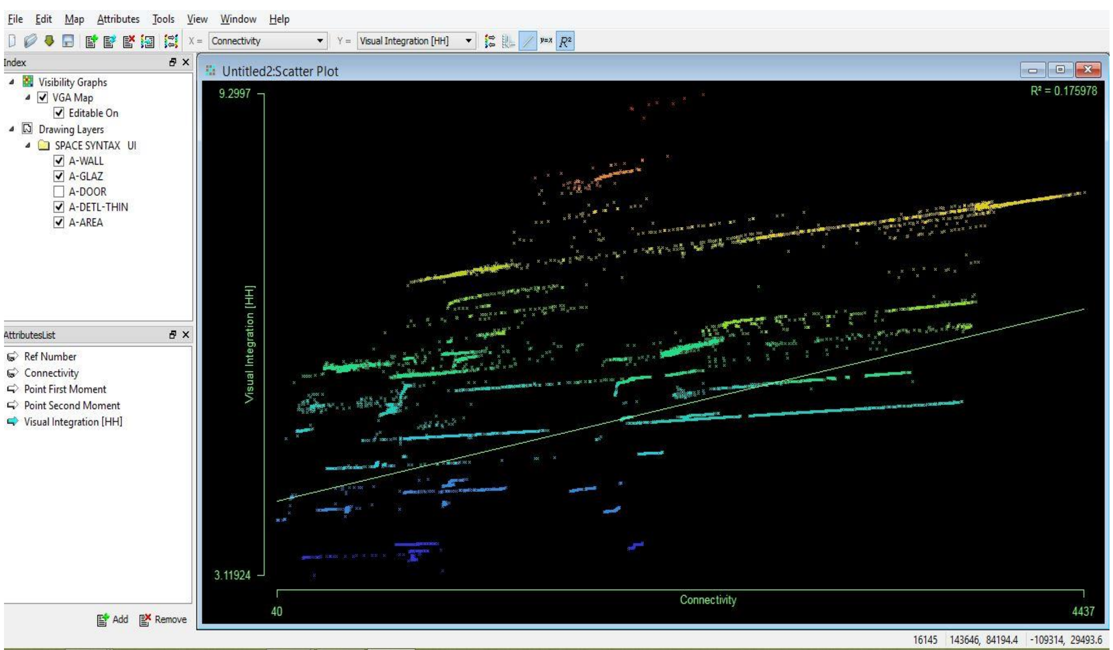

Plate XLV: V.G.A Graph Showing Visual Integration, Connectivity and R^2 Values.
Source: Author's fieldwork, 2016

Integration [HH] of the floor plan

Figure 4.9 shows the V.G.A map of a floor plan indicating the relationship between individual space units. The most integrated spaces can be observed along the parking lot, courtyard and walkways between the various departments. Areas showing poor integration appear so due to distance, poor connectivity and lack of well-defined spaces.

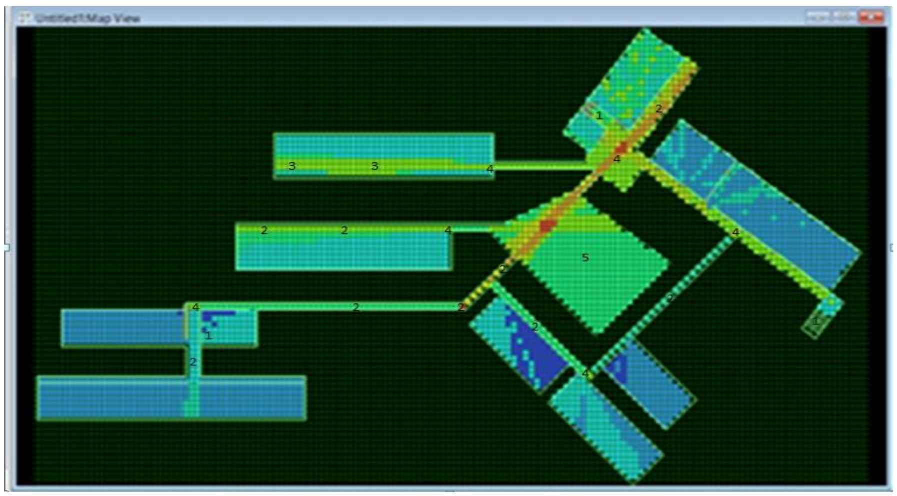

Figure 4.9: Integration of Faculty of Medicine, UI
Source: Author's fieldwork, 2016

4.3.7 Discussion of findings for V.G.A, (case study three).

The V.G.A has shown that location of walkways and parking lots has been the major elements that integrated spaces within the faculty. The parking lot shows highest level of integration. This has influenced near-by buildings and department; however, its positioning is not well located and did not define the major access into the faculty. The building has no defined access that connects individual departments. The overall effect of this was indicated from an R^2 value of 0.175978, which can be expressed as a percentile value of (17.5%); this does not meet the minimum requirement for a good design.

5.0 RESULTS AND DISCUSSION OF FINDINGS

5.1 Discussion of Findings

Findings revealed that although case study 3 ranks best from the instruments used to verify the application of flexibility strategies base on visual survey finding, this, however, is not true of all the individual variables assessed, this is because case study 3 has, to the extent of the assessment of the research variables, achieved some of its long-term space needs but neglected other variables that could have aided its short-term spatial needs. The uniformity of the form concept and use of materials adopted for construction in case study 1 & 3 shows good tendency for efficient expansion and future alterations; this is also aided by good structural detailing and the grid system method of construction suggesting the tendencies to adapt to future changes. Findings from case study 2 & 3 shows that most of their spatial organization problems were compounded by the pavilion concept of arrangement of spaces (where each building is conceived of as a freestanding rectilinear unit). This had, over time, created confusion and difficulty for visitors and sometimes regular users to locate or access individual department within the faculties. An attempt made to reconcile this has been averagely successful for case study 1, because the only access provided to connect all the departments has been designed to pass through other usable spaces, creating a temporary breakage for users to effectively access individual laboratories and classrooms.

Since medical school is involved in this research the research looked at the variables from the general principles of flexibility in architecture and their unique implications in medical schools. In line with the first research question (What are the concepts and strategies of flexibility required for faculty of Medicine)? The research has identified that, like any other educational spaces flexibility has to be considered both over a *long-term* and *short-term* use. This happens both at the micro level (daily or hourly usage) or micro level (monthly or yearly changes). However, to answer research two (What are the factors that affect the strategies of flexibility in faculty of Medicine)? The research had to look in two different directions- firstly factors that affect flexibility in the generic sense based on basic principles of flexibility which are *adaptation*, *transformation*, *mobility* and *interaction*- then secondly factors that affects these basic principles of flexibility unique to medical practice, which has to do with *changes in curriculum* (brought about by problem based learning for encouraging research, need for outdoor learning spaces, need for a sense of interaction between the interior and exterior spaces) and changes in technology (use of computer for mannequin based simulation, integration of facilities with related laboratory technology and alternatives for design of laboratories). These factors identified affect the potentials of flexible spaces in faculties of medicine over both short and long-term basis. In order to look more specifically on research questions three (What are the factors that enhance spatial flexibility in faculty of Medicine)? The research tested the three study areas both on the basic principles of flexibility, *adaptation, transformation, mobility and interaction* and the basic factors that affects them base on the trends of medical practice as earlier mentioned suggested in objective two. In this case the research identified, (1) integration and connectivity of related lab facilities, (2) outdoor learning spaces, (3) convenience of mobility for departments at all levels, (4) sense of interaction and transition between interior and exterior spaces, (5) convenience of delivery into the cadaver unit, and (6) arrangement of furniture as key attributes for enhancing flexibility in faculty of Medicine. In order to answer research question four (How can a framework be developed for faculty of Medicine with flexibility strategies based on the research out-come)? The research went on to be more scientific in its approach by introducing the *depthmap* software for space-syntax analysis. This helped to investigate the basic principles of flexibility, and how they can be accessed based on the demands of medical schools. The analysis also focuses on the principle of spatial interaction which shows the least values and consideration in all the three study-areas. Evidence of this has been indicated numerically as 2.6, 2.2 and 3.4 as the mean score values for spatial interaction and organization- which does not show good values based on the scaling factor utilized. Meanwhile the intelligibility values of 0.316166, 0.1293962 and 0.1833098 for case-studies 1, 2 and 3 respectively shows that the three study areas has not met the minimum connectivity and integration standard requirement for a good design.

In line with the fifth research question (How can the outcome of the research be demonstrated in the design of Faculty of Medicine, Yobe state university)? The research employed its findings in a design in order to have a flexibility strategy unique to the design of Faculty of Medicine. This took into cognizance attribute of flexibility from *Spatial interaction, Mobility, Adaptation and Transformation*. The outcome of the design has been able to show how flexibility strategies have been improved with an overall intelligibility rating of 0.601816 which is higher than all the three case-study areas assessed and has met the requirement for a good design.

The four principles used as checklist for flexibility have been summarised in table 5.1. It shows the attributes for spatial, Adaptation, Transformation, Interaction and Mobility for the three case study areas used in the research, and their appropriate remarks. Their mean score ratings have also been recorded.

5.2 Summary of Findings

Table 5.1: Summary of Findings from Visual Survey.
Scale factor: 1= Poor, 2= Fair, 3= Average, 4= Good, 5= Excellent.

S/N	VARIABLES	CHECKLIST	LEVEL OF REFLECTION			MEAN SCORES	REMARKS
			Case study 1	**Case study 2**	**Case study 3**		
1.	**Adaptation** (Building form).	Suitability of the building geometry to periodic extension.	4	2	4	The mean scores obtained were; 4, 2.3 & 4.3 for the assessment of building adaptability in case-study 1, 2 & 3 respectively.	Case studies 1 & 3 used a framed structural system which allows for adaptability and encourages expansion and alterations. The use of form to follow function allows both interior and exterior spaces to adapt to changes uniformly within the case study areas. The span for the structural system, however, was not convenient for laboratory practices. Case-studies 2 have the least adaptation potentials.
		Design of structural system for future alterations and expansion.	5	2	5		
		Convenience for change of functions within interior spaces.	3	3	4		
2.	**Transformation**	Ease of replacement for the building materials.	3	3	4	The mean scores obtained were; 4, 2.6 & 4 for the assessment of building transformation in case-study 1, 2 & 3 respectively.	Easily replaceable building materials were used for construction which allows for periodic changes. The trabeated style used for construction allows for transformation within the interior and exterior spaces either by addition or elimination of partition and elements of the building structure. This is more convenient for case study 1& 3; however, these materials were used mainly as cladding element but not as walls or partition elements.
		Convenience of space units to addition or elimination of partition elements.	5	2	4		
		Ease of structural system to addition or elimination of forms.	4	3	4		
3.	**Interaction** (Spatial organization)	Zoning of the facilities to related functions.	3	1	2	The mean scores obtained were; 2.6, 2.2 & 3.4 for the assessment of building interaction in case-study 1, 2 & 3 respectively.	Case study 1 shows good zoning; however, the buildings show partial integration due to inadequate link and access between departments and laboratory units. Case study 3 shows high level of space compartmentalization. Transition between indoor, semi-indoor and out-door spaces were not considered in the three case-
		Spatial sequencing.	3	3	4		
		Compartmentalization.	3	3	4		
		Design of Circulation within and outside the building.	2	1	4		

		Existing spaces performing multiple functions.	3	3	3		study areas. The level of space performance for multiple functions is minimal in the three study areas.
4.	**Mobility** (Use of Facility/ building and installation technology).	Accessibility of installation components	4	4	4	The mean scores obtained were; 2.75, 3.25 & 3.5 for the assessment of mobility in case-study 1, 2 & 3 respectively.	Technology and installations are readily accessible and easy to fix or dismantle. Movement of furniture and facilities within laboratories is however limited in case-study 1 by the span of the structural grid system adopted for the construction.
		Presence of easily replaceable and dismantling materials and furniture.	2	3	2		
		Placement of structural design and installations on a maximum partition.	2	3	4		
		Design provision and convenience of spaces to the movement of facilities.	3	4	4		
		Total	49	40	56		Case study 3 has the highest total score.

Source: Author's fieldwork, 2016

The four principles used as checklist for flexibility have been represented on a bar chart on figure 5.1. It shows the hierarchy for Adaptation, Transformation, Interaction and Mobility for the three case study areas used in the research, based on a mean score rating of 1-5.

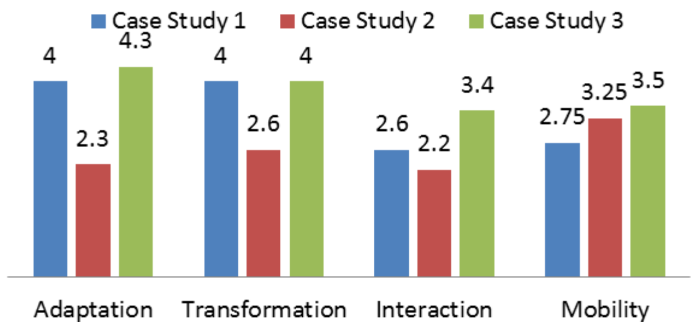

Figure 5.1: Mean Score Rating of Findings from Survey Checklist.
Author's fieldwork, 2016

The implication of findings was further identified on the micro-level of the spaces in the study areas, as shown in figure 5.2. This has been identified on the floor plans.

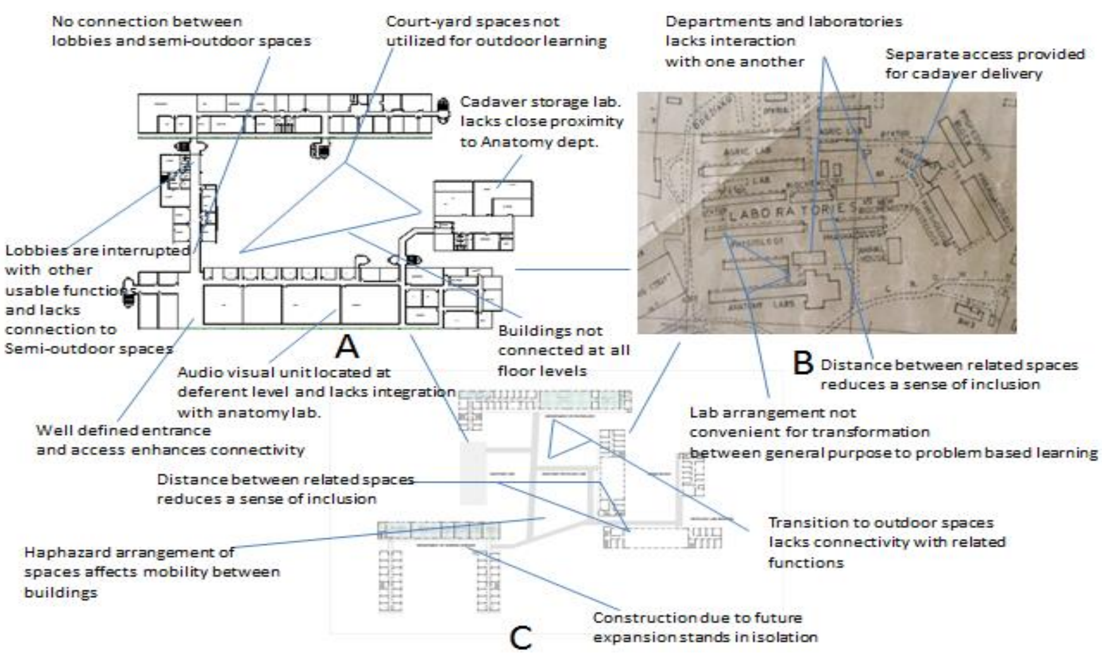

Figure 5.2: [A] Ground Floor Plan, Faculty of Medicine A.B.U [B] A Layout for the Faculty of Medicine UI [C] Ground Floor Plan, Faculty of Medicine UJ

Author's fieldwork, 2016

5.3 Summary of Findings from Space-Syntax analysis

I. The study reveals that strategic positioning of key elements such as the entrance, placement of staircase, well designed walkways and accesses enhances the integration values of an entire building.

II. The Space-Syntax analysis indicated the major entrances of the study areas as a very critical point. This area indicates a high level of connectivity because of its accessibility to many other spaces and can be used to determine the positioning of other spaces.

III. Findings also reveals that staircases which should provide vertical means of access and integration stands in isolation and their potentials have been weakened due to poor access and lengthy corridors.

IV. The Space-Syntax intelligibility rating (R^2) values of 0.31 (31%), 0.22 (22%) and 0.175 (17.5%) for case studies 1, 2 and 3 respectively shows that the three study areas has not met the minimum standard requirement for a good design.

6.0 DESIGN REPORT

6.1 Preamble

This chapter reveals comparative study of how the research findings affect the design of the proposed Faculty of Medicine based on relevant design criteria.

6.2 Design Framework

(Ponti, 2005)**,** identified the need for flexibility of educational spaces to be considered both for a short-term and long-term usage, simultaneously, in order to serve for immediate and day-day activities and also for future considerations.

However, a research titled *"Enhancing space multi-functionality through flexibility strategies in the design of faculty of medicine"* revealed that flexibility strategies are usually affected by the nature of activities and ethics of any building typology and hence its application has to be done within that context. In this regard the research took cognizance of the nature of changing and evolving curriculum in medical schools as well as changes in evolving technology. All these contributed to the reduction of individual interior spaces but posing more demands on logically designing reconfigurable space and harmonizing the interior with the exterior space, thereby changing the model of the exterior spaces as potential learning environment. Figure 6.1 below gives schematic illustrations of the design framework.

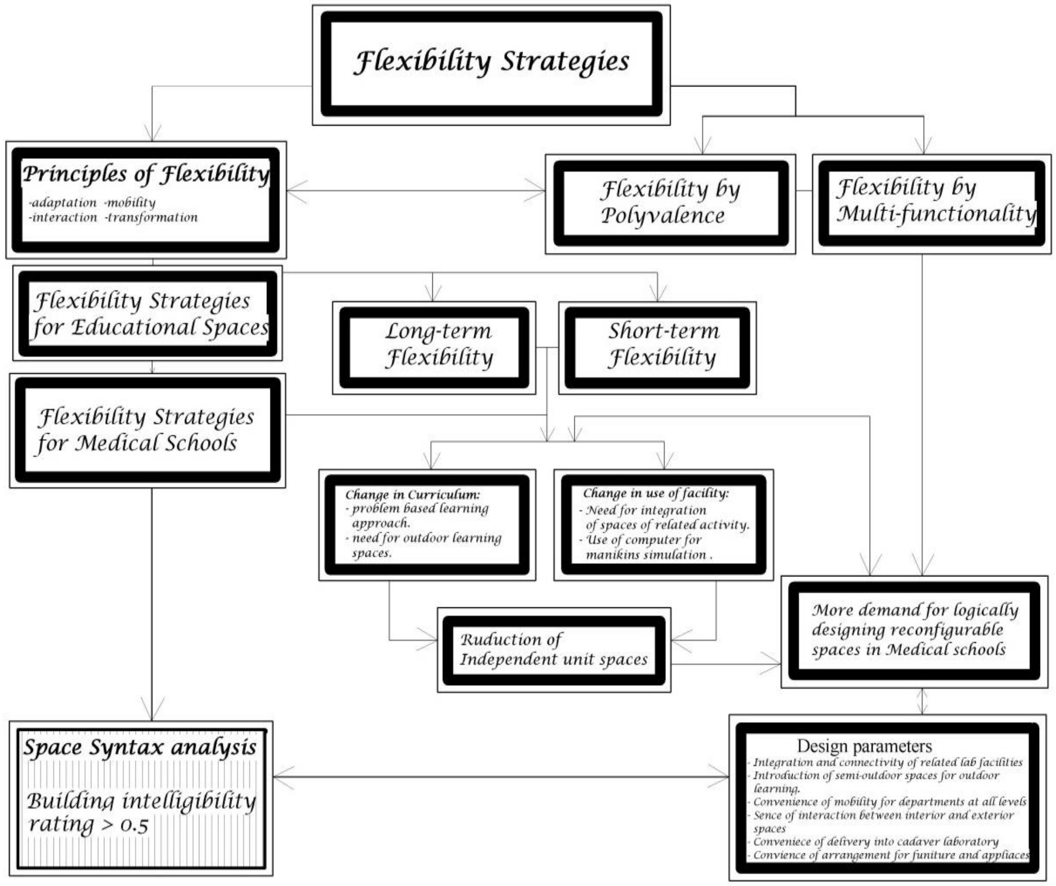

Figure 6.1: Schematic Diagram of the Design Frame Work.
Source: Authors fieldwork, 2016

6.3 Design Brief

Due to the increase in the demand for new medical schools and institutions in Yobe State as a result of the increase in population and poor medical workforce; the researcher proposed to design a Faculty of Medicine that will help to address these challenges. This is with consideration to 100 MBBS student capacity per academic session alongside the departments of Anatomy, Physiology Biochemistry and nursing sciences to be located in Damaturu town of Yobe State; the reason is, to match the provision of health care with social and economic demands and improve the allocation of medical resources. The design will take into consideration the current challenges of flexibility in spaces of Faculties of Medicine and also incorporate its contemporary needs.

6.4 Study Area

The study area is Damaturu town, the capital of Yobe state, shown in figure 6.2. Damaturu is located at North-eastern part of Nigeria. It is situated at 11.75° North latitude, 11.96° East longitude and 456 meters elevation above sea level with a population of about 255,895. The map of Damaturu shares boundaries with Gujba, Tarmuwa and Fune local government area. Mean-while the State shares boundaries with Borno, Bauchi, Gombe and Jigawa States.

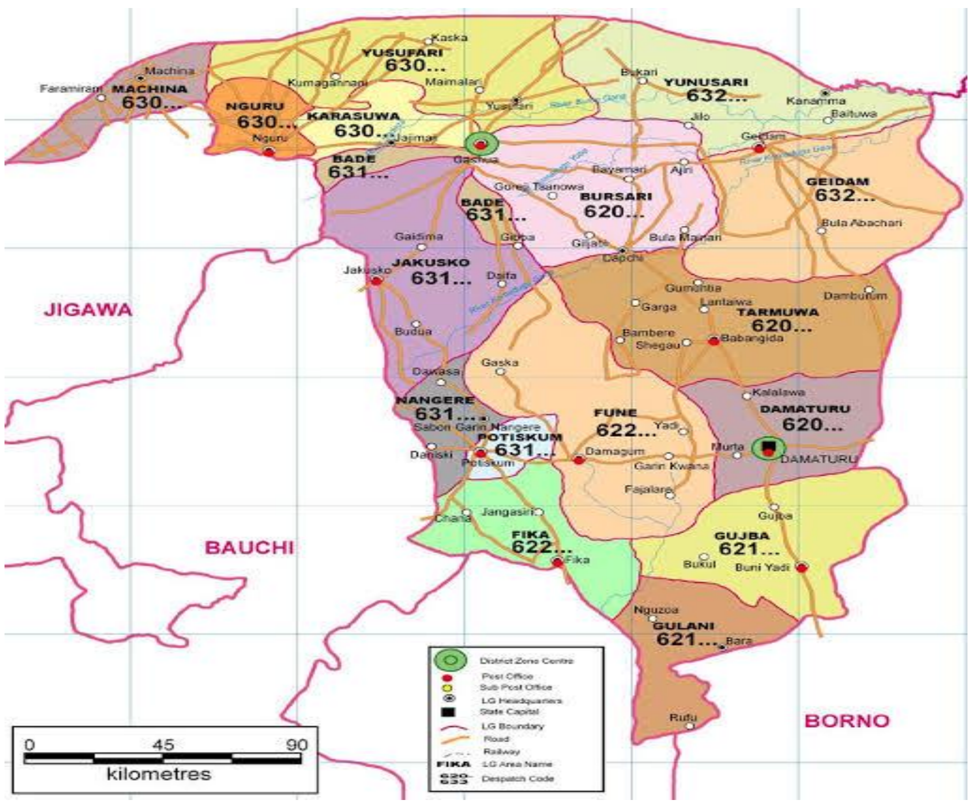

Figure 6.2: Map of Damaturu Yobe State.
Source: Google Earth, 2017

6.5 Site Selection and Justification

For any design of a good medical school a range of criteria has been recommended by medical authorities and researchers. The proposed site has been chosen from the site established from the land-use plan of Yobe State universities. Plate XLVI shows site ‘A’ and the basic features of the site for design consideration.

- The site has good proximity to already existing facilities.
- Potentiality of accessibility to the site at different location.
- Size of site convenient for potential future expansion.
- Potentiality of accessibility to the site at a lesser traffic areas for convenience of delivery into the cadaver unit.
- The site strategic positioning satisfies the requirements for the location of good parking spaces.
- The site has close proximity to electricity and water supply.

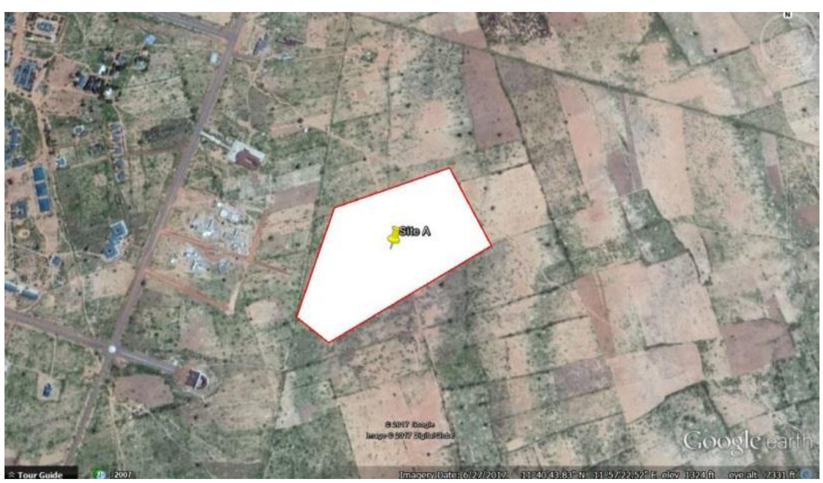

Plate XLVI: Google image of site A.
Source: Google earth, 2017

Plate XLVII shows site B as an alternative site chose for the design of the proposed Faculty of Medicine for Yobe State University. This was further discussed in table 6.1 This has also been considered for its good design attribute for the proposed design.

Plate XLVII: Google image of site B.
Source: Google earth, 2017

Table 6.1 shows the site selection criteria scoring sheet by comparing the good design attributes of both site A and B from the proposed site for Yobe State University.

Table 6.1: Site Selection Criteria Scoring Sheet.

S/N	Criteria	Site A	Site B	Remarks
1	The site's proximity to already existing facilities.	**5**	**4**	Site A has closer proximity to existing facilities.
2	Potentiality of accessibility to the site at different location.	**5**	**5**	The two sites have equal and good accessibility potentials.
3	Convenience of size of site for future expansion.	**4**	**4**	The two sites have equal and potentials for expansion.
4	Convenience of site location on the land-use map	**5**	**5**	Both sites are on a good location on the land-use map.
5	Convenience of access and delivery into the cadaver area.	**4**	**4**	Both sites are on a good location for cadaver delivery.
6	Potentials of site to satisfy parking requirement.	**3**	**3**	The two sites has equal potentials for parking space.
7	Proximity of site to electricity and water supply	**5**	**3**	Site A has closer range to electricity and power supply.
Total		**31**	**28**	Site A is best suited for the proposed facility.

Source: Author's fieldwork, 2017

6.6 The Proposed Site Location

Figure 6.3 shows the site for the proposed faculty located in Yobe State University, Damaturu. The university is located along Gujba- Biu road. The university is situated opposite Yobe State Radio Broadcasting Cooperation. In the university the site is situated towards the north-western side a few meters from the undeveloped site.

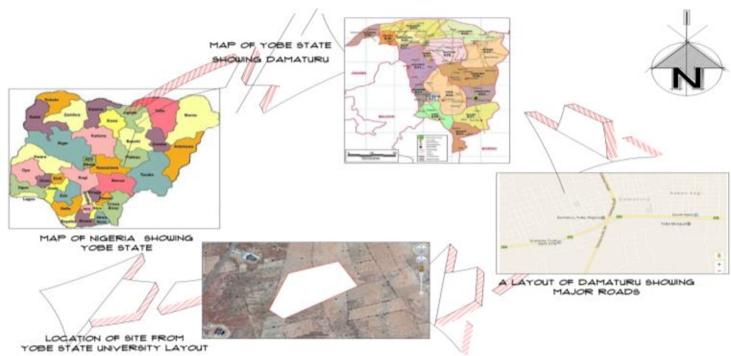

Figure 6.3: Site Location.
Source: Author's sketch, 2017

Figure 6.4 shows the Yobe State University land-use plan, indicating positions of individual buildings for future designs and expansions within the university system.

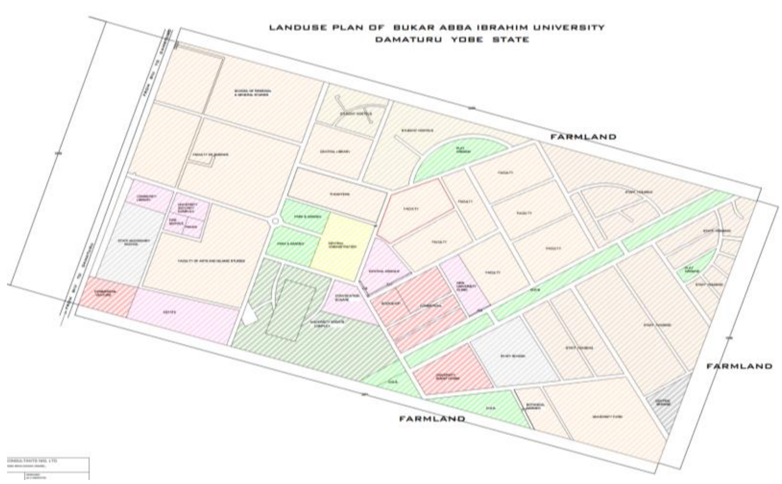

Figure 6.4: Yobe State University Land-Use Plan.
Source: Yobe State University, 2016

6.7 Analysis of the Site

6.7.1 Topography and vegetation

Figure 6.5 shows that the site is relatively flat. It sloped gently towards its North-western direction. Drainage of the site will take advantage of this. The site is characterized by dense grasses and shrubs sparsely distributed across. However little of these grasses can be seen during dry season.

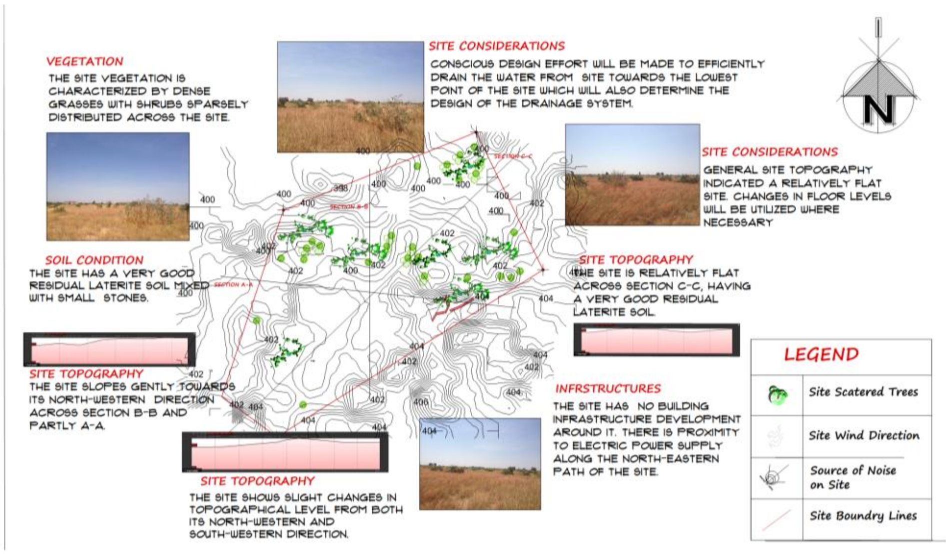

Figure 6.5: Topographical and Vegetation Analysis of the Site.
Source: Author's sketch, 2017

6.7.2 Climatic data analysis

The climate of the site is same as that of the Damaturu town characterized by two distinct climates, rainy season and dry season. Rainfall starts from the month of April and ends in October with August having the peak fall. During this time temperature range between 35°c – 40°c in the afternoon and comes down to20°c – 25°c in the night. However, records have shown that for over two decades the rise and fall of temperature fluctuates over the years. The humidity is low during the dry season and high during the rainy season. Hence fenestrations will be provided to ventilate the building especially during the day and proper building orientation will be considered both for the building setting and flexibility attributes assessed from the visual survey checklist during the course of the fieldwork, as identified in figure 6.6 for climatic data analysis.

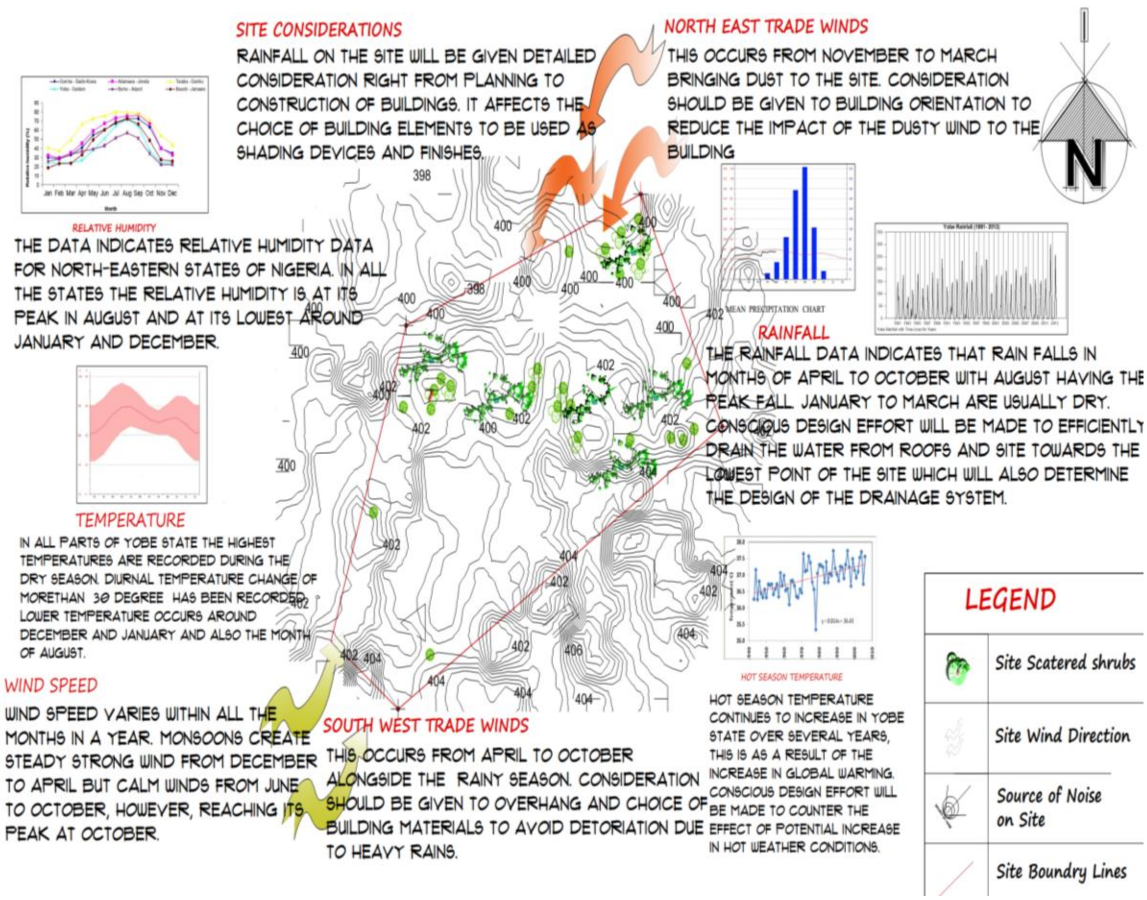

Figure 6.6: Micro climatic data analysis of the site.
Source: Author’s sketch, 2017

6.7.3 Site solar data analysis

The sun rises from the east at about 6:30-7:00am. Solar heat gain is not intense at this period of the day. Devices for passive means of lighting and ventilation will be encouraged. Meanwhile the sun sets at about 6:30-7:00pm with hot radiation. Effort towards achieving a bio-climatic comfort is necessary at this region. Fenestration will also be minimized. This has been demonstrated in figure 6.7.

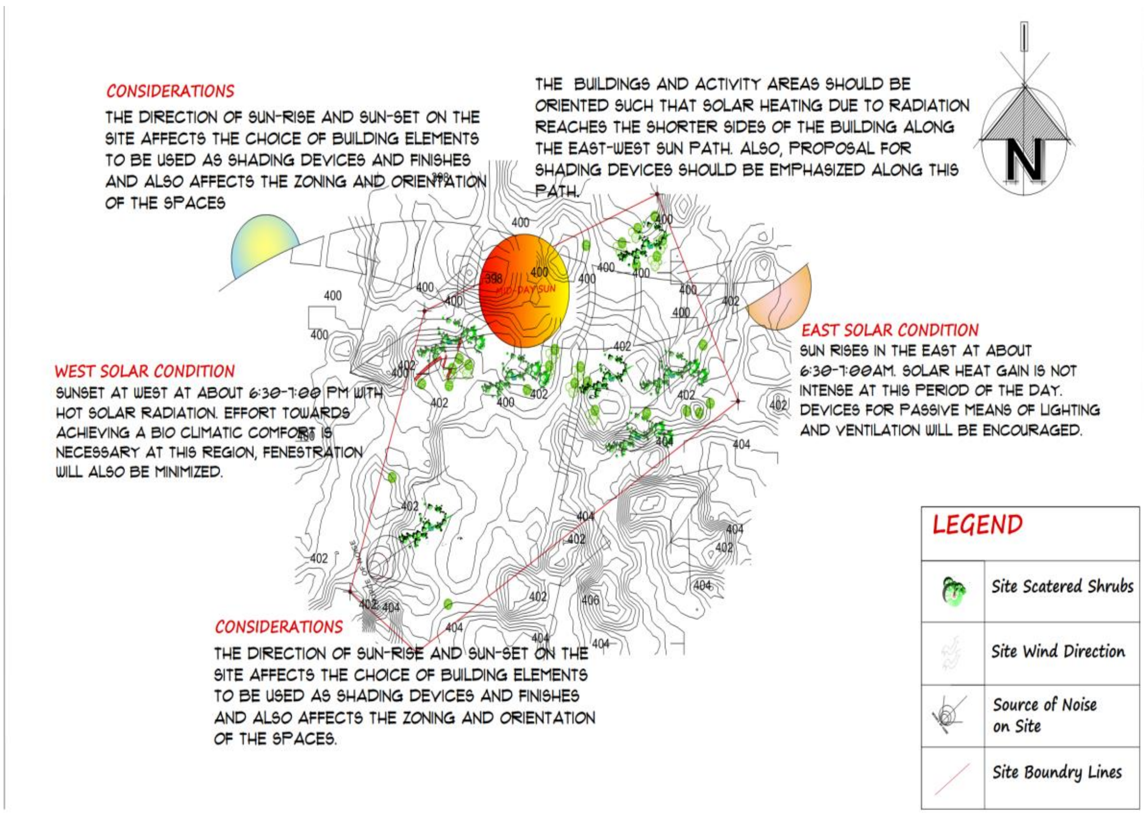

Figure 6.7: Site Solar Data Analysis.
Source: Author’s sketch, 2017

6.8 Brief Development

A careful study of case studies, consultation of related books, articles, medical students and practitioners as well as NUC guidelines made the development of the client's brief possible, thereby forming a schedule of accommodation, as shown in table 6.2. This took into cognisance relevant spatial requirements needed for the proposed design.

Table 6.2: Schedule of Accommodation.

S/No	FUNCTION	SPACE REQUIREMENT	UNIT	AREA
A	ACCOMMODATION FACILITIES			
1	STUDIO SUITES	IN-SUITE ROOM WITH BALCONY	36	$30M^2$
2	DOUBLE SUITES	IN-SUITE ROOM WITH BALCONY	30	$36M^2$
3	EXE. SUITES	IN-SUITE ROOM WITH BALCONY	18	$40M^2$
4	LUXURY SUITES	IN-SUITE ROOM WITH BALCONY	12	$56M^2$
5	PRES. SUITES	IN-SUITE ROOM WITH BALCONY	1	$84M^2$
6	HOUSE KEEPERS	ON EACH FLOOR	1	$30M^2$
6	CIRCULATION	ON EACH FLOOR	?	?
B	ADMINISTRATIVE & STAFF FACILITIES			
1	MANAGER OFF	STANDARD OFFICE WITH STATIONERY	1	$30M^2$
2	SECRETARY OFF	STANDARD OFFICE WITH STATIONERY	1	$24M^2$
3	GENERAL OFF	STANDARD OFFICE WITH STATIONERY	1	$36M^2$
4	RECEPTION	ENTRANCE, WAITING AND RECEPTION	1	$42M^2$
5	STAFF LOUNGE	CANTEEN PROVIDED & REST ROOM	1	$36M^2$
6	CHANGING	MALE & FEMALE PROVIDED	2	$15M^2$
7	STAFF TOILETS	MALE & FEMALE PROVIDED	3	$12M^2$
C	BUSINESS FACILITIES			
1	CONFER. HALL	MINIMUM OF 300 SEATING CAPACITY	1	$400M^2$
2	BANQUET HALL	MINIMUM 100 EATING CAPACITY	1	$200M^2$
3	SEMINAR ROOM	ABOUT 50 PERSONS CAPACITY	3	$100M^2$
4	MEETING ROOM	ABOUT 10-15 PERSONS	5	$48M^2$

S/No	FUNCTION	SPACE REQUIREMENT	UNIT	AREA	TOTAL AREA
5	CINEMA	ABOUT 60 PERSONS	2	$120M^2$	
6	RENTABLE SHOP	ABOUT 10	5	$48M^2$	
D	RECREATION FACILITIES				
1	GYM	?	1	$60M^2$	
2	SPA	PEDICURE & MANICURE	1	$48M^2$	
3	OPEN COURTS	OUT-DOOR	?	?	
4	LAWN TENNIS	OUT-DOOR	1	?	
5	BADMINTON	OUT-DOOR	1	?	
6	SWIMMING POOL	IN-DOOR & OUT-DOOR	2	$48M^2$	
E	AUXILLARY FACILITIES				
1	RESTAURANT	?	1	$60M^2$	
2	KITCHEN	PEDICURE & MANICURE	1	$48M^2$	
3	LOUNGE	OUT-DOOR	?	?	
4	CONVENIENCE	OUT-DOOR	1	?	
5	LAUNDRY SER	OUT-DOOR	1	?	
6	GEN SERVICES	IN-DOOR & OUT-DOOR	2	$48M^2$	
7	GOLF FIELD	OUT-DOOR	1	?	
8	SECURITY	OUT-DOOR	1	?	
9	TREATMENT PLA	IN-DOOR & OUT-DOOR	2	$48M^2$	

Source: Author's fieldwork, 2016

6.9 Architectural Design of the Proposed Faculty of Medicine

6.9.1 Site development plan

After the studies and analysis, a site development plan was developed taking all necessary research findings into consideration. The concept was developed with the consciousness of flexible design approach. Figure 6.8 shows the detailed illustration of the concept.

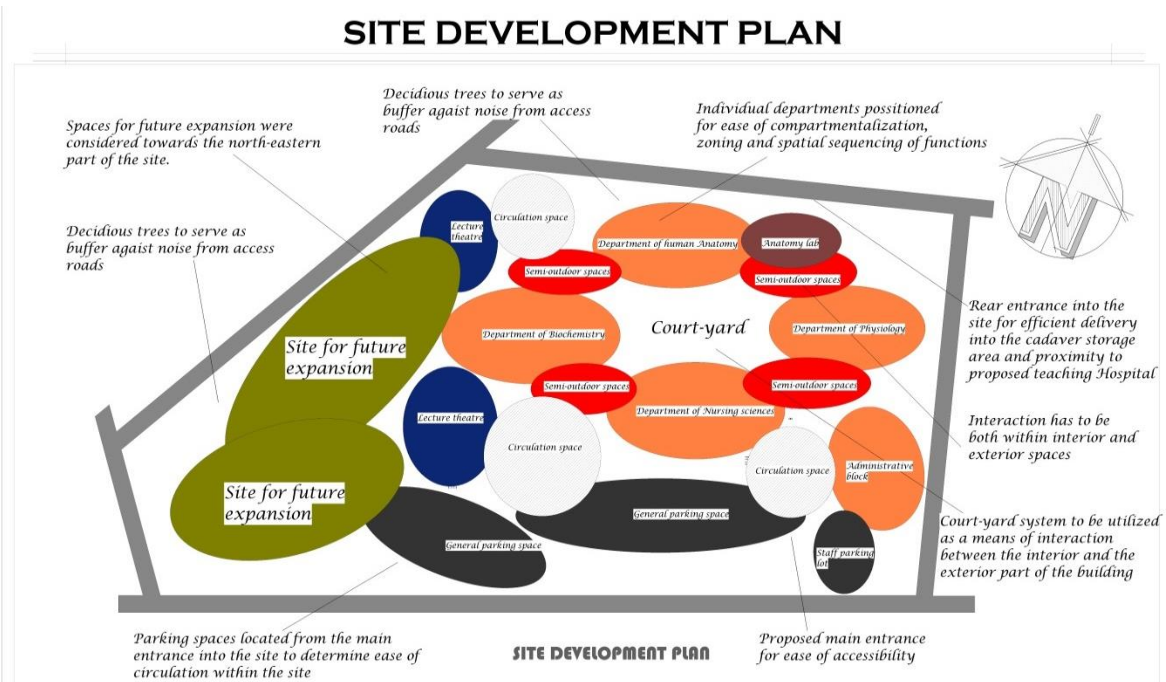

Figure 6.8: Site development plan.
Source: Author's sketch, 2017

6.9.2 Site plan

After careful analysis of the site and the surrounding landscape, the proposed facilities were systematically arranged on the site in accordance with a medical school oriented design and planning; it also took into consideration the basic concepts and principles of flexibility for a school design. The administrative unit was placed as a first point of contact into the site and in a way that it is clearly visible to visitors. The entrance took advantage of proximity of the proposed building to existing facilities. A special point of access into the cadaver laboratory was provided at the rear of the site for efficient delivery. Individual departments were harmonized at all floor levels through a means of interaction between the interior and exterior spaces. Lecture theaters were zone at a less noisy area of the facility. The reasons for separating each department, shown in figure 6.9 means that changes are allowed to occur individually without disrupting the existence of other departments.

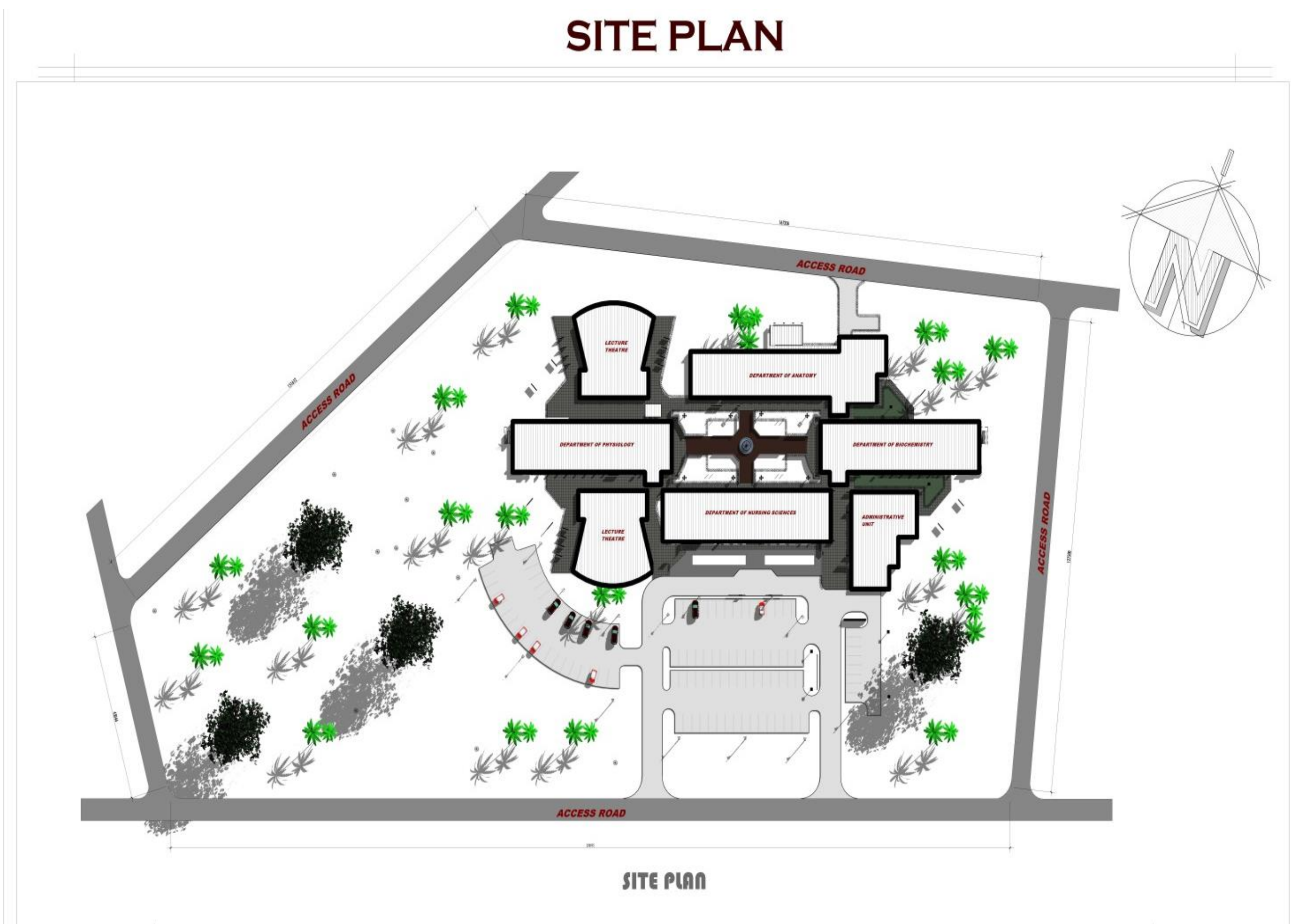

Figure 6.9: Site Plan.
Source: Author’s sketch, 2017

6.9.3 Floor plans

Figure 6.10 shows a conscious design effort for zoning and compartmentalization of spaces based on their functions, as well as creating harmony between individual units. These allow for uniformity and flexibility for specific changes in spaces. It shows how these can be efficiently utilized by reducing lengthy and over-stretched corridors and defined access.

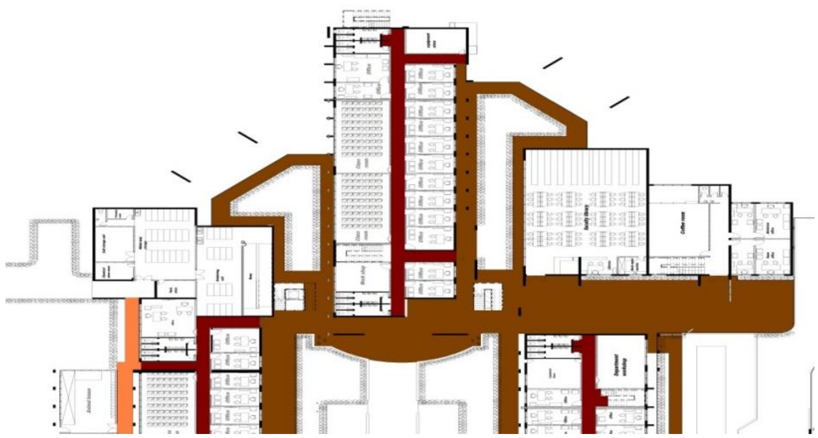

Figure 6.10: Floor Plan Showing Relationship between Buildings.
Source: Author's sketch, 2017

Figure 6.11 shows how some of the flexibility strategies identified from the research has been incorporated within floor plans of the proposed design of the Faculty of Medicine in order to ensure convenience of u**s**age over a long and short-term.

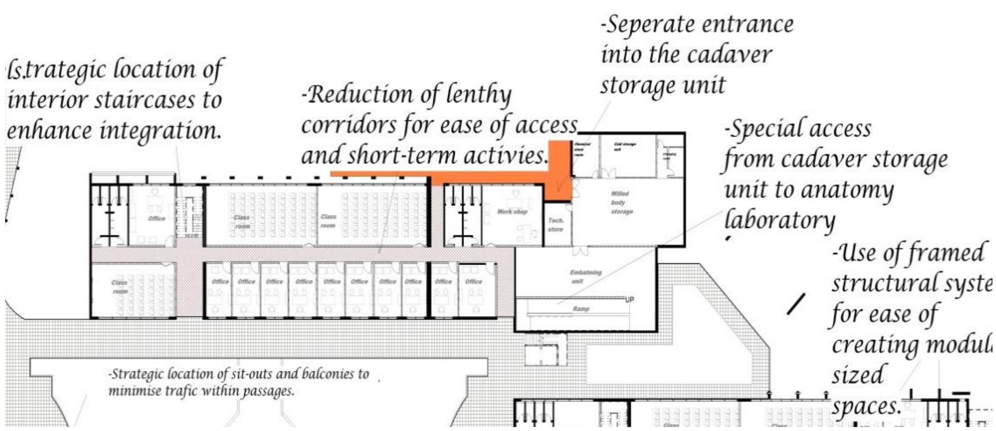

Figure 6.11: Floor Plan of the Anatomy Department.
Source: Author's sketch, 2017

Ground floor plan: Figure 6.12 below shows the proposed ground floor plan of the Faculty of Medicine. The floor plan demonstrated the basic principles of flexibility, which has to do with *Adaptation, Transformation, Interaction and Mobility*. Departments have been separated from each other to allow unique changes to be possible within a unit, and without disrupting other units. Nevertheless, this has been reconciled by providing a sense of interaction between them through transition spaces and outdoor learning environments. A sense of adaptation has been created through the framed structural system used for construction. This allows for adaptation of the building, either through the periodic addition or elimination of some building elements.

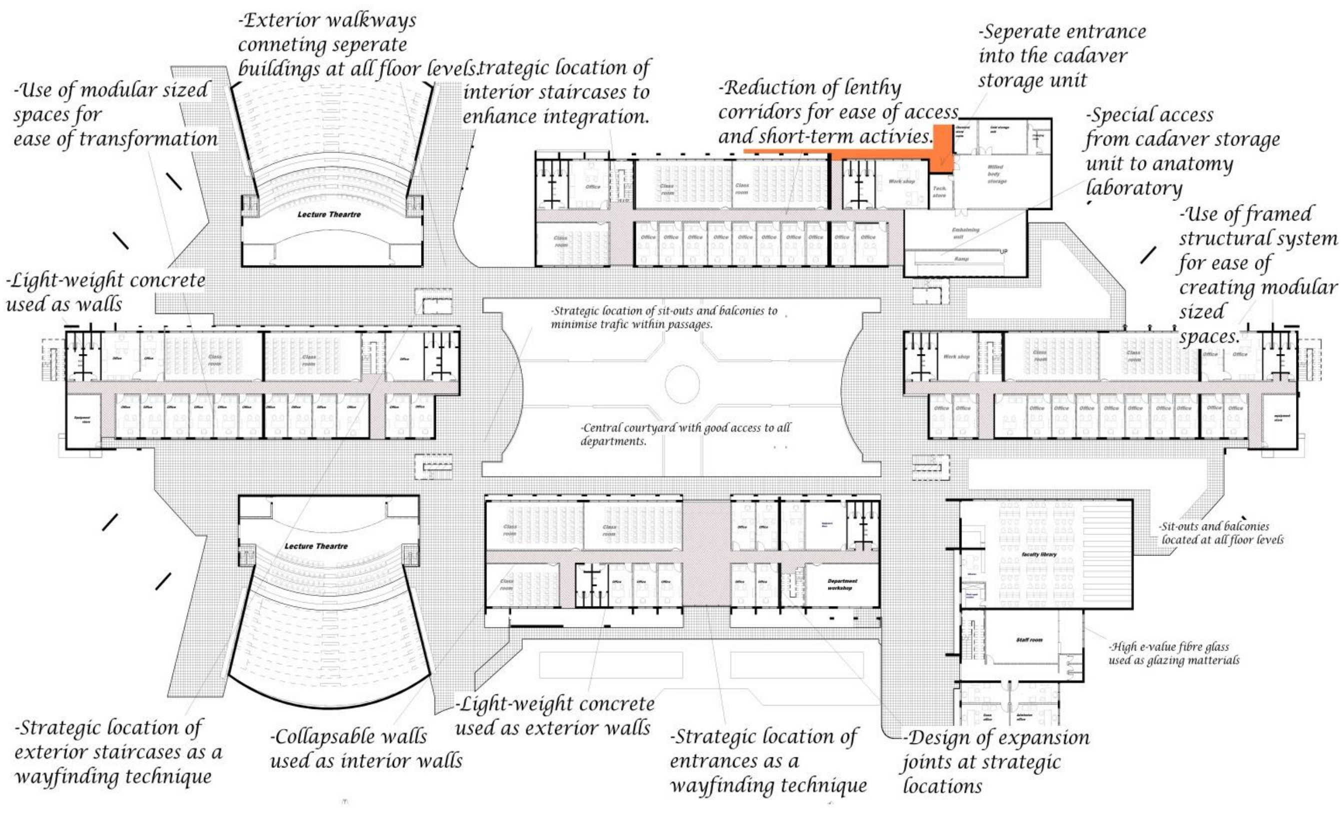

Figure 6.12: Ground Floor Plan of the Faculty of Medicine.
Source: Author's sketch, 2017

First floor plan: Figure 6.13 below shows the first floor plan. A sense of interaction has also been demonstrated at this level. The histology laboratory, which is a common feature of all the departmental units have been strategically located at this area.

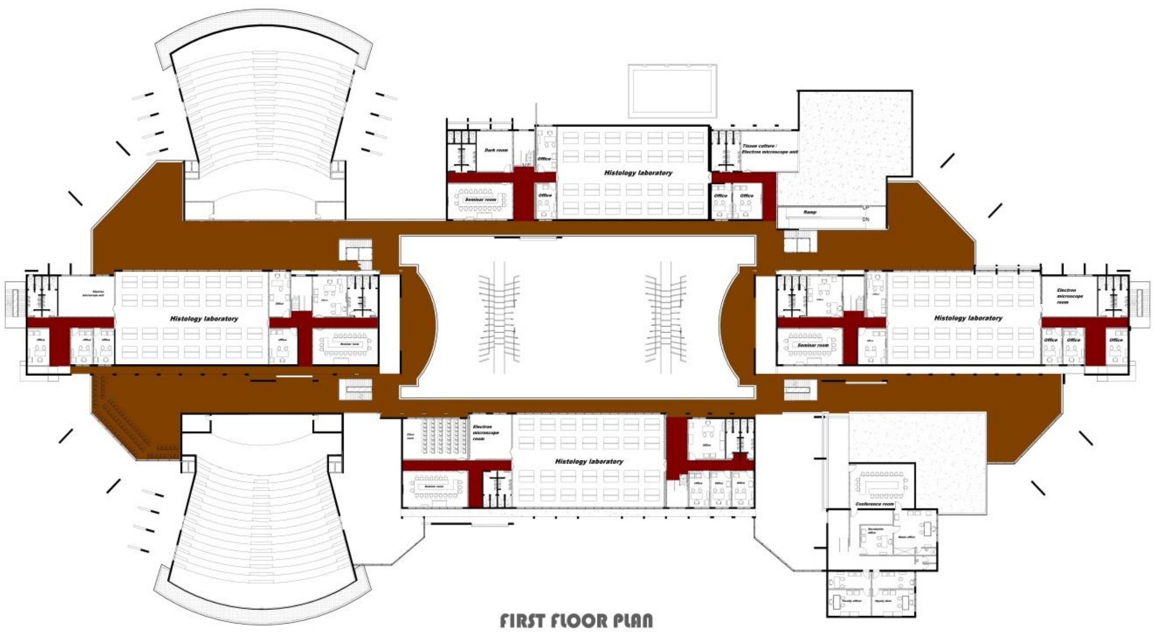

Figure 6.13: First Floor Plan of the Faculty of Medicine.
Source: Author's sketch, 2017

The plan also shows good access to all floor levels from the interior by providing staircases at strategic locations and also by reduction of lengthy corridors across all departmental units. Lift systems have also been provided to this effect.

First floor plan: Figure 6.14 shows the continuous harmony from the grown floor plan to the first floor plan. This is necessary in other to show the continuous changes within spaces due to periodic growth as well as a defined pattern of growth. The plan shows the transition from the cadaver dissecting unit on the ground floor plan to the Anatomy laboratory from second floor. The framed structural system serves as the support to the entire structure. The alteration of the position of spaces within the entire structure means that all partitions have the potentials of being eliminated and redesigned.

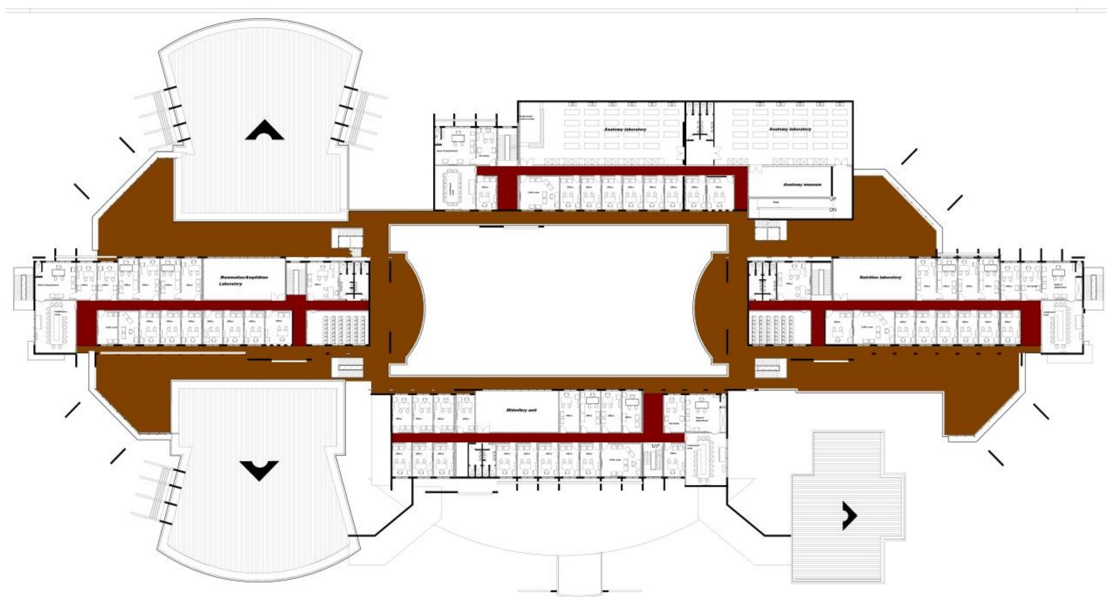

Figure 6.14: Second Floor Plan of the Faculty of Medicine.
Source: Author's sketch, 2017

6.9.4 Elevations

Figure 6.15 shows the approach and rear elevation of the proposed Faculty of Medicine, Yobe State University. The elevation shows the framed structural system used for the design as part of the flexibility attributes identified from the research work. It has also captured the individual departmental unit of the faculty building based on their organisation on the site plan. The framed structural system serves as the major support system for both interior and exterior walls.

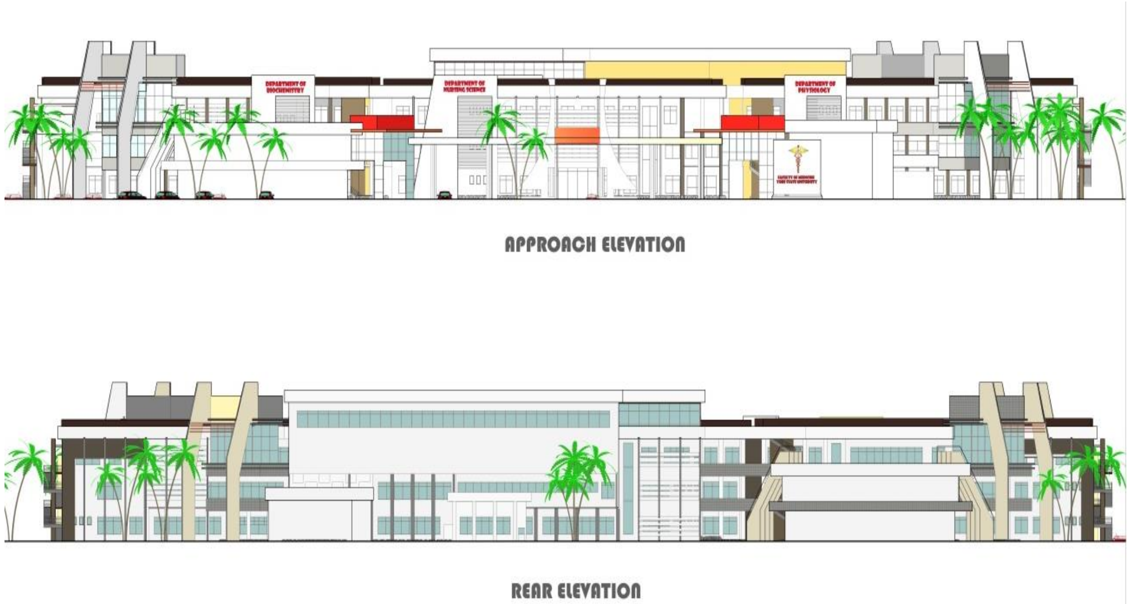

Figure 6.15: Approach and Rear Elevation.
Source: Author's sketch, 2017

Figure 6.16 shows the East and South elevations of the proposed Faculty of Medicine, Yobe State University. The elevation shows the framed structural system used for the design as part of the flexibility attributes identified from the research work. It has also captured the individual departmental unit based on their organisation on the site plan.

Figure 6.16: East and West Elevation.
Source: Author's sketch, 2017

6.9.5 Space syntax data, (proposed faculty of medicine).

Visibility Graph Analysis

Relationship between user spaces and space integration values

Plate XLVIII is a visibility graph analysis showing how individual spaces of the proposed Faculty of Medicine, Yobe State University, were integrated. Different levels of integration were indicated by a straight line going along a path. The most integrated areas within the building correspond with a value of 7.88267, while the least integrated areas corresponds with the value 1.53823 on V.G.A. The intelligibility value, records 0.601816; this value, has met the standard requirement for a good design.

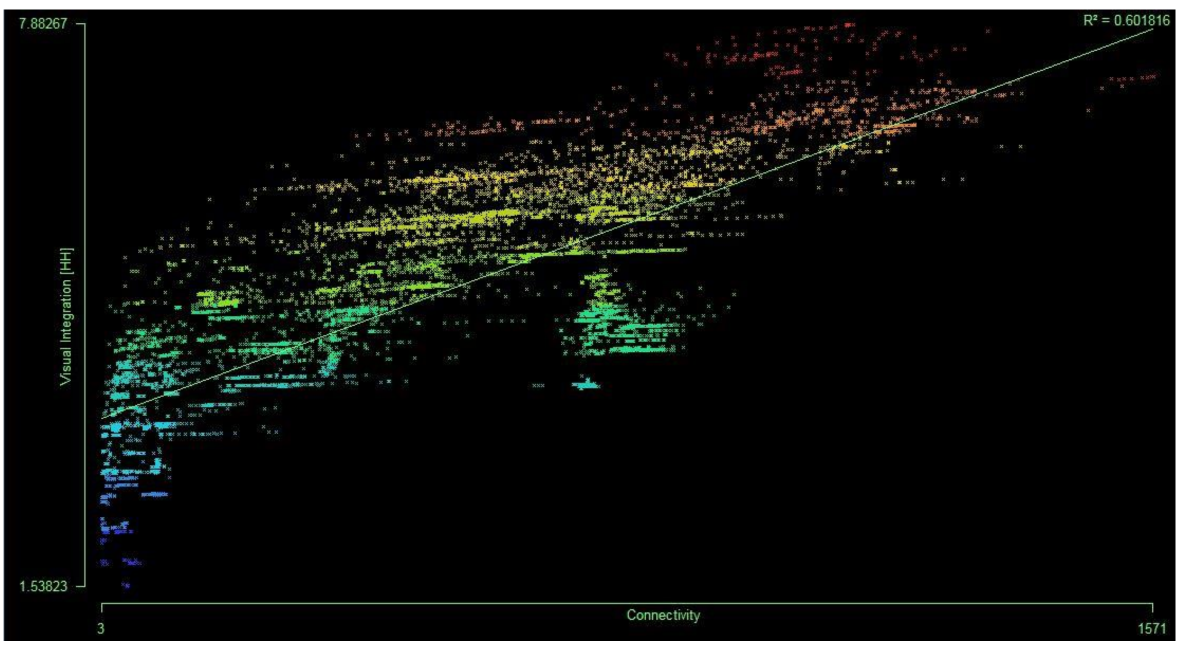

Plate XLVIII: V.G.A Graph Showing Visual Integration, Connectivity and R^2 Values.
Source: Author's fieldwork, 2017

Integration [HH] of the floor plan

Figure 6.17 shows the V.G.A map of a floor plan indicating the relationship between individual space units. The most integrated spaces can be observed along the areas indicated in red colour and then areas of least integration in blue colour.

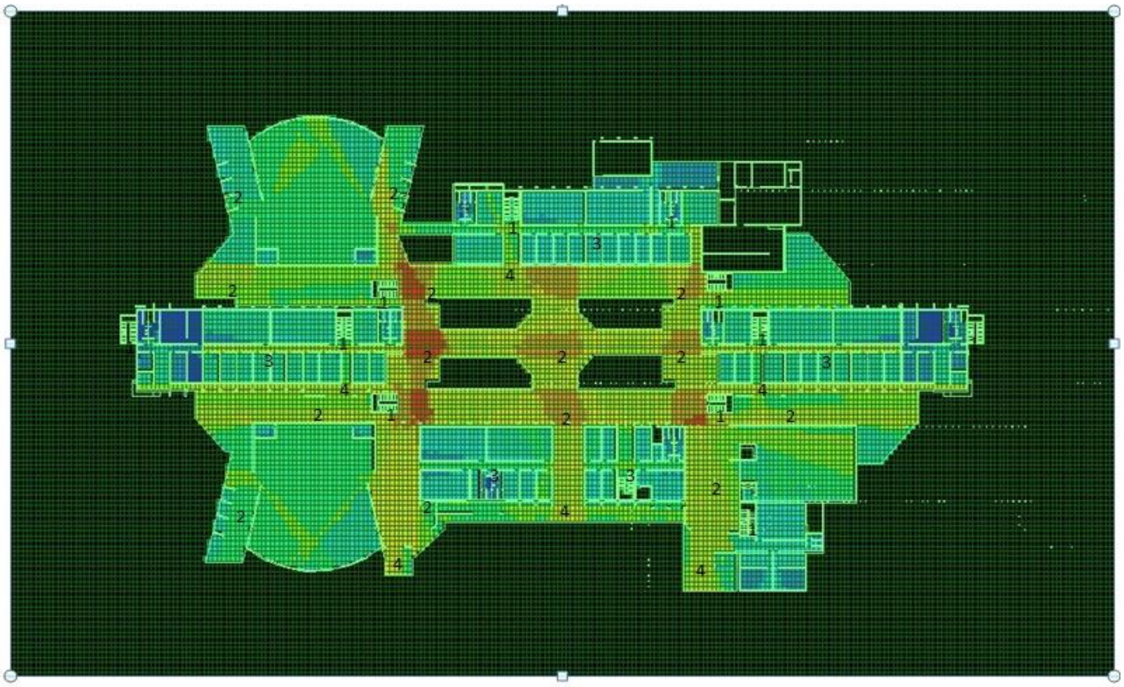

Figure 6.17: Map of the Integration of the Proposed Faculty of Medicine.
Source: Athor's fieldwork, 2017

6.9.6 Discussion of findings for V.G.A, (proposed Faculty of Medicine).

The V.G.A has taken into consideration key areas where flexibility strategies where incorporated and how they influence the overall outcome of the analysis. It has shown the importance of strategic location of access between the departments at all levels. Also the strategic location of staircases both within the interior and exterior has not only created convenient access but also aided in integrating the entire building. Reduction of lengthy corridors also aided connectivity between near-by buildings and departments. The overall effect of this was indicated from an R^2 value of 0.601816 which can be expressed as a percentile score of 60%; this has met the requirement for a good design.

7.0 CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Findings has shown that although efforts were made towards expansion by providing ample spaces, and in some cases integration within the case-study areas, achieving periodic changes has been haphazard due to lack in a clear strategy that should have guided these processes in conformity with the settings of medical schools. This has been shown through the variables that have been used to analyze both findings and resultant implications on the study areas as follows:

Adaptation: use of a framed structural system allows for adaptability and encourages expansion and alterations. The use of form to follow function allows both interior and exterior spaces to adapt to changes uniformly within the case study areas. The span for the structural system has to be convenient for laboratory practices. Rectangular building forms adapt to future changes more than irregular forms.

Transformation: easily replaceable building materials used for construction allows for periodic changes. The use of framed structural system for construction allows for transformation within the interior and exterior spaces either by addition or elimination of partition and elements of the building structure; however, this is subject to the choice of easily replaceable materials. The effect for the potentials for building transformation was weakened due to the fact that replaceable building materials were mainly used as cladding element but not as walls or partition elements.

Mobility: good structural span system adopted for construction is convenient for movement of furniture and facilities within laboratories. This has been limited in case-study 1 by the span of the structural system adopted. Technological and installed components, however, should be made accessible and easy to dismantle so they can be relocated and adjusted at any given time.

Interaction: good zoning, compartmentalization, sequencing and transition between indoor and outdoor spaces enhance its interaction and integration; however, the three study areas in this research work show partial integration due to inadequate link and access between departments, offices, walkways, staircases entrance and exit points and laboratory units. Evidence of this has been indicated numerically as 2.6, 2.2 and 3.4 for the values of spatial organization in the three study areas- which does not show a good value based on the scaling factor utilized. These variables were further tested using space syntax analysis by taking note of their positions and mode of application through the Visibility Graph Analysis and also taking note of the resultant values for spatial connectivity and integration to obtain intelligibility values of 0.31 (31%), 0.22 (22%) and 0.175 (17.5%) for case study 1,2 and 3. However, the research also took into account all findings and their implication to come-up with and alternative and proposed design. The proposed design obtained an intelligibility value of (60%) which was above the minimum requirement for a good design

The ripple effect of ignoring the aforementioned variables has been seen from the space challenges experienced by the case study areas. The research instruments used identified critical elements of design such as *the need for framed structural system, need for easily replaceable building materials, use of modular sized spaces and building form, the need for integration and connectivity of related laboratory facilities, the need for a reduction of* *lengthy corridors, need for outdoor learning spaces, convenience if mobility and access between all departments, sense of interaction and transition between the interior and exterior spaces and the convenience of delivery into the cadaver laboratory, alternative laboratory design through the high rate ceiling system or the individual downdraft method and also design of laboratory for problem based learning,* to be properly considered for a flexibility design of the Faculty of Medicine . It is therefore, paramount that the design of future Faculties of Medicine should utilize these good attributes to achieve a flexibility strategy that is convenient for its future needs.

7.2 Recommendations

The following are therefore recommended for use in the design of Faculty of Medicine

1. Zoning of activities to aid smooth transitioning from general public areas to more restricted areas.
2. The use of transition spaces to create a sense of interaction and outdoor learning environment.
3. The use of framed structural system for convenience of expansion both within the interior and exterior spaces.
4. Compartmentalization of spaces to enhance access and reduce distractions.
5. Creation of spacious laboratories with high-level headroom, convenient for achieving good ventilation through high-level ceiling system or individual downdraft method.
6. Lengthy corridors should be discouraged in order to improve space efficiency.

7. Spaces of related function and activities should be zoned and compartmentalized accordingly to enhance efficiency of usage.

8. Convenient access should be provided for delivery into cadaver storage room.

9. Easily replaceable building materials should be used for construction.

7.3 Contribution to Knowledge

The key contributions of this research are:

1. The study has shown the ineffectiveness of the use of flexibility strategies in Faculty of Medicine by establishing space intelligibility of r^2=0.31 (31%), r^2=0.22 (22%) and r^2=0.17.5 (17.5%) for case study 1, 2 and 3 respectively.
2. The study has established the following flexibility strategies for future faculties of medicine in Nigeria, (1) reduction of long corridors, (2) integration of core laboratory facilities, (3) creation of transition spaces, and (4) use of framed structural system.
3. The proposed design demonstrated the incorporation of established flexibility strategies which improve intelligibility to 60%.

7.4 Areas for Further Research

With respect to the architecture of schools, there are areas that need to be exploited for further research. This research addressed flexibility challenges related to medical schools which has identified challenges based on changes in curriculum, modern technology and the building system, as key factors that affects its flexibility attributes both on a long and short-term basis. While these remains true, as far as this research is concern, different or other factors might be responsible for the challenges of flexibility in other school building typologies. The author, therefore, suggests that further research on the flexibility of other schools building typology can be carried out by discovering their unique challenges of flexibility in other to come-up with the appropriate strategies.

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Appendix A: Visual Survey Checklist

S/N	VARIABLES	CHECKLIST	LEVEL OF REFLECTION 1	2	3	4	5	MEAN SCORE	REMARKS
1.	**Adaptation** (Building form)	Suitability of the building geometry to periodic extension.						.	.
		Design of structural system for future alterations and expansion.							
		Convenience for change of functions within interior spaces.							
2.	**Transformation**	Ease of replacement of the building materials.							
		Convenience of spatial lay-out to addition or elimination of partition elements.							
		Ease of structural system to addition or elimination of forms.							
3.	**Interaction** (Spatial organization)	Zoning of the facilities.						.	
		Spatial sequencing.							
		Compartmentalization.							
		Design of Circulation within and outside the building.							
		Existing spaces performing multiple functions.							
4.	**Mobility** (Use of Facility**)**	Accessibility of installation components.						.	
		Presence of easily replaceable and dismantling materials.							
		Placement of structural design for construction and installations on a maximum partition.							
		Design provision and convenience of spaces to the movement of facilities.							

Source: Author's fieldwork, 2016

Appendix B: Interview Questions for the Case-Study Areas.

1. **INTERVIEW QUESTIONS FOR THE STAFF**

a). Can you please tell me, based on historical records, the challenges of space you have faced so far in terms of its sizes and adjustment to daily activities?

b). Are there existing functional space units that should be incorporated for multi-functional use?

c). Base on the trends of medical practice, what units do you anticipate will require rapid changes in the future?

d). 21st century medical schools are said to be distinguished by changes in curriculum, modern technology and need for increased capacity. What is the actual nature of these challenges?

e). If a framework for the design of future medical schools were to be established, what specific requirements do you think needs to be standardized.

2. **INTERVIEW QUESTIONS FOR THE STUDENT**

a). Social and spatial interaction has been identified as one of the goals of 21st century medical schools, what in your opinion will improve interaction both for curricular and extra-curricular activities?

b). Which spaces will you recommend to be larger or smaller for activities.

c). What space unit do you spend longer hours daily, how many activities do you partake-in within the space, and what do you think can be done to improve the state of the space to suit the activities?

Appendix C: Letter of approval from the Faculty of Medicine, A.B.U, Zaria.

FACULTY OF MEDICINE

AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

Nulli Secundus

Vice Chancellor: Professor Ibrahim Garba, B.Sc. (Hons) Geology, M.Sc. (Mineral Exploration) ABU, Ph.D Geology (London), D.I.C., FNMGS
Dean: Professor A. G. Bakari, MBBS, M.Sc, FWACP, FACP, FACE.

E-mail: deanmedicine@abu.edu.ng
Tel: 069-875530

F.MED/11.1 **9th May, 2016**

Wakil Midala
Department of Architecture
Ahmadu Bello University,
Zaria.

Dear Sir,

RE: LETTER OF INTRODUCTION: WAKIL MIDALA M.SC II POSTGRADUATE ARCHITECTURE WITH REG. NO (P.13 EVAT8046)

Please reference to your letter dated 30th of March 2016 with reference of A/2.27 on the above subject matter, I have been directed to convey Dean's approval for you to conduct your research in the faculty of Medicine.

Thank you.

Yours faithfully,

Abdulkadir Shehu
For: Faculty Officer

Cc: Dean of Medicine
Faculty Officer

Dr. A.J. Randawa, MBBS,FWACS (Deputy Dean), Dr. M.S. Isah, MBBS, FWACP (Assist Dean PG), Dr. A. Hassan, MBBS, M.Sc, FMCPATH (Assist. Dean Clinical), Dr. M. I. A. Saleh, MBBS, M.Sc, Ph.D (Fac. Exam Officer, Pre-Clinical), Dr. A. Abdulwahab, B.Sc, MBBS, M.Sc., Ph.D, MSFN, MNMA, MPSN (Asst. Dean Pre-Clinical), Dr. A. Bello, MBBS, FWACS (Fac. Exams Officer Clinical)

Appendix D: Letter of approval from the Faculty of Medicine, University of Jos.

UNIVERSITY OF JOS
FACULTY OF MEDICAL SCIENCES
OFFICE OF THE DEAN

Private Mail Bag 2084,
Jos, Nigeria
E-mails:dmed@unijos.edu.n
deanfms@yahoo.c
Phone: 073-610936 Ex 233

Ref:..

Date: **1st June, 2016**

Dr. H. Babangida
Head of Postgraduate Section
Department of Architecture
Faculty of Environmental Design
Ahmadu Bello University
Zaria.

Dear Sir,

RE: LETTER OF INTRODUCTION: WAKIL MIDALA – M.SC II POSTGRADUATE ARCHITECTURE STUDENT WITH REGISTRATION NUMBER (P. 13EVAT8046)

With reference to your memo A/2.27 dated 30th March, 2016 with the above subject matter.

I am directed to inform you that your request has been approved to carry out your research in the pre-clinical site.

Wishing you the best of luck.

D.C. Adeagbo (Mrs)
Faculty Officer, FMS
For: Dean, Faculty of Medical Sciences

FACULTY OF MEDICAL SCIENCES
FACULTY OFFICER
01 JUN 2016
Signature..........
University of Jos, Jos Nigeria

Appendix E: Letter of Introduction to the Faculty of Medicine, University of Ibadan.

DEPARTMENT OF ARCHITECTURE
AHMADU BELLO UNIVERSITY, ZARIA
VICE CHANCELLOR: Professor Ibrahim Garba, BSc (Hons) MSc (ABU) PhD (London), DIC, FNMGS, MCOMEG

Ref: A/2.27

26th May, 2016

The Head of Department,
Department of Works and Maintenance,
University of Ibadan,
Oyo State.

Dear Sir,

LETTER OF INTRODUCTION: MIDALA WAKIL - M.SC III POSTGRADUATE ARCHITECTURE STUDENT WITH REGISTRATION NUMBER (P13EVAT8046)

I wish to request your kind permission to allow the above named M Sc III Postgraduate Architecture Student of this Department who is undertaking a Project work on a Topic "Enhancing Expansion and Space Multi-use through Flexibility Startegies in the Design of Faculty of Medicine, Yobe State University." to use your Dedpartment as a Case Study and the same time collecting data relevant to the subject to be used purely for academic purpose. Kindiy assist him with relevant information.

Thank you for your cooperation.

With regards,

Yours faithfully,

HEAD
Dept. of Architecture
Fac. of Environmental Design
A .B. U. Zaria Nigeria

Dr. H. Babangida
HEAD OF POSTGRADUATE SECTION

FACULTY OF ENVIRONMENTAL DESIGN
DEPARTMENT OF ARCHITECTURE
Head: Dr. A. S. Salisu BSc (Hons) MSc, PhD Arch (ABU) mnia, maarches

Telephone: +234-818063987
E-Mail: architecture@abu.e

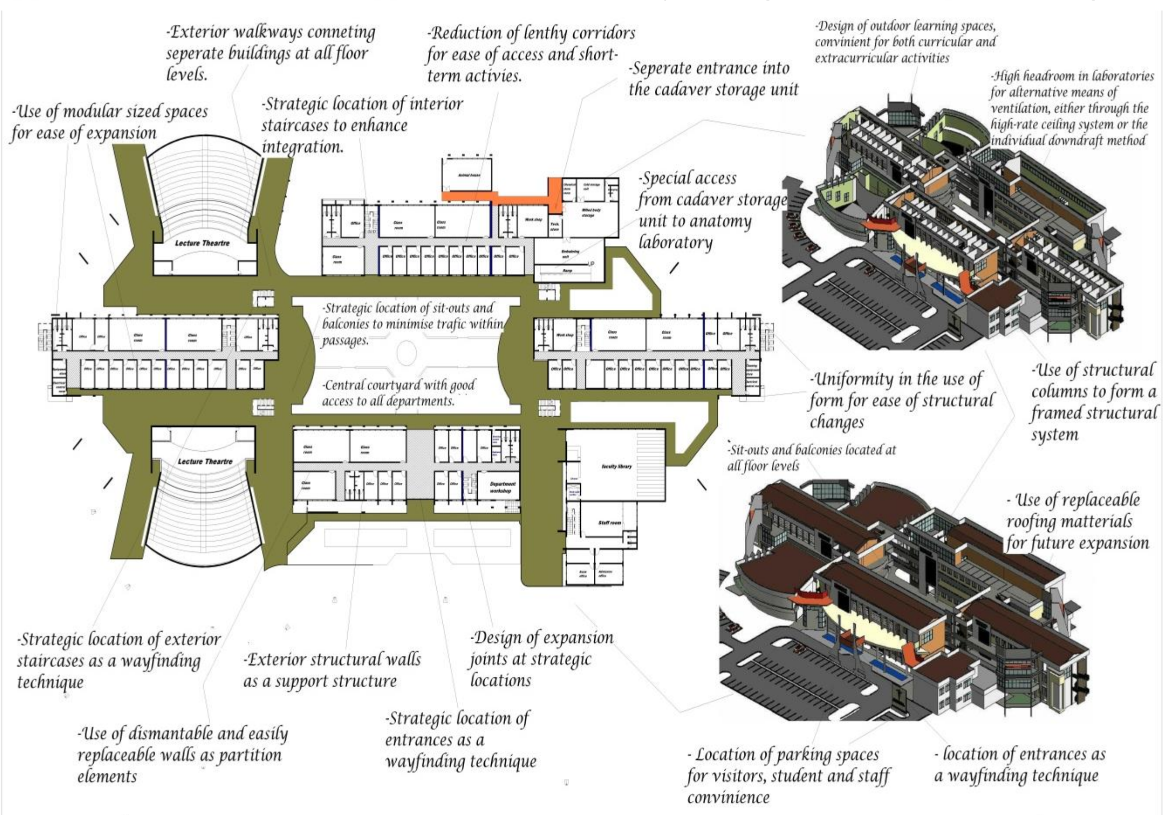
Appendix F: (a) & (b) 3-Dimentional View of the Proposed Faculty of Medicine

(a)

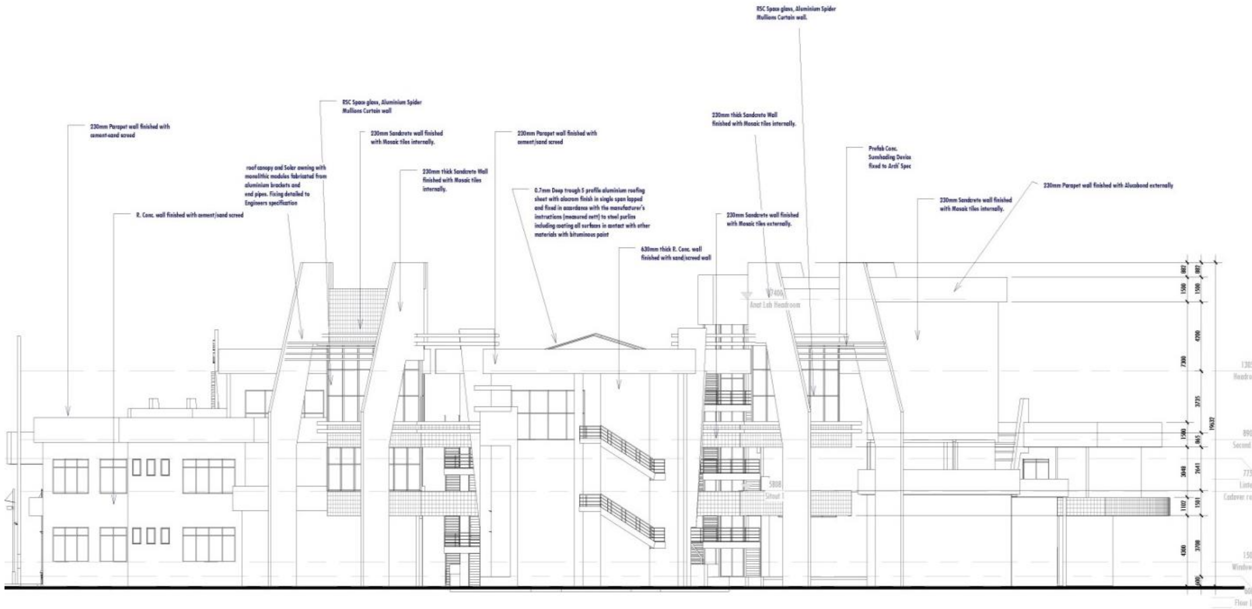
(b)

Appendix G: 3-Dimentional View of the Courtyard for the Proposed Design

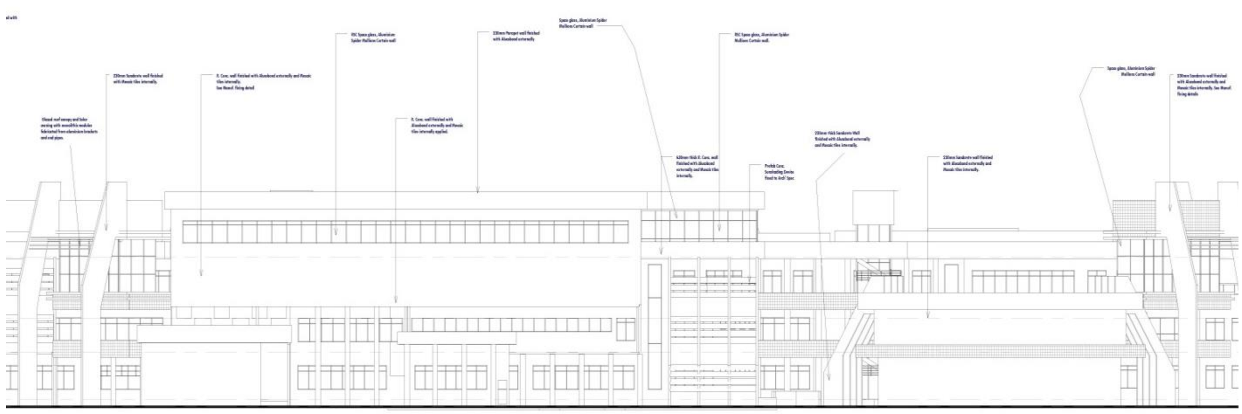
Appendix H: Reflection of Application of Flexibility Strategies in the Proposed Design



Appendix I: (a) & (b) Sections of the Proposed Design



(a)



(b)